Ocean Optics

bringing answers to light

07

catalog

Milestone Mania

On April 9, 2007, we'll mark the 15th anniversary of our first miniature spectrometer sale – quite an accomplishment for a bunch of dreamers who originally worked out of a shed (we couldn't even afford a garage!). To frame that accomplishment, consider this: sometime this year we'll sell our 100,000th spectrometer. Here are some milestones from along the way:

1989 Ocean Optics is incorporated in Dunedin, Florida, a lovely town on the Gulf of Mexico, thus beginning a long history of people asking us why we named a spectrometer company "Ocean" Optics.

1992 The "World's First Miniature Spectrometer" is sold to Los Alamos National Laboratories. The guy who sells the system also builds it, packs it, and drops it off at UPS. Fortunately, it's not his turn to take out the trash that day.

1993 The S1000 Spectrometer earns the company's first Photonics Circle of Excellence Award.

1995 Our booth space at the PITTCON show exceeds our headquarters office space (750 square feet). Four employees ask to move their desks to the booth.

1999 We establish a Thin Films Division, securing a supply of optical components and expanding into new markets with a patented technology for patterned thin film filters.

2000 First overseas office, in Europe, is founded. In the States, everyone immediately asks to have off the month of August. (Just kidding!)

2001 Founder Mike Morris turns 50 during PITTCON. We celebrate by building a pirate ship (really) for our booth, donning foppish pirate shirts, and throwing a parade in the streets of New Orleans complete with motorcycle escort, jazz band and (of course) beads.

2003 Our Laser-induced Breakdown Spectrometer wins our third Photonics Circle of Excellence Award.

2005 SeaChanger, a color-changer technology from our Thin Films Division, is awarded the Entertainment Services & Technology Association's Dealers' Choice Product Award for Equipment. Six months later, SeaChanger makes its Broadway debut in TARZAN®.

2006 Our company establishes its first Asia-based Sales, Service & Support Office in China.

2007 The Jaz family of flexible sensing modules – a new concept in optical sensing – has a dazzling debut at Photonics West. The show is the most successful in company history.

Contact Information

Worldwide Headquarters

830 Douglas Avenue
Dunedin, FL 34698
USA

Tel 727.733.2447
Fax 727.733.3962
Info@OceanOptics.com
Orders@OceanOptics.com

Worldwide Sales, Service & Support Locations

See page 5 for contact information for all of our Sales, Service & Support locations including Europe and Asia.

Expanded Service Hours

8 a.m to 8 p.m. (EST)
Mondays - Thursdays

8 a.m. to 6 p.m. (EST)
Fridays

Real People, Real Answers

Call Ocean Optics and discuss your optical sensing needs with one of our knowledgeable Applications Scientists.

727.733.2447

Ordering Information

Terms:

Net 30 days with credit approval. Contact us for further information. All shipments are delivered EXWORKS, Dunedin, Florida, USA. For all shipments into Florida, we are required to charge sales tax unless a valid resale certificate is received prior to shipment. Fax resale certificates to our Accounting Department at 727.734.0957. Specifications, descriptions, ordering information and item codes described herein are subject to change without notice. These commodities, technology or software are to be exported from the United States in accordance with the Export Administration Regulations. Diversion contrary to U.S. law prohibited.

Pricing:

Our Worldwide Pricing Policy ensures that a single, universal price applies to every Ocean Optics product, regardless of where it's sold. While extra costs due to currency exchange, and customs, shipping and other costs are borne by the customer, they should not be confused with a product's selling price. We adopted this policy to provide clients with relief from excessive add-on costs that others pass on to overseas customers. Here's some additional tips about pricing:

- All prices are subject to change without notice.
- For the most up-to-date pricing, contact us at 727.733.2447 or visit our website at OceanOptics.com.
- We honor the pricing cited in a quotation for 30 days.
- You can purchase Ocean Optics products from any of our four locations around the world (for contact information, see page 5), from an Ocean Optics distributor (visit www.oceanoptics.com/corporate/distributors.asp for a complete contact list) and from VWR (visit www.vwr.com).
- Pricing for some light sources and accessories manufactured in Europe are subject to exchange rates, and vary frequently.

Credit Cards:

Ocean Optics accepts American Express, MasterCard and VISA credit cards.

Shipping:

Shipping charges are the responsibility of the customer. Orders are shipped UPS Ground, unless otherwise requested. Customers may reverse shipping charges to use the carrier of their choice.

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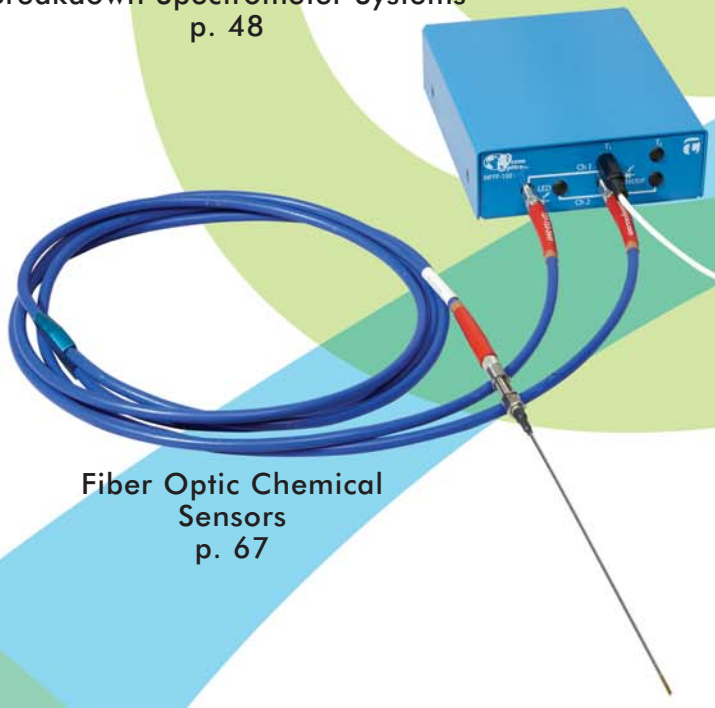

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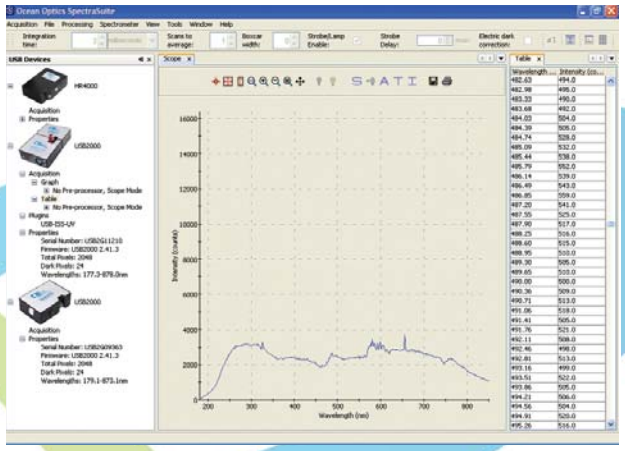

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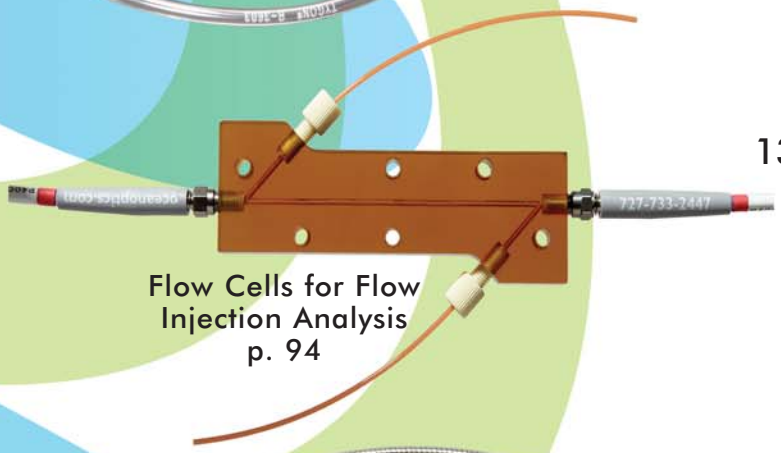

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15 Years of Bringing Answers to Light

What Really Matters

We value the opportunities to learn and to grow -- and to expand the frontiers of optical sensing -- that come from partnership. Recognizing and seizing these opportunities is what Ocean Optics is all about -- and is reflected in an open, collaborative approach that appeals to everyone from the innovators and early adopters to the skeptics and the traditionalists.

Ocean Optics in 2007: 100,000 Spectrometers!

Founded in 1989, Ocean Optics manufactures miniature fiber optic spectrometers and accessories, optical sensors, optical fibers, and thin films and optics. Our palm-sized fiber optic spectrometer -- "the world's first miniature fiber optic spectrometer" -- has spawned dozens of imitators and enabled thousands of optical-sensing applications across a variety of industries and disciplines. We've never been much for self-congratulation, but Ocean Optics will mark two major milestones in 2007: the 15th anniversary of our first sale, and the 100,000th spectrometer sold since 1992. So we've paused to reflect:

- We started in 1989, when our founding fathers, a group of university researchers, developed a fiber optic pH sensor to study the role of the oceans in global warming. Later, a Small Business Innovation Research grant from the U.S. Department of Energy led to the development of the world's first miniature fiber optic spectrometer.

- Our first commercial sale was in April 1992, to a researcher at Los Alamos National Laboratories named Ed Kaukell. Ed purchased an S1000 Spectrometer, which he used in an application involving plutonium. Years later we tracked down that first spectrometer -- no, it's not radioactive -- and now display it at company headquarters.

- In 1993, our S1000 Miniature Fiber Optic Spectrometer earned the Photonics Circle of Excellence Award, which recognizes innovation in photonics. We also won the award in 2000 and 2003.

- Our original miniature fiber optic spectrometer, the S1000, retailed for $1,800 and required an additional $500 A/D Converter. Its modern equivalent, the USB4000 Spectrometer, retails for just $2,200 and includes an onboard A/D Converter.

- At the end of 1992, we had about 20 items in our product line. Today, we offer nearly 1,200 spectrometers and accessories.

- NanoDrop Technologies purchased our 50,000th spectrometer, a milestone we celebrated in January 2005. NanoDrop, a Delaware-based supplier of UV-VIS spectrophotometers for extremely small-volume sampling, is a prototypical Ocean Optics customer: a small team of researchers with an interesting application, the passion and know-how to make it happen, and an appreciation for the advantages of size, cost and flexibility that our spectrometers provide.

NanoDrop Technologies founder and engineering director, Charles Robertson, celebrates our 50,000th spectrometer sold in 2005.

- If you took all 100,000 spectrometers and laid them end-to-end, the line would stretch for nearly eight miles.

- The optical benches of the 100,000 spectrometers project spectra across approximately 200 million detector pixels.

From its humble beginnings as a garage-shop operation with just a handful of products, Ocean Optics has grown to two manufacturing facilities and four Sales, Service & Support locations worldwide selling nearly 1,200 unique products. Our spectrometers have been used in thousands of applications, from the volcanologist who duct-taped the spectrometer to a bicycle helmet as he ventured inside an active site to monitor sulphur dioxide, to the NASA researcher who strapped the spectrometer to a reentry rocket to measure its exhaust plume.

Thanks to the thousands of Ocean Optics customers who have helped us achieve such milestones!

Ocean Optics Vision Statement

To expand the frontiers of optical sensing and make it the foundation on which innovative, life-changing ideas are built.

Worldwide Sales, Service & Support

From our humble beginning as a garage-shop operation with a handful of dreamers and too many bills, we've grown to six sales and manufacturing facilities worldwide supported by over 200 employees. Recent developments include the expansion of our customer service and technical support departments at headquarters and the addition of full-service sales and support offices in Europe and Asia.

This 27,000-square-foot facility has been company headquarters since 1998.

Worldwide Headquarters: Dunedin, Florida, USA

Worldwide headquarters in Dunedin, Florida (at right), are home to our Sales & Marketing, Customer Service, Technical Support, Engineering and R&D, and Accounting and Human Resources Departments. Our three-story, 27,000-square-foot facility on the Gulf of Mexico is a 35-minute drive west of Tampa and is conveniently located near major airports.

Address: 830 Douglas Ave., Dunedin, FL 34698 USA
Telephone: 727.733.2447
Fax: 727.733.3962
Email: Info@OceanOptics.com (general sales inquiries)
Hours: 8 a.m. to 8 p.m. EST Monday-Thursday
8 a.m. to 6 p.m. EST Friday

Asian Operations: New Office Opens in China

Ocean Optics is excited to announce that it has established a full-time presence in Asia. Ocean Optics Asia opened its Sales, Service & Support office in Shanghai, China to support rapidly growing markets in Asia. This new office provides sales consultations and technical support; training services; and enhanced support for OEM, distributor, academic and research lab customers.

Address: 666 Gubei Rd, Kirin Tower, Suite 601B, Changning District, Shanghai 200051, People's Republic of China
Telephone: +86 21-6295-6600
Fax: +86 21-6295-6708
Email: Sun.Ling@OceanOptics.com
Hours: 9 a.m. to 6 p.m. CST Monday-Friday

Sun Ling, Ph.D., Director of Asia Operations for Ocean Optics, and her new staff of application scientists operate in the Changning District in Shanghai.

European Operations: 7-Year Anniversary for OOBV

Established in 2000, Ocean Optics B.V. is a full-service subsidiary of Ocean Optics dedicated to serving customers and prospects in Europe, the Middle East and Africa. The office is located in Duiven, The Netherlands, just outside of Arnhem. Ocean Optics B.V. provides sales and application assistance and technical support for the entire line of Ocean Optics products.

Address: Geograaf 24, 6921 EW Duiven, The Netherlands
Telephone: +31 (0) 26 319 0500
Fax: +31 (0) 26 319 0505
Email: Info@OceanOptics.eu
Hours: 8:30 a.m. to 5 p.m. CET Monday-Friday

Kees van de Steeg, Managing Director of Ocean Optics B.V., has nearly 30 years of experience in the optoelectronics industry.

European Operations: Old Friend Now a Part of the Family

In 2006, Mikropack GmbH, an innovative developer and manufacturer of light sources, photonics accessories and metrology systems, became part of the Ocean Optics family. Mikropack adds depth and experience to our presence in Europe by providing support for our spectrometers and accessories in Germany, Switzerland and Austria, and continues to sell and support its thin film and plasma-emission metrology systems.

Address: Maybachstrasse 11, D-73760 Ostfildern, Germany
Telephone: +49 (0) 711 34 16 96-0
Fax: +49 (0) 711 34 16 96-85
Email: Sales@Mikropack.de
Hours: 8 a.m. to 5 p.m. CET Monday-Friday

Co-presidents of Mikropack, Gerald Nitsch and Dieter Steck, accept a Baden-Wuerttemberg award for enterprise companies. For over a decade, Mikropack and Ocean Optics have collaborated successfully on engineering and sales projects. Now Mikropack is *Ocean Optics.*

Worldwide Distribution Network

Trusted Experience Around the World

We have an extensive network of domestic and international distributors who provide comprehensive pre- and post-sales service for our line of optical-sensing products. Our distributors offer considerably more than simple order-taking: they provide a local source for applications expertise and sales consultation, as well as hands-on demonstrations of our spectrometers and accessories. Many of them are former customers who liked our products so well they jumped at the opportunity to join our sales network. For an up-to-date list of Ocean Optics distributors, click on the "Worldwide Distribution" link at OceanOptics.com.

Ocean Optics Distributors & Worldwide Pricing

Our distributors abide by our "Worldwide Pricing" policy, which ensures that a single, universal price applies to every Ocean Optics product. Extra costs due to currency exchange, customs duties and shipping charges should not be confused with a product's selling price. We originated this policy to provide clients with relief from excessive add-on costs that other manufacturers and distributors pass on to overseas customers. Worldwide pricing is prominently displayed on our website and in our print catalog. We adhere to fair business practices and employ these principles in the Ocean Optics worldwide distributors agreement.

Distributors from around the globe met in Singapore for training in November 2006. Such events are scheduled throughout the year.

Join Our Distributor Team

Our distributors come from a variety of backgrounds, experiences and cultures, yet they all have one thing in common: a passion for using Ocean Optics technologies to help their customers solve an array of optical-sensing applications challenges. We're always looking for skilled and enthusiastic people to help us sell the most innovative line of photonics products in the market. If you are interested in becoming part of our worldwide distributor network, contact us at DistributorSupport@OceanOptics.com -- we'd love to discuss opportunities. If you qualify as a distributor, here are some of the benefits you'll enjoy:

Discounted Pricing

Qualifying distributors reap the benefits of discounted pricing on spectrometers and accessories. Discount rates -- based on gross margin of the product -- depend on sales volume, which is reviewed annually and adjusted to reward top performers. Also, top-tier distributors can take advantage of prospect-generation and marketing support to promote Ocean Optics products.

OEM Client Development

Our spectrometers are used in thousands of OEM devices in various industries worldwide. We offer special pricing for distributors who prospect and manage OEM clients within their territories. Under this unique margin-sharing program, OEM client development offers a premium profit advantage for both Ocean Optics and the distributor.

Technical Training

Because selling Ocean Optics products requires skilled applications engineers who perform a significant consultative role, we provide distributors with regular technical training. Nick Sebastian, Worldwide Distributor Manager, and Gary Manche, Training Manager, are available to provide provide sales and technical support for new programs and products.

Sales & Marketing Support

Ocean Optics makes available to distributors various promotional items, and encourages distributor participation at major tradeshows. For top-tier distributors we offer cooperative marketing support, in the form of expertise, cost-sharing and other collaborative efforts on tradeshows and other promotional items. Top-tier distributor support also includes sales prospect lead-sharing and market-coordination programs designed for greater territorial coverage and customer support.

Lead Sharing

Ocean Optics marketing efforts generate thousands of prospects. Top-tier distributors qualify for lead sharing, an exchange of leads between Ocean Optics and the distributor. Lead sharing ensures that our overseas prospects receive rapid response to their sales and technical needs.

Nick Sebastian, Worldwide Distributor Manager.

Contact Information

To find a distributor, visit www.oceanoptics.com/corporate/distributors.asp. For information on distributing our products, contact Nick Sebastian at DistributorSupport@OceanOptics.com.

OEMs & Application Developers

Build your Success Using Ocean Optics Products!

Do you have a great idea for a commercial product that uses optics? Maybe you've developed a new analytical technique, or perhaps your company is already a world leader in spectroscopy-based instrumentation. Whether you're developing a groundbreaking new analytical technique or designing the next-generation system for a demanding and sophisticated market, Ocean Optics has the skills, service, and knowledge to help you succeed. We can we enable your success with our innovative Original Equipment Manufacturer (OEM) Partner Program. It is designed to guide you through product development and launch by giving you the two things you need most during this crucial period: 1) discounted pricing; and 2) customized advice on how to get the most out of your Ocean Optics equipment.

NanoDrop Technologies, an Ocean Optics OEM, manufactures and sells unique instruments that provide 1 µl photometric analytical capability for labs throughout the world. The company's patented retention system uses inherent surface tension and fiber optic technology for highly accurate quantitation of nucleic acids, proteins, and a wide variety of other chromophores and fluorophores, without the need for cuvettes or capillaries. This novel technology is an essential component in today's research environment as investigators continue to perform molecular analysis on ever-smaller amounts of material. For more on NanoDrop, visit www.nanodrop.com or call 302-479-7707.

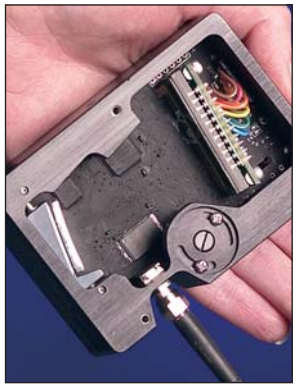
Full-service Support

As a member of the OEM Partner Program, you get free consulting services from applications specialists with the knowledge and connections to assist you from the beginning of your product development cycle through launch and ramp-up. The result is a high-performance, low-cost product designed for manufacturability and quality field performance. In addition, OEMs have at their disposal an array of a la carte R&D services, from optical design and software engineering to prototype development and testing and validation. In addition, members receive these added-value benefits:

- Discounts without minimum orders or commitments
- Free access to all user interface and driver software programs (a $1000+ value)
- Order status notification and expedited order fulfillment
- Development assistance from the technical experts
- Access to software development consultants with Ocean Optics experience
- OEM Interface Guide, wiring diagrams, register maps and spectrometer pin-out information
- Co-marketing opportunities through our website, tradeshows and our distribution network

Modular Components

Ocean Optics offers a comprehensive tool kit of optical components and accessories that can be combined to serve markets in medical diagnostics, analytical chemistry, semiconductor process monitoring, and even intensity measurements. By mixing and matching optical bench components such as gratings and slits, one optical bench alone can be configured more than 500 different ways!



Discounts & Savings

Our goal is to make you successful; we want our OEMs to grow. The annual OEM Developer's Program membership starts at $999 -- a great value even for a small OEM. We also have outstanding volume discounts for those with larger needs. With added volume comes added benefits:

- Volume pricing to ensure you can provide the best value to your customers -- with discounts of up to 50%!
- Flex-Order -- Our flexible product delivery program that allows you to adjust delivery times and forecasts easily
- Quarterly Account Status meetings to ensure we continue to meet your needs
- A subscription to Ocean Insider -- our OEM Newsletter that keeps you informed on new products and services.

Contact Information

For more information on OEM opportunities, call us at 727.733.2447 and ask for our OEM Sales Manager, or email us at oem@oceanoptics.com.

Number of Units per Year	Discount	USB4000-UV-VIS with OEM Discount*
1	Gross Margin	$2,649
5	10%	$2,384 per unit
10	15%	$2,251 per unit
20	20%	$2,119 per unit
35	25%	$1,986 per unit
50	30%	$1,854 per unit
75	35%	$1,721 per unit
100	40%	$1,589 per unit
150	45%	$1,456 per unit
200	50%	$1,324 per unit
250	53%	$1,245 per unit
500	55%	$1,192 per unit

** OEM Discount Price does not include the OEM Developer's fee of $999 in the first year and the $599 renewal fee each year thereafter.*

Educational Spectroscopy Grants

Innovations in Educational Spectroscopy Grant Program

Today's students are the most tech-savvy generation in history. Tap their enthusiasm by bringing the power of optical sensing to the modern teaching lab. The *Innovations in Educational Spectroscopy Grant Program* provides cost-sharing resources to educators and researchers to promote the use of fiber optic spectroscopy in curricula and research. This is a great option for educators on a limited budget, or for those outfitting an entire lab.

Cost Sharing on Proposals for Extramural Funding

We provide cost-sharing support for proposals to federal, state or private institutions for the express purpose of purchasing our products to be used in science or engineering teaching. Cost sharing varies according to the product. There is no limit to the total cost-sharing amount.

Cost Sharing for Ocean Optics Equipment Used in Curricula

We provide cost sharing for purchasing products used to develop new science and engineering curricula. Cost sharing varies according to the product. Funding may come from any source, including an organization's internal funds; however, awards are based on the strength of the applicant's technical proposal and the novelty of the proposed curricula. The developed materials must be made available for publication at OceanOptics.com, so that other educators may have access to the information.

Trade-in Savings

Our trade-in programs provide discounts for all educational institutions on the purchase of CHEM4-series Spectrophotometers for the purpose of setting up a lab. Institutions qualify for discounts on our CHEM4-series Spectrophotometers, provided the institution trades in an old spectrometer, regardless of its condition.

Eligibility

Cost sharing is available to any qualified non-profit learning institution. For more information, or to request an application:

- Visit us online at OceanOptics.com/Corporate/Grantprogram.asp.
- Call an Applications Scientist at 727.733.2447.
- Email us at Education@OceanOptics.com.
- For details on the Grant Program outside of the U.S., contact your regional Ocean Optics Sales, Service & Support office.

$1,500,000 Worth of Grant Winners

Since 1999, we have awarded over $1.5 million to learning institutions for funding spectroscopic applications such as:

- Analysis of surface water samples
- Identification of organic dyes in textiles
- Chlorophyll absorbance and its relationship to photosynthesis
- High school-level introduction to principles of nanotechnology
- Visible tissue reflectance as a diagnostic tool in studies of the use of laser therapy for dermatological lesions
- Raman spectroscopy to analyze atmospheric pollutants
- Luminescence of mineral crystals to determine the histories of components in sedimentary rocks
- Metabolic rate, oxygen tension and hemoglobin concentration in fish
- Detection and identification of atomic emission lines from gas discharge tubes
- Measurement of ionization constants in acids and pH dyes
- Study of seaweed photosynthesis and animal respiration in aquatic chambers and under various water velocities
- Determination of DNA concentration using absorbance spectroscopy
- Fluorescence measurements of luminescent semiconductor-nanocrystal quantum dots
- Analysis of stellar and planetary absorption spectra
- Identification of organic dyes in Peruvian textiles for archaeological and ethnographic origin
- Measuring photosynthetic radiation through leaf reflectance
- Theoretical functioning and the effects of different variables on the ability of glow discharge plasmas to destroy pollutants
- Color perception of bees
- High temporal resolution measurements of volcanic degassing
- NIR analysis of the nutritional content of (yikes!) feces of various grazing animals

Education Division

Preparing Students for a Future in Science

The Spec20 -- for decades that workhorse spectrometer so ubiquitous to university labs around the world -- is yesterday's technology. At least, that's what you told us way back in 1995, when we launched the first of our PC-based, full-spectrum spectrometers for teaching labs. Today, we've built a full line of education-friendly spectrometers, accessories and instructional resources that take students and teachers beyond the limits of old-fashioned technology and into the possibilities of the future.

Tools for the Modern Teaching Lab

Ocean Optics offers small-footprint, multi-purpose PC-based instrumentation -- and more -- to meet most any educational application requirement:

- Our fully integrated CHEM4-series Spectrophotometers come with light sources and cuvette holders that attach directly to the spectrometer or connect via fiber. See pages 36-37.
- The $999 Red Tide is a general-purpose instrument for budget-strapped teaching labs. It is a good choice for simple visible absorbance setups. For more, see page 38.
- For users who prefer to avoid PCs, consider our educational partner Pasco and its Xplorer GLX, a datalogger and lab analysis tool in one. The GLX turns our USB-based spectrometers into PC-free systems. See page 39.
- Our modular spectrometers work well with the industry's most extensive selection of spectroscopy accessories, from cuvettes and standards to optical fibers and dip probes.

Hardware is just part of the equation. Our SpectraSuite Operating Software is a powerful yet student-friendly tool that operates in Macintosh, Linux and Windows. Our educational system hardware is also compatible with the software of our educational vendor partners, including PASCO Scientific, Vernier Software & Technology, and MeasureNet Technology, Inc.

Curricula and Other Resources

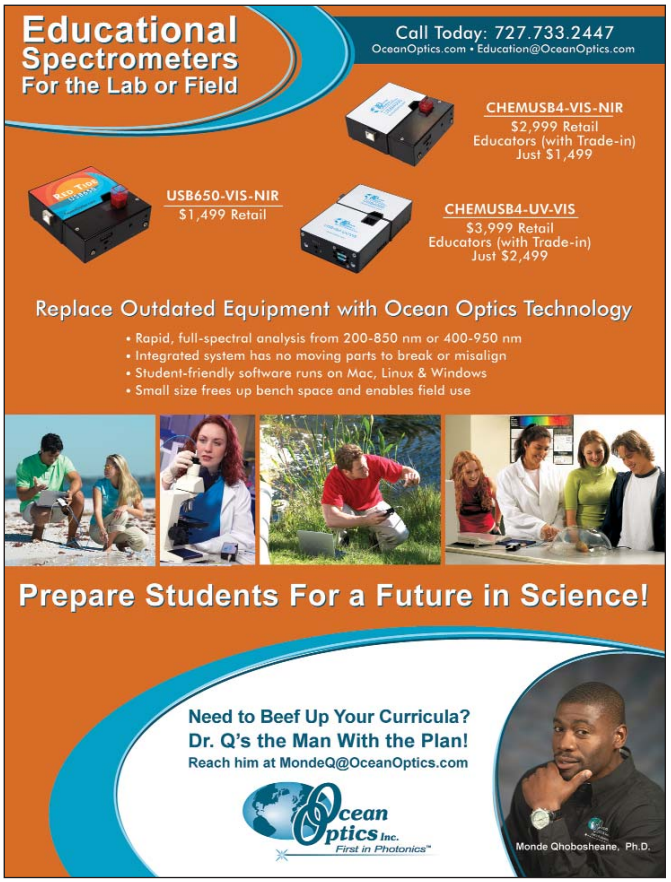
When you invest in Ocean Optics for your teaching lab or educational application, you're tapping into the collective power of 85,000+ spectrometers' worth of applications know-how. What's more, we've begun to capture that knowledge in a variety of easily accessible media:

- Database of curricula from our Educational Spectroscopy Grant Program awardees
- The Basics of Spectroscopy Measurements video on CD-ROM. See page 36 for more on the EDU-SPEC-CD.
- An 84-page handbook, *Introduction to Spectroscopy in the Teaching Lab Using Ocean Optics Spectrometers*, with sample lab exercises, available in print or on CD (page 36).

"Spectroscopy 101" Educator Training

Our educator seminar is designed for teachers and department heads interested in enhancing their science teaching curriculum. (Contact Education@OceanOptics.com for details.) Here are some of the topics to be covered:

- New approaches to teaching Beer's Law, kinetics, and absorbance and transmission measurements
- Reworking your old single-wavelength spectrometer curricula to labs based on Ocean Optics spectrometers
- Getting the most out of your modular spectrometer -- how one spectrometer design can be easily configured to explain principles in chemistry, physics or other disciplines



You may have seen our new promotions featuring "Dr. Q" Monde Qhobosheane, who received his Ph.D. from the University of Florida and taught chemistry at St. Petersburg College before coming to Ocean Optics to lead our Educational Division. Email Dr. Q at Education@OceanOptics.com.

Multiple Options, Maximum Convenience

Our low-cost, small-footprint educational spectrometer systems are now available directly from Ocean Optics or through one of our educational vendor partners:

- PASCO Scientific (pasco.com)
- Vernier Software & Technology (vernier.com)
- MeasureNet Technology Ltd. (measurenet-tech.com)
- MicroLab, Inc. (microlabinfo.com)
- Nicholl Education (nicholl.co.uk)
- SK Science Kit & Boreal Laboratories (sciencekit.com)
- VWR Education (vwreducation.com) network of brands, including Sargent-Welch and ScholAR Chemistry
- WARD'S Natural Science (wardsci.com)

Customer Service: Accessible & Flexible

Making Great Service Our Hallmark

We designed our products by first imagining how we would sell them -- i.e., we actually pictured ourselves talking to our prospects, discovering their needs and wants, and offering them the best solutions possible. As researchers ourselves, we realized the key to serving you well was flexibility -- flexibility in our modular products, flexibility in our attitude, flexibility in the way we handle your needs. We realize that great service is not a slogan -- it's an attitude, a philosophy.

Before the Sale: R&D and Applications Support

Our Applications Scientists are consultants in the best sense of the word, because they're guided by one central question: Why? If we don't ask you what your sample is and why you want to measure it, we haven't given you our best effort.

Sentiment is all well and good, you say, but what specifically can you do for me? Well, consider our pre-sale support:

- R&D. Prospects interested in developing new applications using our technology can draw on the resources of our OEM and Applications Groups, which comprise sales, engineering and technical support resources. We offer optical and electronic design services, software and firmware engineering, testing and validation services, and rapid prototyping.
- Applications. Our Applications Scientists take ownership of your most challenging applications needs. When you ask if our spectrometer can measure a certain sample, we respond, "Well, we don't know -- what is this sample and why do you want to measure it?" In short order, we have configured a system to measure the sample, we have put your order in the queue, and we've perhaps even started to work on a new accessory that we'll need to fill the order.
- Tradeshows and Seminars. What better opportunity to see our products in action than to attend a tradeshow? Our combined locations will exhibit at nearly 100 tradeshows worldwide this year (for a schedule of shows in the U.S., see www.oceanoptics.com/tradeshows.asp). In addition, we will host various seminars throughout the year, including our Customer Forum and Educator Training. Check OceanOptics.com for details.
- Sales & Service. With offices in Europe, Asia and the United States, and a network of distributors around the world, our service reach is truly global. In the States, we offer expanded service hours (Mondays-Thursdays 8 a.m.-8 p.m. and Fridays 8 a.m.-6 p.m. EST) and late-day shipping options. Customer sales & service representatives are available to take orders, provide order status, relay pricing and product information, and handle any basic service request. We are available via email and soon will add e-commerce and other multimedia services to our website. For a list of our locations see page 5 or visit oceanoptics.com/contactus.asp.

After the Sale: Customer Service & Tech Support

Our relationship with the customer doesn't end once the order goes out the door. In fact, our assistance after the sale is often where we provide the most value to our customers. Whether it's helping you to get started, or troubleshooting a challenge you're facing, we offer post-sale support in various guises:

- Help with the "Little" Things. Contact our Customer Sales & Service Department (727.733.2447 or Orders@OceanOptics.com) for questions regarding order status, delivery times, shipping charges and more. And when you call, you'll speak to an actual person.
- Troubleshooting Challenges. If you run into an issue with your order, our Applications Scientists and Technical Support staff (TechSupport@oceanoptics.com) can help. The former are especially useful for help with your configuration or experiment; the latter can assist with getting started, hardware-software compatibility, firmware and software programming issues and more.
- Repairs and Returns. Occasionally, orders don't work out exactly as planned. If you need a Return Merchandise Authorization (RMA) for a repair or an upgrade, contact us at 727.733.2447 or Repairs@oceanoptics.com. It's rare that spectrometer components or accessories fail; more often than not, our RMAs cover changes in spectrometer configuration, bench upgrades and the like.

Additional Resources

We provide readily accessible technical and support information on our website and in other media:

- Our Software & Technical Resources CD ships with every order, and contains manuals, operating instructions and software. These materials are also conveniently available online at oceanoptics.com/technical.asp.
- Engineering-level documents are also available online, at oceanoptics.com/technical/engineeringdocs.asp. This is where you'll find information on topics such as CCD detectors and linearity, lamp stability and USB adapter interfaces.
- Click the APPLICATIONS button at OceanOptics.com to view an Applications Database of journal articles that reference our products. And it's always fun to do a search at http://scholar.google.com. The last time we looked, there were over 5,000 listings for Ocean Optics spectrometers.
- Other resources include a UV-Vis Spectral Database CD, short video clips on basic spectroscopy measurements, and a handbook in both print and CD formats on the use of spectroscopy in the teaching lab. For details, contact an Applications Scientist.

How Are We Doing?

We love hearing from our customers. Your feedback helps us serve you better. Please direct your questions, concerns and comments to Info@OceanOptics.com or write to us at Ocean Optics, Inc., 830 Douglas Ave., Dunedin, FL 34698 USA.

Spectrometers

User-configured Spectrometers are for those who wish to select components and options in their spectrometer, from the wavelength range and grating type to the size of the entrance aperture and type of coatings on the detector.

14 USB4000 Plug-and-Play Spectrometer
15 "USB" Optical Bench Options

20 HR2000+ High-speed High-Resolution Spectrometer
21 HR4000 High-resolution Spectrometer
22 "HR"-series Optical Bench Options

26 QE65000 Scientific-grade Spectrometer
27 "QE" Optical Bench Options

30 NIR-512 Near-infrared Spectrometer
30 NIR256 Extended-range NIR Spectrometers
32 "NIR"-series Optical Bench Options

Overview: Spectrometers

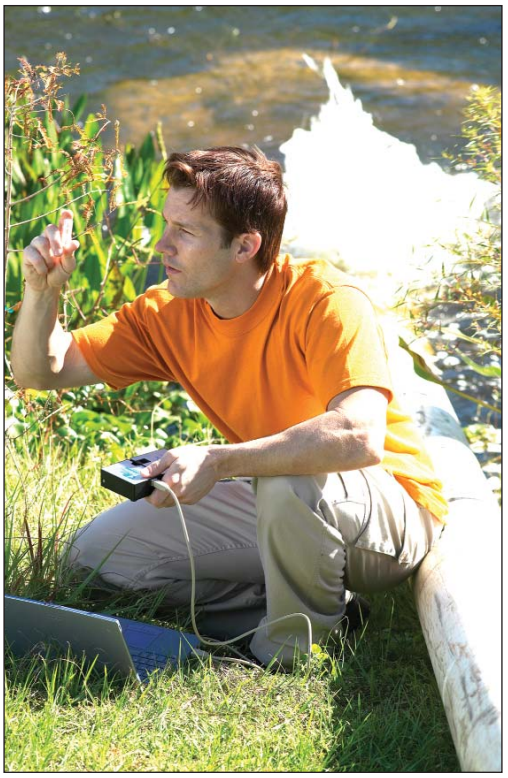
We Have Your Spectrometer!

Since we introduced the world's first miniature spectrometer 15 years ago, we've sold more than 85,000 spectrometers and enabled thousands of applications. We pioneered the notion of flexible, modular spectroscopy, making it possible for users in many industries to configure systems for very different applications.

For those who wish to select the components in their spectrometer, we offer a complete range of options. You can make it your way:

- The size of your entrance aperture helps determine how much light enters your optical bench and is a factor in determining optical resolution. We have six sizes of entrance apertures.
- Our filters block second- and third-order effects or balance color.
- You can opt to install standard collimating and focusing mirrors or SAG+ mirrors, which increase reflectance and sensitivity.
- We offer 14 different gratings. Your choice helps determine your resolution and wavelength range.
- An optional collection lens increases light-collection efficiency.
- Our OFLV filters precisely block second- and third-order light from reaching specific detector elements.
- A UV upgrade enhances the spectrometer's performance in the UV.

Our Applications Scientists have configured thousands of spectrometer setups. Simply tell us what you want to measure and why and we'll configure the optimum system for your application.



Detector Type

CCD Detectors
We use a 3648-pixel CCD-array detector from Toshiba in both our "USB" and "HR" optical benches that's ideal for general-purpose applications. The Sony ILX511 is a 2048-pixel linear CCD-array detector that's still used in a couple of our specialized spectrometer offerings.

Photodiode Detectors
Less-sensitive photodiode detectors provide a high signal-to-noise ratio for applications with high light levels. We use Hamamatsu's S3903 and S3904 photodiode silicon linear arrays for our Deep-well Spectrometers.

Back-thinned TE-cooled Detector
The Hamamatsu S7031-1006 detector in the "QE" optical bench provides high quantum efficiency, fast signal processing speed and a high signal-to-noise ratio. This TE-cooled detector generates virtually no dark noise.

InGaAs Detectors
We use three different Hamamatsu linear array InGaAs detectors in our "NIR" optical bench for general-purpose NIR applications.

Bench Type

General-purpose "USB" Bench
The "USB" optical bench (also called the "S" bench) is ideal for absorbance, reflectance, fluorescence and color measurements. It's a versatile bench that is used in tens of thousands of spectrometers around the world.

High-resolution "HR" Bench
The "HR" optical bench is designed for applications requiring sub-angstrom optical resolution, such as laser characterization and atomic emission spectroscopy.

Scientific-grade "QE" Bench
The "QE" optical bench is designed for demanding applications with low light levels such as Raman and fluorescence.

Near-Infrared "NIR" Bench
The "NIR" optical bench is designed for applications that require sensitivity in the NIR region, such as moisture analysis, tunable laser wavelength characterization and general NIR spectroscopy.

Spectrometer Type

Spectrometers
You select the optical bench options, such as the grating, entrance aperture size, detector, wavelength range and more to create the optimum spectrometer for your application.

Spectrometer Systems & Setups
Systems are turnkey spectrophotometers where all the components are included in one integrated enclosure. Setups provide a list of tools necessary for an application. Both Systems and Setups include a spectrometer, the necessary sampling accessories, a light source and software. Some spectrometers are preset with a grating, wavelength range and other bench accessories for specific measurement types such as fluorescence. You still specify other components, such as light sources and sampling accessories.

Spectrometer Comparison Chart

This table outlines the specifications of our most popular user-configured spectrometers.
Please refer to specific product pages for more detailed information.

Specifications	USB4000 p. 14	HR2000+ p. 20	HR4000 p. 21	QE65000 p. 26
PHYSICAL				
Dimensions (in mm):	89.1 x 63.3 x 34.4	148.6 x 104.8 x 45.1	148.6 x 104.8 x 45.1	182 x 110 x 47
Weight:	190 grams	570 grams	570 grams	1050 grams
DETECTOR				
Detector:	Toshiba TCD1304AP linear CCD array	Sony ILX511 linear silicon CCD array	Toshiba TCD1304AP linear CCD array	Hamamatsu S7031-1006 back-thinned area CCD
Detector range:	200-1100 nm	200-1100 nm	200-1100 nm	200-1100 nm
Pixels:	3648 pixels	2048 pixels	3648 pixels	1024 x 58 (1044 x 64 total)
Pixel size:	8 µm x 200 µm	14 µm x 200 µm	8 µm x 200 µm	24.6 µm square size
Pixel well depth:	~100,000 electrons	~62,500 electrons	~100,000 electrons	300,000 electrons/well ~1.5 million electrons/column
Sensitivity:	400 nm: 130 photons/count 600 nm: 60 photons/count	400 nm: 75 photons/count 600 nm: 41 photons/count	400 nm: 130 photons/count 600 nm: 60 photons/count	22 electrons/count for all wavelengths 250 nm: 26 photons/count
OPTICAL BENCH				
Design:	f/4, Asymmetrical crossed Czerny-Turner	f/4, Symmetrical crossed Czerny-Turner	f/4, Symmetrical crossed Czerny-Turner	f/4, Symmetrical crossed Czerny-Turner
Focal length (input):	42 mm	101.6 mm	101.6 mm	101.6 mm
Focal length (output):	68 mm	101.6 mm	101.6 mm	101.6 mm
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits or fiber	5, 10, 25, 50, 100 or 200 µm wide slits or fiber	5, 10, 25, 50, 100 or 200 µm wide slits or fiber	5, 10, 25, 50, 100 or 200 µm wide slits or fiber
Grating options:	14 gratings, UV through Shortwave NIR	14 gratings, UV through Shortwave NIR	14 gratings, UV through Shortwave NIR	14 gratings, UV through Shortwave NIR
HC-1 grating option:	No	No	Yes, HC-1 provides 200-1050 nm range (best efficiency)	Yes, HC1-QE provides 200-950 nm range
Detector collection lens:	Yes, L4	Yes, L2	Yes, L4	No
OFLV filters:	OFLV-200-850 OFLV-350-1000	No	OFLV-200-1100	OFLV-QE
Order-sorting filters:	Longpass OF-1 filters	Longpass OF-1 filters	Longpass OF-1 filters	Longpass OF-1 filters
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC				
Wavelength range:	Grating dependent	Grating dependent	Grating dependent	Grating dependent
Optical resolution:	~0.3-10.0 nm FWHM	~0.035-6.8 nm FWHM	~0.02-8.4 nm FWHM	~0.14-7.7 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)	250:1 (at full signal)	300:1 (at full signal)	1000:1 (at full signal)
A/D resolution:	16 bit	14 bit	14 bit	16 bit
Dark noise:	50 RMS counts	12 RMS counts	12 RMS counts	2.5 RMS counts
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition	2 x 10^8 (system); 1300:1 for a single acquisition	2 x 10^8 (system); 1300:1 for a single acquisition	7.5 x 10^9 (system); 25000:1 for a single acquisition
Integration time:	3.8 ms to 10 seconds	1 ms to 20 seconds	3.8 ms to 10 seconds	8 ms to 15 minutes
Stray light:	<0.05% at 600 nm <0.10% at 435 nm	<0.05% at 600 nm <0.10% at 435 nm	<0.05% at 600 nm <0.10% at 435 nm	<0.08% at 600 nm <0.4% at 435 nm
Corrected linearity:	>99.8%	>99.8%	>99.8%	>99.8%
ELECTRONICS				
Power consumption:	250 mA @ 5 VDC	450 mA @ 5 VDC	450 mA @ 5 VDC	500 mA @ 5 VDC no TE cool 3 A @ 5 VDC with TE cool
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 1 ms with USB 2.0 port, 15 ms with USB 1.1 port, 200 ms with serial port	Full spectrum to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 8 ms with USB 2.0 port, 8 ms with USB 1.1 port
Inputs/Outputs:	Yes, 8 onboard digital user-programmable GPIOs	Yes, 10 onboard digital user-programmable GPIOs	Yes, 10 onboard digital user-programmable GPIOs	Yes, 10 onboard digital user-programmable GPIOs
Analog channels:	No	Yes, one 13-bit analog input and one 9-bit analog output	Yes, one 13-bit analog input and one 9-bit analog output	No
Trigger modes:	4 modes	4 modes	4 modes	4 modes
Auto nulling:	Yes	Yes	Yes	Yes
Strobe functions:	Yes	Yes	Yes	No
Gated delay feature:	Yes	Yes	No	Yes
COMPUTER				
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port
Computer interfaces:	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	SPI (3-Wire); I^2C inter-integrated circuit\	SPI (3-Wire); I^2C inter-integrated circuit	SPI (3-Wire); I^2C inter-integrated circuit	SPI (3-wire); I^2C inter-integrated circuit

USB4000 Plug-and-Play Spectrometer

In this setup, a USB4000 is configured for fluorescence. A PX-2 Pulsed Xenon Light Source provides the excitation via optical fiber and a CUV-FL-DA Direct-attach Cuvette Holder holds the sample and redirects light energy directly into the USB4000 Spectrometer. A filter, such as one of our LVFs, are often used to block excitation wavelengths.

Specifications	
PHYSICAL	
Dimensions (in mm):	89.1 x 63.3 x 34.4
Weight:	190 grams
DETECTOR	
Detector:	Toshiba TCD1304AP linear CCD array (page 17)
Detector range:	200-1100 nm
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	~100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
OPTICAL BENCH	
Design:	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slit or fiber (page 15)
Grating options:	14 gratings, UV through Shortwave NIR (page 16)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC	
Wavelength range:	Grating dependent
Optical resolution:	~0.3-10.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	50 RMS counts
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Integration time:	3.8 ms to 10 seconds
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99.8%
ELECTRONICS	
Power consumption:	250 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	Yes, 8 onboard digital user-programmable GPIOs
Analog channels:	No
Trigger modes:	4 modes
Strobe functions:	Yes
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	SPI (3-wire); I^2C inter-integrated circuit

We've sold over 85,000 spectrometer channels for thousands of applications, and we've used that experience to make the most flexible, versatile and cost-effective spectrometer ever built.

World's Most Popular Spectrometer Just Got Better

We redesigned the USB4000 -- the most popular spectrometer in the world -- to include an advanced detector and powerful high-speed electronics. The USB4000 features a 16-bit A/D, four triggering options, a dark-level correction during temperature changes, and a 22-pin connector with eight user-programmable GPIOs. What's more, the USB4000 interfaces to computers with Linux, Mac or Windows operating systems. The modular USB4000 is responsive from 200-1100 nm and can be configured with various Ocean Optics optical bench accessories, light sources and sampling optics to create application-specific systems for thousands of absorbance, reflection and emission applications.

Electronic Advancements

The USB4000 Spectrometer is distinguished by its enhanced electronics: 16-bit A/D resolution with auto nulling feature (an enhanced electrical dark-signal correction); EEPROM storage of calibration coefficients for simple spectrometer start-up; 8 programmable GPIO signals for controlling peripheral devices; and an electronic shutter for spectrometer integration times as fast as 3.8 milliseconds -- a handy feature to prevent detector saturation. In addition, the USB4000 has signal-to-noise of 300:1 and optical resolution (FWHM) ranging from 0.03-8.4 nm (depending on your grating and entrance aperture selection).

Here the versatile USB4000 is featured in a liquid absorbance setup with optical fiber, a DH2000 Deuterium Tungsten Halogen Light Source and a CUV-UV-10 10-cm Pathlength Cuvette Holder.

Streamlined Start-up Software & Hot Swapping

The USB4000 interfaces to a computer via USB 2.0. Data unique to each spectrometer is programmed into a memory chip on the USB4000; SpectraSuite Spectroscopy Operating Software reads these values for easy setup and hot swapping among computers, whether they run on Linux, Mac or Windows operating systems. When connected to a computer via USB, the USB4000 draws its power from the computer. With its small-footprint design, plug-and-play convenience, advanced electronics and powerful detector, the USB4000 has succeed the USB2000 as the most frequently specified fiber optic spectrometer in the world.

USB4000: $2,199
SPECTRASUITE: $199

USB4000 Optical Bench Options

What makes the USB4000 Spectrometer so special are the options that allow you to configure the bench for your application. Our Applications Scientists can help you choose the optimum components, or you can follow this guide to choose an entrance aperture size, detector accessories, filters, a grating and more. The diagram below shows how light moves through the asymmetrical crossed Czerny-Turner optical bench, which has no moving parts that can wear or break; all components specified are fixed in place at the time of manufacture.

Components of the USB4000 Optical Bench

1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Entrance Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits come in various widths from 5 µm to 200 µm. The slit is fixed in the SMA 905 bulkhead to sit against the end of a fiber.

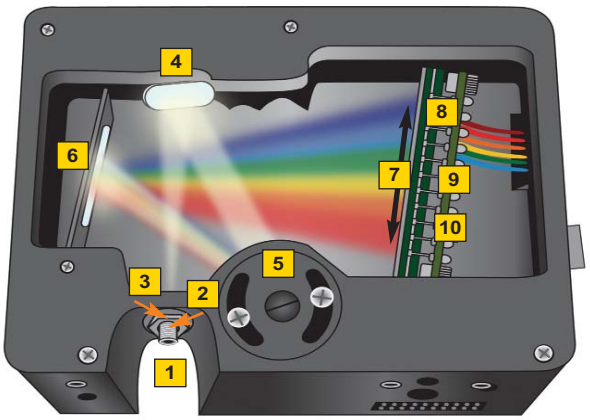
3 Longpass Absorbing Filter: optional
If selected, an absorbance filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to block second- and third-order effects or to balance color.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. You can opt to install a standard mirror or a UV absorbing SAG+ mirror.

5 Grating & Wavelength Range: specify grating & starting wavelength
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. You can opt to install a standard or SAG+ mirror.

7 L4 Detector Collection Lens: optional
This cylindrical lens, made in-house to ensure aberration-free performance, is fixed to the detector to focus the light from the tall slit onto the shorter detector elements. It increases light-collection efficiency.



8 Detector
We offer a 3648-element Toshiba TCD1304AP linear CCD array detector. Each pixel responds to the wavelength of light that strikes it. Electronics bring the complete spectrum to the software.

9 OFLV Variable Longpass Order-sorting Filter: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

10 UV4 Detector Upgrade: optional
When selected, the detector's standard BK7 window is replaced with a quartz window to enhance the performance of the spectrometer for applications <340 nm.

1 SMA 905 Connector

A precision SMA 905 Connector aligns to the spectrometer's entrance slit and ensures concentricity of the fiber. For an upgrade fee that includes the cost of the custom connector and labor, we will replace the standard SMA 905 Connector with a different connector of your choice. We also offer connector adapters, such as an SMA-to-ST Adapter and an SMA-to-FC Adapter. Please call for details on connectors and adapters.

2 Fixed Entrance Slit

Another option available with a USB4000 user-configured spectrometer is the size of the entrance aperture. Entrance slits are rectangular apertures, 1-mm tall and various widths from 5 µm to 200 µm, with the width determining the amount of light entering the bench. A slit is permanent; it only can be changed by our technicians. You can opt against having a slit, in which case the diameter of the fiber connected to the spectrometer determines the size of the entrance aperture.

Slit	Description	Pixel Resolution	Price
SLIT-5	5-µm wide x 1-mm high	~5.3 pixels	$150
SLIT-10	10-µm wide x 1-mm high	~5.7 pixels	$150
SLIT-25	25-µm wide x 1-mm high	~7.5 pixels	$150
SLIT-50	50-µm wide x 1-mm high	~11.6 pixels	$150
SLIT-100	100-µm wide x 1-mm high	~21 pixels	$150
SLIT-200	200-µm wide x 1-mm high	~42 pixels	$150

A slit is installed on the inside edge of the bulkhead of an SMA 905 Connector.

USB4000 Optical Bench Options

3 Longpass Absorbing Filter

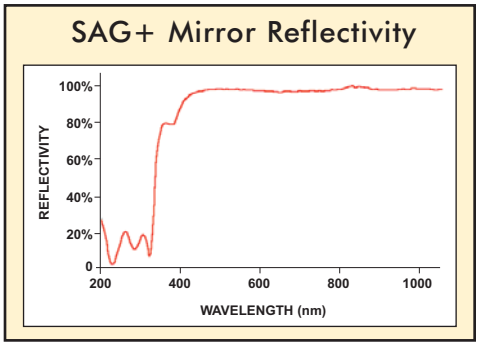
We offer longpass absorbing or blocking filters; each filter has a transmission band and a blocking band to restrict radiation to a certain wavelength region for eliminating second- and third-order effects. These filters are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 Connector.

Item	Description	Price
OF1-WG305	Longpass filter; transmits light >305 nm	$50
OF1-GG375	Longpass filter; transmits light >375 nm	$50
OF1-GG475	Longpass filter; transmits light >475 nm	$50
OF1-OG515	Longpass filter; transmits light >515 nm	$50
OF1-OG550	Longpass filter; transmits light >550 nm	$50
OF1-OG590	Longpass filter; transmits light >590 nm	$50

4 & 6 Collimating & Focusing Mirrors

You can replace standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors, which increase reflectance in the VIS-NIR and, in turn, increase the sensitivity of the spectrometer. SAG+ Mirrors are often specified for fluorescence. These mirrors also absorb nearly all UV light, which reduces the effects of excitation scattering in fluorescence measurements. Unlike typical silver-coated mirrors, the SAG+ mirrors won't oxidize. They have excellent reflectivity -- more than 95% across the VIS-NIR.

SAG+UPG: $250



5 Choosing a Grating & Wavelength Range

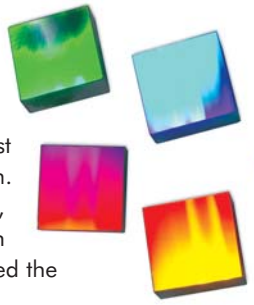
Wide Selection Allows Flexibility

You choose from among 14 gratings for each spectrometer. With each grating, you consider its groove density (which helps determine the resolution), its spectral range (which helps determine the wavelength range) and its blaze wavelength (which helps determine the most efficient range).

Performance & Stability

Instead of the gratings rotating as they do in instruments such as scanning monochromators, our gratings are permanently fixed in place at the time of manufacture to ensure long-term performance and stability. (See page 18 for Grating Efficiency Curves.) A grating must be specified for each spectrometer. We offer ruled and holographic diffraction gratings. Both are polymer replicas of master gratings. There are trade-offs between these gratings: holographic gratings produce less stray light while ruled gratings are more reflective, resulting in higher sensitivity.

Grating Selection Chart



- The **Groove Density** (mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.
- The **Spectral Range** is the dispersion of the grating across the linear array. The spectral range (bandwidth) is a function of the groove density and does not change. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range.
- For ruled gratings, the **Blaze Wavelength** is the peak wavelength in an efficiency curve. For holographic gratings, it is the most efficient wavelength region.
- The **Best Efficiency** region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating #1 has a 650 nm spectral range, but is most efficient from 200-575 nm. In this case, wavelengths >575 nm will have lower intensity due to the the grating's reduced efficiency.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
1	UV	600	650 nm	300 nm	200-575 nm
2	UV-VIS	600	650 nm	400 nm	250-800 nm
3	VIS-Color	600	650 nm	500 nm	350-850 nm
4	NIR	600	625 nm	750 nm	530-1100 nm
5	UV-VIS	1200	300 nm	Holographic UV	200-400 nm
6	NIR	1200	200-270 nm	750 nm	500-1100 nm
7	UV-VIS	2400	100-140 nm	Holographic UV	200-500 nm
8	UV	3600	50-75 nm	Holographic UV	290-340 nm
9	VIS-NIR	1200	200-270 nm	Holographic VIS	400-800 nm
10	UV-VIS	1800	100-190 nm	Holographic UV	200-635 nm
11	UV-VIS	1800	120-160 nm	Holographic VIS	320-720 nm
12	UV-VIS	2400	50-120 nm	Holographic VIS	250-575 nm
13	UV-VIS-NIR	300	1700 nm	500 nm	300-1100 nm
14	NIR	600	625 nm	1000 nm	650-1100 nm

USB4000 Optical Bench Options

7 L4 Detector Collection Lens

This cylindrical lens, made in-house to ensure aberration-free performance, is fixed to the detector's window to focus the light from the tall slit onto the shorter detector elements. It increases light-collection efficiency and reduces stray light. It also is useful in a configuration with a large-diameter fiber for low light-level applications. At right is a detector with the L4 lens.

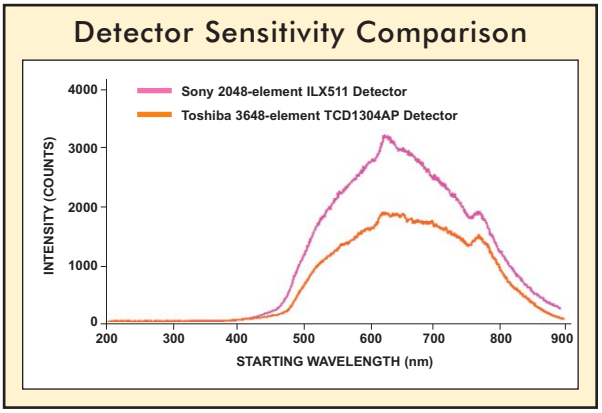
L4 Detector Collection Lens: $150

Toshiba TCD1304AP Detector with L4 Detector Collection Lens (above) and without (below).

8 Detector: 3648-element Linear CCD Array

In each USB4000, we install the Toshiba TCD1304AP linear CCD array detector. In the USB2000, the USB4000's predecessor, we used the Sony ILX511 detector. Both are linear silicon CCD arrays, with an effective range of 200-1100 nm, and with the same dynamic range (1300:1).

There are some differences between the Toshiba detector and the Sony detector. For example, since the Toshiba's pixels are only 8 µm wide instead of 14 µm wide, the sensitivity for a Toshiba pixel seems to be ~60% (8 µm/14 µm) that of a Sony pixel (see graph at right). However, on a per-unit area basis, the sensitivity is about the same since the Toshiba has 3648 pixels compared with the Sony's 2048; the total signal is the same. Because the Toshiba detector has an electronic shutter, you can almost never have too much light; the shutter prevents the detector from saturating.



9 Detector with OFLV Filter

Our OFLV Variable Longpass Order-sorting Filters are applied to the detector's window to eliminate second- and third-order effects. We use patented coating technology to apply the filter onto the substrate. In fact, we are the only miniature spectrometer manufacturer to offer "clean" first-order spectra.

10 Detector with UV4 Detector Window Upgrade

When you specify a detector with the UV4 Detector Window Upgrade, we replace the detector's standard BK7 window with a quartz window to enhance the spectrometer's performance from 200-340 nm.

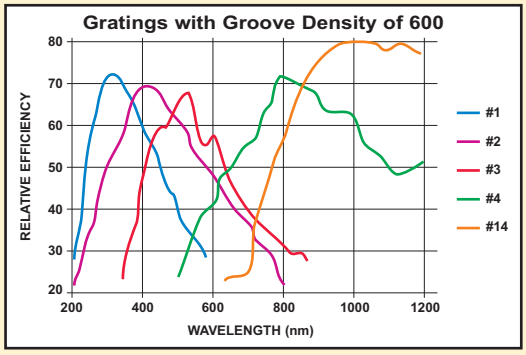
Toshiba TCD1304AP Specifications	
Detector:	Toshiba TCD1304AP linear CCD array
Detector range:	200-1100 nm
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	~100,000 electrons
Sensitivity:	400 nm: 130 photons/count, 600 nm: 60 photons/count
Maximum pixel rate:	Rate at which pixels are digitized is 1 MHz

Detector	Description	Price
DET4-VIS	Toshiba TCD1304AP Detector installed into a USB4000 User-Configured Spectrometer; best for systems with wavelength ranges above 400 nm	Free
DET4-UV	Toshiba TCD1304AP Detector with UV4 Detector Window Upgrade installed into a USB4000 User-Configured Spectrometer; best for systems with wavelength ranges in the UV	$150
DET4-350-1000	Toshiba TCD1304AP Detector with OFLV-350-1000 Variable Longpass Order-sorting Filter installed into a USB4000 User-Configured Spectrometer; best when using Grating #2, #3 or #4	$150
DET4-200-850	Toshiba TCD1304AP Detector with UV4 Detector Window Upgrade and OFLV-200-850 Variable Longpass Order-sorting Filter installed into a USB4000 Spectrometer; best when using Grating #1 or #2	$300

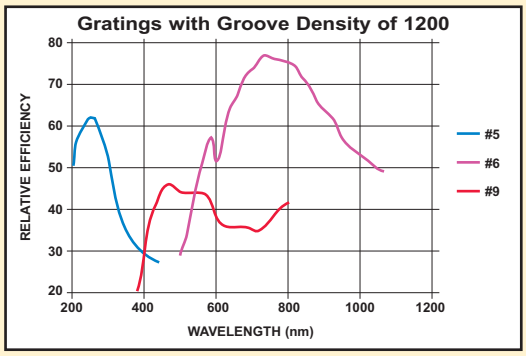
USB4000 Optical Bench Options

Grating Efficiency Curves

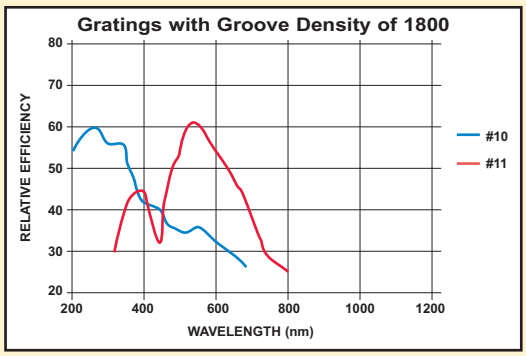
Below are the Grating Efficiency Curves for gratings with groove densities of 600, 1200, 1800 and 2400 mm^{-1}. See curves for all of our gratings at OceanOptics.com/Technical/GratingCharts.asp.



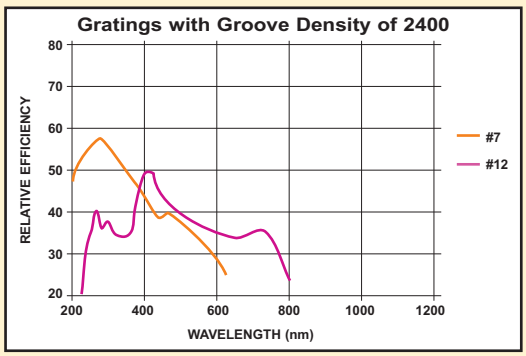
Efficiency Curves for Gratings 1, 2, 3, 4 and 14.



Efficiency Curves for Gratings 5, 6 and 9.



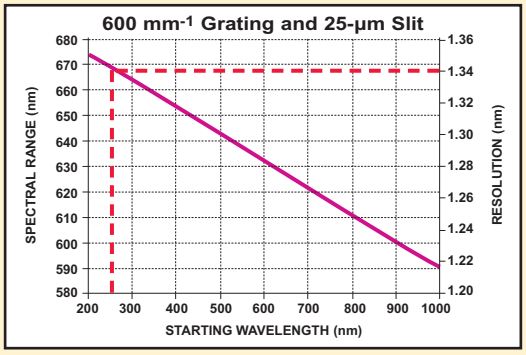
Efficiency Curves for Gratings 10 and 11.



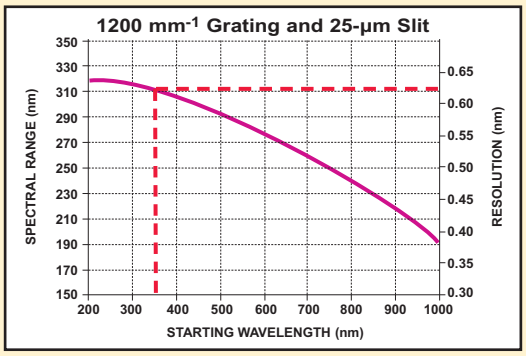
Efficiency Curves for Gratings 7 and 12.

Predicted Ranges & Resolution

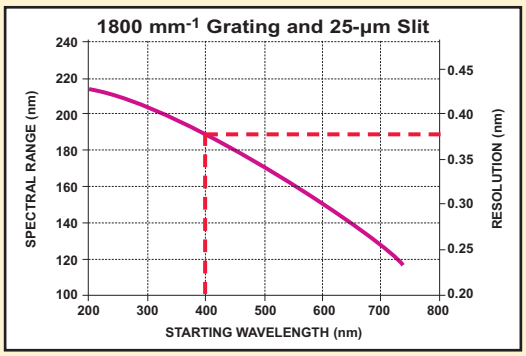
Here are a series of graphs to demonstrate the range and optical resolution (FWHM) of your USB4000 Spectrometer with a 25 µm slit. See our website for additional graphs of ranges and resolutions for every slit size.



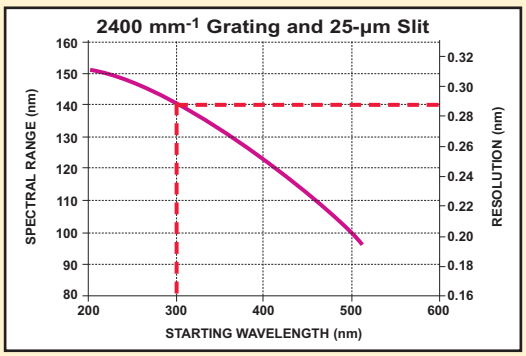
Example: *If the starting wavelength is 250 nm, then the range is ~667 nm, providing a 250-917 nm wavelength range and 1.34 nm resolution.*



Example: *If the starting wavelength is 350 nm, then the range is ~310 nm, providing a 350-660 nm wavelength range and 0.63 nm resolution.*



Example: *If the starting wavelength is 400 nm, then the range is ~190 nm, providing a 400-590 nm wavelength range and 0.38 nm resolution.*



Example: *If the starting wavelength is 300 nm, then the range is ~140 nm, providing a 300-440 nm wavelength range and 0.29 nm resolution.*

USB4000 Direct-attach Accessories

USB-DT Deuterium Tungsten Light Source

The USB-DT Deuterium Tungsten Light Source is our most versatile combination UV-VIS lamp. Use the USB-DT as a stand-alone unit with any spectrometer, stack it with a USB4000 Spectrometer, or combine it with a "breakout box" accessory and an "HR"-series or QE65000 Spectrometer for software control of lamp functions. This compact source is about the size of a deck of cards, provides stable, broadband output from 200-2000 nm, and requires a simple 5-volt wall transformer to operate. See page 124 for details.

USB-DT: $1,499

USB-DT

USB-ISS-UV-VIS Integrated Sampling System for Cuvettes

The USB-ISS-UV-VIS is a direct-attach sample holder and deuterium tungsten light source (200-1100 nm) for measuring absorbance. This sampling system allows you to control both the intensity of the tungsten bulb and the shutter via software. The USB-ISS-UV-VIS requires an external power supply (included). See page 92 for more.

USB-ISS-UV-VIS: $1,499

USB-ISS-UV-VIS

USB-ISS-VIS Integrated Sampling System for Cuvettes

The USB-ISS-VIS is a direct-attach sample holder and violet LED-boosted tungsten light source (390-900 nm) combination for measuring relative absorbance. The light source boosts signal in the blue and provides over 10,000 hours of use. See page 92 for full specifications.

USB-ISS-VIS: $499

USB-ISS-VIS

USB-ISS-T Integrated Sampling System for Test Tubes

The USB-ISS-T is a direct-attach sample holder and violet LED-boosted tungsten light source (390-900 nm) combination for measuring absorbance in 12-mm outer diameter test tubes. The sampling optics combine a diffuse source with a collimated input to the spectrometer to eliminate optical artifacts in the test tubes. See page 92 for specifications.

USB-ISS-T: $499

USB-ISS-T

USB-LS-450 Pulsed Blue LED Module

The USB-LS-450 is an LED module designed for fluorescence measurements in the lab or field, or as part of an Oxygen Sensor system. In addition, the USB-LS-450 has a port for attaching a 100 ohm RTD temperature sensor and onboard memory for storing temperature and oxygen calibration coefficients. See page 131 for details.

USB-LS-450: $549

USB-LS-450

USB-FHS Filter Holder System

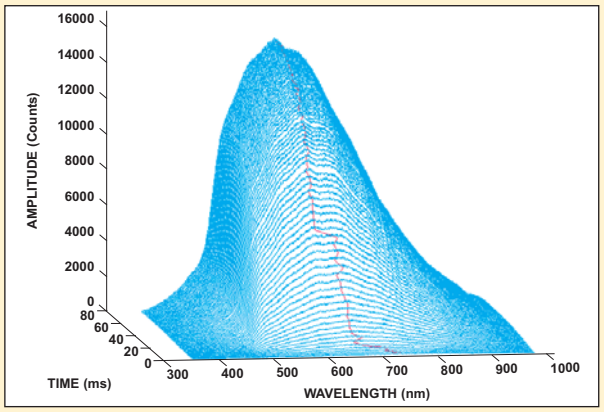
The USB-FHS is a filter holder and violet LED-boosted tungsten light source for measuring filters and other samples up to 18-mm thick. The USB-FHS is optimized for 390-900 nm and attaches to the USB4000 via a mounting plate.

USB-FHS: $499

USB-FHS

HR2000+ High-speed Spectrometer

Monitoring LS-1 Start-up Condition



This power-up data for our LS-1 Tungsten Halogen Light Source was taken by an HR2000+ at 2-millisecond intervals. The graph shows the tremendous amount of data generated with the HR2000+'s acquisition rate speed of 1000 spectra per second.

In this setup, a DH2000 Deuterium Light Source provides light via optical fiber to a CUV-10 Cuvette Holder for 10-cm sample cells. A second optical fiber collects the light and sends it to the HR2000+.

Specifications	
PHYSICAL	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
DETECTOR	
Detector:	Sony ILX511 linear silicon CCD array (page 24)
Detector range:	200-1100 nm
Pixels:	2048 pixels, pixel size of 14 µm x 200 µm
Sensitivity:	75 photons/count at 400 nm; 41 photons/count at 600 nm
OPTICAL BENCH	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 22) or fiber
Grating options:	14 gratings, UV through Shortwave NIR (page 23)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC	
Wavelength range:	Grating dependent
Optical resolution:	~0.035-6.8 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
Dark noise:	12 RMS counts
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Integration time:	1 ms to 20 seconds
ELECTRONICS	
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 1 ms with USB 2.0 port, 15 ms with USB 1.1 port, 200 ms with serial port
Inputs/Outputs:	Yes, 10 onboard digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input, one 9-bit analog output
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; any 32-bit Windows OS with serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	SPI (3-Wire), I^2C inter-integrated circuit

** Programming the GPIOs requires SpectraSuite, OmniDriver or one of our other device drivers. See pages 80-82 for details.*

Dynamic Electronics Enhances Control

The HR2000+ Spectrometer integrates a powerful analog-to-digital (A/D) converter, programmable electronics and a high-resolution optical bench. This innovative combination produces our fastest spectrometer yet and provides resolution to 0.035 nm (FWHM).

1,000 Full Spectra/Second

The HR2000+ utilizes an onboard, 2-MHz A/D converter, which allows you to capture and transfer one full spectrum into memory every millisecond when the spectrometer is interfaced to a PC via the USB port.

Programmable Microcontroller

The HR2000+ has an onboard programmable microcontroller that provides flexibility in controlling the spectrometer and accessories. Through a new 30-pin connector, you can implement all operating parameters in the software, such as controlling external light sources, creating processes and routines and retrieving data from external devices. The HR2000+ gives you access to 10 user-programmable digital I/Os for interfacing to other equipment; one analog input and one analog output; and a pulse generator for triggering other devices. (Programming the I/Os requires SpectraSuite Spectroscopy Operating Software.)

"HR" Optical Bench

The HR2000+ is responsive from 200-1100 nm, but its specific range, resolution and sensitivity depend on your "HR" Optical Bench options. You select the grating, wavelength range, mirror coating, detector window and entrance aperture size. Choose from hundreds of accessories to create application-specific systems.

High-resolution Applications

The HR2000+ is ideal for applications where fast reactions need to be monitored and high resolution is necessary, such as protein dynamics. For solution chemistry or color measurements, the USB4000 is more likely to fill your requirements.

Plug-and-Play Operation

The HR2000+ interfaces to a PC, PLC or other embedded controllers via USB 2.0 or serial port. When connected to a PC via the USB port, the HR2000+ does not require an external power supply -- the spectrometer draws its power from the PC. When operating via the serial port, the HR2000+ requires a power supply (not included). Data unique to each spectrometer are programmed into a memory chip on the HR2000+; software reads these values for easy setup and hot swapping among PCs.

HR2000+: $3,499

HR4000 High-resolution Spectrometer

0.02 nm Optical Resolution (FWHM) Possible

The HR4000 Spectrometer is our next-generation high-resolution spectrometer. The HR4000 has a 3648-element CCD-array detector from Toshiba that enables optical resolution as precise as 0.02 nm (FWHM). The HR4000 is responsive from 200-1100 nm, but the specific range and resolution depend on your grating and entrance slit choices (see pages 22-24 for options). This novel combination of optics and electronics is ideal for applications such as characterizing lasers, measuring gas absorbance, and determining atomic emission lines.

Electronic Shutter Prevents Saturation

Integration Time is a setting in our software that is specified by the user. It's analogous to the shutter speed of a camera: the value specified for the integration time is the amount of time the detector "looks" at the incoming photons. Because the Toshiba detector has an electronic shutter, you can specify, via software, minimum integration times as short as 3.8 milliseconds, which allow you to measure transient events like laser pulses. Also, the ability to integrate the spectrometer for short durations eliminates saturation problems that can occur in high light-level applications such as laser analysis.

One popular application for the HR4000 is laser analysis. A typical setup may look something like this: a laser's beam is directed into the FOIS-1 Integrating Sphere. An optical fiber collects the light and sends it to the HR4000.

Onboard Microcontroller

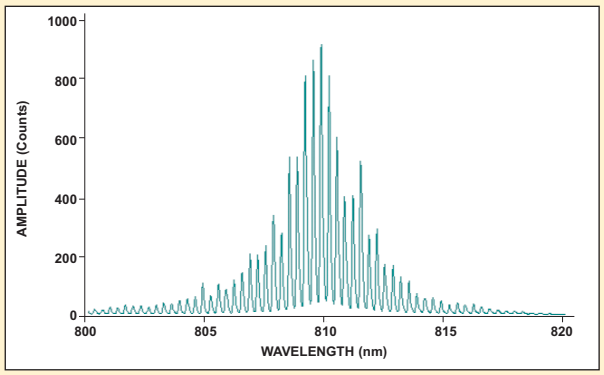
The HR4000's onboard microcontroller provides you with considerable flexibility in controlling the spectrometer and accessories. Through a 30-pin connector, you can implement all operating parameters in the software: control light sources, create processes, and retrieve information on external objects. You have access to 10 user-programmable digital inputs/outputs for interfacing to other equipment; one analog input and one analog output; and a pulse generator for triggering other devices. (Programming the GPIOs requires SpectraSuite, OmniDriver or one of our other device drivers. See pages 80-82 for details.)

Plug-and-Play USB Operation

The HR4000 interfaces to a PC, PLC or other embedded controllers via USB 2.0 or RS-232 serial port. When using the serial port, the HR4000 requires a single 5-volt power supply (not included). Data unique to each spectrometer are programmed into a memory chip on the HR4000; our spectrometer operating software reads these values for easy setup and hot swapping among PCs.

HR4000: $3,999

Sample Spectrum of Laser



We acquired this spectrum of a 810-nm Multimode Diode Laser with an HR4000, Grating H11 and a 5-µm slit.

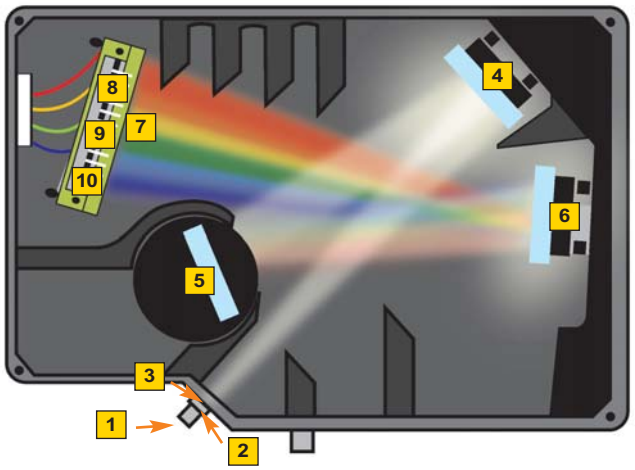
Specifications	
PHYSICAL	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
DETECTOR	
Detector:	Toshiba TCD1304AP linear CCD array (page 24)
Detector range:	200-1100 nm
Pixels:	3648 pixels, pixel size of 8 µm x 200 µm
Pixel well depth:	~100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
OPTICAL BENCH	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 22) or fiber
Grating options:	14 gratings, UV through Shortwave NIR (page 23)
Order-sorting filters:	longpass OF-1 filters and OFLV-200-1100 (page 24)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC	
Wavelength range:	Grating dependent
Optical resolution:	~0.02-8.4 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
Dark noise:	12 RMS counts
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Integration time:	3.8 ms to 10 seconds
ELECTRONICS	
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	Yes, 10 onboard digital user-programmable GPIOs
Analog channels:	One 13-bit analog input, One 9-bit analog output
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; any 32-bit Windows OS using serial port*
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	SPI (3-Wire), I^2C inter-integrated circuit

** You cannot use SpectraSuite if you're interfacing an HR4000 to a PC via RS-232. A Command Set is included for writing your own software.*

Options for the "HR" Optical Bench

Below is a diagram of the "HR" Optical Bench used in HR2000+ and HR4000 High-resolution Spectrometers. It shows how light moves through the symmetrical crossed Czerny-Turner design of the bench. All components in the bench are fixed in place during manufacturing. Not only do you have detector choices with the "HR" bench, you also have a whole host of other options when configuring your High-resolution Spectrometer. You can choose various entrance aperture sizes, detector accessories, filters, gratings and more to optimize your spectrometer.

Components of the "HR" Optical Bench



1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Entrance Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits are available in widths from 5 µm to 200 µm. Each is permanently fixed to the SMA 905 bulkhead. (Without a slit, a fiber acts as the entrance aperture.)

3 Longpass Absorbance Filter: optional
If selected, an absorbance filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to block second- and third-order effects or to balance color.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. You can opt to install a standard mirror or a UV absorbing SAG+ mirror.

5 Grating & Wavelength Range: specify grating & starting wavelength
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. You can opt for a standard mirror or SAG+ mirror.

7 L2 and L4 Detector Collection Lenses: optional
This cylindrical lens, made in-house to ensure aberration-free performance, is fixed to the detector to focus the light from the tall slit onto the shorter detector elements. It increases light-collection efficiency.

8 Detector: specify Sony or Toshiba detector
We offer two detectors for the "HR" Bench; both are linear CCD arrays. Each pixel responds to the wavelength of light that strikes it. Electronics bring the complete spectrum to the software.

9 OFLV Variable Longpass Order-sorting Filter: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

10 UV2 and UV4 Detector Upgrades: optional
When selected, the detector's standard BK7 window is replaced with a quartz window to enhance the performance of the spectrometer for applications <340 nm.

1 SMA 905 Connector

A precision SMA 905 Connector aligns to the spectrometer's entrance slit and ensures concentricity of the fiber. For an upgrade fee that includes the cost of the custom connector and labor, we will replace the standard SMA 905 Connector with a different connector of your choice. We also offer connector adapters, such as an SMA-to-ST Adapter and an SMA-to-FC Adapter. Please call for details on connectors and adapters.

2 Fixed Entrance Slit

Another option available with "HR" User-configured Spectrometers is selecting the size of the entrance aperture. Entrance slits are rectangular apertures, 1-mm tall and various widths from 5 µm to 200 µm, with the width determining the amount of light entering the bench. A slit is fixed in place. Note that the smallest slit achieves the best optical resolution.

A slit is installed on the inside edge of the bulkhead of an SMA 905 Connector.

Slit	Description	HR2000+ Pixel Resolution	HR4000 Pixel Resolution	Price
SLIT-5	5-µm wide x 1-mm high	1.5 pixels	2.0 pixels	$150
SLIT-10	10-µm wide x 1-mm high	2.0 pixels	3.7 pixels	$150
SLIT-25	25-µm wide x 1-mm high	2.5 pixels	4.4 pixels	$150
SLIT-50	50-µm wide x 1-mm high	4.2 pixels	7.4 pixels	$150
SLIT-100	100-µm wide x 1-mm high	8.0 pixels	14.0 pixels	$150
SLIT-200	200-µm wide x 1-mm high	15.3 pixels	26.8 pixels	$150

Options for the "HR" Optical Bench

3 Longpass Absorbing Filters

We offer longpass absorbing or blocking filters; each filter has a transmission band and a blocking band to restrict radiation to a certain wavelength region for eliminating second- and third-order effects. These filters are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 Connector.

Item	Description	Price
OF1-WG305	Longpass filter; transmits light >305 nm	$50
OF1-GG375	Longpass filter; transmits light >375 nm	$50
OF1-GG475	Longpass filter; transmits light >475 nm	$50
OF1-OG515	Longpass filter; transmits light >515 nm	$50
OF1-OG550	Longpass filter; transmits light >550 nm	$50
OF1-OG590	Longpass filter; transmits light >590 nm	$50

4 & 6 Collimating & Focusing Mirrors

Another bench option is to replace the standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors, which increase reflectance in the VIS-NIR and, in turn, increase the sensitivity of the spectrometer. SAG+ Mirrors are often specified for fluorescence. These mirrors also absorb nearly all UV light, which reduces the effects of excitation scattering in fluorescence measurements. Unlike most silver-coated mirrors, the SAG+ mirrors won't oxidize. See page 16 for a spectral graph illustrating SAG+ reflectivity.

SAG+UPG-HR: $250

5 Choosing a Grating & Wavelength Range

Wide Selection Allows Flexibility

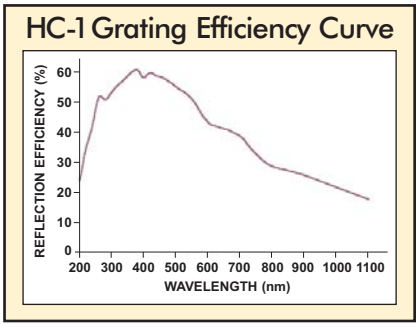
You choose from among 14 gratings for each spectrometer. With each grating, you consider its groove density (which helps determine the resolution), its spectral range (which helps determine the wavelength range) and its blaze wavelength (which helps determine the most efficient range). Our gratings are permanently fixed in place at the time of manufacture to ensure long-term performance and stability. We offer ruled and holographic diffraction gratings. Both are polymer replicas of master gratings. There are trade-offs between these gratings: holographic gratings produce less stray light while ruled gratings are more reflective, resulting in higher sensitivity.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC1*	UV-NIR	300	200-1100 nm	variable	200-1100 nm
H1	UV	600	425-445 nm	300 nm	200-575 nm
H2	UV-VIS	600	415-445 nm	400 nm	250-800 nm
H3	VIS-Color	600	410-440 nm	500 nm	350-850 nm
H4	NIR	600	410-430 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	205-220 nm	holographic: UV	200-400 nm
H6	NIR	1200	140-195 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	72-102 nm	holographic: UV	200-500 nm
H9	VIS-NIR	1200	165-205 nm	holographic: VIS	400-800 nm
H10	UV-VIS	1800	95-140 nm	holographic: UV	200-635 nm
H11	UV-VIS	1800	75-135 nm	holographic: VIS	320-800 nm
H12	UV-VIS	2400	60-100 nm	holographic: VIS	250-575 nm
H13	UV-VIS-NIR	300	900 nm	500 nm	300-1100 nm
H14	NIR	600	410-420 nm	1000 nm	650-1100 nm

Grating Selection Chart

- The **Groove Density** (mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.
- The **Spectral Range** is the dispersion of the grating across the linear array. The spectral range (bandwidth) is a function of the groove density and does not change. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range.
- For ruled gratings, the **Blaze Wavelength** is the peak wavelength in an efficiency curve. For holographic gratings, it is the most efficient wavelength region.
- The **Best Efficiency** region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating #1 has a 650 nm spectral range, but is most efficient from 200-575 nm. In this case, wavelengths >575 nm will have lower intensity due to the the grating's reduced efficiency.

Grating Efficiency Curves for the "HR" bench are the same as those for the USB (see page 18) except for the HC-1 Grating; its curve is shown here. All gratings are free with the purchase of a spectrometer, except for the HC-1, which is $600.



Options for the "HR" Optical Bench

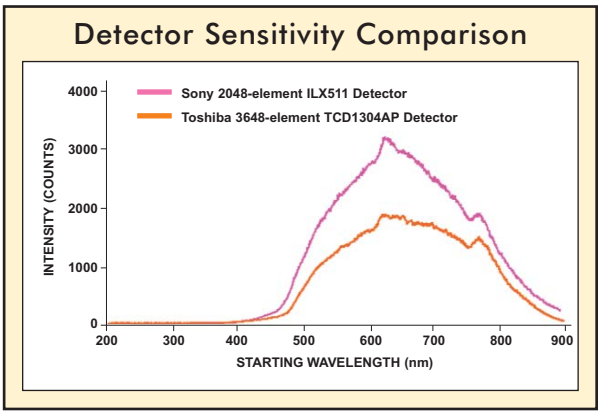
7 L2 or L4 Detector Collection Lens

The cylindrical L2 and L4 Detector Collection Lenses -- made in-house to ensure aberration-free performance -- are fixed to a detector's window to focus the light from the tall slit onto the shorter detector elements. They increase light-collection efficiency and reduce stray light. They are also useful with a large-diameter fiber for low light-level applications. Use the L2 with the Sony detector and the L4 with the Toshiba detector.

L2 or L4 Detector Collection Lens: $150

8 Detector: 2048-element or 3648-element Linear CCD Array

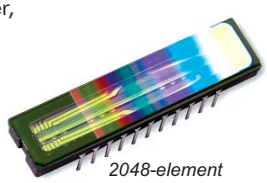
The HR2000+ utilizes the Sony ILX511 linear silicon CCD array detector. Our next-generation HR4000 High-resolution Spectrometer utilizes the Toshiba TCD1304AP linear CCD array detector, which has some electronic advances over the Sony, such as a user-programmable microcontroller. Both are linear silicon CCD arrays, with an effective range of 200-1100 nm, and with the same dynamic range (1300:1).



There are some differences between the detectors. For example, the Toshiba detector achieves better optical resolution (see the facing page for details). Also, since the Toshiba's pixels are only 8 µm wide instead of 14 µm wide, the sensitivity for a Toshiba pixel seems to be ~60% (8 µm/14 µm) that of a Sony pixel (see graph at right). However, on a per-unit area basis, the sensitivity is about the same since the Toshiba has 3648 pixels compared with the Sony's 2048; the total signal is the same. Because the Toshiba detector has an electronic shutter, you can almost never have too much light; the shutter prevents the detector from saturating, making possible analysis of transient events such as laser pulses.

Specifications

	Sony ILX511 linear silicon CCD array	Toshiba TCD1304AP linear CCD array
Detector range:	200-1100 nm	200-1100 nm
Pixels:	2048 pixels	3648 pixels
Pixel size:	14 µm x 200 µm	8 µm x 200 µm
Pixel well depth:	~62,500 electrons	~100,000 electrons
Maximum pixel rate:	Rate at which pixels are digitized is 2 MHz	Rate at which pixels are digitized is 1 MHz



2048-element Sony Detector

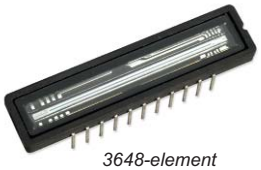
3648-element Toshiba Detector with L4 Collection Lens

9 Detector with OFLV Filter:

Our OFLV Variable Longpass Order-sorting Filters are applied to the detector's window to eliminate second- and third-order effects. We use patented coating technology to apply the filter onto the substrate. In fact, we are the only miniature spectrometer manufacturer to offer "clean" first-order spectra.

10 Detector with UV2 or UV4 Detector Window Upgrade

When you specify a detector with a UV2 or UV4 Detector Window Upgrade, we replace the detector's standard BK7 window with a quartz window to enhance the spectrometer's performance from 200-340 nm.



3648-element Toshiba Detector

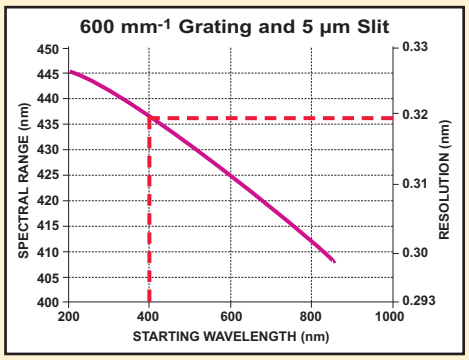
Item	Description	Spectrometer	Price
DET4-VIS	Toshiba TCD1304AP Detector installed into a HR4000 User-Configured Spectrometer; best for systems with wavelength ranges above 400 nm	HR4000	Free
DET4-UV	Toshiba TCD1304AP Detector with UV4 Detector Window Upgrade installed into a HR4000 User Configured Spectrometer; best for systems with wavelength ranges in the UV	HR4000	$150
DET4-200-1100	Toshiba TCD1304AP Detector with OFLV-200-1100 Variable Longpass Order-sorting Filter and UV4 Detector Window Upgrade installed into a HR4000 User-configured Spectrometer; used with HC1 Grating ($600)	HR4000	$400
DET2-VIS	Sony ILX511 Detector installed into an HR2000+ User-Configured Spectrometer; best for systems with wavelength ranges above 400 nm	HR2000+	Free
DET2-UV	Sony ILX511 Detector with UV2 Detector Window Upgrade installed into an HR2000+ User-Configured Spectrometer; best for systems with wavelength ranges in the UV	HR2000+	$150

Options for the "HR" Optical Bench

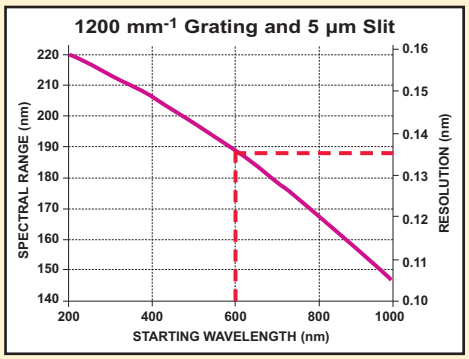
Predicted Ranges & Resolution

These graphs demonstrate the range and resolution of your "HR" Bench Spectrometer with a 5 µm slit. See our website for additional graphs of ranges and resolutions for every slit size.

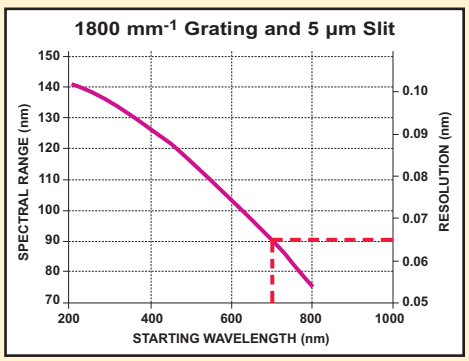
"HR" Bench with Sony Detector: HR2000+



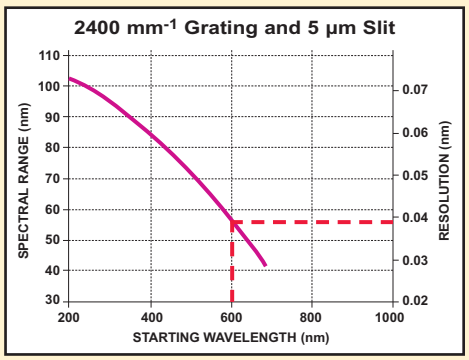
Example: *If the starting wavelength is 400 nm, then the range is ~437 nm, providing a 400-837 nm wavelength range and 0.32 nm resolution.*



Example: *If the starting wavelength is 600 nm, then the range is ~188 nm, providing a 600-788 nm wavelength range and 0.137 nm resolution.*

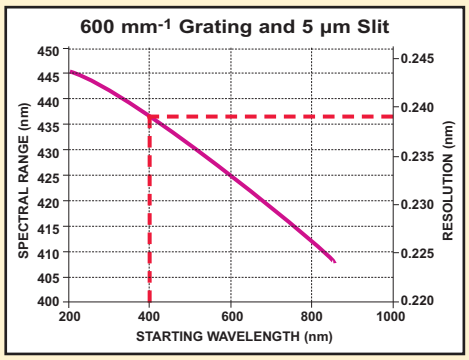


Example: *If the starting wavelength is 700 nm, then the range is ~90 nm, providing a 700-790 nm wavelength range and 0.065 nm resolution.*

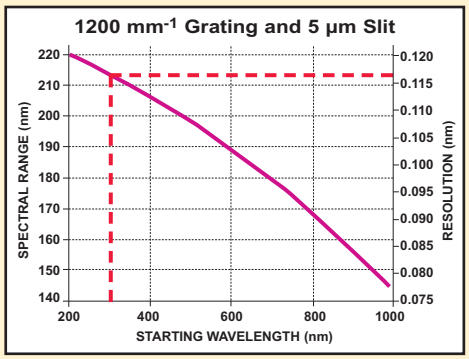


Example: *If the starting wavelength is 600 nm, then the range is ~56 nm, providing a 600-656 nm wavelength range and 0.039 nm resolution.*

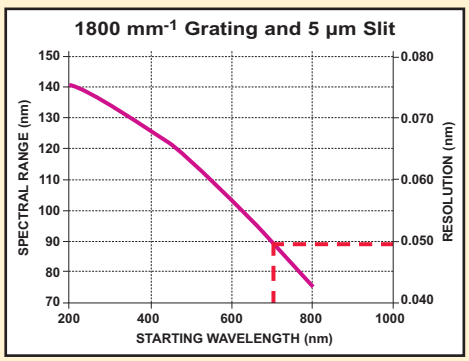
"HR" Bench with Toshiba Detector: HR4000



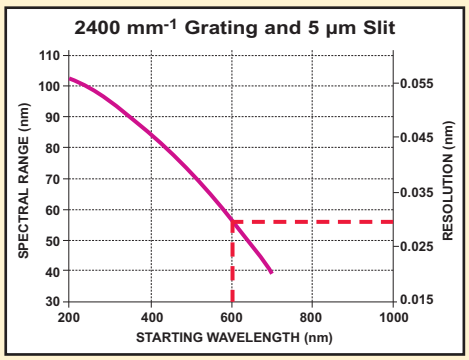
Example: *If the starting wavelength is 400 nm, then the range is ~437 nm, providing a 400-837 nm wavelength range and 0.239 nm resolution.*



Example: *If the starting wavelength is 300 nm, then the range is ~215 nm, providing a 300-515 nm wavelength range and 0.117 nm resolution.*

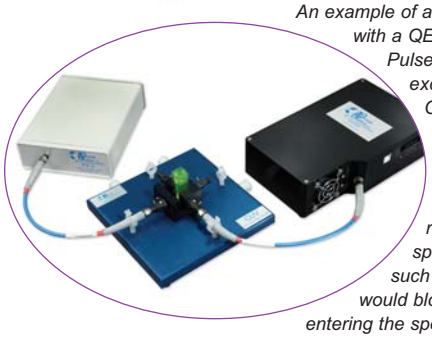


Example: *If the starting wavelength is 700 nm, then the range is ~90 nm, providing a 700-790 nm wavelength range and 0.05 nm resolution.*



Example: *If the starting wavelength is 600 nm, then the range is ~56 nm, providing a 600-656 nm wavelength range and 0.029 nm resolution.*

QE65000 Scientific-grade Spectrometer



An example of a fluorescence setup with a QE65000 uses the PX-2 Pulsed Xenon Lamp as an excitation source and the CUV-ALL Cuvette Holder for samples. An optical fiber delivers excitation light to the sample holder and read light to the spectrometer. A filter, such as one of our LVFs, would block excitation light from entering the spectrometer

Specifications	
PHYSICAL	
Dimensions (in mm):	182 x 110 x 47
Weight:	1.18 kg (without power supply)
DETECTOR	
Detector:	Hamamatsu S7031-1006 back-thinned FFT-CCD
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total); 24.6 µm square size
Pixel well depth:	300,000 electrons/well ~1.5 mill. electrons/column
Sensitivity:	400 nm: 22 electrons/count, 250 nm: 26 photons/count
OPTICAL BENCH	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits (page 27)
Grating options:	14 gratings, UV through Shortwave NIR (page 28)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC	
Wavelength range:	Grating dependent
Optical resolution:	~0.14-7.7 nm FWHM
Signal-to-noise ratio:	1000:1 (at full signal)
Dark noise:	2.5 RMS counts
Dynamic range:	25000:1 a single acquisition; 7.5 x 10^9 (system)
Integration time:	8 milliseconds to 15 minutes
Stray light:	<0.08% at 600 nm, <0.4% at 435 nm
ELECTRONICS	
Power consumption:	500 mA @ 5 VDC no TE cool; 3 A @ 5 VDC with TE cool
Data transfer speed:	Full spectrum to memory every 4 ms with USB 2.0 port, 8 ms with USB 1.1 port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs
TEMPERATURE & THERMOELECTRIC (TE) COOLING	
Temperature limits:	0 °C to 50 °C for spectrometer, no condensation
Temperature range:	13 °C maximum range between the high and low
Set point:	Software controlled
Lowest set point:	40 °C below ambient, to -15 °C
Stability:	±0.1 °C of set temperature in <2 minutes
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; 32-bit Windows OS when using the serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115K baud
Peripheral interfaces:	SPI (3-wire); I^2C inter-integrated circuit

New Scientific-grade Spectrometer

The QE65000 Spectrometer is a unique combination of detector and optical bench technologies that provides users with high spectral response and high optical resolution in one scientific-grade spectrometer package.

Quantum Efficiency to 90%

The Hamamatsu FFT-CCD detector used in the QE65000 provides 90% quantum efficiency (defined as how efficiently a photon is converted to a photo-electron). Most of our other detectors are linear CCDs but with this "2D" area detector, we can bin a vertical row of pixels, which offers significant improvement in the signal-to-noise ratio and signal processing speed of the detector compared with a linear CCD, where signals are digitally added by an external circuit.

Increased System Sensitivity

In our spectrometers with linear CCDs, the slit's width, not its height, regulates the amount of light entering the bench because linear CCDs cannot efficiently collect the light from the entire height of the slit. But in the QE65000, the 2D area detector can better take advantage of the height of the slit and the additional light, greatly improving system sensitivity.

Back-thinned: Great for the UV

Because the detector in the QE65000 is back-thinned (or back-illuminated), it has great native response in the UV and does not require the additional coatings that we typically apply to other detectors for UV applications.

Demanding Low Light-level Applications

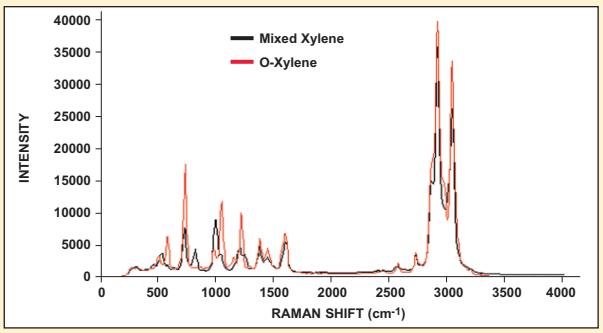
The QE65000 Spectrometer is a great option for low-light level applications such as fluorescence, Raman spectroscopy, DNA sequencing, astronomy and thin-film reflectivity. The TE-cooled (down to -15 °C) detector features low noise and low dark signal, which enables low-light-level detection and long integration times from 8 milliseconds to 15 minutes.

Onboard Programming

The QE65000 also has an onboard programmable micro-controller for controlling the spectrometer and accessories. You have access to 10 user-programmable digital inputs/outputs and a pulse generator for triggering other devices.

QE65000: $9,999

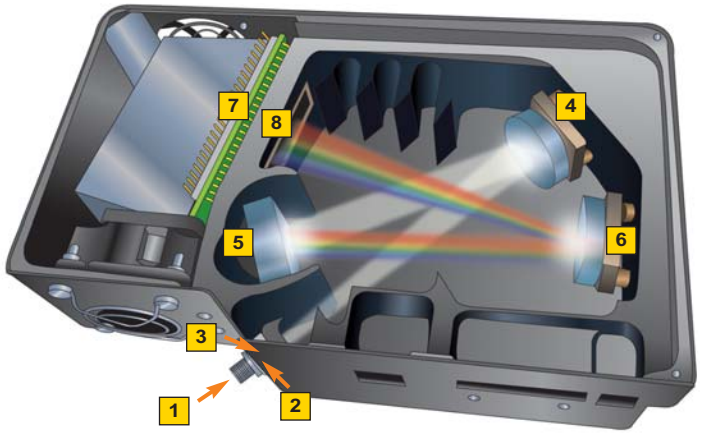
Comparing Xylenes



To acquire Raman spectra for xylene, we used a QE65000 with a 10 µm slit and Grating H14, plus a 532 nm laser and probe.

Options for the "QE" Optical Bench

Components of the "QE" Optical Bench



1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Entrance Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits are available in widths from 5 µm to 200 µm. Each is permanently fixed to the SMA 905 bulkhead. (Without a slit, a fiber acts as the entrance aperture.)

3 Longpass Absorbing Filter: optional
If selected, an OF-1 absorbance filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to block second- and third-order effects.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. Opt to install a standard mirror or a SAG+UPG-HR mirror.

5 Grating: specify grating
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane and sends higher orders to light traps built into the optical bench. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. Opt for a standard mirror or a UV-absorbing SAG+UPG-HR mirror.

7 Detector with TE cooling
The TE-cooled, back-thinned, "2D" detector provides great signal processing speed, improved signal-to-noise ratio and great native response in the UV. It generates virtually no dark noise, allowing for long integration times.

8 OFLV Filters: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

1 SMA 905 Connector

A precision SMA 905 Connector aligns to the spectrometer's entrance slit and ensures concentricity of the fiber. For an upgrade fee that includes the cost of a another connector and labor, we will replace the standard SMA 905 Connector with a different connector of your choice.

2 Fixed Entrance Slit

One option available with the user-configured QE65000 Spectrometer is the size of the entrance aperture, with the width determining the amount of light entering the bench. A slit is fixed in place; it only can be changed by our technicians.

Slit	Description	Pixel Resolution	Price
SLIT-5	5-µm wide x 1-mm high	~2.0 pixels	$150
SLIT-10	10-µm wide x 1-mm high	~2.2 pixels	$150
SLIT-25	25-µm wide x 1-mm high	~2.6 pixels	$150
SLIT-50	50-µm wide x 1-mm high	~3.3 pixels	$150
SLIT-100	100-µm wide x 1-mm high	~4.7 pixels	$150
SLIT-200	200-µm wide x 1-mm high	~8.9 pixels	$150

3 Longpass Absorbing Filters

We offer longpass absorbing or blocking filters; each filter has a transmission band and a blocking band to restrict radiation to a certain wavelength region for eliminating second- and third-order effects. These filters are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 Connector.

Item	Description	Price
OF1-WG305	Longpass filter; transmits light >305 nm	$50
OF1-GG375	Longpass filter; transmits light >375 nm	$50
OF1-GG475	Longpass filter; transmits light >475 nm	$50
OF1-OG515	Longpass filter; transmits light >515 nm	$50
OF1-OG550	Longpass filter; transmits light >550 nm	$50
OF1-OG590	Longpass filter; transmits light >590 nm	$50

4 & 6 Collimating & Focusing Mirrors

Another bench option is to replace the standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors, which increase reflectance in the VIS-NIR and, in turn, increase the sensitivity of the spectrometer. SAG+ Mirrors are often specified for fluorescence. These mirrors also absorb nearly all UV light, which reduces the effects of excitation scattering in fluorescence measurements. Unlike most silver-coated mirrors, the SAG+ mirrors won't oxidize. See page 16 for a spectral graph illustrating SAG+ reflectivity.

SAG+UPG-HR: $250

Options for the "QE" Optical Bench

5 Choosing a Grating & Wavelength Range

You choose from among 14 gratings for each spectrometer. With each grating, you consider its groove density (which helps determine the resolution), its spectral range (which helps determine the wavelength range) and its blaze wavelength (which helps determine the most efficient range).

- The **Groove Density** (mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.
- The **Spectral Range** is the dispersion of the grating across the linear array. The spectral range (bandwidth) is a function of the groove density and does not change. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range.
- For ruled gratings, the **Blaze Wavelength** is the peak wavelength in an efficiency curve. For holographic gratings, it is the most efficient wavelength region.
- The **Best Efficiency** region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating #1 has a 650 nm spectral range, but is most efficient from 200-575 nm so wavelengths >575 nm will have lower intensity.

Grating Efficiency Curves are on the next page. (The HC-1 curve is on page 23.) All gratings are free with the purchase of a spectrometer, except for the HC1-QE, which is $600.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC1-QE	UV-NIR	300	200-950 nm	variable	200-950 nm
H1	UV	600	373-390 nm	300 nm	200-575 nm
H2	UV-VIS	600	365-390 nm	400 nm	250-800 nm
H3	VIS-Color	600	360-386 nm	500 nm	350-850 nm
H4	NIR	600	360-377 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	180-193 nm	holographic: UV	200-400 nm
H6	NIR	1200	123-170 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	63-90 nm	holographic: UV	200-500 nm
H9	VIS-NIR	1200	145-180 nm	holographic: VIS	400-800 nm
H10	UV-VIS	1800	83-123 nm	holographic: UV	200-635 nm
H11	UV-VIS	1800	66-120 nm	holographic: VIS	320-800 nm
H12	UV-VIS	2400	52-88 nm	holographic: VIS	250-575 nm
H13	UV-VIS-NIR	300	790 nm	500 nm	300-1100 nm
H14	NIR	600	360-370 nm	1000 nm	650-1100 nm

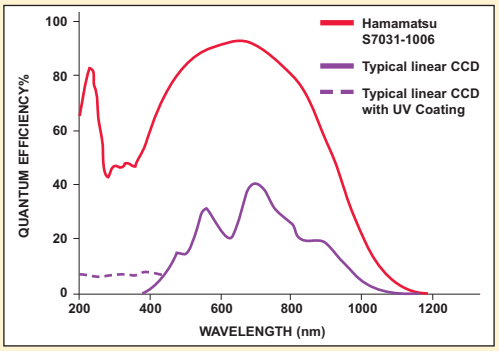
7 Back-thinned Area Detector

The QE65000's Hamamatsu S7031-1006 FFT-CCD area detector provides 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). The TE-cooled detector features low noise and low dark signal, which enables low-light-level detection and long integration times, thus achieving a wide dynamic range.

The S7031 is a 2D array, which allows us to bin pixels in a vertical column to acquire light from the entire height of the spectrometer's slit image. This improves light collection and signal-to-noise significantly. Because the detector is back-thinned (or back-illuminated), it has great native response in the UV and does not require the UV detector upgrade that we apply to other detectors.

In our spectrometers with linear CCDs, the slit's width, not its height, regulates the amount of light entering the bench because linear CCDs cannot efficiently collect the light from the entire height of the slit. But in the QE65000, the 2D area detector can better take advantage of the height of the entrance slit and the additional light, greatly improving system sensitivity.

Detector Quantum Efficiency



Detector Specifications	
Detector:	Hamamatsu S7031-1006 area CCD
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total); 24.6 µm square size
Pixel area:	active area: 24.576 mm x 1.392 mm
Pixel well depth:	300,000 electrons/well; ~1.5 million electrons/column sum well
Sensitivity:	400 nm: 22 electrons/count; 250 nm: 26 photons/count
Dark current:	4000 e^-/pixel/sec @ 25 °C; 200 e^-/pixel/sec @ 0 °C

8 Detector with OFLV Filter

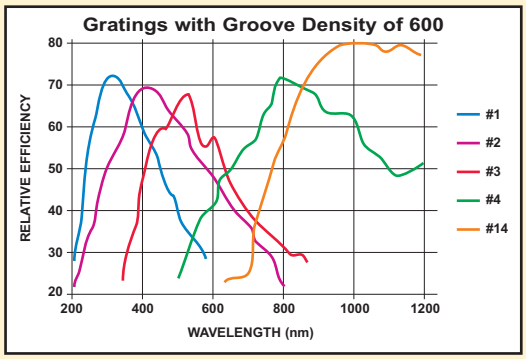
The OFLV-QE is one of our Variable Longpass Order-sorting Filters used to eliminate second-order effects and is used with an HC-1 Grating in a 200-950 nm wavelength range system in a QE65000. We use patented coating technology to apply the filter onto the substrate of the detector's window.

OFLV-QE: $250

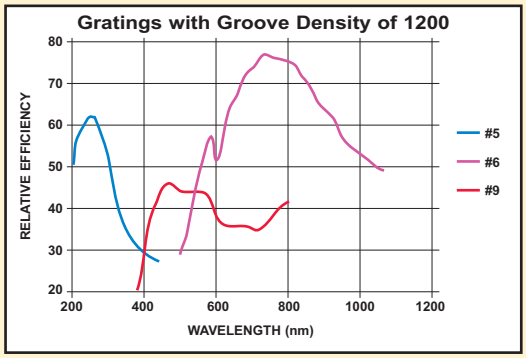
Options for the "QE" Optical Bench

Grating Efficiency Curves

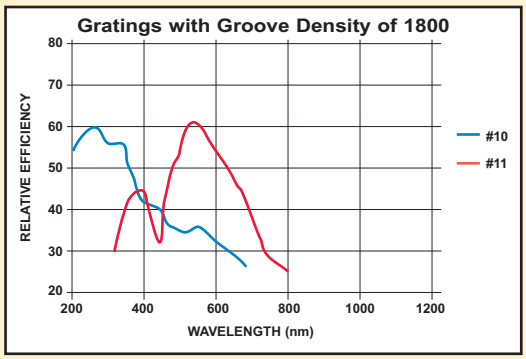
Below are the Grating Efficiency Curves for gratings with groove densities of 600, 1200, 1800 and 2400 mm^{-1}. See curves for all of our gratings at our website.



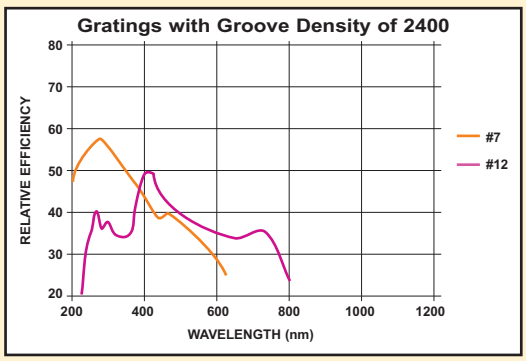
Efficiency Curves for Gratings 1, 2, 3, 4 and 14.



Efficiency Curves for Gratings 5, 6 and 9.



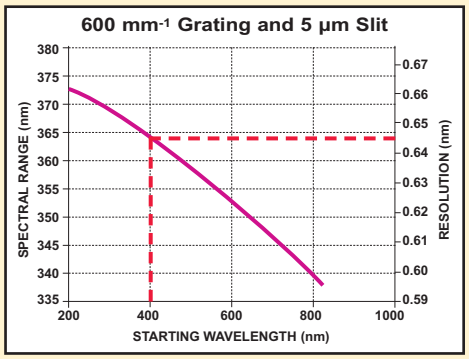
Efficiency Curves for Gratings 10 and 11.



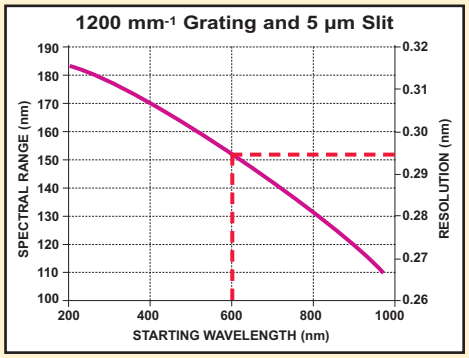
Efficiency Curves for Gratings 7 and 12.

Predicted Ranges & Resolution

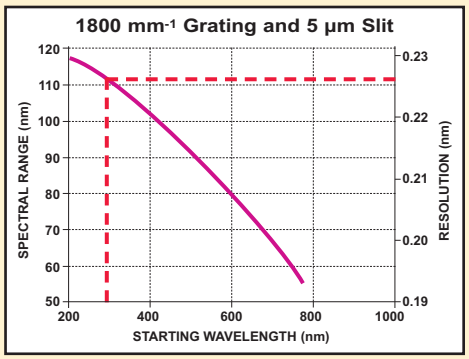
These graphs demonstrate the range and resolution of your "QE" Bench Spectrometer with a 5 µm slit. See our website for more graphs of ranges and resolutions for every slit size.



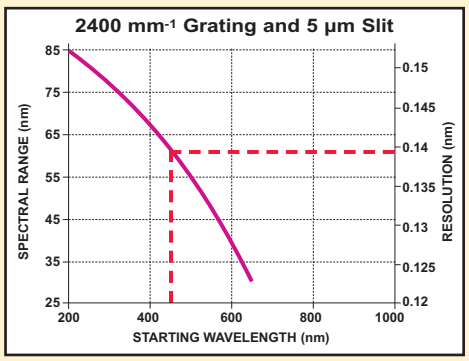
Example: *If the starting wavelength is 400 nm, then the range is ~364 nm, providing a 400-764 nm wavelength range and 0.645 nm resolution.*



Example: *If the starting wavelength is 600 nm, then the range is ~152 nm, providing a 600-752 nm wavelength range and 0.295 nm resolution.*



Example: *If the starting wavelength is 300 nm, then the range is ~112 nm, providing a 300-412 nm wavelength range and 0.226 nm resolution.*



Example: *If the starting wavelength is 450 nm, then the range is ~62 nm, providing a 450-512 nm wavelength range and 0.139 nm resolution.*

NIR-series Near-infrared Spectrometers

3 Wavelength-Range Options

Our NIR-series Near-infrared Spectrometers provide full spectral analysis in real time and meet a wide variety of measurement needs. Three different NIR systems provide you with multiple wavelength ranges for measuring sugar, alcohol, moisture, fats and more. These small-footprint, plug-and-play systems provide a full spectrum in one millisecond, and offer optical resolution as low as 3.0 nm FWHM.

InGaAs Detector Cooled for Optimum Signal-to-Noise and Sensitivity

The NIR-series Spectrometers each feature a Hamamatsu InGaAs linear-array detector with onboard thermoelectric cooling. A thermistor monitors the array's temperature and a thermoelectric device can cool each array to 30 °C below ambient, keeping the array stable to within ±0.1 °C. You can set and monitor the detector's temperature via software.

NIR512 Spectrometer: 900-1700 nm

The NIR-512 Spectrometer features a 512-element InGaAs linear-array detector. With the NIR-512, the only diffractive grating available is Grating N1, and it provides a 900-1700 nm wavelength range, producing an optical resolution of <5.0 nm FWHM.

NIR256-2.1 Spectrometer: 1200-2100 nm or 900-2100 nm

The NIR256-2.1 Spectrometer uses a 256-element InGaAs linear-array detector. With the NIR256 you have two grating options. With Grating N1, you have a 1200-2100 nm wavelength range. Grating N2 provides a 900-2100 nm wavelength range.

NIR256-2.5 Spectrometer: 900-2500 nm

The NIR256-2.5 Spectrometer extends farther into the NIR, acquiring real-time spectra up to 2.5 µm. With the NIR256-2.5, you select Grating N2, which provides a wavelength range of 900-2500 nm.

Plug-and-Play USB Operation

All of the NIR-series Spectrometers interface to PCs via USB 2.0. When operating the spectrometer via the USB port, you have access to the spectrometer's EEPROM, where wavelength calibration coefficients and other data unique to your spectrometer are stored. SpectraSuite Spectroscopy Operating Software reads these values for easy setup and swapping among PCs. A 16-bit A/D converter is mounted with the spectrometer in the same housing. A 5 VDC wall transformer (included) is required. These systems also have a serial port for interfacing to PCs, PLCs and other devices that support the RS-232 protocol.

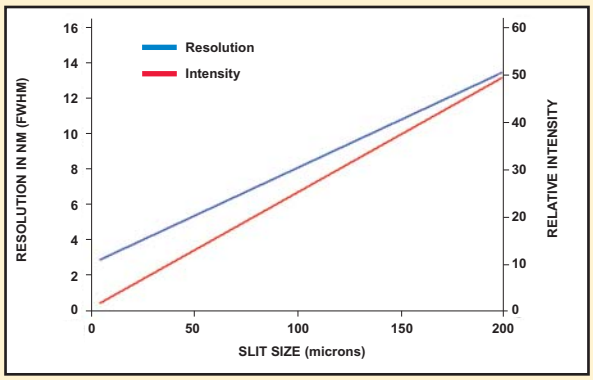
NIR-512: $14,995
NIR256-2.1: $19,999
NIR256-2.5: $21,995
SpectraSuite: $199

Specifications	NIR-512	NIR256-2.1	NIR256-2.5
PHYSICAL			
Dimensions (in mm):	153.4 x 105.2 x 76.2	153.4 x 105.2 x 76.2	153.4 x 105.2 x 76.2
Weight:	190 grams	190 grams	190 grams
DETECTOR			
Detector:	Hamamatsu G9204-512 InGaAs linear array	Hamamatsu G9206-256 InGaAs linear array	Hamamatsu G9208-256 InGaAs linear array
Detector range:	850-1700 nm	900-2100 nm	900-2550 nm
Pixels:	512	256	256
Pixel size:	25 µm x 500 µm	50 µm x 250 µm	50 µm x 250 µm
Pixel well depth:	187,000,000 electrons	187,000,000 electrons	187,000,000 electrons
Defective pixels:	None	2%	5%
OPTICAL BENCH			
Focal length:	f/4, 40 mm	f/4, 40 mm	f/4, 40 mm
Entrance aperture:	10, 25, 50, 100 or 200 µm wide slits or fiber	10, 25, 50, 100 or 200 µm wide slits or fiber	10, 25, 50, 100 or 200 µm wide slits or fiber
Grating options:	Grating N1	Grating N1 and N2	Grating N2
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single strand fiber	SMA 905 to 0.22 numerical aperture single strand fiber	SMA 905 to 0.22 numerical aperture single strand fiber
SPECTROSCOPIC			
Wavelength range:	900-1700 nm with Grating N1	900-2100 nm with Grating N2; 1200-2100 nm with Grating N1	900-2500 nm with Grating N2
Responsivity peak:	1.6 µm	1.95 µm	2.3 µm
Optical resolution:	With grating N1, 4.2-14.0 nm FWHM, slit dependent	With grating N1, 4.5-14.0 nm FWHM, slit dependent; with grating N2, 7.5-25.0 nm FWHM, slit dependent	With grating N2 7.5-25.0 nm FWHM, slit dependent
Signal-to-noise ratio:	4000:1	4000:1	4000:1
A/D resolution:	16 bit	16 bit	16 bit
Dark noise:	12 RMS counts	12 RMS counts	12 RMS counts
Dynamic range:	5 x 10^6 (system); 5000:1 for a single acquisition	5 x 10^6 (system); 5000:1 for a single acquisition	5 x 10^6 (system); 4000:1 for a single acquisition
Integration time:	1 ms to 3 seconds*	1 ms to 1 second*	1 to 30 milliseconds*
Corrected linearity:	>99.8%	>99.8%	>99.8%
Max. dark current:	60 pA @ 20 °C	120 pA @ -15 °C	2000 pA @ 15 °C
ELECTRONICS			
Power consumption:	2 A @ 5 VDC	3 A @ 5 VDC	2 A @ 5 VDC
Data transfer speed:	Full spectrum to memory every 10 ms with USB port	Full spectrum to memory every 10 ms with USB port	Full spectrum to memory every 10 ms with USB port
Trigger modes:	3 modes	3 modes	3 modes
Strobe functions:	Yes	Yes	Yes
COMPUTER			
Operating systems:	Windows 98/Me/ 2000/XP, Mac OS X & Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/ 2000/XP, Mac OS X & Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/ 2000/XP, Mac OS X & Linux with USB port; Any 32-bit Windows OS with serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)

** Hardware allows integration times up to 32 seconds, but the detectors' dark characteristics do not support it.*

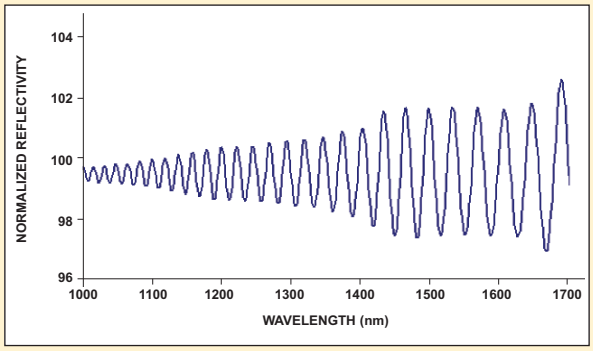
NIR-series Near-infrared Spectrometers

NIR-512 Resolution & Intensity vs. Slit Size

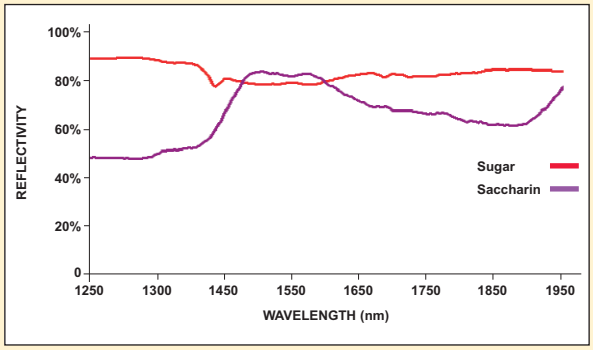


Use this chart to help determine the best entrance aperture slit size for your application. Note that the smaller-sized slits provide excellent resolution, but lower levels of throughput to the detector.

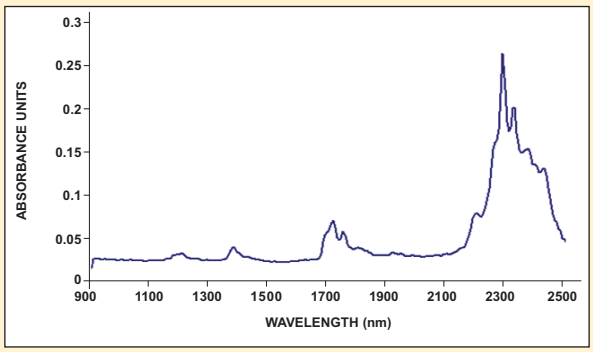
NIR-512: Silicon Wafer Reflectivity



NIR256-2.1 Reflectance of Sugar



NIR256-2.5 Heptane Absorbance



NIR-series Applications

- Sugar analysis
- Alcohol analysis in brewing
- Moisture analysis
- Nitrogen detection in soils
- Pulpwood QC
- Analysis of lubricants
- Laser characterization
- Fat, oil and lipid determination

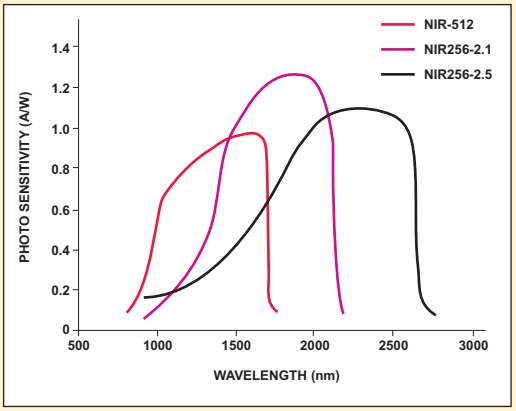
Options for the "NIR" Optical Bench

Detectors

In the "NIR" Spectrometers, we offer three different InGaAs linear array detectors, one 512-element array and two 256-element arrays. The Hamamatsu detectors used in the "NIR" Optical Bench are InGaAs photodiode linear arrays with each pixel connected to a charge amplifier array consists of CMOS transistors. These detectors deliver high sensitivity and stable operation in the near infrared.

The detectors all include onboard thermoelectric cooling. A thermistor monitors the array's temperature and a thermoelectric device can cool the arrays to 30 °C below ambient, keeping the array stable to within ±0.1 °C. In addition, you can set and monitor the detector's temperature via software.

Spectral Response Curves



This graph compares the spectral response of the three NIR detectors at an operating temperature of 25 °C.

Fixed Entrance Slits

An option available with user-configured "NIR" spectrometers is selecting the size of the entrance aperture. Entrance slits are rectangular apertures, 1-mm tall and various widths from 10 µm to 200 µm, with the width determining the amount of light entering the optical bench. A slit is fixed in place; it only can be changed by our technicians. You can opt against having a slit, in which case the diameter of the fiber connected to the spectrometer determines the size of the entrance aperture.

A slit is installed on the inside edge of the bulkhead of an SMA 905 Connector.

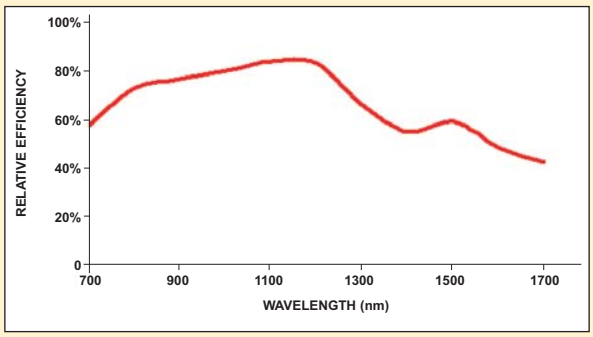
Slit	Description	NIR-512 Pixel Resolution	NIR256-2.1 Pixel Resolution	NIR256-2.5 Pixel Resolution	Price
SLIT-10	10-µm wide x 1-mm high	~2.4 pixels	~1.2	~1.2	$150
SLIT-25	25-µm wide x 1-mm high	~2.4 pixels	~1.2	~1.2	$150
SLIT-50	50-µm wide x 1-mm high	~2.9 pixels	~1.5	~1.5	$150
SLIT-100	100-µm wide x 1-mm high	~4.4 pixels	~2.2	~2.2	$150
SLIT-200	200-µm wide x 1-mm high	~7.9 pixels	~4.0	~4.0	$150

Grating Selection Chart & Grating Efficiency Graphs

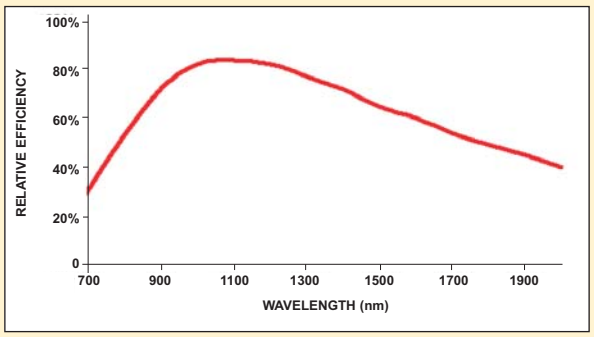
Here are the Grating Selection Chart and the Grating Efficiency Curves for the two gratings available with the "NIR" optical bench.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency
N1	NIR-512 or NIR256-2.1	300	900 nm	1000 nm	700-2100 nm
N2	NIR256-2.1 or NIR256-2.5	150	1600 nm	1600 nm	700-2500 nm

N1 Grating Efficiency



N2 Grating Efficiency



Spectrometer
Systems & Setups

Systems and Setups are either turnkey spectrometers or complete setups necessary for a specific measurement technique, such as fluorescence, or a specific application, such as measuring LEDs.

General-purpose Spectrometers
- 34 UV-VIS & VIS-NIR Spectrometers
- 35 HR4000CG Spectrometer: UV-NIR
- 36 CHEM4 Systems for Education
- 38 Red Tide Spectrometer for Education
- 39 Xplorer GLX Handheld Datalogger
- 40 MEMS-based NIR Spectrometers
- 41 Process-2000 Process Control Systems

Liquid Absorbance Systems
- 42 Deep-well Spectrometer for High S:N
- 43 Flow Injection Analysis System

Fluorescence Measurement Tools
- 44 PMT for Fluorescence Flow Analysis
- 45 QE65000 Configured for Fluorescence
- 46 Fluorescence Spectrometers
- 47 Gated Spectrometer for Fluorescence

Laser-induced Breakdown Spectroscopy
- 48 LIBS2500 Spectrometer & Accessories
- 50 LIBS-ELITE Laser Ablation Sampling System

Raman Spectroscopy
- 51 Raman Selection Guide
- 52 Modular Raman Measurement Tools
- 54 Raman Systems for Lab & Field
- 55 Multimodal Multiplex Raman System

Spectroradiometric Systems
- 56 LED Measurement Tools
- 57 Spectroradiometric Tools

Metrology Systems
- 58 NanoCalc Thin-film Analysis System
- 59 SpecEl Ellipsometer System
- 59 PlasCalc Plasma Monitoring & Control
- 60 Transmission of Optics Tools

UV-VIS & VIS-NIR Spectrometers

Great Versatility

We offer general-purpose UV-VIS and VIS-NIR spectrometers that are preconfigured -- where all of the optical bench options are already selected. By switching out light sources and sampling accessories, these spectrometers can measure absorbance in solutions or reflectance of solids.

200-850 nm UV-VIS Preconfigured Spectrometer

The USB4000-UV-VIS utilizes the "USB" (also called the "S") Optical Bench. It has a 200-850 nm wavelength range and comes with a detector upgrade for working in the UV, a variable longpass detector filter for second- and third-order rejection, and a 25-µm slit as the entrance aperture. Optical resolution is ~1.5 nm (FWHM).

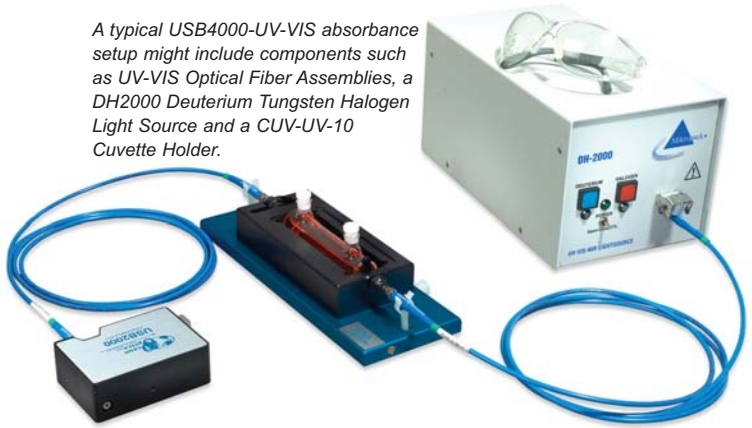
350-1000 nm VIS-NIR Preconfigured Spectrometer

The USB4000-VIS-NIR spectrometer also utilizes the "USB" (also called the "S") Optical Bench. It has a 350-1000 nm wavelength range and comes with a 25-µm entrance slit and a variable longpass detector filter for second- and third-order rejection. With this optical bench configuration, the USB4000-VIS-NIR achieves ~1.5 nm optical resolution (FWHM).

Accessorize

To complete your spectrometer system, select from our comprehensive line of fiber optic accessories -- light sources, sensors and probes, sample holders, flow cells, optical fiber assemblies and more.

USB4000-UV-VIS: $2,649
USB4000-VIS-NIR: $2,499



A typical USB4000-UV-VIS absorbance setup might include components such as UV-VIS Optical Fiber Assemblies, a DH2000 Deuterium Tungsten Halogen Light Source and a CUV-UV-10 Cuvette Holder.

A reflection setup with the USB4000-VIS-NIR could include these components: an R200-VIS-NIR Reflection Probe, an LS-1 Tungsten Halogen Light Source and an RPH-1 Reflection Probe Holder.

Specifications

	USB4000-UV-VIS	USB4000-VIS-NIR
PHYSICAL		
Dimensions (in mm):	89.1 x 63.3 x 34.4	89.1 x 63.3 x 34.4
Weight:	190 grams	190 grams
DETECTOR		
Detector:	Toshiba TCD1304AP linear CCD array (page 17)	Toshiba TCD1304AP linear CCD array (page 17)
Pixels:	3648 pixels, size of each is 8 µm x 200 µm	3648 pixels, size of each is 8 µm x 200 µm
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm	130 photons/count at 400 nm; 60 photons/count at 600 nm
OPTICAL BENCH		
Design:	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output	42 mm input; 68 mm output
Entrance aperture:	25 µm wide slit (page 15)	25 µm wide slit (page 15)
Grating:	Grating #1, 600 lines per mm grating, blazed at 300 nm (page 17)	Grating #3, 600 lines per mm grating, blazed at 500 nm (page 17)
Order-sorting filters:	OFLV-200-850 (page 17)	OFLV-350-1000 (page 17)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC		
Wavelength range:	200-850 nm	350-1000 nm
Optical resolution:	~1.5 nm FWHM	~1.5 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)	300:1 (at full signal)
Dynamic range:	2 x 10^8 (system); 1300:1 for a single spectrum	2 x 10^8 (system); 1300:1 for a single spectrum
Integration time:	3.8 ms to 10 seconds	3.8 ms to 10 seconds
ELECTRONICS		
Power consumption:	250 mA @ 5 VDC	250 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port	Full spectrum to memory every 5 ms with USB 2.0 port
Inputs/Outputs:	8 onboard digital user-programmable GPIOs	8 onboard digital user-programmable GPIOs
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port

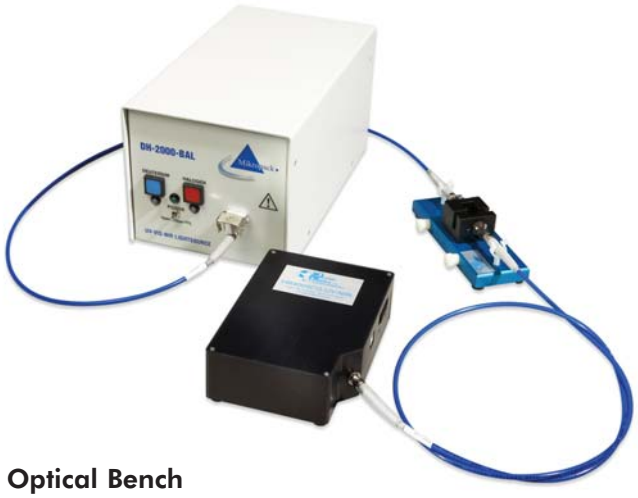
HR4000CG Spectrometer: UV-NIR

200-1100 nm Range, 0.75 nm Resolution

The HR4000CG Composite-grating Spectrometer utilizes a proprietary grating and order-sorting filter to provide a 200-1100 nm wavelength range and 0.75 nm optical resolution (FWHM). The revolutionary HR4000CG is a preconfigured HR4000 Spectrometer -- where all of the optical bench options are already selected for you.

Composite-grating & Order-sorting Filter

The HR4000CG uses the HC-1 grating, which is a revolutionary and proprietary variable blazed grating designed to provide a 200-1100 nm wavelength range. (Though the spectrometer is configured for 200-1100 nm, its best efficiency is from 200-1050 nm. See the grating efficiency curve for the HC-1 on page 23.) In addition to this new composite grating, the HR4000CG has an OFLV-200-1100 variable longpass order-sorting filter to eliminate second- and third-order effects. Both are installed at the time of manufacture and are fixed in place.



Optical Bench

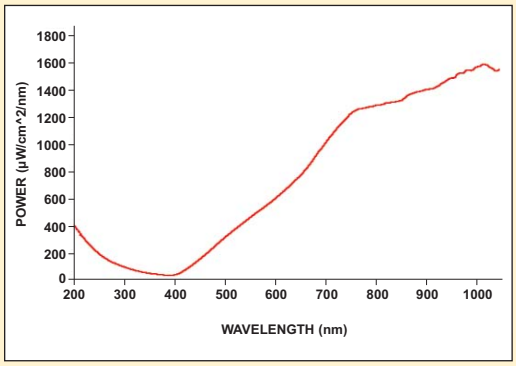
The HR4000CG Spectrometer uses the "HR" Optical Bench, comes with a 5 µm entrance slit, and has a UV4 Detector Upgrade to enhance the performance of the spectrometer in the UV. The HR4000CG is an upgrade from the HR2000CG. The HR4000CG comes with a 3648-element linear-array CCD detector that provides better optical resolution throughout the UV-NIR range.

USB 2.0 Compatibility and New Digital I/Os

The HR4000CG interfaces to a PC via a USB port. Software reads programmed data unique to each spectrometer for easy setup. The HR4000CG also offers 10 user-programmable digital inputs/outputs, 1 analog input and 1 analog output.

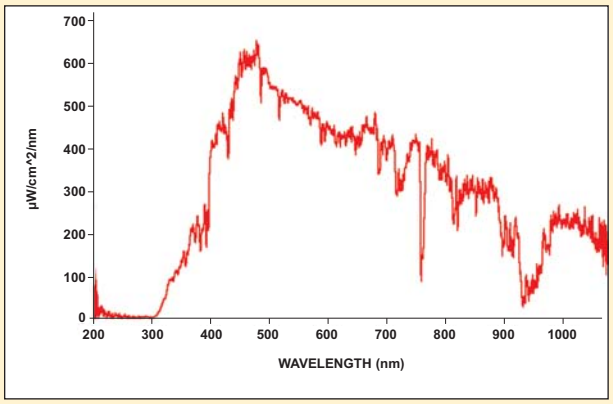
HR4000CG-UV-NIR: $4,999

Sample Spectrum



An irradiance spectrum of the DH2000 Deuterium Tungsten Halogen Light Source taken with the HR4000CG.

Sample Spectrum



A solar irradiance spectrum taken with the HR4000CG.

Specifications	
PHYSICAL	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
DETECTOR	
Detector:	Toshiba TCD1304AP linear CCD array (page 24)
Pixels:	3648 pixels, pixel size of 8 µm x 200 µm
Pixel well depth:	~100,000 electrons
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
OPTICAL BENCH	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5 µm wide slit (page 22)
Grating:	HC-1, 300 lines per mm grating (page 23)
Order-sorting filters:	Installed OFLV-200-1100 (page 24)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
SPECTROSCOPIC	
Wavelength range:	200-1100 nm, best efficiency 200-1050 nm
Optical resolution:	0.75 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
Dark noise:	12 RMS counts
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Integration time:	3.8 ms to 10 seconds
ELECTRONICS	
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input, One 9-bit analog output
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; any 32-bit Windows OS using serial port

** Programming the GPIOs requires SpectraSuite or OmniDriver. See pages 80-82 for details.*

CHEM4 Systems for Education

Instructional Materials for Teaching Labs

We've begun to develop a rich library of spectroscopy educational materials for both students and educators. Our first effort, *Introduction to Spectroscopy in the Teaching Lab Using Ocean Optics Spectrometers*, is a handy reference tool for introducing Ocean Optics to the modern teaching lab. Included are experiments and sample lab exercises for our spectrometer and PASCO Scientific's GLX Explorer dataloggers. Here's a sampling of featured exercises:

- Absorbance of Light vs. Concentration (Beer's Law)
- Kinetics of Crystal Violet Bleaching
- Spectrophotometric Determination of an Equilibrium Constant
- Spectrophotometric pH Determination Using Bromocresol Green

With so many lab exercises built around use of the old Spec20, these Ocean Optics spectrometer experiments -- all of which come from recipients of our educational grants -- are great for getting started in your new lab setup, or for use with any post-dispersive spectrometer.

Item	Description	Price
EDU-SPEC-BOOK	Print version of Educational Spectroscopy Handbook	$100
EDU-SPEC-BOOK-S	Print version of Educational Spectroscopy Handbook; when purchased with a spectrometer	$75
EDU-SPEC-CD	CD version of Educational Spectroscopy Handbook in PDF format; includes how-to video for making basic measurements	$45
EDU-SPEC-CD-S	CD version of Educational Spectroscopy Handbook in PDF format; includes how-to video for making basic measurements; when purchased with a spectrometer	$25
EDU-SPEC-D	Online version, educational spectroscopy handbook	$20
EDU-SPEC-D-S	Online version, educational spectroscopy handbook; when purchased with a spectrometer	Free

Unique Teaching Tool = More Data, Faster

Our CHEM4-series Spectrophotometers for Education are small-footprint, PC-based systems designed for professors, teachers and others who use spectroscopy as a teaching tool. These fully integrated systems -- including spectrometer, light source and cuvette holder -- are available at dramatic discounts with the trade-in of an old lab instrument. Acquire and display real-time complete spectral data (3648 wavelengths) in <1 second with our convenient, PC-based systems.

Sampling Optics: Direct-attach or Fiber

Each CHEM4 system comes with a fully integrated light source and cuvette holder that attaches to the spectrometer, either directly or via fiber, for a small-footprint system.

Direct Attach: The CHEM4-UV-VIS has a state-of-the-art, miniature RF-excited deuterium tungsten source. The CHEM4-VIS-NIR has a direct-attach combination tungsten and blue LED source. You can separate each spectrometer from its integrated light source to couple the spectrometer to any of our fiber optic accessories and light sources.

Fiber: The CHEM4-UV-FIBER and CHEM4-VIS-FIBER include a light source and cuvette assembly that attaches to the spectrometer with an optical fiber. The advantage of this design is that the light source can be easily coupled to other fiber optic accessories such as reflection probes or transmission dip probes. The CHEM4-UV-FIBER uses a deuterium tungsten source and the CHEM4-VIS-FIBER comes with a tungsten source.

USB Interface for Easy Startup

All of our CHEM4 systems interface to a PC via USB. All you need is to install the software and connect the included USB cable to your PC to be up and running. Wavelength calibration data are loaded automatically upon startup, and spectrometer power is supplied through the USB.

Software for Linux, Macintosh & Windows

All CHEM4 systems come with student-friendly software, which includes functions for absorbance, transmission, relative irradiance and kinetics measurements. Our new SpectraSuite Spectroscopy Operating Software (pages 80-81) works in Linux, Macintosh and Windows operating systems.

Discount Pricing & Cost Sharing

Any learning institution qualifies for trade-in prices for CHEM4 systems. Save $1,500 by trading in your old monochromator or spectrometer. See the facing page for retail and trade-in prices. Our *Innovations in Education Spectroscopy Grant Program* rewards educators and researchers for utilizing fiber optic spectroscopy in curricula or in research. See page 8 for more.

CHEM4 Systems for Education

		Spectrometer & A/D Converter	Wavelength Range*	Light Source & Sample Holder	Optical Fiber	Retail Price	Trade-in Price
CHEM4-UV-VIS		USB4000-UV-VIS	210-880 nm	USB-ISS-UV-VIS integrated deuterium tungsten halogen light source and cuvette holder for 1-cm square cuvettes	None -- integrated light source and sample holder directly attaches to spectrometer	$3,999	$2,499 (save $1,500)
CHEM4-VIS-NIR		USB4000-VIS-NIR	370-985 nm	USB-ISS-VIS integrated tungsten bulb with a violet LED and cuvette holder for 1-cm square cuvettes	None -- integrated light source and sample holder directly attaches to spectrometer	$2,999	$1,499 (save $1,500)
CHEM4-UV-FIBER		USB4000-UV-VIS	200-885 nm	ISS-UV-VIS integrated deuterium tungsten halogen light source and cuvette holder for 1-cm square cuvettes	Lamp and sample holder attach to spectrometer via 1-meter long P300-1-SR assembly with 300 µm diameter solarization-resistant fiber	$3,999	$2.499 (save $1,500)
CHEM4-VIS-FIBER		USB4000-VIS-NIR	430-990 nm	ISS-2 integrated tungsten halogen light source and cuvette holder for 1-cm square cuvettes	Lamp and sample holder attach to spectrometer via 2-meter long P400-2-UV-VIS assembly with 400 µm diameter fiber	$2,999	$1,499 (save $1,500)

Specifications

	CHEM4-UV-VIS	CHEM4-VIS-NIR	CHEM4-UV-FIBER	CHEM4-VIS-FIBER
SYSTEM				
Wavelength range*:	210-880 nm	370-985 nm	200-885 nm	430-990 nm
Optical resolution:	~1.0 nm FWHM	~1.0 nm FWHM	~1.0 nm FWHM	~1.0 nm FWHM
Integration time:	3.8 ms to 10 seconds	3.8 ms to 10 seconds	3.8 ms to 10 seconds	3.8 ms to 10 seconds
Dimensions (in mm):	89.1 x 63.3 x 34.4 (USB4000) 198 x 105.1 x 40.6 (USB-ISS-UV)	89.1 x 63.3 x 34.4 (USB4000) 40.7 x 88.8 x 34.1 (USB-ISS-VIS)	89.1 x 63.3 x 34.4 (USB4000) 198 x 104.9 x 40.9 (ISS-UV-VIS)	89.1 x 63.3 x 34.4(USB4000) 155 x 50 x 53.3 (ISS-2)
DETECTOR & OPTICAL BENCH				
Detector:	Toshiba CCD array (page 17)	Toshiba CCD array (page 17)	Toshiba CCD array (page 17)	Toshiba CCD array (page 17)
Pixels:	3648 pixels	3648 pixels	3648 pixels	3648 pixels
Optical bench design:	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner
Entrance aperture:	25 µm wide slit (page 15)	25 µm wide slit (page 15)	25 µm wide slit (page 15)	25 µm wide slit (page 15)
Grating:	Grating #1 (page 16)	Grating #2 (page 16)	Grating #1 (page 16)	Grating #2 (page 16)
Order-sorting filters:	OFLV-200-850 (page 17)	OFLV-350-1000 (page 17)	OFLV-200-850 (page 17)	OFLV-350-1000 (page 17)
LIGHT SOURCE/SAMPLE CHAMBER				
Bulb(s):	Deuterium and tungsten halogen	Tungsten halogen and violet LED	Deuterium and tungsten halogen	Tungsten halogen
Bulb lifetime:	800 hours	45,000 hours	800 hours	900 hours
Cuvette pathlength:	1 cm	1 cm	1 cm	1 cm
Optical fiber:	N/A	N/A	300 µm solarization-resistant, 1 m	400 µm diameter fiber, 2 m
ELECTRONICS & COMPUTER				
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port			
Computer interfaces:	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud			

** The actual ranges may exceed these listed here. Ranges listed are where you will see changes as small as 1.0 absorbance units.*

Red Tide Spectrometer for Education

At just $999, the Red Tide is a great general-purpose spectrometer for budget-strapped teaching labs. Combine the Red Tide with Ocean Optics light sources, accessories and software to create a fully integrated, small-footprint system.

Specifications	
PHYSICAL	
Dimensions (in mm):	89.1 x 63.3 x 34.4 (USB-650); 89.1 x 104 x 34.4 (USB-650-VIS-NIR)
Weight:	190 g
DETECTOR	
Type:	Linear silicon CCD array
Pixels:	650 enabled pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500
Sensitivity:	75 photons/count @ 400 nm
OPTICAL BENCH	
Design:	f/4, asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	25 µm wide slit
Fiber optic connector:	SMA 905
SPECTROSCOPIC	
Wavelength range:	350-1000 nm (USB-650); 370-980 nm (USB-650-VIS-NIR)
Optical resolution:	~2.0 nm FWHM
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	12 bit
Dark noise:	3.2 RMS counts
Dynamic range:	2 x 10^8; 1300:1 for a single acquisition
Integration time:	4 milliseconds to 10 seconds
Stray light:	<0.05% @ 600 nm; <0.10% @ 435 nm
Corrected linearity:	>99.8%
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux w/USB port
Operating software:	SpectraSuite Spectroscopy Operating Software

World's Most Amazing $999 Spectrometer

The Red Tide Spectrometer is a low-cost, small-footprint lab spectrometer that's ideal as a general-purpose instrument for budget-conscious teaching and research labs. The Red Tide has a wavelength range of 350-1000 nm, and utilizes a detector with 650 active pixels; that's 650 data points in one full spectrum, or one data point per nanometer. Configured with a 25 µm entrance slit, the Red Tide offers ~2.0 nm optical resolution (FWHM).

Flexible Platform, Convenient Interface

The Red Tide is a preconfigured, off-the-shelf spectrometer where all of the optical bench options, such as grating and entrance slit size, are already selected. The Red Tide can be used with various Ocean Optics accessories, light sources and sampling optics, to create application-specific systems for various absorbance, reflection and emission applications. With its small footprint, convenient USB interface, and four millisecond integration time, the Red Tide is a great tool for basic lab measurements.

Spectrometer Alone or with Sampling System

The USB-650 Red Tide comes without a light source or sample system, allowing you the freedom to choose the accessories that best fit your setup. The USB-650-VIS-NIR (at right) comes with a direct-attach light source and sample holder. The light source includes an LED-boosted tungsten source and a sample holder for 1-cm cuvettes that connects to the front of the spectrometer. In this configuration, the system has a wavelength range of 370-980 nm.

Operable with PCs or Dataloggers

The Red Tide interfaces to PCs via its USB port, which streamlines start-up and supports hot swapping of the spectrometer. What's more, the Red Tide interfaces to Pasco's Xplorer GLX, a unique combination of datalogger and lab analysis tool that eliminates the need for a PC. For details, see the facing page. The Red Tide also works with Vernier's Logger Pro Software. Visit www.vernier.com/soft/lp.html for details.

Cross-platform Spectrometer Software

Red Tide operates via SpectraSuite Spectroscopy Operating Software, the first spectroscopy software to run in Macintosh, Linux and Windows. The Chemistry module for SpectraSuite includes features specifically designed for educational use, such as a Beer's Law calculator for absorbance experiments.

USB-650: $999
USB-650-VIS-NIR: $1,499
SpectraSuite: $199

Xplorer GLX Handheld Datalogger

The World's First Graphing Datalogger for Science

The new Xplorer GLX from PASCO captures, analyzes, annotates and stores data quickly and seamlessly, without being connected to a desktop computer. The Xplorer GLX has been designed to function with our line of Spectrometers for Education: the CHEM4 Spectrophotometers (pages 36-37) and the USB-650 Red Tide Spectrometer (page 38). The Xplorer GLX is a science lab wherever you need it, whether you are in the lab or out in the field. When combined with the Xplorer GLX, our Spectrometers for Education become powerful measurement, display and analysis tools for students. The Xplorer GLX can display real-time intensity, absorbance, transmission or relative irradiance spectra in less than one second.

The PS-2636 Xplorer GLX (in blue) easily connects via USB cable to the USB-650 Red Tide Spectrometer for capturing, displaying and analyzing real-time spectroscopic data.

For those who already own an Xplorer GLX, you only need to purchase the PS-2555 License Key and an Ocean Optics spectrometer; the key will enable the Xplorer to work with our line of education spectrometers.

Stand-alone Computing Power

The Xplorer GLX is built for the demanding university teaching environment. It incorporates an easy-to-use, icon-based operating system as well as navigation buttons and a numeric/alphanumeric keypad. With 10 MB of internal memory, the Xplorer can be used as a stand-alone computer but also can interface to traditional desktop computers. If more memory is needed, save Xplorer data to a flash drive. For traditional navigation and annotation, you can plug in an optional USB mouse and keyboard. The Xplorer's rechargeable NiMH battery enables field portability and its large backlit LCD screen is visible in both sunlight and low-light conditions. In addition, a USB port allows students to print graphs and tables directly from the Xplorer GLX to select Hewlett-Packard printers.

Built for Science

The Xplorer GLX includes helpful student features such as a built-in graphing calculator with an expression editor for analyzing trends. The datalogger also includes statistical and mathematical tools to easily review data and perform basic data analysis, such as linear curve fits. Students can annotate data points with either text notes or recorded voice messages (the GLX has a built-in speaker for sound output). The Xplorer GLX has four universal sensor ports as well as ports for two Temperature Sensors, a Sound Sensor, and a Voltage Sensor (included).

Ordering Information

Order the PS-2555 License Key if you already own an Xplorer GLX but want it to work with an Ocean Optics Spectrometer. The PS-2555 is a License Key only; it does not include a spectrometer or the Xplorer GLX. The PS-2636 comes with the Xplorer GLX and the License Key (an Ocean Optics spectrometer is sold separately). The License Key also includes a feature set from our SpectraSuite Spectroscopy Operating Software; however, if you wish to download data from the Xplorer GLX and utilize it on a desktop PC, you may want to purchase the full SpectraSuite Software.

PS-2636 Xplorer GLX & License Key: $425
PS-2555 License Key: $129

The Xplorer GLX comes with software, a power supply, a USB cable, two temperature sensors, a sound sensor, a voltage sensor and easy-to-use instructions.

Specifications	
Dimensions (in mm):	89.1 x 63.3 x 34.4
Display screen:	320 x 240 backlit transflective LCD grayscale display
Sampling rate:	50,000 Hz maximum
Internal memory:	10 MB
Battery:	Rechargeable NiMH battery
Xplorer with USB-650 Red Tide:	Supports basic functions
Xplorer with CHEM4 units:	Supports triggering functions and digital user-programmable GPIOs

MEMS-based NIR Spectrometer

We recommend our VIS-NIR Optical Fiber Assemblies in diameter sizes greater than 500 µm for use with the DTS Spectrometers.

Compact, Low-Cost NIR Spectrometers

Digital Transform Spectroscopy (DTS) NIR Spectrometers by Polychromix are compact, low-cost NIR systems powered by MEMS architecture. Available in 0.9-1.7 µm, 1.7-2.5 µm and 1.1-1.3 µm wavelength ranges, the spectrometers have no moving parts, and feature a single-element InGaAs detector. The fully programmable spectrometers can be configured to operate in various scanning modes for a variety of general-purpose NIR applications that include quality control, education, R&D and industrial process control. The DTS-series NIR Spectrometers are compact and portable, interface to PCs via USB, and require no external power.

Digital Transform Spectroscopy (DTS)

Polychromix's DTS-series Spectrometers use a grating and an innovative MEMS spatial light modulator to disperse light onto the the system's single-element InGaAs detector. Each wavelength of light can be modulated on and off with differing time sequences. The resulting time-varying signal is processed to create a spectrum.

Spectrometer Models and Accessories

Ocean Optics offers three Polychromix DTS NIR Spectrometer models that vary by wavelength range. Each DTS Spectrometer includes a protective cover, DTS software, a USB cable and documentation.

DTS-1700: $7,199
DTS-2500: $10,999
DTS-NB: $7,199

Specifications

	DTS-1700	DTS-2500	DTS-NB
Dimensions:	105 mm x 85 mm x 145 mm	105 mm x 85 mm x 145 mm	105 mm x 85 mm x 145 mm
Weight:	1.8 kg	1.8 kg	1.8 kg
Spectral range:	~930-1690 nm	~1710-2460 nm	1100-1350 nm
Detector:	Single-element InGaAs	Single-element InGaAs	Single-element InGaAs
Optical resolution:	12.0 nm	22.0 nm	4.0 nm
Photometric stability:	<0.05% over 6 hours	<0.05% over 6 hours	<0.05% over 6 hours
Measurement time:	<1 second per spectrum	<1 sec. per spectrum	<1 sec. per spectrum
Operating systems:	Windows Me, 2000, XP	Windows Me, 2000, XP	Windows Me, 2000, XP
Operating temp:	-5 °C to 40 °C	-5 °C to 40 °C	-5 °C to 40 °C

Phazir MEMS-based NIR Material Analyzer

Specifications

Dimensions:	254 mm x 292 mm x 152 mm
Weight:	1.7 kg
Light source:	Tungsten light bulb
Wavelength range:	DTS-PHAZIR-1016: 1000-1600 nm; DTS-PHAZIR-1624: 1600-2400 nm
Resolution (FWHM):	DTS-PHAZIR-1016: 8.0 nm; DTS-PHAZIR-1624: 12.0 nm
Security:	Password protection, multiple security levels
Operating temp.:	5 °C to 45 °C (40 °F to 115 °F)
Batteries:	Rechargeable 5-8 hour lithium-ion battery pack
Included:	Waterproof carrying case, reference/calibration cap, PC interface cable, 110/220 VAC battery charger/adapter, documentation CD, spare bulb, bulb replacement tools

Point-and-shoot NIR Measurement Tool

The handheld Phazir NIR Material Analyzer enables real time and instantaneous qualitative and quantitative material analysis and provides both material ID and concentration levels via its onboard color LCD screen. This non-destructive measurement tool stores all data into memory, which allows the user to transfer the data to a PC for logging or additional processing.

Applications

Designed for the technician, the point-and-shoot Phazir requires minimal training to operate. The Phazir is perfect for use in materials identification, incoming material inspection, quality control, quality assurance and portable field use.

Portability & Durability

The Phazir is a portable and handheld device weighing only 1.7 kg. Its rechargeable batteries allow 5-8 hours of continued use. The instrument is housed in injection-molded plastic that can withstand harsh environments.

DTS-PHAZIR-1016: $20,000
DTS-PHAZIR-1624: $24,000

Process-2000 Process Control Systems

Multichannel Spectrometer Systems for Process Control

Process-2000 Multichannel Spectrometer Systems are designed for the process control environment. The custom experiment feature allows you to configure custom experiment methods for your process. Once you save a custom method, you need only select the method file to execute your custom experiment. The systems allow you to have full access, remotely if needed, to all software and hardware functions via easy-to-use monitoring and control software. Your spectral data (absorbance, transmission, reflection or emission) can be acquired in 3.8 milliseconds, and mathematically calculated, subtracted and monitored in situ and in real time.

Inputs/Outputs Provide Full Control

A Process-2000 system interfaces to a computer via a USB cord and can be controlled remotely. These systems interface to other process equipment and control hardware via digital and analog inputs/outputs. You have access to 16 digital inputs/outputs per spectrometer channel and eight analog outputs per spectrometer channel. Some ways the inputs/outputs can be used:

- A digital input could come from the process control setup
- A digital output can display the upper and lower limits you have set for a monitoring cycle, or could stop a process under special circumstances, such as when an abnormal phenomena are detected
- An analog output can read out measurement specifications or control a pressure or liquid flow valve

Multichannel Spectrometer Systems

Process-2000 systems provide the ultimate flexibility. Detector options for each spectrometer channel include a 1024-, 2048- or 3648-element linear CCD array. Choose all of your spectrometer options from the size of the bench's entrance aperture to the wavelength range of the channel for a true application-specific system. Specify from two to six spectrometer channels.

Included Process-2000 Software

Process-2000 systems come with sophisticated software tools. The Recipe Editor tool allows you to easily and rapidly configure, build and save experiment methods even for the most difficult and complex processes. After creating a "recipe," you select it to execute the experiment. The Integrated Formula Editor provides easy access to a full range of mathematical and algorithmic functions. The Wavelength Editor allows you to optimize signal-to-noise. A dual-window interface shows the actual spectrum and all process control information.

Additional Software: SpecLine Software for Compound ID

SpecLine Software is a powerful tool designed for identifying atomic emission lines and molecular bands in spectral data. SpecLine's advanced evaluation, search, compare and identify functions enable you to quickly identify unknown lines, peaks and bands. SpecLine was designed for scientists, engineers and researchers using emission spectroscopy in fields such as astrophysics, the plasma sciences, and plasma processing. For more on SpecLine, see page 83.

Process-2000 systems can make absorbance, transmission, reflection and emission measurements. Application-specific measurements include:

- Light emission
- Peak detection
- Particle densities
- Electron densities
- Electron temperature
- Planarization
- Contamination
- Failure analysis
- Pulsed magnetron sputtering
- Quality control (pollutants, discharges, etc.)
- Endpoint detection
- Film/layer monitoring
- Thin film thickness
- Etching and deposition
- Plasma chamber health control
- Protection coatings

Item	Description	Price
PROCESS-2000-2	2-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$19,998
PROCESS-2000-3	3-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$22,678
PROCESS-2000-4	4-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$25,358
PROCESS-2000-5	5-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$28,038
PROCESS-2000-6	6-channel spectrometer system with housing; select detector, wavelength range, entrance slit for each channel	$30,718

Deep Well for High S:N

Sensitivity to 0.00001 Absorbance Units

The S1024DW Deep Well Detector Spectrometer has a 1024-element photodiode array detector for applications requiring high signal-to-noise ratio measurements. With the S1024DW, you can observe absorbance changes of less than 0.00001 absorbance units -- performance that makes the spectrometer ideal for high light-level applications.

"X" Option: Extra-deep Well Detector

The S1024DW is our standard deep well detector spectrometer. Its photodiode-array detector has a signal-to-noise ratio of 2500:1. Also available is the S1024DWX, with a detector distinguished by both its deeper well depth and S:N of 8000:1.

Bench Ideal for High Light-level Applications

The S1024DW uses the "USB" (also called the "S") Optical Bench, which allows you to configure the bench for your application. You can choose an entrance aperture size, detector accessories, filters, a grating and more (see pages 15-17). The S1024DW bench operates much like the USB4000 bench seen on page 15. The bench accepts light energy via an optical fiber and disperses it across a very sensitive 1024-element photodiode array, instead of the 3648-element CCD array that's used in the USB4000.

Stackable System for Multipoint Sampling

You can add up to seven S1024DW Spectrometer channels to your master S1024DW Spectrometer channel to measure multiple samples, expand your wavelength range or monitor a reference. All channels operate from a single ADC1000-USB A/D Converter, which has a channel rotator function that enables simultaneous acquisition of data from up to eight spectrometer channels. The ADC1000-USB interfaces the S1024DW to your PC via a USB port. You can purchase the S1024DW and the ADC1000-USB separately, or buy them as one item (S1024DW-USB) and save $99. See page 84 for more on the ADC1000-USB.

S1024DW-USB:	$3,099
S1024DW (master channel):	$2,599
S2-1024DW (additional channel):	$1,399
S1024DW X (master channel):	$3,999
S2-1024DWX (additional channel):	$2,899
ADC1000-USB:	$599

Detector Options for S1024DW-series

Features	S1024DW	S1024DWX
Detector:	Hamamatsu S3903 linear photodiode array	Hamamatsu S3904 linear photodiode array
Number of Elements:	1024 pixels	1024 pixels
Pixel Size:	25 µm x 500 µm	25 µm x 2500 µm
Well Depth:	31,000,000 electrons	156,000,000 electrons
S:N (at full signal):	2500:1	8000:1
A/D Resolution:	12 bit	16 bit
Dark Noise:	2 RMS counts	2 RMS counts
Corrected Linearity:	>99%	>99%

Detector Accessories for S1024DW-series

Item	Description	Price
L2 Detector Collection Lens	Cylindrical lens placed on the detector for increased light-collection efficiency	$150
OFLV-DW	Variable longpass filter removes second- and third-order effects for systems from 200-850 nm	$150
OFLV-350-DW	Variable longpass filter removes second- and third-order effects for systems from 350-1000 nm	$150

Specifications

Dimensions:	153.4 mm x 105.2 mm x 65.6 mm (when housed with the ADC1000-USB A/D Converter)	Order-sorting filters:	Installed bandpass and longpass filters (page 17)
		Focal length:	42 mm (input); 68 mm (output)
Power consumption:	180 mA @ 5 VDC (master channels for S1024DW & DWX) 140 mA @ 5 VDC (additional channels for S1024DW & DWX)	Optical resolution:	~0.3-10.0 nm FWHM (depending on grating and size of entrance aperture)
Detector:	Linear photodiode array (see above)	Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Detector range:	200-1100 nm	Relative sensitivity:	Compared to CCD detector in USB2000, S1024DW is ~30x less sensitive in the UV and ~80x less sensitive in the VIS
Gratings:	14 gratings; UV through Shortwave NIR (page 16)		
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 15) or fiber (no slit)	Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
		Integration time:	31 milliseconds to 65 seconds

Flow Injection Analysis System

Automated System for Assays

The FIA-LAB-2500 is a flow injection analysis system from FIAlab Instruments, a longtime Ocean Optics partner. The FIA-LAB-2500 was designed for automation of common environmental and agricultural assays such as nitrate, phosphate and ammonia. A complete, automated FIA-LAB-2500 system -- including a USB4000 Spectrometer, light source, flow cell, accessories and optional XYZ autosampler -- can be configured for about $20,000. Affordability and flexibility make the system ideal for teaching, research and commercial labs, especially where routine analyses demand a robust, easy-to-use system. Commonly measured analytes include ammonia, chloride, copper, iron, nitrate, nitrite and phosphate.

Built-in Flexibility, Affordability

The standard FIA-LAB-2500 consists of an automated flow injection system with a four-channel peristaltic pump, a six-port injector valve with fittings and tubing, a flow cell, an LED light source and software. (Other light sources are available at additional cost.) A spectrometer does not come with the FIA-LAB-2500; we recommend the USB4000-VIS-NIR (page 34). A range of accessories is available, including the FIA-ASX260 Autosampler with 180-sample capacity, the flow-through FIA-HEATER for elevated-temperature assays, and flow cells of varying optical pathlengths. Longpath flow cells are available for ultra-low concentration assays.

Ease of Use Tops List of Benefits

The FIA-LAB-2500 automates the handling of sample and reagent solutions, so that messy, awkward and inexact manual handling of solutions is unnecessary. Ease of operation is one of several benefits:

- There is no need to purchase separate expensive manifolds for each type of analytical method.
- Wavelength selections are made through software; no additional filters or lamps are required.
- Monitoring multiple wavelengths (up to four) substantially extends the system's dynamic range.
- Reference wavelengths are utilized for compensation of colored matrices and index of refraction effects.
- The system automatically corrects for response drift.

Example Applications

Nitrate/Nitrite Assay. This method performs FIA assays for soil testing and analysis of potable water and ground, surface, domestic and industrial wastewaters.

Phosphate Assay. A phosphate measurement method based on U.S. EPA protocols, best suited for agricultural and environmental testing.

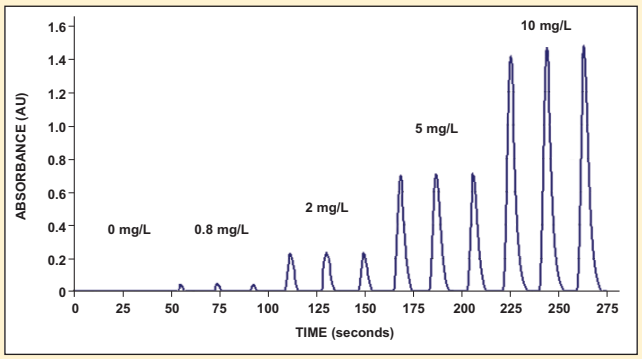
Ammonia Assay. An FIA assay for low ammonia concentrations using the salicylate method. Ideal for agricultural and environmental testing.

FIA-LAB-2500:	**$10,500**
FIA-ASX260:	**$5,800**
FIA-HEATER:	**$450**

Assay	Throughput	Working Range*
Nitrate	180 samples/hour	0.03 mg-200 mg/liter
Nitrite	220 samples/hour	0.005 mg-100 mg/liter
Ammonia	120 samples/hour	0.5 mg-200 mg/liter
Phosphate	120 samples/hour	0.1 mg-25 mg/liter
Chloride	120 samples/hour	1.0 mg-50 mg/liter
Iron	140 samples/hour	0.1 ppm-100 ppm

** Lower working ranges available with long pathlength flow cells, please contact Ocean Optics for details.*

Nitrate Run: Raw Data of Triple Injections

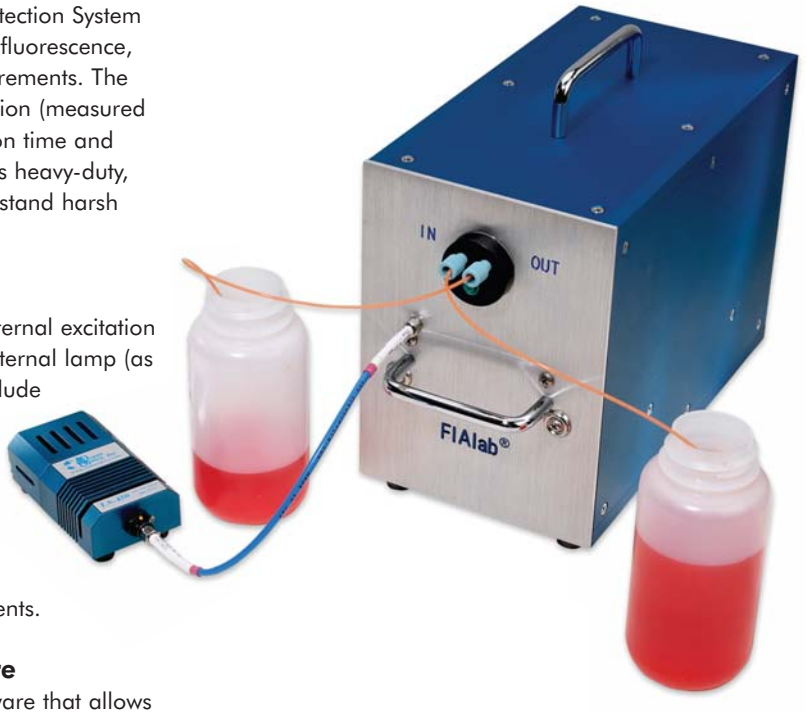


Specifications	
Accuracy (typical):	2%-3%
Precision (typical):	1%-2%
Pump:	4-channel standard, 6-channel available
Dimensions:	24 cm height x 24 cm depth x 16.5 cm width
Weight:	6.75 kg
Recommended light source:	LS-1 Tungsten Halogen Light Source (360-2000 nm), see page 128
Recommended spectrometer:	USB4000-VIS-NIR (350-1000 nm), see page 34
Autosampler (optional):	180, 270 or 360 samples; 10 standards
Flow-through heater (optional):	Ambient up to 50 °C (accuracy is +/- 0.5 °C)

PMT for Fluorescence Flow Analysis

Parts-per-trillion Sensitivity

The FIA-PMT-FL Photomultiplier Flow-through Detection System provides parts-per-trillion sensitivity for ultra-low fluorescence, chemiluminescence and bioluminescence measurements. The system can achieve sensitivity of 10 parts per trillion (measured with fluorescein with a 200 millisecond integration time and using an internal LED light source). Because of its heavy-duty, chemically resistant housing, the system can withstand harsh industrial environments.



Modular Design

The FIA-PMT-FL is built to order with either an internal excitation lamp or with an optical fiber interfacing to an external lamp (as seen at right). Excitation lamp source options include tungsten, mercury vapor, ultraviolet and visible LEDs, and laser diodes. Emission and excitation filters are mounted in slots in the enclosure, allowing for easy removal or exchange. Though the system uses a 25 μL flow-through cuvette, you can also use standard 1-cm pathlength cuvettes for manual measurements.

Easy PC Interface & Optimized Software

Included with the system is Windows-based software that allows you to set the integration time and acquisition rates, and to obtain time histories of the measurements, both plotted and tabulated. The software can also automatically create calibration curves, as well as controlling a host of additional devices such as FIAlab's FIA/SIA systems, syringe and peristaltic pumps, injection valves, selection valves, and autosamplers (please inquire for details). For users who desire to control the PMT-FL from their own software project, included is an ActiveX control for use with Visual Basic, VC++, LabVIEW, or nearly any other ActiveX-compatible development environment.

Example Assays Applications for the PMT-FL

- Fluorometric ammonium analysis: ultra low level assays, parts per billion sensitivity.
- F4551: Fluorescein di(b-D-glucuronide) hydrolyzes to fluorescent fluorescein. It has been used to detect ß glucuronidase activity, an assay for lysosomal enzyme release from neutrophils.
- M8639: 2'-(4-Methylumbelliferyl)-a-D-N-acetylneuraminic acid sodium salt hydrate, which is a fluorometric assay of neuraminidase.
- L9009: Luciferase Photinus pyralis. The bioluminescent reaction of this enzyme with luciferin, ATP, and O_2 results in the emission of light. Luciferase can be used to detect trace amounts of ATP.
- GUS-A: b-Glucuronidase Fluorescent Activity Detection Kit. The substrate used in this kit is MU-GlcA (4-methylumbelliferyl b-D-glucuronide), a widely used fluorogenic substrate for determining glucuronidase activity.

FIA-PMT-FL: $6,495

Specifications	
Dimensions:	~13 cm x 18 cm x 25.4 cm
Spectral range:	310-750 nm (filter/lamp selection dependent)
Detector:	Photo-counting photomultiplier tube
PMT dynamic range:	2 x 10^6
Responsivity:	5 x 10^{17} cps/watt (@ 400 nm)
Detection limits:	10 parts per trillion measured with fluorescein @ 200 msec integration time and internal LED light source
Pulse-pair resolution:	10 ns
Flow cell pathlength:	10 mm
Flow cell volume:	25 µL with standard flow-through cuvette
Filters:	Each FIA-PMT-FL includes your waveband choice of 1 excitation filter and 1 emission filter (call for options)
Computer interface:	RS-232
Operating systems:	Windows 98/Me/2000/XP operating systems
Flow through heater:	Heated flow cell (optional), ambient to 60 °C, +/- 0.5 °C accuracy.

Internal Excitation Source Options:

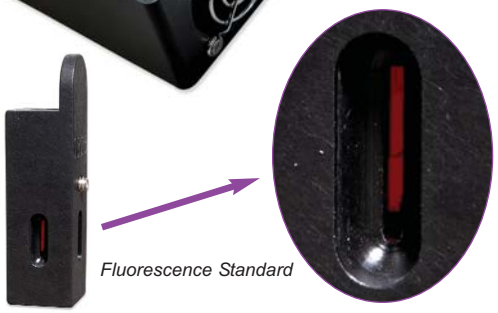
- Laser Diodes (532 nm, 635 nm or 650 nm)
- Quartz tungsten lamp (440-750 nm)
- Mercury Vapor lamps (350-400 nm)
- UV LED lamp (270-410 nm)
- Various visible LED lamps

External Excitation Source Options:

- Laser Diodes (532 nm, 635 nm or 650 nm)
- Quartz tungsten lamp (440-750 nm)
- Mercury Vapor lamps (350-400 nm)
- UV LED lamp (270-410 nm)
- Various visible LED lamps
- Deuterium lamp (200-400 nm)

QE65000 Configured for Fluorescence

QE65000 Scientific-grade Spectrometer



Fluorescence Standard

Specifications

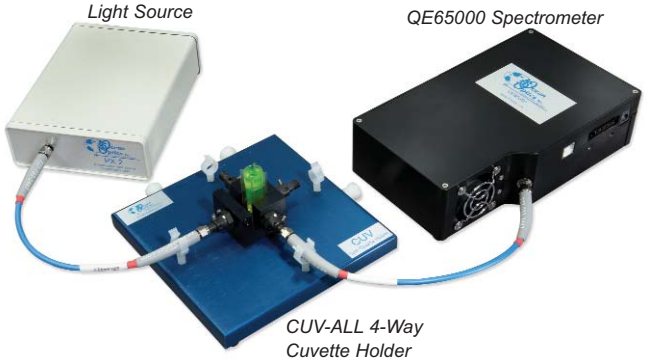
PHYSICAL	
Dimensions (in mm):	182 x 110 x 47
Weight:	1.05 kg
DETECTOR	
Detector:	Hamamatsu S7031-1006 back-thinned CCD (page 28)
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total)
Pixel size:	24.6 µm square size
Signal-to-noise ratio:	1000:1 (at full signal)
Dark noise:	2.5 RMS counts
Sensitivity:	400 nm: 22 electrons/count, 250 nm: 26 photons/count
OPTICAL BENCH	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits (page 27)
Gratings:	14 gratings, UV through Shortwave NIR (page 28)
Filters:	OFLV-QE and OF-1 order sorting filters (page 27)
SPECTROSCOPIC	
Wavelength range:	Grading dependent
Optical resolution:	~0.14-7.7 nm FWHM
Integration time:	8 milliseconds to 15 minutes
Dynamic range:	25000:1 a single acquisition; 7.5 x 10^9 (system)
Stray light:	<0.08% at 600 nm, <0.4% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
ELECTRONICS	
Power consumption:	500 mA @ 5 VDC no TE cool; 3 A @ 5 VDC with TE cool
Data transfer speed:	Full spectrum to memory every 8 ms with USB 2.0 port, 8 ms with USB 1.1 port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs
TEMPERATURE & THERMOELECTRIC (TE) COOLING	
Temperature limits:	0 °C to 50 °C for spectrometer, no condensation
Temperature range:	13 °C maximum range between the high and low
Set point:	Software controlled
Lowest set point:	40 °C below ambient, to -15 °C
Stability:	±0.1 °C of set temperature in <2 minutes
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; 32-bit Windows OS when using the serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115K baud
Peripheral interfaces:	SPI (3-wire); I^2C inter-integrated circuit

Scientific-grade Spectrometer

The QE65000 Spectrometer is a unique combination of detector and optical bench technologies that provides users with high spectral response and high optical resolution in one scientific-grade spectrometer package.

Demanding Low Light-level Applications

The QE65000 was designed for low-light level applications such as fluorescence, Raman spectroscopy, DNA sequencing, astronomy and thin-film reflectivity. For a complete fluorescence system, combine the QE65000 with a PX-2 Pulsed Xenon Light Source (page 127) to excite your sample in a CUV-ALL 4-Way Cuvette Holder (page 90). In addition, we offer LVF Linear Variable Filters (page 114) to spectrally shape excitation energy from broadband sources such as the PX-2. A solid secondary fluorescence standard, the STAN-FL-RED, can be used for quick and easy calibration, stability, and performance checks of your fluorescence system.



PX-2 Pulsed Xenon Light Source

QE65000 Spectrometer

CUV-ALL 4-Way Cuvette Holder

Quantum Efficiency to 90%

The Hamamatsu FFT-CCD detector used in the QE65000 achieves up to 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). Most of our other detectors are linear CCDs, but with this "2D" area detector we can bin a vertical row of 64 pixels that offers significant improvement in the signal-to-noise ratio (1200:1) and signal processing speed of the detector compared with a linear CCD, where signals are digitally added by an external circuit.

Increased System Sensitivity

QE65000 system sensitivity is improved because the 2D detector allows us to take advantage of the height of the entrance slit. In our spectrometers, you regulate the light entering the bench according to the slit's width. Most of our other spectrometers use linear detectors; in those spectrometers, slit height doesn't matter because linear detectors cannot efficiently collect the light from the entire height of the slit. But with the 2D detector in the QE65000, we can better take advantage of this additional light, extremely useful in low-light fluorescence applications.

QE65000:	$9,999
PX-2:	$769
CUV-ALL:	$809
STAN-FL-RED:	$179

Fluorescence Spectrometers

USB4000-FL

Preconfigured Spectrometers for Use with Sensors

Our high-sensitivity, preconfigured fluorescence spectrometers -- the USB4000-FL, USB4000-FL-450 and USB4000-FL-395 -- were conceived for use with fluorescence-based sensors. Each unit is set to 360-1000 nm and comes with a 200-µm entrance aperture and an L4 Detector Collection Lens for increased light throughput for fluorescence applications.

USB4000-FL: Excitation Source not Included

The USB4000-FL does not include an excitation source; this allows you the flexibility of choosing from several compact, low-cost, modular excitation sources available, such as one of our LEDs (pages 130-131). The excitation sources produce pulsed or continuous output and couple easily to our spectrometers, optical fibers and accessories.

USB4000-FL-450

USB4000-FL-450 & USB4000-FL-395: Excitation Source Included

The USB4000-FL-450 and USB4000-FL-395 Spectrofluorometers are spectrometers configured the same as the USB4000-FL, but each comes with a direct-attach excitation source. The USB4000-FL-450 comes with a 470 nm LED and the USB4000-FL-395 comes with a 395 nm LED Excitation source. (When using these Spectrofluorometers with one of our sensor probes, we recommend the USB4000-FL-450 with FOXY and HIOXY sensing formulations and the USB4000-FL-450 with the FOSPOR sensing formulation. See pages 65-68 for details.) The spectrometer provides power to the LED and enables synchronization functions and I^2C communications. In addition, these sources connect to temperature sensors and contain onboard memory that can be programmed to store temperature and oxygen calibration coefficients.

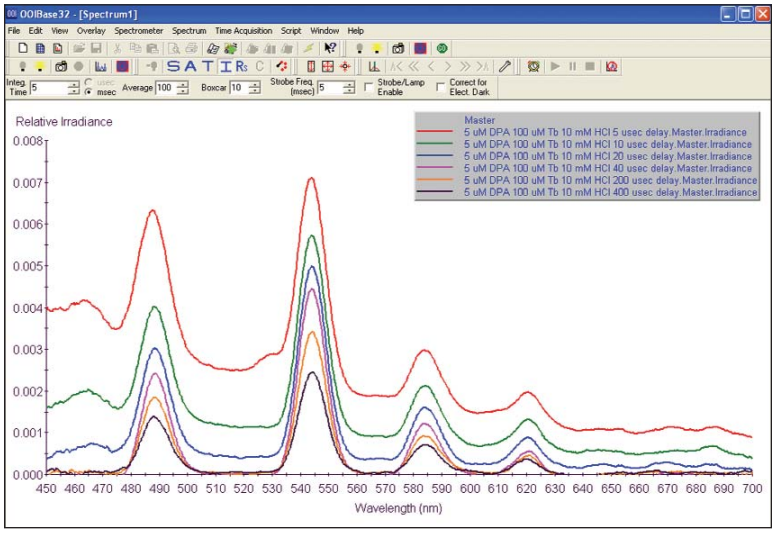
USB4000-FL: $2,499
USB4000-FL-450: $3,049
USB4000-FL-395: $3,049

Specifications

	USB4000-FL	USB4000-FL450	USB4000-FL395
PHYSICAL			
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 120.3 mm x 34.4 mm	89.1 mm x 120.3 mm x 34.4 mm
Weight:	190 grams	310 grams	310 grams
DETECTOR			
Detector:	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)
OPTICAL BENCH			
Design:	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output	42 mm input; 68 mm output	42 mm input; 68 mm output
Entrance aperture:	200 µm wide slit	200 µm wide slit	200 µm wide slit
Grating:	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber
SPECTROSCOPIC			
Wavelength range:	360-1100 nm	360-1100 nm	360-1100 nm
Optical resolution:	~10.0 nm FWHM	~10.0 nm FWHM	~10.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)	300:1 (at full signal)	300:1 (at full signal)
A/D resolution:	16 bit	16 bit	16 bit
Dark noise:	50 RMS counts	50 RMS counts	50 RMS counts
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm	<0.05% at 600 nm; <0.10% at 435 nm	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99.8%	>99.8%	>99.8%
ELECTRONICS			
Power consumption:	250 mA @ 5 VDC	250 mA @ 5 VDC and 60 mA @ 5 VDC	250 mA @ 5 VDC and 60 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	Yes, 8 digital user-programmable GPIOs	Yes, 8 digital user-programmable GPIOs	Yes, 8 digital user-programmable GPIOs
COMPUTER			
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)
LIGHT SOURCE			
Stability:	n/a	±1.0% drift after 2-minute warm-up period	±1.0% drift after 2-minute warm-up period
Wavelength range:	n/a	460-490 nm	380-410 nm
Power consumption:	n/a	60 mA @ 5 VDC	60 mA @ 5 VDC
Power output:	n/a	60 µW (minimum) into a 600 µm optical fiber	60 µW (minimum) into a 600 µm optical fiber

Gated Spectrometer for Fluorescence

In addition to the USB2000-FLG, a common fluorescence setup may include products like those shown above: the PX-2 Pulsed Xenon Source, the CUV-ALL-UV Cuvette Holder, LVF Linear Variable Filters, and optical fibers.



Terbium-dipicolinic acid (Tb-DPA) photoluminescence spectra acquired with the USB4000-FLG while in the Gated Mode, with the data acquisition delay set at a range of values. Analysis of samples with long emission lifetimes such as Tb-DPA improves when data acquisition is delayed until the energy from the lamp pulse is no longer observed in the spectrum, resulting in a cleaner, more resolved Tb-DPA spectrum -- achieved without using optical filters. At delay times below 40 microseconds, lingering excitation energy and background fluorescence overlap the Tb-DPA photoluminescence spectrum.

Specifications	
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g
Power consumption:	90 mA @ 5 VDC
Wavelength range:	380-1050 nm
Detector:	2048-element linear silicon CCD array
Grating:	Grating #3 -- 600 lines per millimeter, blazed at 500 nm
Entrance aperture:	200 µm wide slit
Optical resolution:	~10.0 nm FWHM
Stray light:	~0.05% at 600 nm, <0.10% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Integration time:	Gated mode - 5 milliseconds, normal mode - 3 milliseconds to 60 seconds
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux operating systems when using the USB port; any 32-bit Windows OS when using the serial port

Ultimate Fluorescence Spectrometer

The USB2000-FLG Spectrofluorometer is a preconfigured spectrometer for fluorescence applications from 380-1050 nm. We utilize a proprietary thin film technology and a time-gated spectrometer to provide a spectro-fluorometer that is 20 percent more sensitive than the standard USB4000 Spectrometer.

Avoiding Scattered Light

In addition to detecting fluorescence from a sample, a spectrofluorometer will also detect scattered excitation light from the light source and the sampling compartment. (Scattering is especially prevalent in turbid samples.) The USB2000-FLG uses two features to avoid detecting scattered light: special mirrors in the optical bench to absorb ultraviolet light and improve sensitivity and -- for fluorophores with long fluorescence lifetimes -- a time-gated mode that delays the start of spectral data acquisition by 5-500 microseconds after the excitation source is turned on (or pulses).

Gated Fluorescence Mode

The USB2000-FLG is preloaded with variable-delay gating microcode, which allows you to select a delay (from 5-500 microseconds) in our software between the light turning on and the start of the spectrometer's integration time, when the detector "sees" the sample. In this Gated Mode, the spectrometer only detects the sample light when the source is off. In order to use the Gated Mode, your fluorophore must have a long fluorescence lifetime. Those working with lanthanides and photoluminescent materials will find this mode very useful. The best excitation source to use with the Gated Mode is our PX-2 Pulsed Xenon Source.

SAG+ High-reflectivity Mirrors

In the USB2000-FLG, we replaced our standard mirrors with proprietary Ag-coated mirrors to increase reflectance, which increases the sensitivity of the spectrometer by more than 20 percent. They also absorb nearly all ultraviolet light, virtually eliminating the excitation source's spectra from interfering with the sample spectra.

Application Flexibility

The USB2000-FLG can detect fluorophores in solutions and powders, and from surfaces. The USB2000-FLG has been used to measure fluorescence in coral, fruit and other flora and fauna.

USB2000-FLG: $2,999

LIBS2500 Spectrometer & Accessories

Above is a LIBS2500-7 Spectrometer System with a LIBS-BUN-7 Fiber Bundle. This seven channel spectrometer system provides elemental analysis from 200-980 nm. A LIBS2500 system requires a laser to ablate the sample (see page 49) and a sampling system, such as our LIBS-SC Sample Chamber, to collect the emitted light.

Specifications*	
Dimensions:	33.4 cm X 15 cm x 14 cm maximum (spectrometer system)
Weight:	6.4 kg (spectrometer system only)
Power consumption:	1 A @ 5 VDC (spectrometer system only)
Detector:	(7) 2048-element linear silicon CCD arrays
Wavelength range:	Channel dependent
Optical resolution:	~0.1 nm (FWHM)
Frame rate:	10 Hz capability (PC-controlled)
Integration time:	2.1 ms; variable in free-run mode
Trigger delay:	-121 µs to +135 µs in 500 ns steps (PC-controlled)
Trigger jitter:	± 250 nanoseconds (± 20 nanoseconds optional)
Trigger level:	TTL not to exceed 5.5 volts

** For seven-channel LIBS2500-7 system.*

Instant Elemental Analysis from 200-980 nm

We offer a full range of systems and components for laser-induced breakdown spectroscopy, a noninvasive technique for real-time, qualitative and semi-quantitative spectral analysis of elements in solids, solutions and gases. The LIBS2500-7 is a broadband (200-980 nm), high-resolution detection system with optical resolution of ~0.1 nm (FWHM). Sensitivity to parts-per-billion and picogram levels is possible.

How the LIBS Systems Work

A high-intensity, pulsed laser beam is focused on the sample area. A single 10 nanosecond-wide laser pulse ablates the sample and generates plasma. As the plasma decays or cools, excited atoms in the plasma emit light at wavelengths distinct to each element. The emission is collected by a probe and sent to the spectrometer system. The system provides full spectral analysis in less than a second. OOILIBS Operating Software includes a library of elemental emission lines and enables automatic identification of all elements present in the sample.

High-resolution Spectrometers

Our LIBS2500-7 Spectrometer System uses seven linear CCD-array detectors for broadband 200-980 nm analysis. All spectrometers are triggered to acquire and read out data simultaneously. The detection system can be portable and is interfaced to a PC via a USB port. As lower-cost options, LIBS2500 Systems are available with fewer than seven channels (see table below), with a narrower wavelength range for element-specific analyses. Depending on the range of your analyses, you may require a system with less than seven channels at a significantly lower cost.

LIBS2500 Uses in Diverse Applications

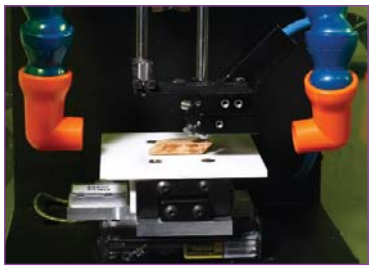
- Environmental: soil, particulates, sediments
- Materials Analysis: metals, slag, plastics, glass
- Forensics & Biomedical: teeth, bones
- Metrology: silicone wafers, semiconductor materials
- Bioresearch: plants, grains
- Safety & Military: explosives, chemical and biological warfare agents
- Art Restoration & Conservation: pigments, paints
- Gemology & Metallurgy: precious metals, gems

Item	LIBS System Description	Price of LIBS System	Optical Fiber Bundle Required	Price of Fiber Bundle
LIBS2500-7	7 channel LIBS System, includes all channels (A-G) below	$29,999	LIBS-BUN-7	$985
LIBS2500-6	6 channel LIBS System, choose 6 channels from A through G	$25,740	LIBS-BUN-6	$885
LIBS2500-5	5 channel LIBS System, choose 5 channels from A through G	$21,450	LIBS-BUN-5	$785
LIBS2500-4	4 channel LIBS System, choose 4 channels from A through G	$17,160	LIBS-BUN-4	$685
LIBS2500-3	3 channel LIBS System, choose 3 channels from A through G	$12,870	LIBS-BUN-3	$485
LIBS2500-2	2 channel LIBS System, choose 2 channels from A through G	$8,580	BIF600-2-UV/VIS	$385
LIBS2500-1	1 channel LIBS System, choose 1 channel from A through G	$4,290	P600-2-UV/VIS	$205
OOILIBS	LIBS System Software (includes elemental emission lines library)	$500	n/a	n/a
LIBS2500 Spectrometer Channels				
LIBS-CH-A	Spectrometer channel with 200-305 nm wavelength range			
LIBS-CH-B	Spectrometer channel with 295-400 nm wavelength range			
LIBS-CH-C	Spectrometer channel with 390-525 nm wavelength range			
LIBS-CH-D	Spectrometer channel with 520-635 nm wavelength range			
LIBS-CH-E	Spectrometer channel with 625-735 nm wavelength range			
LIBS-CH-F	Spectrometer channel with 725-820 nm wavelength range			
LIBS-CH-G	Spectrometer channel with 800-980 nm wavelength range			

Ordering a LIBS2500 System is easy. Components are offered to give you maximum flexibility so that you order only what you need. Select the Spectrometer Channels (LIBS-CH-X) for your LIBS2500 System depending on the wavelength ranges needed for your application. Channels (A, B, C, etc.) do not have to be consecutive. You will also need to specify the fiber bundle that corresponds to the number of channels being ordered. For additional accessories, see the following page.

Additional LIBS Components

LIBS Sample Chamber



The LIBS-SC includes an evacuation system that removes material from the sample area. You also can feed gases such as argon into the chamber. Flooding the chamber with an inert gas provides greater sensitivity for many elements.

The LIBS-SC Sample Chamber is a key component of a LIBS system and is designed to perform various functions safely and in clear view of the sample. The LIBS-SC has an eyewear-safe enclosure. The chamber has a safety-interlock so the laser will not fire when the door is open. It houses a manually controlled x-y-z stage and provides illumination for the optional LIBS-IM-USB Imaging Module. The LIBS-SC has an inert gas induction port and a suction nozzle to remove particulates. In addition, you have the ability to focus the laser to a 40 µm spot size. The sample chamber is designed for use with the Big Sky Lasers we resell (see below for laser details). If you wish to use the LIBS-SC with a different laser, please contact Ocean Optics.

LIBS-SC: $9,800

Specifications	
Stages:	Manual x-y-z stage
Sample size:	6.5 cm x 6.5 cm x 4 cm max.
Laser safety shield:	OD 6 for 1.064 mm laser energy (call for other wavelengths)
Internal optics:	25 mm diameter focusing lens, 75 mm focal length supplied
Ablation spot size:	approximately 40 µm

LIBS Imaging Module for Pinpoint Analysis

This image is the "O" in the text "Quarter Dollar" on a U.S. coin.

The LIBS-IM-USB Imaging Module directly attaches to the LIBS-SC Sample Chamber to enable users to magnify a sample image and to establish a laser ablation target on the sample. The camera is also useful when you want to adjust the laser focus at the surface of the sample, or above or below the sample surface. When used with the LIBS-SC and laser, the LIBS-IM-USB and laser are in the same focal plane enabling precise, rapid and convenient laser focus. The USB-enabled color camera captures pre- and post-ablation images of the sample and provides up to 1280 x 1024 pixel resolution.

LIBS-IM-USB: $8,000

Specifications	
Interface:	USB 2.0 (480 Mb/sec)
Power:	USB 5 VDC, max. 180 mA
Frame size:	1280 x 1024, 640 x 480, 320 x 240, 160 x 120
Data output:	RGB 24 bit
Requirements:	-- Windows XP Professional SP1 -- Support of Direct X -- Driver compatible Windows driver model (WDM) -- SDK iREZ WDM library -- 3.2 GHz or higher processor -- 1 GB recommended memory -- 10 GB free hard disk space -- Rocket-fast GeForce 4200Ti or better video card recommended

LIBS Laser Options

We offer two LIBS25000 laser power options from industry leader Big Sky Laser Technologies. Laser ablation and plasma formation are very specific to the sample matrix, and therefore the power requirements will vary by sample type. For most applications we employ a Q-switched 1064 nm Nd:YAG laser, and for maximum versatility, we recommend a 200 mJ laser with attenuator to adjust the laser power according to the sample matrix. The choice of laser power and wavelength depend on the material being analyzed and the sample's tolerable damage threshold. The LIBS-LASER is a 50 mJ CFR Nd:YAG laser for metal and thin film samples. The LIBS-LAS200MJ is a 200 mJ CFR Nd:YAG laser for most all other materials.

LIBS-LASER: $14,500
LIBS-LAS200MJ: $22,500

LIBS Versus Other Technologies

Parameter	LIBS	SEM/EDS	XRF	LA-ICP-MS	EPMA
Sample depth:	~50-100 µm	~5 µm	~100 µm	~80 µm	<1 µm
Sensitivity:	10-50 ppm	1000 ppm	100 ppm	<1 ppm	100 ppm
Precision:	Fair-good	Poor	Fair-good	Excellent	Fair
Accuracy:	Semi-quantitative	Qualitative	Semi-quantitative	Quantitative	Semi-quantitative
Analysis time:	Fast	Slow	Very slow	Slow	Slow
Sample consump:	almost non-destructive	non-destructive	non-destructive	almost non-destructive	non-destructive
Complexity:	Easy to use	Easy to use	Easy to use	Complicated	Complicated
Discrimination:	Good	Poor	Good	Excellent	Fair
Cost:	$60,000	$120,000	$120,000	$250,000	$600,000

LIBS-ELITE Laser Ablation System

Highly Refined Sampling System for LIBS

Laser-induced Breakdown Spectroscopy is a noninvasive technique for real-time, qualitative and semi-quantitative spectral analysis of elements in solids, solutions and gases. The LIBS-ELITE, developed by New Wave Research and Ocean Optics, is a high-quality LIBS sampling system with unparalleled sample imaging and control. The LIBS-ELITE consists of a laser head, sample chamber, software-controlled X-Y positioner and a high-resolution imaging system in a single housing. New Wave Research developed the LIBS-ELITE to work with the LIBS2500 System (page 48).

200 mJ Nd:YAG Laser

The LIBS-ELITE-200 comes with New Wave Research's Tempest 200 mJ Nd:YAG laser. The Tempest delivers high-energy densities to the sample to create plasma from even the most challenging materials. The accuracy and precision of the system results from the 98% pulse-to-pulse stability of the Tempest. A laser power meter located adjacent to the sample and a software-controlled attenuator are standard features that help enable quantitative sample analysis. Another laser option is available; the LIBS-ELITE-90 comes with a 90 mJ laser.

Sample Chamber: Unprecedented Control

The open architecture of the sample chamber allows the sample and ablation plume to be viewed easily through its Class 1 shield. The sample chamber includes a quick-loading sample drawer, and can accommodate samples up to two inches in diameter. A gas port on the rear of the housing enables the chamber to be purged with argon, which is useful for increasing sampling sensitivity, or with nitrogen or helium, which is useful when measuring emissions of elements such as oxygen that are found in ambient environments. An integrated rotometer regulates the gas flow in the chamber.

Exact Positioning & High-resolution Imaging

The ELITE's software-controlled X-Y stage allows you to precisely control the target location, to create reproducible maps, and to automate sample mapping, patterning and rastering for testing sample homogeneity or for bulk analysis. The spot size controller sets the ablation spot size from 20 µm to 1200 µm. The LIBS-ELITE's high-resolution sample magnification capability (see software screen capture at right) allows you to view an exact spot before and after the ablation event.

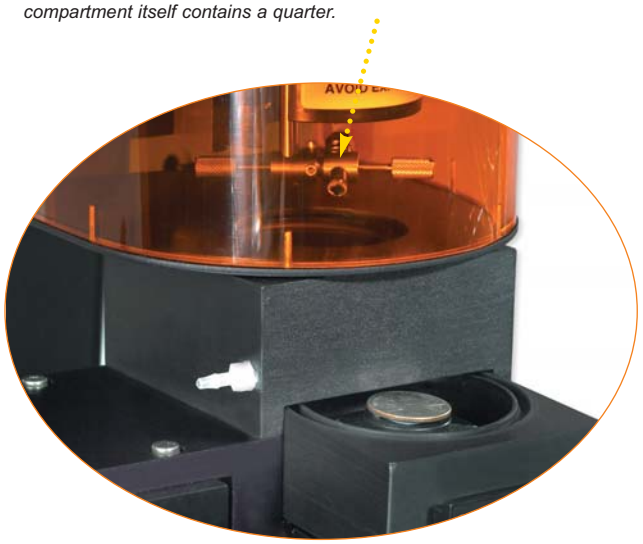
Software with Spectral Library

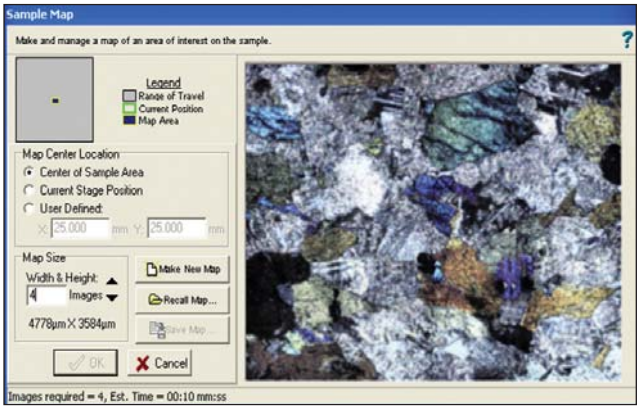
The LIBS-ELITE comes with intuitive operating software and a library of elemental emission lines, which enables automatic identification of all elements present in a sample. The software includes controls for ablation mode, laser repetition rate, laser power, sample spot size selection, X-Y positioning, sample viewing, sample mapping, gas routing, spectrometer system triggering and automating sampling processes.

Sold Exclusively by New Wave Research

For pricing on the LIBS-ELITE systems, contact New Wave Research at lasers@new-wave.com or 800-566-1743. Also, visit www.new-wave.com for more product information.

The LIBS-ELITE works with the Ocean Optics LIBS2500-7 Spectrometer System (see page 48) to provide full spectral analysis from 200-980 nm, with optical resolution of 0.1 nm and sensitivity to parts-per-billion. Below is a magnification of the sampling area where the ablation plume is produced behind an orange Class 1 shield. The sample compartment itself contains a quarter.





View an exact spot of the sample before, during and after the ablation process. The LIBS-ELITE provides real-time, high-resolution qualitative analysis of trace elements in diverse materials such as metals, biological tissues, soils, optics, semiconductors, gems and other geological, biological and environmental specimens.

Raman Selection Guide

Raman System Selection Guide

Raman spectroscopy is quickly becoming one of the preferred chemical identification techniques in many application areas. Raman is advantageous because it is:

- Non-invasive: Sample through glass and plastic
- Non-destructive: Sample can be reused
- Fast: Typical measurement times 5-30 seconds

Raman spectroscopy provides rapid and reliable non-destructive chemical analysis of aqueous solutions, powders, tablets, gels and surfaces. A basic setup consists of a monochromatic source, typically a laser, which interacts with the sample. The scattered radiation is then collected by a spectrometer. We offer several options for using Raman as a measurement tool:

QE65000 Modular Raman System, pages 52-53

The QE65000 Scientific-grade Spectrometer was designed for low-light level applications such as Raman spectroscopy. You have several grating and entrance aperture sizes from which to choose to optimize a system for your specific application. In addition, we have lasers and Raman probes to complete your own modular Raman setup.

Turnkey Raman Systems, page 54

We offer several Raman turnkey sensing systems from our partner, Raman Systems, Inc. Their high-performance systems are designed specifically for quick material identification and verification in almost any setting. The RSL-Plus is for field deployment and fast incident response, while the R-3000 is a self contained semi-portable system for lab or field use.

MMS-Raman, page 55

Centice Corporation offers their Multimodal Multiplex Spectroscopy Raman System to provide high performance chemical analysis for a fraction of the cost of research-grade systems. Due to its high sensitivity and great resolution, the MMS-Raman is an ideal system for substance verification and accurate concentration analysis, as well as for analysis of very low-concentration samples.

Raman System Selection Guide

Specification	QE65000	R-3000	R-3000-HR & R-3000 QE	RSL-Plus	MMS-RAMAN
Optical resolution	6-18 cm^{-1}; Grating and slit dependent	10 cm^{-1}	6 cm^{-1}; 8 cm^{-1}	12 cm^{-1}	4 cm^{-1}
Excitation wavelength	785 nm or 532 nm	785 nm or 532 nm	785 nm or 532 nm	785 nm	785 nm
Spectral range	Several options from 150 cm^{-1} to 7500 cm^{-1}; Grating & laser dependent	200-2700 cm^{-1} (785 nm); 200-4000 cm^{-1} (532 nm)	200-2700 cm^{-1} (785 nm); 200-4000 cm^{-1} (532 nm)	200-2700 cm^{-1} (785 nm)	220-2000 cm^{-1}
Detector	Hamamatsu	Sony/Toshiba/ Hamamatsu	Sony/Toshiba/ Hamamatsu	Sony/Toshiba/ Hamamatsu	Hamamatsu
Detector type	Back Thinned	Linear CCD/ Back Thinned	Linear CCD/ Back Thinned	Linear CCD/ Back Thinned	Back Thinned
Pixels	1044 x 64	2048 or 1024 x 58	2048 or 1024 x 58	2048 or 1024 x 58	512 x 122

Raman Application Areas

Raman spectroscopy is useful for analyzing molecules without a permanent dipole moment, which does not show up on an IR spectrum. Raman spectroscopy is used to determine bond lengths in non-polar molecules. It is useful for determining the identity of organic and inorganic species in solution, as the Raman transitions for these species are more characteristic than for IR, where the transitions are much more affected by the other species present in the solution. Raman can be used to analyze solid, liquid and gaseous sample components even through glass and plastic containers.

- Art: Pigments, inks, substrates, resins
- Biology: in vivo studies, surface studies, SERS
- Catalysts: NO decomposition, kinetics of hydrogenation reactions
- Corrosion: corrosion kinetic studies, bronze, aluminum
- Forensics: drugs, explosives, pigments, powders, tablets, gels and surfaces, chemicals
- Materials: diamond films, semiconductors, nanotubes, asbestos, materials ID
- Pharmaceuticals: in situ crystal growth monitoring, kinetics, active ingredients, polymorphs differentiation
- Polymers: polymerization monitoring, plasticizer studies, density mapping of films
- Process: online monitoring, quality control, research
- Other: gemology, geology, chemical and petrochemical processes, water-quality analysis

Modular Raman Measurement Tools

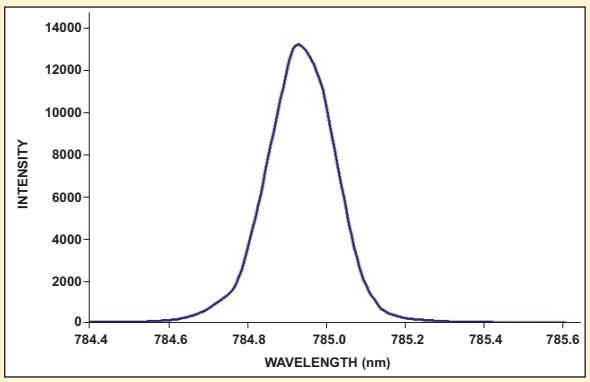
785 nm Excitation Laser for Raman

The LASER-785 is a 500-milliwatt, continuous-wave laser specifically developed for Raman spectroscopy. The high-power excitation source has an integrated laser driver, a thermoelectric cooler, a TEC controller and a TTL modulation port for controlling the input up to 100 kHz. The LASER-785 has a narrow spectral line width of only 0.2 nm (see spectrum below). Its compact and rugged design and its hermetically sealed laser component make it optimal for various industrial and medical applications.

LASER-785: $6,499

Specifications			
Dimensions:	110 mm x 89 mm x 53 mm	Laser life:	10,000 hours
Weight:	600 grams	Power consumption:	3.0 A @ 5 VDC
Noise:	<0.5% RMS	Power output (CW):	>500 mW
Output fiber:	100 µm @ 0.22 NA	Peak wavelengths:	785 +/- 0.3 nm
Warm-up:	15 minutes	Spectral line width:	0.2 nm (typical)
Temperature:	-10 °C to 40 °C	Rise time:	<500 msec
Stability:	<3% peak-to-peak in 8 hours	Control:	TTL modulation -- 0 to 100 kHz
Humidity:	5-95% non-condensing	Connector:	SMA 905

HR4000 Spectrum of LASER-785



Fiber Optic Probes for Raman Applications

We offer several fiber optic probes for Raman spectroscopy from our corporate partner InPhotonics. Each probe provides complete optical filtering of the Rayleigh line and high signal collection in a compact, rugged probe design. Several probe models are available for laboratory, industrial and environmental applications.

The probes listed below are available for several excitation wavelengths. Please contact Ocean Optics for details.

RPB Laboratory Probe

Item	Description	Probe Size (in mm)	Fiber Length	Price
RIP-RPB	Laboratory probe for use with lasers up to 3 nm from specified operating wavelength; has 7.5-mm focal length	114 x 38 x 12.7	1.5 meter	$2,750
RIP-RPS	Stainless-steel focused probe for lab and field use; has 5-mm focal length (7.5 mm or 10 mm also available)	12.7 OD x 101 length	5 meters	$4,950
RIP-RP2	Stainless-steel immersion probe is immersible up to 200 °C and has adjustable working distance	15.87 OD x 203 length	5 meters	$6,745
RIP-RPR-H	Hastelloy C immersion probe with gold gasket for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance	15.87 OD x 330 length	5 meters	$9,200
RIP-RPR-S	Stainless-steel immersion probe with elastomeric O-ring seal for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance	15.87 OD x 330 length	5 meters	$8,200
RIP-RPP	Stainless-steel probe with external optics for process control applications up to 500 °C and 3000 psi; comes with sapphire lens and has short working distance	9.52 OD x 300 length	5 meters	$10,200
RIP-PA-SH	Sample holder, with inserts for round vials, square cuvettes, and cups	not applicable	not applicable	$850

Modular Raman Measurement Tools

QE65000 Scientific-grade Spectrometer for Raman

New Scientific-grade Spectrometer

The QE65000 Spectrometer is a unique combination of detector and optical bench technologies that provides users with high spectral response and high optical resolution in one package.

Demanding Low Light-level Applications

The QE65000 was designed for low-light level applications such as Raman spectroscopy. The detector is TE-cooled, resulting in virtually no dark noise, which allows you to set the integration time of the spectrometer (analogous to a camera's shutter speed) at up to 15 minutes with little spectral distortion.

Quantum Efficiency to 90%

With its scientific-grade detector, the QE65000 achieves up to 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). With this "2D" detector in the QE65000, we bin a vertical row of 64 pixels, which increases the signal-to-noise ratio to 1200:1. (See page 26 for detailed QE65000 specifications.)

Increased System Sensitivity

QE65000 system sensitivity is improved because the 2D detector allows us to take advantage of the height of the entrance slit. In our spectrometers, you regulate the light entering the bench according to the slit's width. Most of our other spectrometers use linear detectors; in those spectrometers, slit height doesn't matter because linear detectors cannot efficiently collect the light from the entire height of the slit. But with the 2D detector in the QE65000, we can better take advantage of this additional light.

NIST-traceable Raman Standards

The STAN-RAM785 and STAN-RAM532 are NIST-certified standards for determining the absolute spectral intensity of your Raman system. They consist of an optical glass that emits a broadband luminescence spectrum when excited with a laser. (Select the STAN-RAM785 when using a 785 nm laser as your excitation source; select the STAN-RAM532 when using a 532 nm laser.) The shape of this luminescence spectrum is expressed by a polynomial equation that relates the relative spectral intensity to the wavenumber from the excitation wavelength. Determining the absolute spectral intensity of your Raman system is essential for those performing peak-to-peak height analysis and those collecting a spectral library.

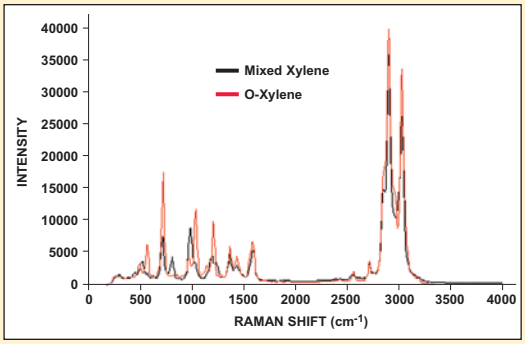
QE65000:	$9,999
STAN-RAM532:	$1,015
STAN-RAM785:	$1,015

Examples of QE65000 Configurations for Raman

Sample Config.	Spectral Range	Excitation Source	Grating p. 28	Slit p. 27	Resolution (approx.)
1	150-4000 cm^{-1}	532 nm laser	H6	10 µm	~8 cm^{-1}
2	150-4000 cm^{-1}	532 nm laser	H6	25 µm	~10 cm^{-1}
3	150-7500 cm^{-1}	532 nm laser	H14	10 µm	~16 cm^{-1}
4	150-7500 cm^{-1}	532 nm laser	H14	25 µm	~19 cm^{-1}
5	150-2100 cm^{-1}	785 nm laser	H6	50 µm	~6 cm^{-1}
6	150-2100 cm^{-1}	785 nm laser	H6	100 µm	~8 cm^{-1}
7	150-3950 cm^{-1}	785 nm laser	H14	50 µm	~13 cm^{-1}
8	150-3950 cm^{-1}	785 nm laser	H14	100 µm	~18 cm^{-1}

Above, the QE65000 is configured for use with a LASER-785 and an RIP-RPB probe (see facing page for details). At left is the STAN-RAM785 for determining the absolute spectral intensity of your Raman system.

Comparing Xylenes Using Raman

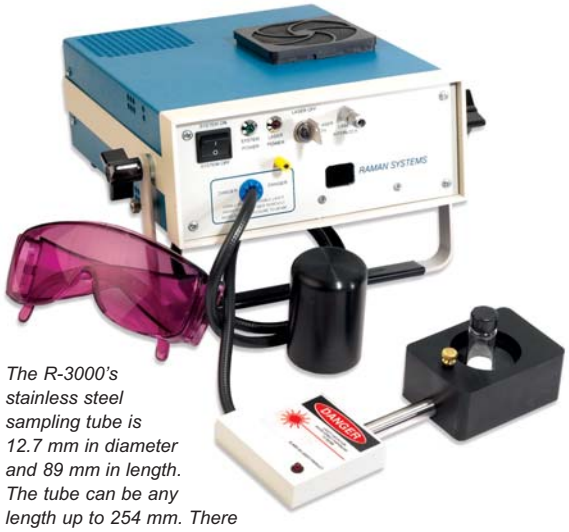


We used the QE65000 Sample Configuration #3 (described in the table at lower left), and an InPhotonics probe to acquire Raman spectra of xylene samples.

Specifications

Dimensions:	182 mm x 110 mm x 47 mm; 1.05 kg
Detector:	Hamamatsu back-thinned CCD (page 28)
Pixels:	1024 x 58 (1044 x 64 total pixels)
Signal-to-noise ratio:	1000:1 (at full signal)
Dark noise:	2.5 RMS counts
Optical bench design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits (page 27)
Gratings:	14 gratings UV through Shortwave NIR (page 28)
Integration time:	8 milliseconds to 15 minutes
Dynamic range:	7.5 x 10^9 (system); 25000:1 for one acquisition
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber
Power consumption:	3 A @ 5 VDC with TE cooling
Data transfer speed	Full spectrum to memory every 8 ms with USB 2.0
Inputs/Outputs	10 onboard digital user-programmable GPIOs
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port
Temperature limits:	0 °C to 50 °C
Temperature range:	13 °C maximum range between high and low
Set point:	Software controlled
Lowest set point:	40 °C below ambient, to -15 °C
Stability:	±0.1 °C of set temperature in <2 minutes

Raman Measurement Systems



The R-3000's stainless steel sampling tube is 12.7 mm in diameter and 89 mm in length. The tube can be any length up to 254 mm. There are two focusing caps: one for direct contact with a sample; the other for use with a sample container.

Specifications	
Lasers:	Solid-state 785 nm or 532 nm diode
Raman shift range:	~200-2700 cm^{-1}
Resolution:	~10 cm^{-1} to ~6 cm^{-1}
Detector:	Linear CCD array; option of cooled detector
Stability:	1 cm^{-1} wavelength, 4% output stability
Power output:	125 mW and 250 mW; software-controlled
Sampling via:	Fiber optic probe for solutions, solids, gels
Remote sampling:	Up to 200 meters using optical fibers
PC interface:	USB
Data storage:	SPC or ASCII format
Calibration:	One-touch calibration
Laser safety:	Class 3b laser requires use of safety eyewear
Tolerances:	Up to 1500 psi and up to 200 ºC for tube and caps
Temperature limit:	Up to 80 ºC for probe head and fiber

Great Resolution & Stability in a Versatile Package

Raman Systems' R-3000-series of Raman instruments are fully integrated analyzers for real-time qualitative and quantitative analysis of solutions, powders, tablets, gels and surface media from ~200-2700 cm^{-1}. The systems include high-performance lasers that provide excellent resolution and achieve better than 1 cm^{-1} wavelength stability and 4% output stability. The R-3000s are used in pharmaceutical monitoring, petrochemical process control, drug and explosives detection, and water-quality analysis.

Fully Integrated System with New Software

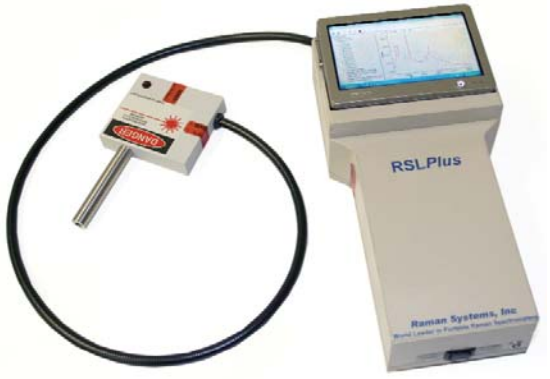
The R-3000 systems come with a 785 nm or 532 nm solid-state diode laser; a software-controlled laser shutter; a fiber optic spectrometer with optional TE cooling; a multi-purpose fiber optic probe for solutions, solids and powders; focusing and calibration caps; a sample holder; operating software; and safety goggles. In addition, the R-3000 systems have new software features that include fingerprinting and quantification capabilities, and a multiple-spectrum display function.

Versatile Sampling Optics Add Value

The sample tubes and probe "caps" that come with the R-3000 systems provide easy transferability between samples in transparent containers and in immersion applications. The probe head is coupled to the spectrometer and laser via two 1-meter fibers (200 μm and 100 μm in diameter).

R-3000-785: $14,950
R-3000-532: $18,300
R-3000-HR-532: $19,950
R-3000-QE-532: $23,450
R-3000-QE-785: $21,950

RSL-Plus Handheld Raman System



Specifications	
Dimensions:	305 mm x 52 mm x 76 mm
Weight:	1.72 kg
Raman shift range:	~200-2700 cm^{-1}
Resolution:	~12 cm^{-1}
Laser:	Solid-state 785 nm diode
Output power:	500 mW
Detection via:	Linear CCD-array detector spectrometer
Sampling via:	Shuttered probe for solutions, solids, gels, etc.
Remote sampling:	Up to 200 meters using optical fibers
Battery:	2-hour rechargeable battery
Computer:	Embedded PC with spectral-matching software
Calibration:	Self-calibration and automated validation
Compliance:	Compliant with 21CFR Part 11

Small Footprint

The RSL-Plus Handheld Raman Spectrometer is a 12" x 6" system for performing low-resolution Raman spectroscopy for on-site materials analysis. Although a high-resolution Raman spectrum provides detailed information about the vibrational fine structure of sample molecules, most routine applications need only ~15 cm^{-1} resolution for quantitative or qualitative analysis. As a result, a system such as the RSL-Plus can be assembled using less expensive optics and lasers -- without sacrificing the power of Raman analysis.

Compact Spectral Matching System

The RSL-Plus consists of an embedded computer with spectral matching software for quality control, verification and validation routines. The system includes a spectrometer, a 785 nm diode laser, a fiber optic probe, and a 2-hour rechargeable battery.

FDA Compliance

The operating software of the RSL-Plus is compliant with the Food and Drug Administration's 21CFR Part 11, and includes features such as audit logging, database creation, spectral matching, and automatic detection of data tampering.

RSL-PLUS: $25,000

MMS-Raman Spectrometer

Next-generation Raman Spectroscopy

We've teamed with Centice Corporation to offer next-generation Raman spectroscopy that combines the simplicity of dispersive instruments with the multiplex advantage of a transform spectrometer. The MMS-Raman Spectrometer uses Centice's patent-pending Multimodal Multiplex Spectroscopy to provide high-performance Raman analysis for a fraction of the cost of research-grade systems. The MMS-Raman Spectrometer offers a unique combination of resolving power, spectral range and flexibility, making it an ideal system for the routine analysis of many types of liquids and solids.

How Multimodal Multiplex Spectroscopy Works

Dispersive, fixed-grating spectrometer designs typically use a slit or a fiber as the input into the spectrometer. These apertures restrict the amount of light that can reach the detector. In these designs, there is an inherent tradeoff between resolution and light throughput. While spectral resolution increases as slit width decreases, a narrow input slit limits the light throughput and, likewise, measurement sensitivity. In the MMS-Raman Spectrometer, a wide-area coded aperture takes the place of a traditional slit entrance that allows 10-1000x greater light throughput -- and then applies precise algorithms to extract a high resolution spectrum from the collected light. There is much more light collected, without sacrificing resolution. Multimodal Multiplex Spectroscopy instruments are ideal for measuring weak, scattering and diffuse samples because the spectrometer can collect and process far more light through its wide-area aperture, without affecting spectral resolution.

Key Applications

Key applications include material inspection, identification of unknown materials, and quantitative analysis of both intermediates and final products in the chemical and pharmaceutical industries. Typical samples include powders, liquids and polymers. All experimental and parameter set-up options are computer-controlled for increased ease of use, reliability and speed.

Integrated Sample Holder

The MMS-Raman Spectrometer has a sample holder with cover for operation in full ambient light without affecting performance. The spectrometer's removable sample compartment is integrated into the optical path, avoiding inefficiencies associated with remote compartments. Sample positioning is rapid and precise using the external z-axis alignment control knob. The sample compartment is especially useful for measuring measure weak, scattering and diffuse sources with the highest possible sensitivity. The sample holder supports up to 10-mm cuvettes and test tubes.

MMS-Raman Delivers Great Sensitivity & Resolution

The MMS-Raman spectrometer samples up to 1,000 optical channels simultaneously through the large coded aperture. A mathematical transformation algorithm precisely reconstructs the spectrum with a 4x signal-to-noise improvement as compared with a slit-based system equipped with identical source, grating and detector components, and 70-80x greater than with a fiber input of equivalent resolution.

MMS-RAMAN: $19,995

Specifications	
SYSTEM	
Wavelength range:	220 cm^{-1} to 2000 cm^{-1}
Spectral resolution:	~4 cm^{-1}
Grating:	Transmissive
Stray light:	<0.1%
Integration time:	50 ms to 100 seconds
A/D resolution:	16-bit
APERTURE AND DETECTOR	
MMS aperture size:	0.58 mm x 2.3 mm
Detector array size:	512 x 122 pixels
Number of active pixels:	62,464
Pixel size:	24 µm x 24 µm
Well depth:	~300,000 electrons
Quantum efficiency:	85% at 250 nm
Dark noise:	300 e^-/pixel/sec @ 0° C
Readout noise:	2 RMS counts, 8 RMS electrons
Gain:	4.7
Detector temperature:	To -20 °C below ambient
LASER	
Excitation wavelength:	785 nm
Laser power:	70 mW at sample
SAMPLE CHAMBER	
Cuvettes:	Square, up to 10 mm
Test tubes:	Up to 17 mm
COMPUTER	
Interface:	USB 2.0
Operating systems:	Windows XP (with SP2)
RAM requirements:	12 MB

LED Measurement Tools

When coupled with the optimum sampling accessories, the USB4000 Spectrometer is a highly accurate spectroradiometer for measuring the color, relative power and absolute spectral intensity of LEDs.

Miniature Fiber Optic Spectrometer

A USB4000 Spectrometer optimized for LED measurements is configured with a 350-1000 nm wavelength range, a 25 µm entrance aperture and an L4 Collection Lens to increase light efficiency. With this configuration, optical resolution is ~1.33 nm (FWHM).

LED Power Supply: Secures, Powers & Drives LED

The LED-PS Power Supply provides three useful functions: securing the LED in place, powering the LED, and displaying the LED's drive current. Use the adjustable drive current feature to increase or decrease an LED's current up to 50 mA. We offer a standard LED-PS and a NIST-traceable version.

Integrating Sphere: 360° Energy Collection

The LED is powered by the LED-PS and is inserted into the 9.5-mm diameter port of the FOIS-1 Fiber Optic Integrating Sphere, which has a 360° field of view. The P400-2-VIS-NIR Optical Fiber collects the light from the FOIS-1 and funnels it to the USB4000 Spectrometer.

Light Source: Radiometric Reference Source

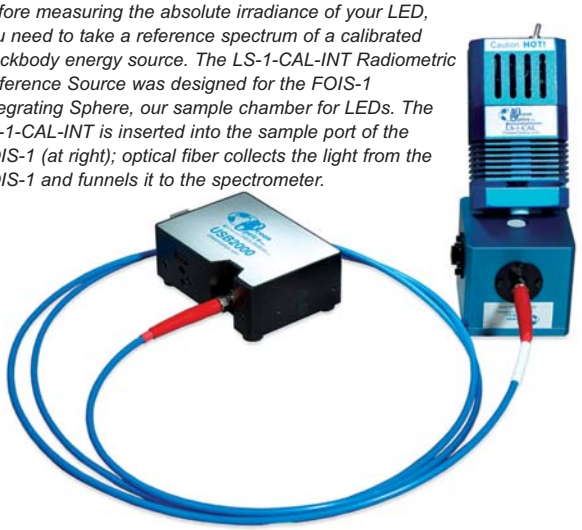
The LS-1-CAL-INT is a NIST-traceable light source designed specifically to calibrate the spectral response of a spectroradiometric system that uses the FOIS-1 as the sampling device. It provides known absolute intensity values at several wavelengths. The LS-1 is used as a reference for relative power measurements.

Spectral & Color Measurement

Our software provides absolute spectral intensities for LEDs, and calculates L*a*b*, XYZ, xyz, u'v'w', hue, RGB, chroma, saturation and more. See page 81 for details.

Spectrometer Specifications	
Detector:	Toshiba TCD1304AP linear CCD array (page 17)
Detector range:	200-1100 nm
Pixels:	3648 pixels, size of 8 µm x 200 µm
Sensitivity:	130 photons/count at 400 nm; 60 photons/count at 600 nm
Bench design:	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slit or fiber (page 15)
Grating options:	14 gratings, UV through Shortwave NIR (page 16)
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber
Wavelength range:	Grating dependent
Optical resolution:	~0.3-10.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Integration time:	3.8 milliseconds to 10 seconds
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Power consumption:	250 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 5 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	Yes, 8 onboard digital user-programmable GPIOs
Operating systems:	Windows 98/Me/2000/XP, Mac OSX and Linux with USB port; Any 32-bit Windows OS with serial port

Before measuring the absolute irradiance of your LED, you need to take a reference spectrum of a calibrated blackbody energy source. The LS-1-CAL-INT Radiometric Reference Source was designed for the FOIS-1 Integrating Sphere, our sample chamber for LEDs. The LS-1-CAL-INT is inserted into the sample port of the FOIS-1 (at right); optical fiber collects the light from the FOIS-1 and funnels it to the spectrometer.



After taking a reference and a dark spectrum, insert an LED into the LED-PS Power Supply, which holds and powers the LED, displays the LED drive current, and allows you to adjust the current. The LED-PS is placed over the FOIS-1, so that the LED is inserted into the sample port of the FOIS-1.

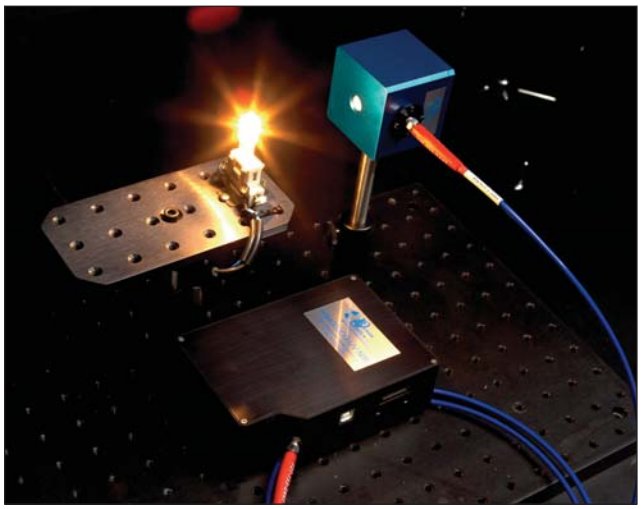
In this setup, the LED-PS is on top of the FOIS-1 Integrating Sphere. A P400-2-VIS-NIR Optical Fiber collects the light energy from the FOIS-1 and sends it to the spectrometer. Our software reports the absolute spectral intensities for the LED as well as color values, photopic data and more.

Item	Description	Page	Price
USB4000	Spectrometer ($2,199) with 25 µm slit ($150), L4 Lens ($150), and DET4-350-1000 with OFLV-350-1000 filter ($150)	14	$2,649
LS-1-CAL-INT	Radiometrically calibrated LS-1	133	$749
FOIS-1	Fiber Optic Integrating Sphere	105	$499
LED-PS-NIST	NIST-traceable LED power supply	104	$749
SpectraSuite	Software for Color and Irradiance	81	$199
P400-2-VIS-NIR	Optical fiber for connecting FOIS-1 to USB4000	144	$120
P200-2-VIS-NIR	Optical fiber for connecting LS-1-CAL-INT to USB4000	144	$100

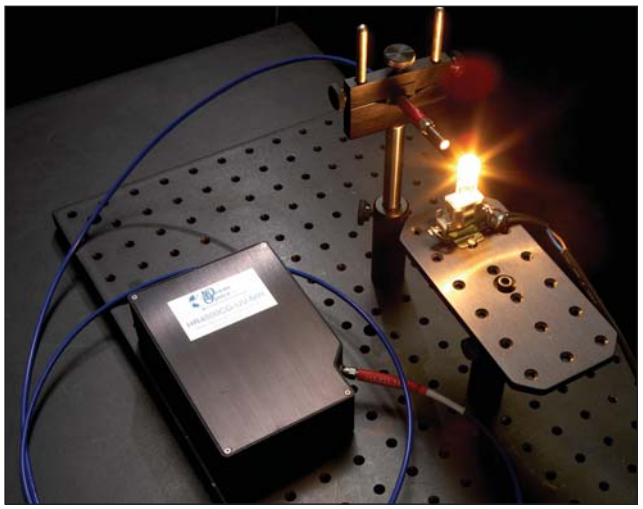
Spectroradiometric Tools

Spectrometer for Light Analysis

Our spectrometers and accessories can be configured easily into spectroradiometric systems for measuring the absolute or relative irradiance of radiant sources such as flat panel displays, CRTs, incandescent lamps and the sun. The HR2000+ and HR4000 Spectrometers are designed for laser analysis (pages 20-21), while the USB4000 (page 14) and the HR4000CG (page 35) are good general-purpose choices. Working with our Applications Scientists to select and configure the right spectrometer for your spectroradiometric system is the first step. Once the spectroradiometer is configured, it's time to select from several sampling options to complete your system.



The FOIS-1 Integrating Sphere collects light from 360° field of view.



The CC-3-UV (attached to a fiber) collects light from 180° field of view.

Fiber Optic Integrating Sphere

The FOIS-1 (at right) is used to collect light from a 360° field of view and funnel it to a spectrometer via an optical fiber for measuring the spectral properties of emission sources. Light enters the sphere via a 9.5-mm diameter port and an optical fiber -- oriented at 90° to the sample port -- collects the light. For details, see page 105.

FOIS-1: $499

The FOIS-1.

Cosine Correctors

Our Cosine Correctors collect radiation with a 180° field of view. When used in a fiber coupled to a spectrometer, they measure light intensity at the surface of the probe. See page 104 for more.

CC-3-DA: $299
CC-3-UV: $129

CC-3-DA (above left) directly attaches to a spectrometer while the CC-3-UV screws onto an optical fiber.

NIST-traceable Calibration Standards

Our NIST-traceable Calibration Standards provide you with known absolute intensity values at the sources' fiber optic sample ports. These sources are strictly for calibrating the absolute spectral response of your system before measuring the absolute irradiance of radiant sources. For all your options, see pages 132-133.

LS-1-CAL: $749
DH2000-CAL: $3,302

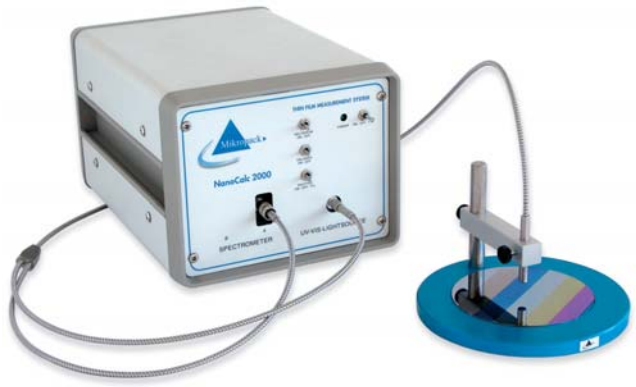
The LS-1-CAL.

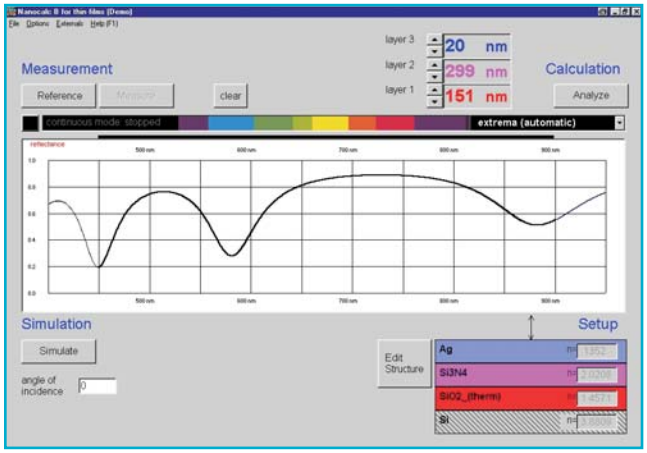
SpectraSuite Spectroscopy Operating Software

SpectraSuite Spectroscopy Operating Software is 32-bit acquisition and display software for performing a number of functions in measuring the absolute spectral intensity of emission sources. For more on the software, see pages 80-81.

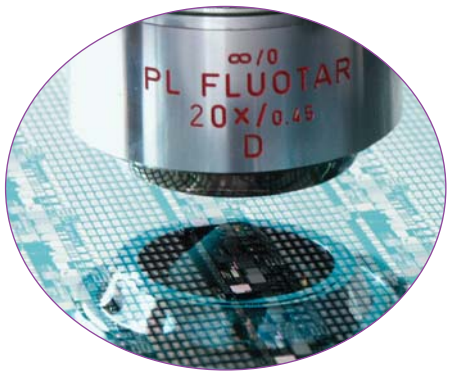
SpectraSuite: $199

NanoCalc Thin Film Analysis System





NanoCalc Software displays a sample interference spectrum, predicted spectra and up to four layers.



Analyze Layers from 10 nm in Thickness

The optical properties of thin films arise from reflection and interference. The NanoCalc Thin Film Reflectometry System allows you to analyze the thickness of optical layers from 10 nm to ~250 µm. You can observe a single thickness with a resolution of 0.1 nm. Depending on your software choice, you can analyze single-layer or multilayer films in less than one second and can measure the thickness and removal rates of semiconductor process films or anti-scratch coatings, hard coatings and anti-reflection coatings.

Theory of Operation

The two most common ways to measure thin film characteristics are spectral reflectance/transmission and ellipsometry. NanoCalc utilizes the reflectance method and measures the amount of light reflected from a thin film over a range of wavelengths, with the incident light normal to the sample surface.

Search by *n* and *k*

As many as four layers can be specified in a film stack. The various films and substrate materials can be metallic, dielectric, amorphous or crystalline semiconductors. The NanoCalc Software includes a large library of *n* and *k* values for the most common materials. You can edit and add to this library. Also, you can define material types by equation or dispersion formulas.

Applications

NanoCalc Thin Film Reflectometry Systems are ideal for in situ, on-line thickness measurements and removal rate applications, and can be used to measure the thickness of oxides, SiNx, photoresist and other semiconductor process films. NanoCalc Systems measure anti-reflection coatings, anti-scratch coatings and rough layers on substrates such as steel, aluminum, brass, copper, ceramics and plastics.

Item	Wavelength Range	Thickness	Light Source Included
NC-UV-VIS-NIR	250-1100 nm	10 nm-70 µm	Deuterium and Tungsten Halogen
NC-UV-VIS	250-850 nm	10 nm-20 µm	Deuterium and Tungsten Halogen
NC-VIS-NIR	400-1100 nm	50 nm-100 µm (optional 1 µm-250 µm)	Tungsten Halogen
NC-VIS	400-850 nm	50 nm-20 µm	Tungsten Halogen
NC-NIR	650-1100 nm	70 nm-70 µm	Tungsten Halogen
NC-NIR-HR	700-978 nm	1 µm-250 µm	Tungsten Halogen
NC-512-NIR	900-1700 nm	50 nm-200 µm	High-power Tungsten Halogen

Specifications			
Angle of incidence:	90°	On-line possibilities:	Yes
Number of layers:	4 or fewer	Mechanical tolerance (height):	With new reference or collimation (74-UV)
Reference measurement needed:	Yes (bare substrate)	Mechanical tolerance (angle):	Yes, with new reference
Transparent materials:	Yes	Microspot option:	Yes, with microscope
Transmission mode:	Yes	Vision option:	Yes, with microscope
Rough materials:	Yes	Mapping option:	6" and 12" XYZ mapping tables
Measurement speed:	100 milliseconds to 1 second	Vacuum possibilities:	Yes

SpecEl Ellipsometer System

Full Spectral Range in Easy-to-use System

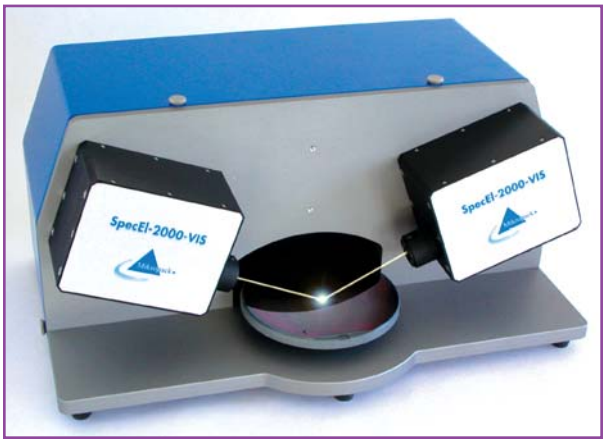
Measure refractive index, absorbance and thickness of substrates with the touch of a button! The SpecEl-2000-VIS Ellipsometer from Mikropack measures polarized light reflected from the surface of a substrate to determine the thickness and refractive index of the material as a function of wavelength. The SpecEl is controlled via a PC.

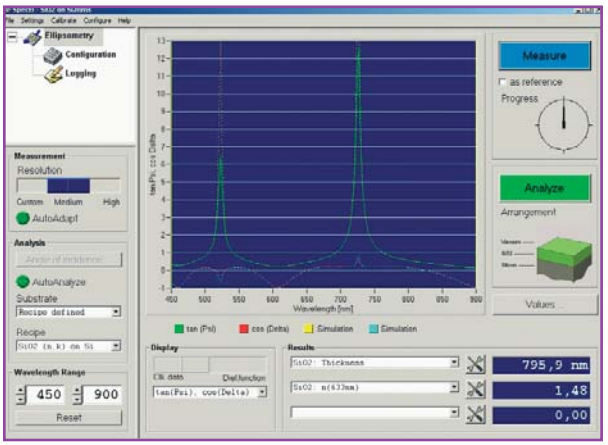
All-in-one Accurate System

The SpecEl houses an integrated light source, a spectrometer and two polarizers fixed to 70°. It also includes a PC with a 32-bit Windows operating system. The SpecEl can detect a single layer as thin as 0.1 nm and up to 5 µm thick. In addition, it can provide refractive indices to 0.005° over lambda.

SpecEl Software and "Recipe" Files

In SpecEl Software, you can configure and save experiment method files for one-step analysis. After creating a "recipe," you can select the recipe to execute the experiment.





This screen from the SpecEl Software demonstrates the Psi and Delta values you can calculate for thickness, refractive index and absorbance.

Specifications	
Wavelength range:	450-900 nm
Optical resolution:	4.0 nm FWHM
Accuracy:	0.1 nm thickness; 0.005% refractive index
Angle of incidence:	70°
Film thickness:	from 0.1 to 8000 nm for single transparent film
Spot size:	2 mm x 4 mm (standard) or 200 µm x 400 µm (optional)
Sampling time:	5-15 seconds (minimum)
Kinetic logging:	5 seconds
Mechanical tolerance:	Height ± 1 mm, angle ± 1.0°
Number of layers:	Up to 32 layers
Reference:	Not applicable

PlasCalc Plasma Monitoring & Control

Real-time, Full-spectral Plasma Monitoring

PlasCalc-UV-NIR measures plasma emission from 200-1100 nm in only three milliseconds. The PlasCalc benefits from advanced process control systems and sophisticated algorithms for data acquisition.

Recipe Editor

The Recipe Editor tool allows you to easily and rapidly configure, build and save experiment methods. It is easy to build robust recipes for the most difficult plasma processes such as measuring film deposition, monitoring plasma etching, examining surface cleaning, analyzing plasma chamber health control, and monitoring abnormal pollution or discharge phenomena.

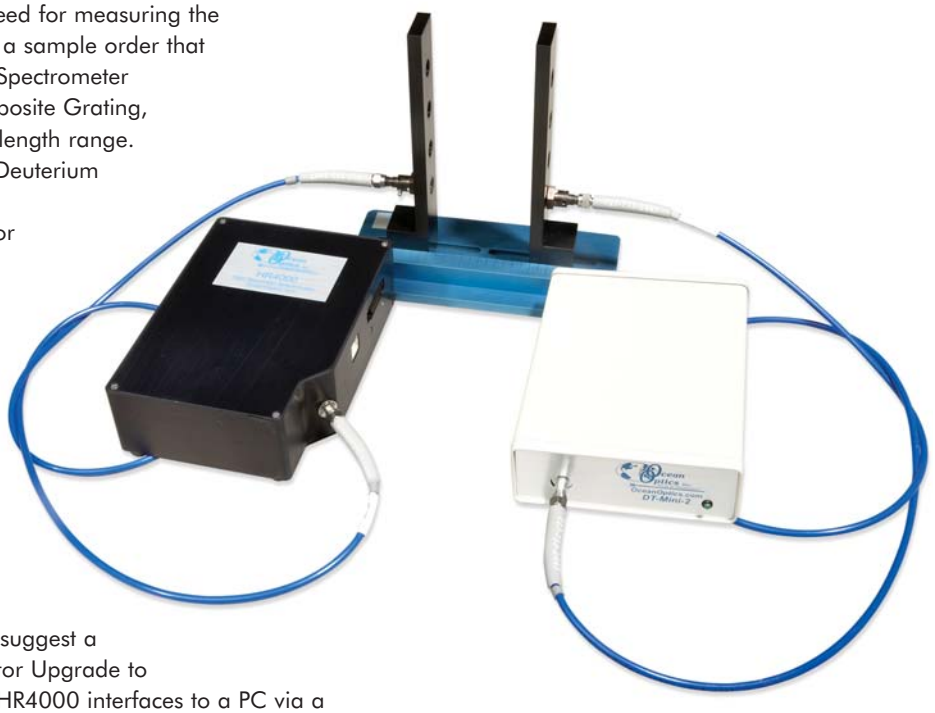
Multiple Tools for Easy Plasma Diagnosis

The Integrated Formula Editor provides easy access to a full range of mathematical and algorithmic functions. An Emission Wavelength Library provides species identification, while the Wavelength Editor allows you to optimize signal-to-noise. A dual-window interface shows the actual spectrum and all process control information.

Specifications	
Spectral range:	200-1100 nm
Optical resolution:	1.0 nm FWHM
D/A-converter:	14 bit
Digital inputs/outputs:	8 x TTL digital inputs/outputs
Analog output:	4 x [0-10V]
Interface:	USB 1.1
Power consumption:	12 VDC @ 1.25 A
Power requirements:	90-240 VAC 50/60 Hz
Dimensions:	257 mm x 152 mm x 263 mm
Weight:	5 kg

Transmission of Optics Tools

We offer all of the components you need for measuring the transmission of optics. Listed below is a sample order that specifies an HR4000 High-resolution Spectrometer configured with our novel HC-1 Composite Grating, which provides a 200-1050 nm wavelength range. In addition, we suggest a DT-MINI-2 Deuterium Tungsten Halogen Source, plus fibers, collimating lenses and a lens fixture for sampling.



HR4000 with 200-1050 nm Wavelength Range

The HR4000 configuration we recommend for this application includes a new 3648-element CCD-array detector, the proprietary HC-1 Composite Grating and an order-sorting filter to provide a 200-1050 nm wavelength range (best efficiency) and optical resolution better than 1.0 nm (FWHM). We also suggest a 25 µm entrance slit and a UV2 Detector Upgrade to enhance performance in the UV. The HR4000 interfaces to a PC via a USB 2.0 port.

Broad Spectral Range Light Source

The DT-MINI-2 Deuterium Tungsten Halogen Light Source combines the continuous spectrum of a deuterium UV light source and a tungsten halogen VIS-NIR light source in a single optical path. The combined-spectrum source produces stable spectral output from ~200-2000 nm in a compact package.

Holder for a Variety of Samples

The 74-ACH Adjustable Collimating Lens Holder consists of adjustable bars with several threaded holes for collimating lenses. The bars can be set to accept samples up to ~100 mm thick, making the 74-ACH a convenient option for transmission measurements of large samples.

Collimating Lenses

The 74-UV Collimating Lenses screw into the threaded holes of the 74-ACH to collimate light. The lenses have an inner barrel threaded for attaching to optical fibers. When focused for collimation, beam divergence is 2° or less. The inner barrel can slide relative to the lens fixture to adjust the focus.

Optical Fiber

Our fiber assemblies can act as both illumination and read fibers. The two 600 µm diameter optical fibers recommended are one meter in length and connect easily from the collimating lenses installed in the 74-ACH to the HR4000 Spectrometer and the light source.

Spectrometer Specifications	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Power consumption:	450 mA @ 5 VDC
Detector:	3648-element linear CCD array (page 24)
Wavelength range:	200-1100 nm, 200-1050 best efficiency
Optical resolution:	~1.0 nm FWHM
Grating:	HC-1, 300 lines per mm grating (page 23)
Entrance aperture:	25 µm wide slit (page 22)
Order-sorting filters:	Installed OFLV-200-1100 (page 24)
Focal length:	f/4, 101 mm
Dynamic range:	2 x 10^8 (system); 2000:1 for a single acquisition
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Data transfer rate:	Full spectrum into memory every 4 ms with USB 2.0; 18 ms with USB 1.1
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; any 32-bit Windows operating system when using the serial port
Inputs/Outputs:	10 digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input and one 9-bit analog output

** Programming the GPIOs requires SpectraSuite, OmniDriver or another one of our device drivers. See pages 80-82 for details.*

Quantity	Item	Description	Page	Price
1	HR4000	HR4000 ($3,999) with HC-1 Composite Grating ($600); 25 µm slit ($150); DET4-200-1100 Detector with OFLV Order-sorting Filter and UV4 Detector Upgrade ($400)	21	$5,149
1	DT-MINI-2	Miniature Deuterium Tungsten Halogen Light Source	125	$1,499
1	74-ACH	Adjustable Collimating Lens Holder	89	$299
2	74-UV	Collimating Lens	88	$318
2	P600-1-SR	600 µm diameter optical fiber in 1-meter length	144	$238
			TOTAL:	**$7,503**

Spectrometer Accessories

Spectral Hyper Adapter for Picometer Resolution

Get even higher spectral resolution from your spectrometer with the SHA-1 Spectral Hyper Adapter from Ocean Optics partner Spectral Applied Research. The SHA-1 Spectral Hyper Adapter further improves the optical resolution of the already high-performance HR4000. Increased resolution is achieved by plugging the SHA-1 into a setup between the sampling device and the HR4000. The SHA-1 plugs directly into the HR4000's 30-pin connector and connects to the HR4000's optical bench via the included 50-µm optical fiber. Commands are transmitted via the USB port and data acquisition is synchronized with the HR4000. The table below gives examples of the improvement in optical resolution the SHA-1 provides for certain HR4000 configurations.

SHA-1: $5,000

Examples of Resolution Improvements

Slit	Grating	Starting Wavelength	Wavelength Range	Resolution no SHA-1	Resolution with SHA-1
5 µm	H11 (1800 mm^{-1})	700 nm	700-791 nm	0.05 nm	0.004-0.006 nm or 4.0-6.0 pm
5 µm	H12 (2400 mm^{-1})	550 nm	550-615 nm	0.035 nm	0.003-0.004 nm or 3.0-4.0 pm

Specifications	
Dimensions:	40.6 mm x 68.6 mm x 68.6 mm
Wavelength range:	550-900 nm
Fiber size:	50 µm diameter optical fiber
Integration time:	2 seconds (minimum)
Optical resolution:	7x-10x improvement; see table at left for examples
Optical throughput:	10-25%, specify throughput required

Breakout Box

For easier access to a variety of functions found in the HR4000, specify the HR4-BREAKOUT, a passive module that separates the signals from its 30-pin port to an array of standard connectors and headers. The Breakout Box allows multiple interfaces to a spectrometer, such as:

- External triggering
- General Purpose Inputs/Outputs (GPIO)
- RS-232 interface
- Light sources
- Analog Inputs/Outputs

In addition to the accessory connector, the Breakout Box features a circuit board based on a neutral breadboard pattern that allows custom circuitry to be prototyped on the board itself. The Breakout Box receives its power from the spectrometer, which runs off of a PC via a USB port, or requires a separate 5-volt power supply when the spectrometer interfaces to a PC via the serial port. If you are wiring custom circuitry on the Breakout Box, you likely will need the USB-CBL-PS power supply (purchased separately).

The Breakout Box can be used with the following spectrometers:

- USB4000 Spectrometers Plug-and-Play Spectrometers (page 14)
- HR4000 High-resolution Spectrometers (page 21).
- HR2000+ High-speed, High-resolution Spectrometer (page 20)
- QE65000 Scientific-grade Spectrometer (page 26)

HR4-BREAKOUT: $199
USB-CBL-PS: $25

The Breakout Box includes a 30-pin HR4000-CBL-BB Ribbon Cable that connects the Box to the spectrometer.

This enlarged photo of the Breakout Box shows the connectors available. Below is an example of a setup with the HR4000 and Breakout Box.

Cables, Adapters, Power Supplies & More

Enclosures & Cases for Spectrometers & Accessories

Item	Description	Price
BOX-DESKTOP	Desktop Box Enclosure, 3U x 42HP, up to 7 slots	$825
BOX-DUAL	Dual Box Enclosure, 153 x 105 x 66 mm	$350
BOX-DUAL-CE	Dual Box Enclosure, 153 x 105 x 66 mm, CE Approved	$450
BOX-RACK	Rack Mount Box Enclosure, 3U x 84HP, up to 14 slots	$900
BOX-SINGLE	Single Box Enclosure, 143 x 104 x 40 mm	$350
BOX-SINGLE-CE	Single Box Enclosure, 143 x 104 x 40 mm, CE Approved	$550
SPEC-CADDY	Rugged, water-tight case for spectrometers and accessories	$150

SPEC-CADDY

Adapters and Cables

Item	Description	Price
USB-CBL-1	Cable connects from USB port on USB-enabled Spectrometers to USB port on computer; included with purchase of USB-enabled Spectrometers	$25
USB-ADP-PC	Cable and adapter block to connect from serial port on spectrometer to serial port on computer; comes with USB-CBL-PS power supply	$75
USB-ADP-PC-E	European version of the USB-ADP-PC	$50
USB-CBL-PS	5 VDC Power Supply for spectrometers in serial mode	$25
USB-ADP-DT2	Adapter for directly attaching the USB-DT Light Source to the USB4000	$75
USB-ADP-PX2	Adapter block and cable to connect PX-2 Pulsed Xenon Lamp (page 127), DT-MINI (page 125) or LS-450 Blue LED (page 130) to the USB4000	$50
HR4-CBL-DB15	HR4000 DB15 Accessory cable	$25
CBL-PX-2	Cable for connecting PX-2 to S2000 Spectrometer	$25
CBL-SER	Serial Cable, 9-pin	$25

USB-CBL-PS Power Supply

Power Supplies*

Item	Description	Price
WT-12V	Regulated 12 VDC Power Supply (1.5A, 110/220 VAC)	$25
WT-12V-R-E	Regulated 12 VDC Power Supply (2.5 A, 220 V)	$100
WT-12V-E	12 VDC Power Supply (800 mA, 220 V)	$20
USB-BP	Lithium Ion Battery Pack has two lithium ion cells; provides 8 hours of power to a USB2000 or USB4000 Spectrometer; comes with charger; charges in 3 hours with the included charger; delivers 2 amp-hours at 5 volts	$499

** Each Ocean Optics Sales, Service & Support location sells power supplies that best serves its region.*

USB-ADP-DT2

USB-ADP-PX2

Device Control

Item	Description	Price
ACC-CON-US4	Accessory connector for external triggering for USB4000 Spectrometers	Free
ACC-CON-US2	Accessory connector for external triggering for USB2000 Spectrometers	Free
HR4-BREAKOUT	A passive module that allows control of a variety of spectrometer functions such as external triggering, GPIOs and light sources; includes USB4-CBL-BB Ribbon Cable to interface to the spectrometer (see page 61 for details)	$199
FIRMWARE-FLG	Gating Firmware Upgrade for USB2000s	$250
PX-2-FIRMWARE	USB2000 or USB4000 programmed for use with PX-2	Free
USB2000-O2CODE	Stand-alone Oxygen Firmware for USB2000	$499
USB-AOUT	4-20 mA Analog Output Module for USB2000 and USB4000 Spectrometers	$499

USB-BP

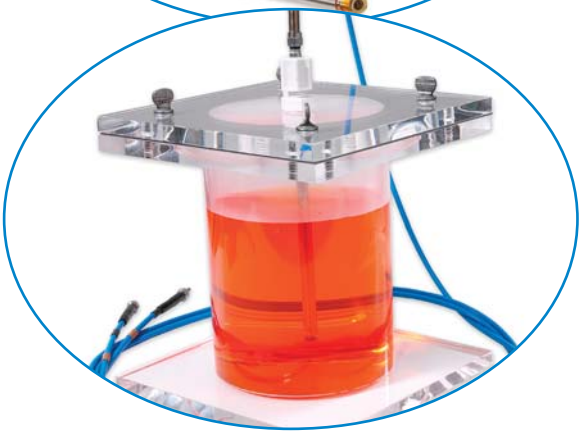
ACC-CON-US2

Extended Warranty and Annual Service Packages

Item	Description	Price
ASP	Extends the standard warranty from 1 year to 2 years. Price is per spectrometer channel.	$250
ASP-ES	A 1-year warranty package available to customers whose original warranty has expired. Price is per spectrometer channel.	$300
ASP-NIR	Extends the standard warranty on NIR Spectrometers from 1 year to 2 years.	$1,000
ASP-QE	Extends the standard warranty on QE Spectrometers from 1 year to 2 years.	$750
ASP-R	1-year renewal option for holders of expiring ASPs; price is per channel.	$250
ASP-R-E	2-year renewal option for holders of expiring ASPs; price is per channel.	$350

HR4-BREAKOUT

Optical Sensors



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75 Sensor Software
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76 Fiber Optic pH Sensors
76 Phenol Red pH Test Kit

Overview: Optical Sensors

Sensors for Real-Time, In Situ Analyte Monitoring

Ocean Optics has combined its expertise in miniature fiber optic spectroscopy with advances in materials science to develop an innovative line of modular fiber optic chemical-sensing systems.

Sensors are constructed by placing a transducer material at the tip of an optical fiber. These materials change optical properties in response to specific analytes in their immediate environment.

Our transducer materials include both fluorescence-based and absorbance-based indicators. These indicators are immobilized or trapped in a variety of proprietary materials, including sol-gels, hydrophobic and hydrophilic polymers, and cellulose acetate. Materials can be coated on flat substrates such as optical fibers, optical flats, cuvettes and other containers.

Optical sensors can be used for a variety of applications. Here, our "R" Optic Oxygen Sensor monitors oxygen in a liquid.

We produce components that can be used to monitor oxygen or pH in biological samples, headspace gases, slurries, cosmetics, foods, gases and liquids in natural environments.

Optical O_2 Sensors vs. Electrodes

Commercial Electrodes		Fiber Optic Oxygen Sensors
Most electrodes are designed for use in gas or liquids, but not both media	✔	Sensors measure both oxygen gas and dissolved oxygen in gases and liquids
Polarographic electrodes can be affected by changes in pH, salinity and ionic strength of the environment	✔	Sensors are immune to environmental changes in pH, salinity and ionic strength
Electrochemical electrodes are subject to interference from a number of substances and sampling conditions	✔	Sensors are immune to interference from moisture, carbon dioxide, methane and other substances
Electrodes can have a response time of 1.5 minutes, depending on temperature	✔	Sensors response time is <1 second for dissolved O_2 and O_2 gas
Electrodes have a typical lifetime of 3 months	✔	Sensors have a long life – more than 1 year
Electrodes can consume oxygen of ~0.1 micrograms/hour	✔	Sensors do not consume oxygen, allowing for continuous contact with sample
Calibration may be needed hourly	✔	Frequent calibration is unnecessary
The temperature range for some electrodes is 0-45 °C	✔	Sensor probe temperature range is -60 °C to +80 °C
Electrodes often introduce electrical currents into a sampling setup	✔	Sensors allows remote sampling without introducing electrical fields to sample

Ocean Optics Offers Optical Sensor Coating Services

Our optical-sensor coating services provide OEMs and product developers with multiple solutions in creating proprietary products for chemical sensing applications. You can take advantage of these services to develop and manufacture a variety of custom optical oxygen and pH sensor accessories including fiber optic probes, cuvettes, Petri dishes, microscope slides and more. The added services include the licensing of Ocean Optics proprietary oxygen and pH coating technologies, custom sensor coating development, and contract manufacturing services.

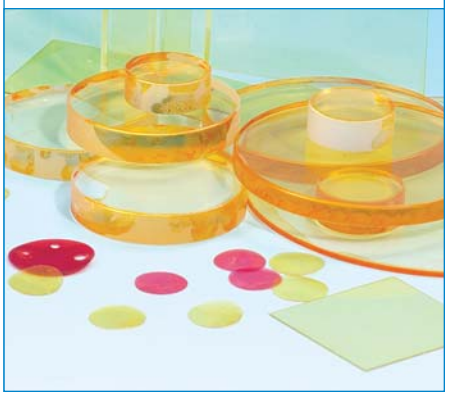
We can supply our proprietary optical sensor coating technologies to you through a license agreement. We manufacture the coatings and apply them to any media specified.

You can supply a proprietary indicator to be included in an Ocean Optics coating. We then produce the coating and apply it to the media specified.

You can supply a proprietary coating and indicator to us and we will apply the coating to the media specified. This option requires a contract agreement.

We can research and develop a proprietary coating for you. This option is available through NRE and/or research fees.

Services may also include costs associated with the type of sensor material; the surface area; and the time required to apply the sensor material to a substrate.

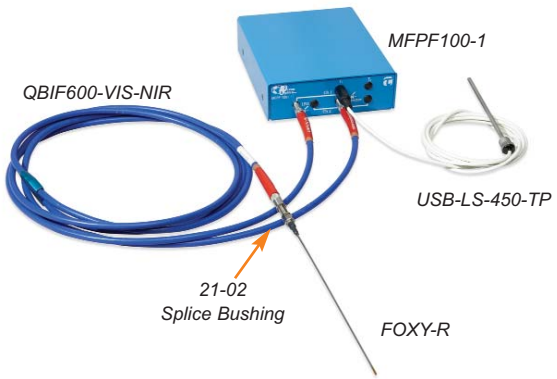


Oxygen Sensor Operation

Our Fiber Optic Oxygen Sensors are coated probes that use fluorescence quenching to measure the partial pressure of dissolved or gaseous oxygen. You specify a sensor probe with one of our three sensing formulations -- along with a sensing detector, excitation source and software -- to build a complete system that typically works like this:

1. An LED sends excitation light to one leg of a bifurcated optical fiber assembly.
2. The fiber carries the light to the oxygen probe, which is polished to a 45° angle. The distal end of the probe tip consists of sensor formulation trapped in a sol-gel matrix, immobilized and protected from the sample. FOXY and HIOXY sensors use a ruthenium formulation, while FOSPOR sensors use a Pt-porphyrin formulation.
3. The light from the LED excites the ruthenium or porphyrin sensor formulation at the probe tip. The excited complexes fluoresce, emitting energy at ~600 nm and 650 nm, respectively.
4. If the excited complex at the probe tip encounters an oxygen molecule, the excess energy is transferred to the oxygen molecule in a non-radiative transfer, decreasing or quenching the fluorescence signal. The degree of quenching correlates to the partial pressure of oxygen in the sol-gel, which is in dynamic equilibrium with oxygen in the sample.
5. The fluorescence is collected by the probe and carried to the USB4000-FL Spectrometer or MFPF Fluorometer via the second leg of the bifurcated optical fiber assembly. The fluorescence intensity (for USB4000-FL Spectrometer) or phase (for MFPF Fluorometer) is measured and related to the partial pressure of oxygen through the Stern-Volmer equation.

Oxygen Sensor with MFPF100-1 MultiFrequency Phase Fluorometer



Overview

Oxygen is sensed by measuring the phase shift of fluorescence of a fluorophore bound to the tip of an optical fiber. The sensor responds to the partial pressure of oxygen. Below is a list of components typically specified in an oxygen sensing application with a MultiFrequency Phase Fluorometer (MFPF) as the sensor detector.

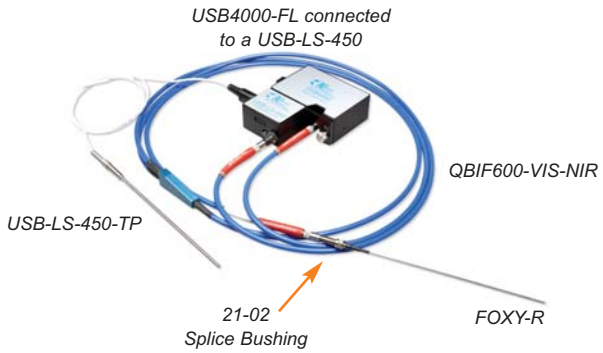
MultiFrequency Phase Fluorometer

The MultiFrequency Phase Fluorometer (MFPF) is a flexible platform for measurement of luminescence lifetime, phase and intensity. The MFPF is especially useful for oxygen sensing applications where sensitivity to drift is important and where sample set-ups must be undisturbed for long periods of time. Because it utilizes phase-shift technology, it is invariant to fiber bending and stray light and has a wide dynamic range of optical intensity as well as low optical and electronic crosstalk, and low drift and phase noise.

Sampling Optics

This compact, self-contained frequency-domain luminescence monitor uses included red and blue LED excitation light that transmits to one leg of a QBIF600-VIS-NIR Bifurcated Optical Fiber Assembly, which is connected to one of our oxygen sensor probes, such as the FOXY-R, via a 21-02 Splice Bushing.

Oxygen Sensor with USB4000-FL Spectrofluorometer



Overview

Oxygen is sensed by measuring the decrease in fluorescence intensity of a fluorophore bound to the tip of an optical fiber. The sensor responds to the partial pressure of oxygen. It works equally well in gases, solutions and even viscous samples. Below is a list of components typically specified in an oxygen sensing application.

Spectrometer

We recommend the USB4000-FL Fluorescence Spectrometer for general purpose oxygen measurements. The USB4000-FL is preconfigured with a 200 μm Slit, Grating #3 and a 360-1000 nm wavelength range. Grating #3 is blazed at 500 nm to optimize the fluorescence signal at 600 nm. Also included in the optical bench is an L4 Detector Collection Lens to increase light-collection efficiency.

Sampling Optics

The USB-LS-450 Pulsed Blue LED Excitation Source transmits light (at ~475 nm) to one leg of a QBIF600-VIS-NIR Bifurcated Optical Fiber Assembly, which is connected to one of our oxygen sensor probes, such as the FOXY-R, via a 21-02 Splice Bushing.

Oxygen Sensor Spectrometers

Preconfigured Spectrometers for Use with Sensors

Our high-sensitivity, preconfigured fluorescence spectrometers -- the USB4000-FL, USB4000-FL-450 and USB4000-FL-395 -- were conceived for use with fluorescence-based sensors. Each fluorescence unit is set to 360-1000 nm and comes with a 200-µm entrance aperture and an L4 Detector Collection Lens for increased light throughput.

USB4000-FL: Excitation Source not Included

The USB4000-FL does not come with an excitation source, which you will need to excite the sample. We have a series of compact, low-cost excitation sources that work with our fluorescence-based sensors such as the LS-450 (at right) or the USB-LS-450 (see pages 130-131). The excitation sources produce pulsed or continuous output and easily couple to our line of spectrometers, optical fibers and other accessories.

USB4000-FL-450 & USB4000-FL-395: Excitation Source Included

The USB4000-FL-450 and USB4000-FL-395 Spectrofluorometers are spectrometers configured the same way as the USB4000-FL, but each comes with a direct-attach excitation source. The USB4000-FL-450 comes with a 470 nm LED Excitation source and the USB4000-FL-395 comes with a 395 nm LED Excitation source. The 470 nm LED is great for exciting the FOXY and HIOXY formulations, while the 395 nm LED is used for exciting the FOSPOR formulation. In addition, these Excitation sources connect to temperature sensors and contain onboard memory that can be programmed to store temperature and oxygen calibration coefficients.

USB4000-FL: $2,499
USB4000-FL-450: $3,049
USB4000-FL-395: $3,049

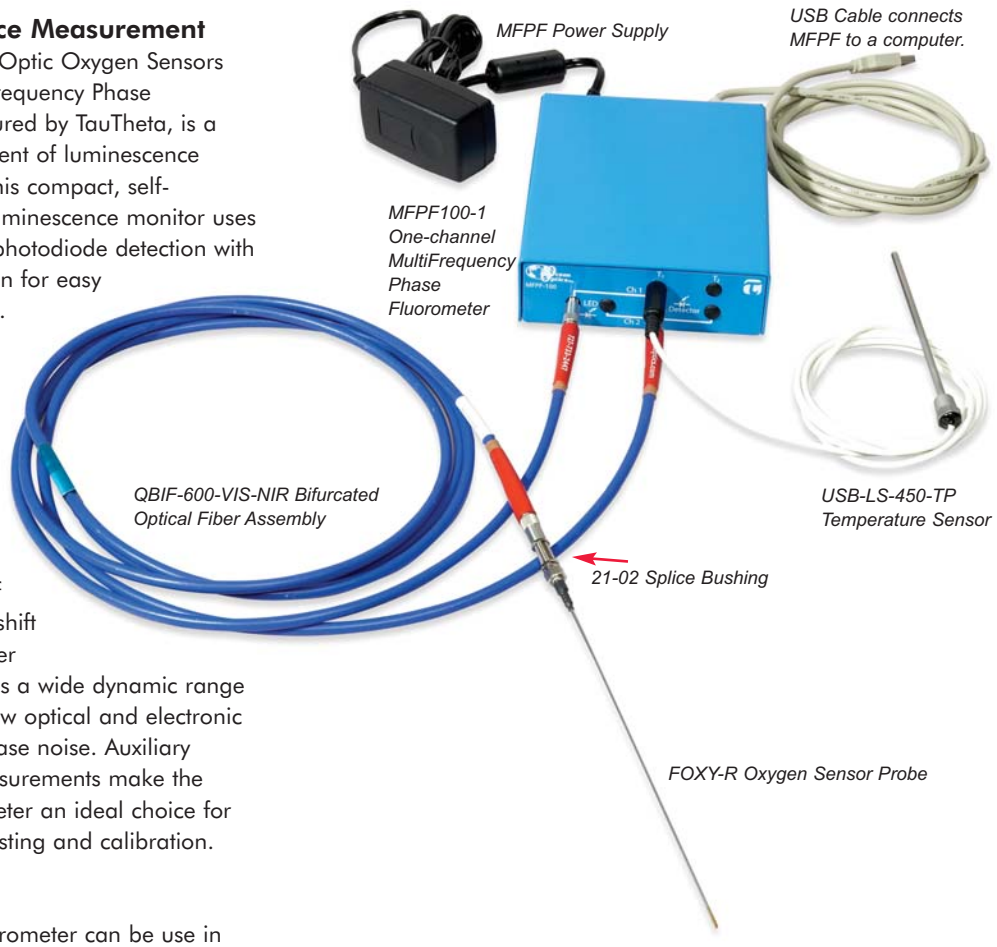
Specifications

	USB4000-FL	USB4000-FL-450	USB4000-FL-395
PHYSICAL			
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm	89.1 mm x 120.3 mm x 34.4 mm	89.1 mm x 120.3 mm x 34.4 mm
Weight:	190 grams	310 grams	310 grams
DETECTOR			
Detector:	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)	Toshiba TCD1304AP linear CCD array (see page 17 for detector specifications)
OPTICAL BENCH			
Design:	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner	f/4, Asymmetrical crossed Czerny-Turner
Focal length:	42 mm input; 68 mm output	42 mm input; 68 mm output	42 mm input; 68 mm output
Entrance aperture:	200 µm wide slit	200 µm wide slit	200 µm wide slit
Grating:	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm	Grating #3, groove density of 600 lines set to 360-1000 nm, blazed at 500 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber
SPECTROSCOPIC			
Wavelength range:	360-1100 nm	360-1100 nm	360-1100 nm
Optical resolution:	~10.0 nm FWHM	~10.0 nm FWHM	~10.0 nm FWHM
Signal-to-noise ratio:	300:1 (at full signal)	300:1 (at full signal)	300:1 (at full signal)
A/D resolution:	16 bit	16 bit	16 bit
Dark noise:	50 RMS counts	50 RMS counts	50 RMS counts
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm	<0.05% at 600 nm; <0.10% at 435 nm	<0.05% at 600 nm; <0.10% at 435 nm
Corrected linearity:	>99.8%	>99.8%	>99.8%
ELECTRONICS			
Power consumption:	250 mA @ 5 VDC	250 mA @ 5 VDC and 60 mA @ 5 VDC	250 mA @ 5 VDC and 60 mA @ 5 VDC
Data transfer speed:	Full spectrum to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port	Full spectrum to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port
Inputs/Outputs:	Yes, 8 digital user-programmable GPIOs	Yes, 8 digital user-programmable GPIOs	Yes, 8 digital user-programmable GPIOs
COMPUTER			
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port	Windows 98/Me/2000/XP, Mac OS X and Linux with USB port; Any 32-bit Windows OS with serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)	I^2C inter-integrated circuit; SPI (3-wire)
LIGHT SOURCE			
Stability:	n/a	±1.0% drift after 2-minute warm-up period	±1.0% drift after 2-minute warm-up period
Wavelength range:	n/a	460-490 nm	380-410 nm
Power consumption:	n/a	60 mA @ 5 VDC	60 mA @ 5 VDC
Power output:	n/a	60 µW (minimum) into a 600 µm fiber	60 µW (minimum) into a 600 µm fiber

Oxygen Sensor Phase Fluorometer

Flexibility in Luminescence Measurement

Used with Ocean Optics Fiber Optic Oxygen Sensors and custom probes, the MultiFrequency Phase Fluorometer (MFPF), manufactured by TauTheta, is a flexible platform for measurement of luminescence lifetime, phase and intensity. This compact, self-contained frequency-domain luminescence monitor uses LED excitation and avalanche photodiode detection with filter-based wavelength selection for easy experimental setup and control.



Perfect System for O_2 Sensing

The MFPF is especially useful for oxygen sensing applications where sensitivity to drift is important and where sample setups must be undisturbed for long periods of time. Because it utilizes phase-shift technology, it is invariant to fiber bending and stray light and has a wide dynamic range of optical intensity as well as low optical and electronic crosstalk, and low drift and phase noise. Auxiliary pressure and temperature measurements make the MultiFrequency Phase Fluorometer an ideal choice for luminescence sensor design, testing and calibration.

Application Flexibility

The MultiFrequency Phase Fluorometer can be use in applications such as:

- Luminescent materials characterization
- Phase/Lifetime sensor development
- Calibration of phase/lifetime sensors
- Stability and photodegradation studies
- Characterization of phase shift over frequency
- Oxygen consumption measurement on cell and islet cultures

Configuration Options

The MFPF can be configured with two-channel LED excitation and detection and modulation frequencies to 500 kHz. This configuration will give you lifetime measurements from 200 µsec down to 0.3 µsec. The onboard pressure transducer measures atmospheric pressure or external pressure with a 1/4" hose fitting. The single-channel MFPF100-1 comes with one thermistor, and the two-channel MFPF100-2 includes two thermistors. The thermistor option allows temperature logging, calibration and temperature correction.

USB Connection for Easy Startup

The MultiFrequency Phase Fluorometer can connect to your PC via an RS-232 or USB connection and saves your data in an easy-to-use Excel format.

MFPF100-1 (one channel): $5,000
MFPF100-2 (two channels): $7,500

Specifications	
LED modulation range:	2 kHz to 100 kHz (200 µsec to 0.3 µsec)
Parameters measured:	Luminescence phase shift, AC luminescence intensity, temperature (optional through external thermistors), pressure (via onboard pressure transducer)
Control software:	Windows 2000/XP control software with data logging capability; controls include: modulation frequency, data rate, LED duty cycle, signal averaging, APD gain, analog gain, LED intensity
Measurement modes:	Intermittent LED (to minimize photodegradation); Continuous LED (for rapid measuring and accelerating photo-bleaching); Frequency sweep for luminescence characterization
Thermistor probes:	Closed end stainless steel tube with thermistor sensor mounted in tip; liquid immersible rugged design; 1/8" NPT fitting; temperature range 0 to 75 °C, absolute maximum 100 °C +/- 0.2 °C; Interchangeable thermistors
Pressure measurement:	Onboard pressure transducer monitors atmospheric pressure, optional configuration allows external connection for 0 to 15 psiA
Power input:	6v - 12v, 1.5 Amps
Communications:	USB or RS-232

Oxygen Sensor Formulations

By combing miniature fiber optic spectrometers, excitation sources and optical probes coated with chemically sensitive transducers, Ocean Optics has created an extensive line of fiber optic oxygen sensors. Sensors are constructed by placing a transducer material -- typically, a dye embedded in a sol gel -- at the tip of an optical fiber. These materials change optical properties in response to specific analytes in their immediate environment. The sensor uses fluorescence quenching of the indicator dye to measure the partial pressure of dissolved or gaseous oxygen.

FOXY Sensor Formulation

General-purpose Oxygen Sensors

Our Oxygen Sensing Probes with the FOXY Formulation are designed for monitoring partial pressure of oxygen in benign gases, liquids and gels. Standard FOXY probe tips are covered with a layer of hydrophobic sol-gel material with a ruthenium compound trapped in the sol-gel matrix. When excited by an LED, the ruthenium complex fluoresces. If the excited ruthenium complex then encounters an oxygen molecule, the excess energy quenches the fluorescent signal. The fluorescence intensity or phase shift is measured by an Ocean Optics spectrometer or MFPF system, and is related to the partial pressure of oxygen.

FOSPOR Sensor Formulation

High-sensitivity Coating

Our FOSPOR sensor coating for Oxygen Sensor Probes is a highly sensitive sol-gel thin film immobilized with Pt-porphyrin, a fluorescent dye with high quantum efficiency and low non-specific adsorption on different surfaces. FOSPOR-coated sensors are capable of monitoring low levels of oxygen in gas (to ppm) and dissolved oxygen in liquids (to ppb), making them especially useful for measuring trace amounts of oxygen in vacuum systems and in food and pharmaceutical packaging.

HIOXY Sensor Formulation

Hydrocarbon Environments

We've developed a high-performance oxygen sensor compatible with hydrocarbon environments. Our new HIOXY formulation is a hydrophobic and oleophobic coating material encapsulated with oxygen-sensitive luminescence molecules. The HIOXY sensor is designed for monitoring oxygen in non-aqueous vapors and solutions. The sensor coating chemistry is ideal for use with oils, alcohols and hydrocarbon-based vapors and liquids. HIOXY has been tested successfully in commercial and military aviation fuels, gasoline, diesel, some alcohols, glycol, military hydraulic fluids and various wines.

Specifications

Specification	FOXY Probes	FOSPOR Probes	HIOXY Probes
Principle:	Photoluminescence-quenching using Ru compound. Measures O_2 partial pressure.	Photoluminescence-quenching using Pt compound. Measures O_2 partial pressure.	Photoluminescence-quenching using Ru compound. Measures O_2 partial pressure.
Sensor mechanism:	Phase shift due to change in partial pressure of O_2	Phase shift due to change in partial pressure of O_2	Phase shift due to change in partial pressure of O_2
Applications:	Benign environment, aqueous liquids and vapors	Low O_2 (0-5%), vacuum systems packaging, benign environment	Hydrocarbon-based liquids and vapors, fuels, alcoholic beverages, vegetable oil
Time-constant (µsec) dynamic range:	Air: 2.50, N2: 5.00; Low 1.00, High 7.00	Air: 10.00; N2: 50.00; Low: 3.00, High: 70.00	Air: 0.50, N2: 2.50; Low: 0.30, High: 6.00
Accuracy: (0-20% O_2, 0-50 ºC):	5% of reading (using polynomial fit to multipoint calibration)	5% of reading (using polynomial fit to multipoint calibration)	5% of reading (using polynomial fit to multipoint calibration)
Response time of probe with no overcoat:	~1 second, in liquid and gas	~1 second, in liquid and gas	~1 second, in liquid and gas
Response time of dissolved oxygen in liquid (with overcoat):	30-45 seconds	30-45 seconds	Overcoat not required
Response time of probe with overcoat of Oxygen Gas (at 1 atmosphere):	15-20 seconds	15-20 seconds	Overcoat not required
Dynamic range of dissolved oxygen in liquid:	0-40.7 ppm; 0-760 mm Hg partial pressure	0-40.7 ppm; 0-760 mm Hg partial pressure	0-40.7 ppm; 0-760 mm Hg partial pressure
Dynamic range of oxygen gas (at 1 atmosphere):	0-100% (mole percent); 0-760 mm Hg partial pressure	0-100% (mole percent); 0-760 mm Hg partial pressure	0-100% (mole percent); 0-760 mm Hg partial pressure
Stability dissolved oxygen in liquid:	Drift <0.01 ppm per hour	Drift <0.00008 ppm O_2 per hour at low dissolved oxygen; Drift ~ 0.006 ppm O_2 per hour in air-saturated water	Drift <0.002 ppm per hour
Stability oxygen gas (at 1 atmosphere):	Drift ~0.03% O_2 per hour	Drift ~0.0002% O_2 drift per hour at low O_2; Drift ~0.015% O_2 per hour air	Drift ~0.01% O_2 per hour
Resolution of dissolved oxygen in liquid:	0.02 ppm at room temperature	0.002 ppm at room temperature	0.02 ppm at room temperature
Resolution of oxygen gas (at 1 atmosphere):	0.05% (0.4 mm Hg) at room temperature	0.005% at room temperature	0.05% (0.4 mm Hg) at room temperature
Lowest detectable limit of dissolved oxygen in liquid:	0.02 ppm	0.002 ppm at room temperature	0.02 ppm
Lowest detectable limit of oxygen gas (at 1 atmosphere):	0.05% (0.4 mm Hg)	0.005% (0.04 mm Hg)	0.05% (0.4 mm Hg)
Overcoat available:	Yes, FOXY-AF and FOXY-AF-MG	Yes, FOSPOR-AF and FOSPOR-AF-MG	No overcoat available
Temperature range:	-50 ºC to +80 ºC	0 ºC to +60 ºC	-50 ºC to +80 ºC
Probe lifetime:	Recondition once per year	Recondition once per year	Recondition once per year
Recommended excitation source:	USB-LS-450 470-nm LED	USB-LS-395 395-nm LED	USB-LS-450 470-nm LED
Recommended detector:	MFPF-100-1, MFPF-100-2, USB4000-FL, USB4000-FL-450	USB4000-FL, USB4000-FL-395	MFPF-100-1, MFPF-100-2, USB4000-FL, USB4000-FL-450

Oxygen Sensor Care & Compatibility

Care of Oxygen Sensor Formulation & Probe

Your Oxygen Sensor probe is very easy to maintain. It can be left in air indefinitely, but don't leave it exposed to your excitation light source when it is not in use. Dropping the probe could cause the optical fiber to break. Be sure not to over-tighten the SMA 905 Connectors. Clean your probes with 10% hypochlorite detergent and sterilize them with gamma radiation or sodium hypochlorite (bleach). See below for further details on cleaning and sterilization methods available for your Sensor Probes.

Method	FOXY	FOSPOR	HIOXY
Sodium hypochlorite (bleach)	Safe	Safe	Safe
Gamma radiation	Safe	Safe	Safe
Hydrogen peroxide plasma gas, low temperature, Plazlyte	Degrades probe signal by about 15% with each cycle	Degrades probe signal by about 15% with each cycle	Degrades probe signal by about 15% with each cycle
Autoclaving (steam sterilization) >30 minutes at 121 °C	Each cycle decreases signal by 50%; probe lifetime is 6-8 cycles	Each cycle decreases signal by 50%; probe lifetime is 6-8 cycles	Each cycle decreases signal by 50%; probe lifetime is 6-8 cycles
Methanol and ethanol wash	Unsafe	Unsafe	Safe with brief exposure to ethanol
Hydrogen peroxide	Unsafe	Unsafe	Unknown
Ozone	Unsafe	Unsafe	Unsafe

Compatibility with Fiber Optic Oxygen Probes: Observational Results

Though our oxygen sensing probes work well in most environments, some chemicals interfere with performance by deteriorating the fluorescence irreversibly or by chemically attacking the coating. In some cases, overcoats may reduce such interference.

This table lists known observational effects of chemicals and gases on sensor probes. If a chemical or gas passes the "observational" test (inserting the probe into the environment for 24 hours and observing no change in sensor performance), it warrants further comprehensive determinate testing. Please note that the table lists compatibility on an observational level only. (Comprehensive determinate testing results are available upon request.)

For chemical compatibility testing of samples, we suggest our SGS products (page 72), coated substrates such as microscope glass cover slips that are ideal for evaluating coating formulations exposed to your sample environment.

For the most up-to-date compatibility list, visit www.oceanoptics.com/products/sensorcarecompatibility.asp.

Chemical	FOXY	FOSPOR	HIOXY
Acetone	No	No	No
Acetonitrile	No	No	Unknown
Acids	Yes	Yes	Unknown
Acrylonitrile	No	No	Unknown
Alcohols >50% concentration	No	No	Yes
Alcohols <50% concentration	Yes, overcoat required	Yes, overcoat required	Yes
Ammonia	Yes	Yes	Unknown
Benzene (long-term)	No	No	Yes
Benzene (short-term)	Yes	Yes	Yes
Diesel Fuel	No	No	Yes
Ethanol	No	No	Yes
Gasoline	No	No	Yes
Heptane	No	No	Unknown
Hexane	No	No	Unknown
Hydrofluoric Acid (HF)	No	No	No
Isopropyl Acetate >60% concen.	No	No	Unknown
Isopropyl Alcohol <60% concen.	Yes, overcoat required	Yes, overcoat required	Yes
Hydrogen Peroxide	No	No	Unknown
Ketones (such as acetone)	No	No	No
Methanol <50% concentration	Yes, overcoat required	Yes, overcoat required	Yes
Methyl Methacrylate	No	No	Unknown
Nitrogen Trifluoride (NF3)	Yes	Yes	Yes
Non-polar solvents	No	No	Unknown
N-Vinyl-2-Pyrrolidinone	No	No	Unknown
Organic solvents	No	No	Unknown
Perfluorodecalin & Perfluorohexane	Yes	Yes	Yes
Skydrol (Aviation Hydraulic Fluid)	No	No	Yes
Sodium Hypochlorite and Sulfide	Yes	Yes	Yes
Sodium Hydroxide (1 Molar) NaOH	Yes	Yes	Yes
Solutions with pH >10	No	No	No
Styrene	No	No	Unknown
Sulfur Dioxide (SO2)	No	No	Unknown
Sulfur Hexafluoride (SF6)	Yes	Yes	Yes
Tetrahydrofuran	No	No	Unknown
Toluene and Toluene/Ethyl Acetate	No	No	No
Trichloroethyelene	No	No	Unknown
Xylene	No	No	No

Oxygen Sensor Probes

Once you select the Sensor Formulation best suited for your application, you need to select the Sensor Probe onto which the formulation or coating is applied. Ocean Optics offers several off-the-shelf Sensor Probes and has the ability to create the custom probe assembly that best fits your needs. After selecting your Sensor Formulation and Sensor Probe, you need to purchase a 21-02 Splice Bushing and Bifurcated Optical Fiber Assembly (page 72) to attach the Sensor Probe to your Oxygen Sensing System.

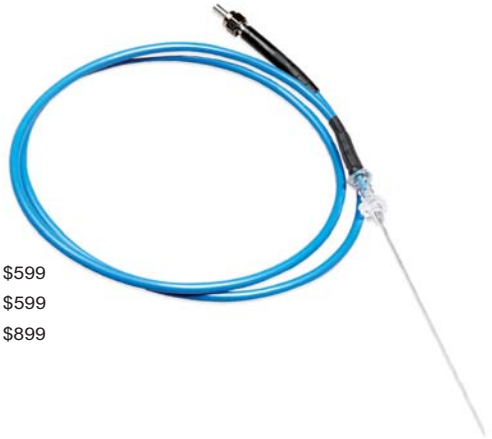
18G Sensor Probe

Typical Usage:	Penetration of vial septa and rigid packaging
Probe Assembly:	300 µm optical fiber, 18-gauge needle tip
Dimensions:	1.27 mm diameter, 90 mm length tip
Pressure:	300 psi

Ordering Information

FOXY-18G	18G Sensor Probe with FOXY Formulation	$599
FOSPOR-18G	18G Sensor Probe with FOSPOR Formulation	$599
HIOXY-18G	18G Sensor Probe with HIOXY Formulation	$899

21G Sensor Probe

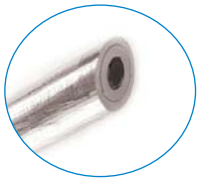


Typical Usage:	Penetration of vial septa and rigid packaging
Probe Assembly:	300 µm optical fiber, 21-gauge needle tip
Dimensions:	1.27 mm diameter, 90 mm length tip
Pressure:	300 psi

Ordering Information

FOXY-21G	21G Sensor Probe with FOXY Formulation	$599
FOSPOR-21G	21G Sensor Probe with FOSPOR Formulation	$599
HIOXY-21G	21G Sensor Probe with HIOXY Formulation	$899

OR125 Sensor Probe



Typical Usage:	Direct replacement for 1/8" OD O_2 electrodes
Probe Assembly:	1000 µm optical fiber, stainless steel ferrule
Dimensions:	3.175 mm OD, 63.5 mm length
Pressure:	300 psi

Ordering Information

FOXY-OR125	OR125 Sensor Probe with FOXY Formulation	$599
FOSPOR-OR125	OR125 Sensor Probe with FOSPOR Formulation	$599
HIOXY-OR125	OR125 Sensor Probe with HIOXY Formulation	$899

OR125-G & OR125-GT Sensor Probes

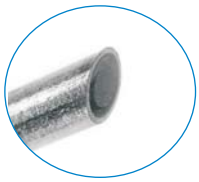
Typical Usage:	Direct replacement for O-ring grooved electrodes
Probe Assembly:	1000 µm optical fiber, stainless steel ferrule or titanium ferrule
Dimensions:	3.175 mm OD, 63.5 mm length
Pressure:	300 psi

Ordering Information

FOXY-OR125-G	OR125-G Sensor Probe with FOXY Formulation, SS ferrule	$599
FOSPOR-OR125-G	OR125-G Sensor Probe with FOSPOR Formulation, SS ferrule	$599
HIOXY-OR125-G	OR125-G Sensor Probe with HIOXY Formulation, SS ferrule	$899
FOXY-OR125-GT	OR125-GT Sensor Probe with FOXY Formulation, titanium ferrule	$649
FOSPOR-OR125-GT	OR125-GT Sensor Probe with FOSPOR Formulation, titanium ferrule	$649
HIOXY-OR125-GT	OR125-GT Sensor Probe with HIOXY Formulation, titanium ferrule	$979

Oxygen Sensor Probes

R Sensor Probe

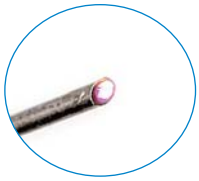


Typical Usage:	General Purpose
Probe Assembly:	1000 µm fiber in a stainless steel 1/16" OD ferrule
Dimensions:	1.587 mm OD, 152.4 mm length
Pressure:	300 psi

Ordering Information

FOXY-R	R Sensor Probe with FOXY Formulation	$499
FOSPOR-R	R Sensor Probe with FOSPOR Formulation	$499
HIOXY-R	R Sensor Probe with HIOXY Formulation	$749

AL-300 Sensor Probe

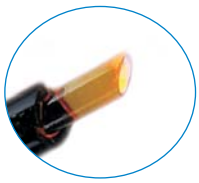


Typical Usage:	Fine spatial resolution applications
Probe Assembly:	300 µm aluminum-jacketed fiber assembly
Dimensions:	500 µm OD, 1 m length
Pressure:	300 psi

Ordering Information

FOXY-AL300	AL300 Sensor Probe with FOXY Formulation	$499
FOSPOR-AL300	AL300 Sensor Probe with FOSPOR Formulation	$499
HIOXY-AL300	AL300 Sensor Probe with HIOXY Formulation	$749

PI600 Sensor Probe



Typical Usage:	Environments where non-metallic probe is indicated
Probe Assembly:	600 µm optical fiber with silicone jacketing
Dimensions:	710 µm OD, 2 m length
Pressure:	300 psi

Ordering Information

FOXY-PI600	PI600 Sensor Probe with FOXY Formulation	$499
FOSPOR-PI600	PI600 Sensor Probe with FOSPOR Formulation	$499

T1000 Sensor Probe

Typical Usage:	Process environments, high-pressure applications
Probe Assembly:	1000 µm optical fiber, stainless steel ferrule
Dimensions:	6.35 mm OD, 177.8 mm length
Pressure:	3000 psi

Ordering Information

FOXY-T1000	T1000 Sensor Probe with FOXY Formulation	$999
FOSPOR-T1000	T1000 Sensor Probe with FOSPOR Formulation	$999
HIOXY-T1000	T1000 Sensor Probe with HIOXY Formulation	$1,499

T1000-RTD Sensor Probe

Typical Usage:	Process environments, has embedded RTD
Probe Assembly:	1000 µm optical fiber, stainless steel ferrule
Dimensions:	6.35 mm OD, 177.8 mm length
Pressure:	300 psi

Ordering Information

FOXY-T1000-RTD	T1000 Sensor Probe with FOXY Formulation	$1,499
FOSPOR-T1000-RTD	T1000 Sensor Probe with FOSPOR Formulation	$1,499
HIOXY-T1000-RTD	T1000 Sensor Probe with HIOXY Formulation	$1,499

Oxygen Sensor Accessories

Bifurcated Optical Fiber Assemblies and Splice Bushing

Our Y-shaped Bifurcated Optical Fiber Assemblies contain two fibers side-by-side in the common end of the assembly, which connects to the Sensor Probe. From the breakout of the assembly, the two fibers diverge into two legs, one connects to a spectrometer, the other to the excitation source. A 21-02 Splice Bushing is an adapter that connects an SMA 905-terminated Sensor Probe to a SMA-terminated Bifurcated Optical Fiber Assembly.

Item	Description	Price
21-02	Splice Bushing to connect Sensor Probe to Bifurcated Optical Fiber Assembly	$13
BIF-600-VIS-NIR	Laboratory-grade Bifurcated Optical Fiber Assembly	$329
QBIF-600-VIS-NIR	Premium-grade Bifurcated Optical Fiber Assembly	$369
QBIF-600-VIS-BX	Premium-grade Bifurcated Optical Fiber Assembly with BX cable jacketing (not shown)	$369

Sensor Probe *21-02 Splice Bushing* *Bifurcated Optical Fiber Assembly*

BIF-600-VIS-NIR Bifurcated Optical Fiber Assembly

QBIF-600-VIS-NIR Bifurcated Optical Fiber Assembly

Respiration Monitor "RESP" Sensor Probe

The FOXY-RESP is a fiber optic oxygen sensor for in situ respiration monitoring of oxygen tension in respiratory gases. The probe can be combined with a spectrometer and accessories to measure inspired and expired oxygen in real time -- valuable data that complements existing respiratory parameters and airway mechanic values. For remote monitoring, use the sensor with optical fiber of variable lengths. You can also configure the stable probe with a monochromator for wavelength-specific analysis. The sensor can be used in magnetic resonance imaging environments. The probe assembly contains 200 μm optical fiber in a plastic ferrule and is 6.35 mm OD and 107.9 mm in length. See the Planar Oxygen Sensors table below on purchasing -RESP-FILM, the membranes needed for the FOXY-RESP Probe.

FOXY-RESP: $549

Planar Oxygen Sensors

Though our fiber optic sensor probes work well in most solutions, some environments interfere with sensor performance by deteriorating the fluorescence irreversibly or by chemically attacking the coating. We offer a variety of coated substrates for testing or for applications where a probe is undesirable.

-GF

-SGS-M

Item	Description	Typical Usage	Price
-SGS	Custom coating service for coating various substrates (supplied by user or Ocean Optics) with different transducer materials, specify Sensor Formulation	qualitative, quantitative feasibility testing	Custom Pricing
-SGS-M	One 1" x 3" sol-gel spin-coated microscope slide, specify Sensor Formulation	qualitative, quantitative testing	$300
-GF	Pack of 5 sol-gel coated fiberglass filters, specify Sensor Formulation	qualitative, quantitative testing	$50
-RESP-FILM	Pack of 25 sol-gel coated glass fiber membranes for Respiration Monitor (above)	qualitative, quantitative testing	$50

Silicone Overcoats

We can apply silicone overcoats over FOXY and FOSPOR Oxygen Sensor Probes to improve chemical resistance, exclude ambient light and eliminate refractive index effects of the sample. We recommend an overcoat if you are using solutions or if you are switching between gases and solutions. Overcoats are free. (The HIOXY Sensor Formulation does not benefit from overcoats.)

Item	Description	Response in Gases	Response in Solutions
-AF	RTV silicone adhesive overcoat (overcoat increases response time), specify FOXY or FOSPOR Sensor Formulation	10-30 seconds	15-45 seconds
-AF-MG	High-strength RTV silicone adhesive overcoat is a medical implant-grade silicone -- a thicker and more robust coating than the -AF (overcoat increases response time); specify FOXY or FOSPOR Sensor Formulation	15-45 seconds	45-60 seconds (depending on viscosity)

Oxygen Sensor Accessories

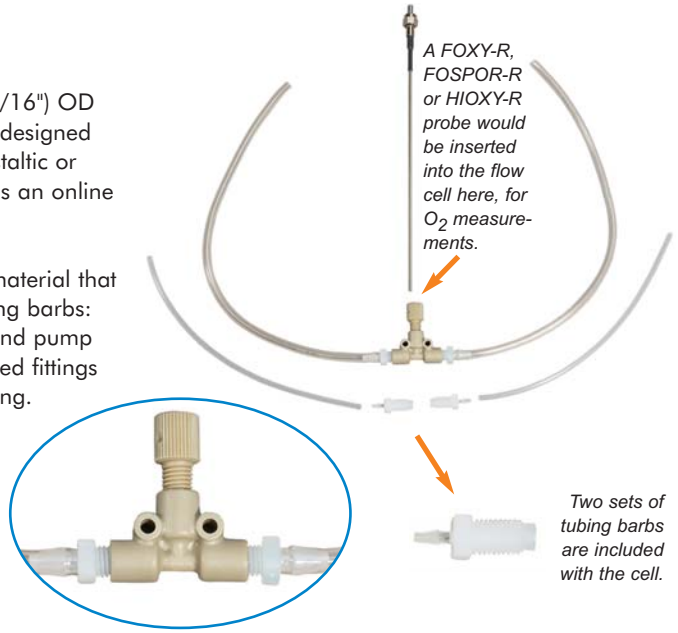
In-line Flow Cell

The FOXY-FLOW-CELL is an in-line flow cell for 1.587 mm (1/16") OD probes, such as the FOXY-R, FOSPOR-R and HIOXY-R. It was designed for use in a low-pressure flowing stream of liquid with a peristaltic or positive displacement pump. The flow cell also can be used as an online sampling accessory for 1/16" OD reflectance probes.

The flow cell is made of PEEK polymer, a radiation-resistant material that has excellent chemical resistance. Also included are four tubing barbs: two for 1/16" ID tubing and two for 1/8" ID tubing. (Tubing and pump are not included.) You can replace these fittings with other-sized fittings from Upchurch Scientific as long as they have 1/4-28 threading.

FOXY-FLOW-CELL: $100

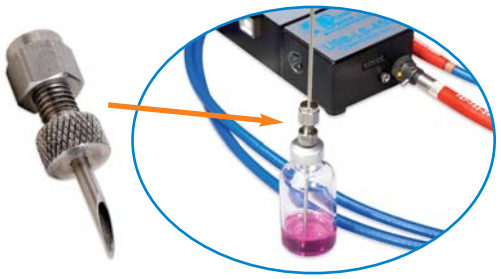
Specifications	
Tee:	Upchurch Scientific PEEK tee
Tubing barbs:	(2) 1/8" Tefzel tubing barbs, (2) 1/16" Tefzel tubings barbs
Ferrule:	1/16" PTFE ferrule
Nut:	1/16" PEEK nut
Threading size:	1/4-28
Pressure limits:	1000 PSI



Puncturing Needle

The Puncturing Needle is an Oxygen Sensor Probe accessory that allows 1.587 mm (1/16") outer diameter sensors -- such as the FOXY-R, FOSPOR-R and HIOXY-R (page 71) -- to puncture a septum and seal without damaging the sensor coating. The Puncturing Needle includes a 1/16" needle and a 1/16" Swagelok adapter to seal the sensor in place.

FOXY-R-PNA: $150



O_2 Acrylic Sampling Chambers, Respirometers

Our Acrylic Sampling Chambers are used by biologists and zoologists in dissolved oxygen sensing applications such as respiration rate and metabolic rate monitoring of fish and crustaceans. You can combine a sample chamber, probe, spectrometer and light source to configure a complete respirometer. The sampling chambers provide users with a fixed-volume environment. Each chamber cover is equipped with high-pressure (220 psi) polypropylene collars and a Swagelok fitting for an Oxygen Sensor Probe. The acrylic chambers have a temperature range of -30 °C to 82 °C and are FDA-approved for food applications. The polypropylene fittings are temperature rated from 0 °C to 100 °C. Each chamber has a watertight seal seated between the body and its cover.

Item	Acrylic Chamber Type	Dimensions (in mm)	Fittings	Price
RESP-CL2IN	Clear Round	44.4 ID x 139.7 length	1 bored 1/4" OD tubing fitting	$160
RESP-BL2IN	Black/Opaque Rectangle	139.7 x 50.8 x 50.8	1 bored 1/4" OD tubing fitting	$180
RESP-CL4IN	Clear Acrylic Round	95.2 ID x 139.7 length	2 bored 1/4" OD tubing fittings	$175
RESP-BL4IN	Black/Opaque Rectangle	140 x 101.6 x 101.6	2 bored 1/4" OD tubing fittings	$195
RESP-CL6IN	Clear Round	146 ID x 139.7 length	3 bored 1/4" OD tubing fittings	$190
RESP-BL6IN	Black/Opaque Rectangle	139.7 x 127 x 127	3 bored 1/4" OD tubing fittings	$210

Sensor Reconditioning/Recoating Service

Each Oxygen Sensor Probe contains a Sensor Formulation at its tip. Cleaning and protection from harsh environments will extend the life of the sensor. Severe biofouling, physical abrasion, and chemical etching of the glass may erode the sensing surface, requiring our probe recovery service. For -18G and -21G Needle Probes, we re-polish the probe and add a new needle tip for $125. For all other probes, we re-polish and re-coat the probe for $100. Specify FOXY, FOSPOR or HIOXY Sensor Formulation.

-RECOV: $100
-RECOV-N: $125

Oxygen Sensor Temperature Compensation

Our Fiber Optic Sensors are affected by temperature. Temperature affects the fluorescence decay time, fluorescence intensity, collisional frequency of the oxygen molecules with the fluorophore, and the diffusion coefficient of oxygen. The net effect: a change in the calibration slope. Because of this, the sample must be maintained at a constant temperature (±3.0 °C) for best results. If this is impractical, the sensor can be calibrated by measuring temperature and oxygen concurrently using one of our temperature-compensation accessories and in-house calibration services.

The USB-LS-450-TP Platinum RTD -- for use with the USB-LS-450 -- helps adjust for temperature changes.

In-house Temperature Calibration Services

If your sample cannot be maintained at a constant temperature (±3.0 °C), you can perform a temperature calibration in OOISensors Software or we can perform the calibration for you. The -CAL is an in-house factory-calibration service for environments from 0-80 °C. The -CAL-EXT is a factory-calibration service for extended temperature ranges below 0 °C or above 80 °C. You'll need to determine the temperature and O_2 concentration range of your sample environment before ordering an in-house calibration service. Be sure to specify the Oxygen Sensor Formulation (FOXY, FOSPOR or HIOXY) being used in the calibration.

-CAL: $199
-CAL-EXT: $299

Thermistor & Thermocouples for Ocean Optics Spectrometers

Item	Description	Price
FOXY-TS1	Thermistor is 1/8" outer diameter stainless steel tubular electrode probe that monitors temperatures from 0 °C to 100 °C; it most often is used for liquid immersion	$105
FOXY-T-MOD-1	An RS-232 module interfaces up to four of the FOXY-TS1 Thermistors to your PC	$500
FOXY-TK1	Thermocouple is a 1/8" outer diameter K-type electrode that monitors temperatures from -150 °C to 220 °C	$105
FOXY-TK1-W	Wire-type thermocouple that monitors temperatures from -150 °C to 220 °C	$105
FOXY-T-MOD-K	An RS-232 module interfaces up to four of the FOXY-TK1 Thermocouples to your PC	$500

RTDs for Sensing Temperature Changes

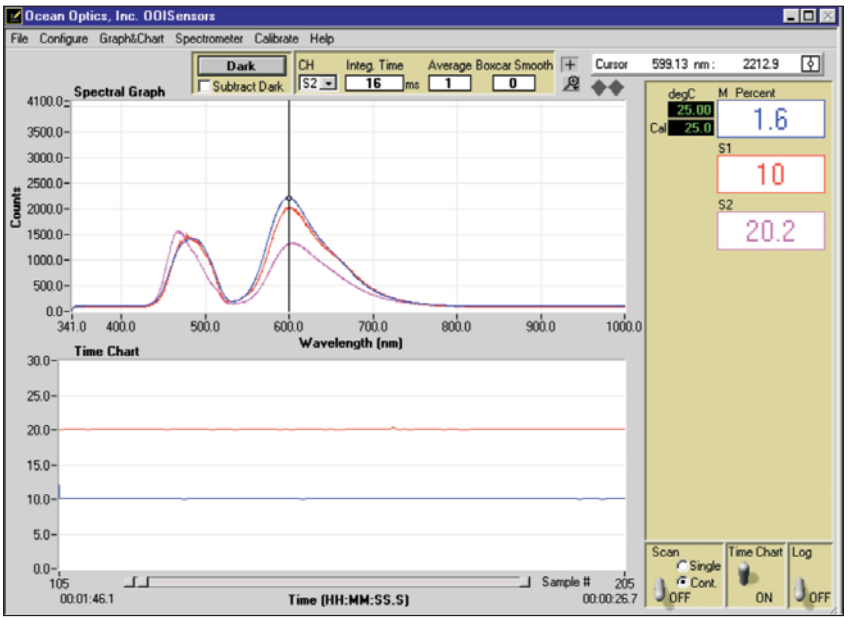
We offer three RTDs to adjust for temperature changes. The USB-LS-450-TP is a 1/8" outer diameter, 100 ohm platinum RTD that connects to the USB-LS-450 Excitation Source (see page 131). The USB-LS-450's onboard memory can be programmed to store temperature and oxygen calibration coefficients. The USB-LS-450-TP16 is a 16-gauge needle RTD, also for use with the USB-LS-450.

The -T1000-RTD (at right) is a -T1000 probe, but with an embedded RTD in the 1/4" outer diameter casing. When ordering the -T1000-RTD, be sure to specify the FOXY, FOSPOR or HIOXY Sensor Formulation being applied to the -T1000 Probe tip.

USB-LS-450-TP: $99
USB-LS-450-TP16: $249
FOXY-T1000-RTD: $1,499
FOSPOR-T1000-RTD: $1,499
HIOXY-T1000-RTD: $1,499

Sensor Software

OOISensors Software is a 32-bit, advanced acquisition and display program that provides a real-time interface to display and processing functions for use with our O_2 and pH sensors as well as with Ocean Optics spectrometers and the MultiFrequency Phase Fluorometer. OOISensors can acquire data, convert the data into concentration values, and save the data in spectral files and logs. The software has the ability to perform timed experiments and to display and correct for temperature fluctuations and for atmospheric pressure changes in the sample. It can also display pH values when used with our pH probe.



OOISensors Software gives you the opportunity to view spectral data from multiple spectrometer channels (top part of the graph) as well as collect and view oxygen, sensor or pH data over time (bottom part of the graph).

OOISensors features include:

- Obtains oxygen partial pressure, pH or concentration values from sensors
- Contains easy-to-use functions for all system parameters
- Performs time acquisition experiments
- Collects data from up to eight spectrometers simultaneously and displays the results in a single window
- Allows each spectrometer channel to have its own data acquisition parameters
- Monitors temperature (when using one of the temperature sensors on page 74), displays temperature data and corrects the data for any fluctuations in temperature and pressure
- Supports oxygen calibration procedures with first-order linear Stern-Volmer algorithm and with second-order polynomial algorithm to provide more accurate data
- Displays a time chart with the data from all active channels at a specific wavelength over time
- Allows user to enable Data Logging function and add experiment notes to a log file
- Works with all Windows 95/98/XP/2000/NT Operating Systems

OOISensors: $199

Pocket Carbon Monoxide Meter

Size as shown.
The tiny Pocket CO runs on a watch battery.

Carbon monoxide (CO) is a colorless, odorless, poisonous gas. Appliances fueled with natural gas, liquefied petroleum, oil, kerosene, coal, or wood may produce CO. Burning charcoal and running cars produce CO. Every year, hundreds of people in the United States die from CO produced by fuel-burning appliances and cars left running in attached garages.

The Pocket CO Carbon Monoxide Meter from Transducer Technology, Inc., is a technically advanced, long-life electrochemical sensor (patents pending) combined with a microprocessor for convenient and reliable monitoring of CO. The sensor's features allow CO monitoring, spot check measurements and CO dosimetry.

The Pocket CO is warrantied for one year. After one year, we recommend a recalibration of the sensor and battery change for best performance.

CHEMSEN-CO: $149

Specifications	
Size:	2.4" x 1.4" x 0.6"
Weight:	Less than 1 ounce, 20 grams
Material:	Impact resistant plastic case
Range:	0-600 ppm CO
Accuracy:	+/- 10% of reading at standard conditions
Response time:	Less than 30 seconds to 90%
Warm-up time	2 seconds (CO is measured every 2 seconds)
Operating life	1 year minimum
Operating temperature:	32 °F to 105 °F, or 0 °C to 40 °C
Temperature limits:	10-120 °F; 3-50 °C
Pressure effect:	Reading decreases with decreasing pressure, to 70% at 10,000 ft.
Humidity limits:	0-100% RH, non-condensing
Alarms, visual, audio:	CO level greater than 25 ppm CO level greater than 125 ppm Temperature greater than 105 °F or 40 °C Temperature less than 32 °F or 0 °C
Interferences:	None significant, except hydrogen

Fiber Optic pH Sensors

Sensor Holds Indicator Dyes

The Fiber Optic pH Sensor system consists of a fiber optic probe designed to hold immobilized colorimetric indicator dye materials, plus a light source, spectrometer and OOISensors Software. You can supply your own indicator material, or select from our line of transparent or reflective films. Calibration involves recording spectra in high and low pH samples, and in at least one pH standard such as a NIST-traceable buffer.

Transmissive & Reflective pH Films

Transmissive films are for clean, transparent samples. These films consist of a cellulose mechanical matrix surrounded by a hydrophilic polymer that entraps the indicator dye. Reflective films are used for turbid or absorbing media. When immersed in water, the film dyes may leach very slowly over time and will have to be replaced. The film response rate is slow (on the order of minutes), being limited by diffusion of ions into the material. Increasing stirring speed, ionic strength and temperature all tend to increase the response rate and do not affect the pH measurement. Nearly any aqueous sample environment is suitable, as are some solvents.

TP300 Probe

The TP300-UV-VIS Probe (at right) is a chemically inert PEEK transmission probe that can be equipped with a tip (RT-PH) for mounting transmissive films in the optical path. Light is directed via one fiber through the mounted film to a mirror. Then light is redirected back through the film to a receive fiber that returns the light to the spectrometer. The sample is free to flow over the sides of the film. By using an RTP-2-10 (adjustable from 2-10 mm) or RTP-10-20 (adjustable from 10-20 mm) transmission tip, the TP300-UV-VIS can be used for routine transmission measurements. See page 151 for details.

TP300-UV-VIS: $750
RT-PH Tip: $240

RFP200 Probe

The RFP200-UV-VIS Reflective Film Probe consists of a 6-around-1 fiber bundle in a chemically inert 6.35-mm outer diameter Torlon body. The open tip of the probe screws onto the body to hold 3.17-mm to 4.76-mm discs of reflective indicator material. The 6-fiber leg attaches to the light source; the central fiber leg connects to the spectrometer. The sample has access to the sensing material from one side only.

RFP200-UV-VIS: $499

Use transmissive films with the TP300-UV-VIS Probe for transparent samples. Use reflective films with the RFP-200-UV-VIS Probe for turbid, dense samples.

Transmissive Indicator Dye Films for pH Sensing

Item	Film Type	pH Range	Color Change	Price
F-PR	Phenol Red	6.5-8.5	yellow-purple	$50
F-CR	Cresol Red	8.0-10.0	orange-purple	$50
F-MCP	m-Cresol Purple	8.5-10.5	yellow-purple	$50
F-TB	Thymol Blue	9.0-12.0	yellow-purple	$50
F-BY	Brilliant Yellow	7.0-9.0	yellow/red-purple	$50
F-xxx	Transparent Film	reference	not applicable	$50
FILM300	Sample pack of transmissive films			$50

All pH films come in packages of 5 films.

Reflective Indicator Dye Films for pH Sensing

Item	Film Type	pH Range	Color Change	Price
FR-PR	Phenol Red	6.5-8.5	yellow-purple	$50
FNY-PR	Phenol Red Nylon	6.5-8.5	yellow-purple	$50
FR-CR	Cresol Red	8.0-10.0	orange-purple	$50
FR-MCP	m-Cresol Purple	8.5-10.5	yellow-purple	$50
FR-TB	Thymol Blue	9.0-12.0	yellow-purple	$50
FR-BY	Brilliant Yellow	7.0-9.0	yellow/red-purple	$50
FILM	Sample pack of reflective films			$50

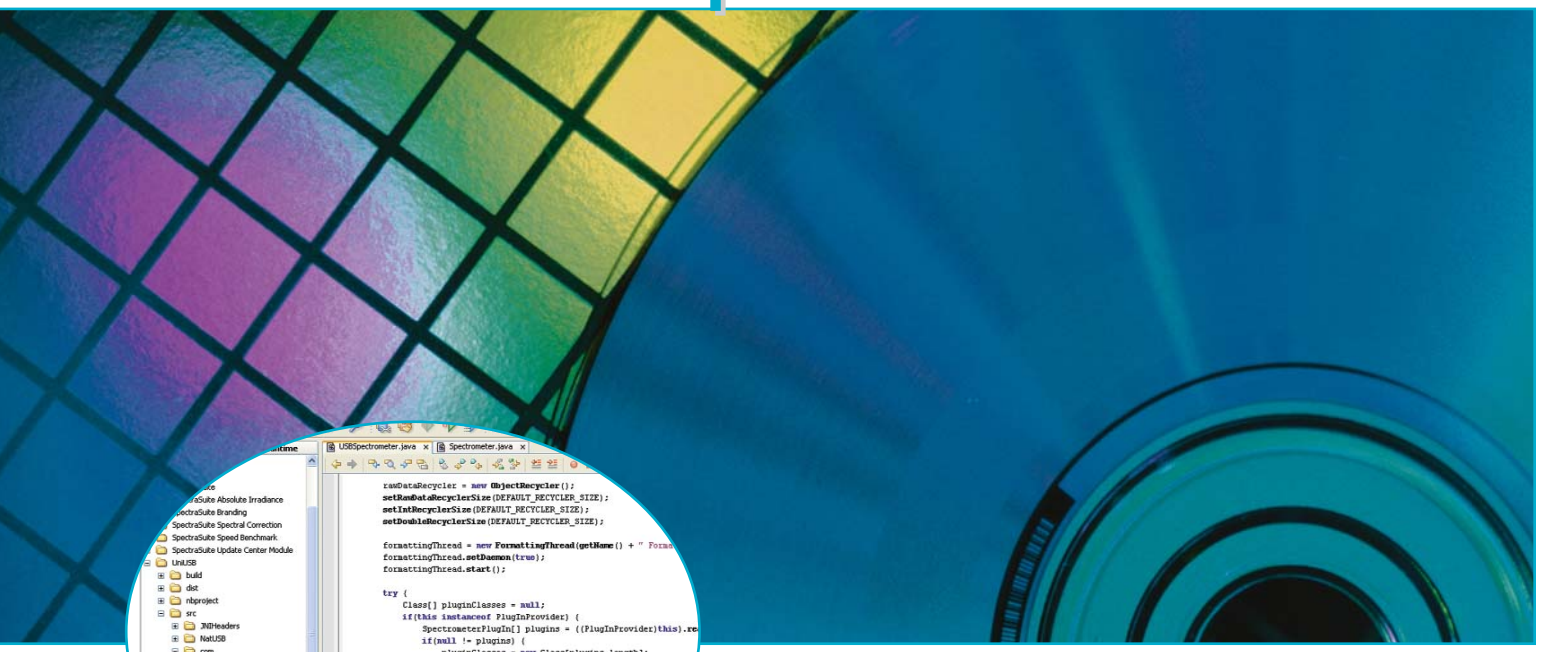
All pH films come in packages of 5 films.

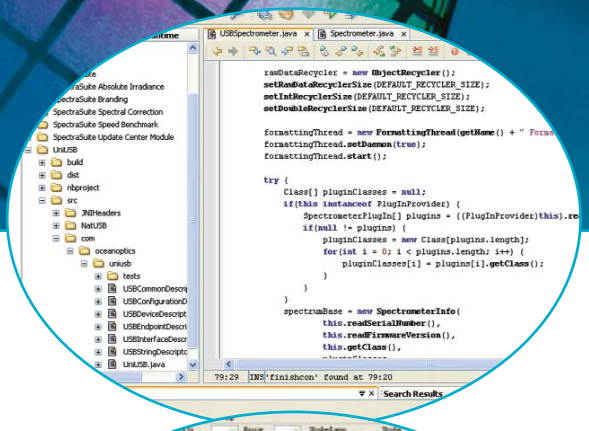
Phenol Red pH Test Kit

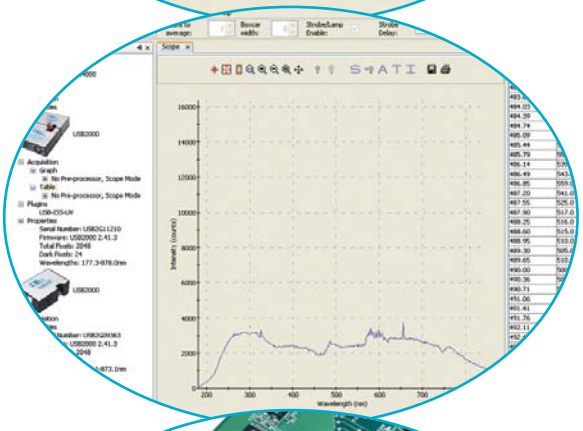
The CHEMTEST-PH is a Phenol Red pH Test Kit that includes 100 tests in cuvettes with covers. The CHEMTEST-PH can be used to determine the pH level in solution. Simply add 3 mL solution to a cuvette, cap it, shake the cuvette to disperse the dye, and then measure the absorbance value of the reactive color to determine the pH level. CHEMTEST-PH works with any Ocean Optics system that is configured for absorbance, including the CHEM4-series Spectrophotometers on pages 36-37. Software included.

CHEMTEST-PH: $99

Software & Data Acquisition







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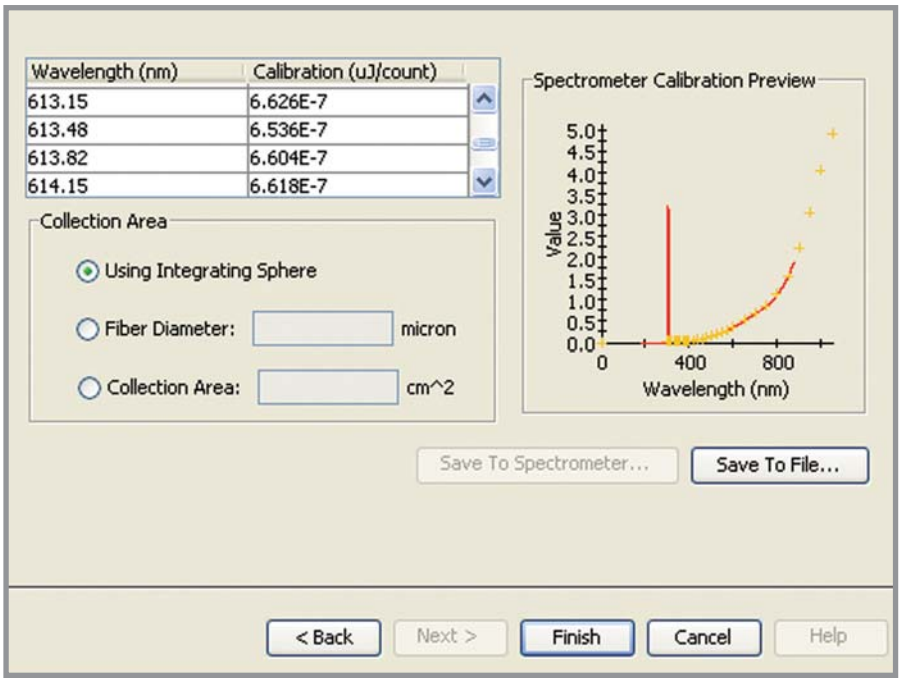
84 Analog-to-Digital Converters

Overview: Software & Data Acquisition

Real-time Interface to the PC of Your Choice

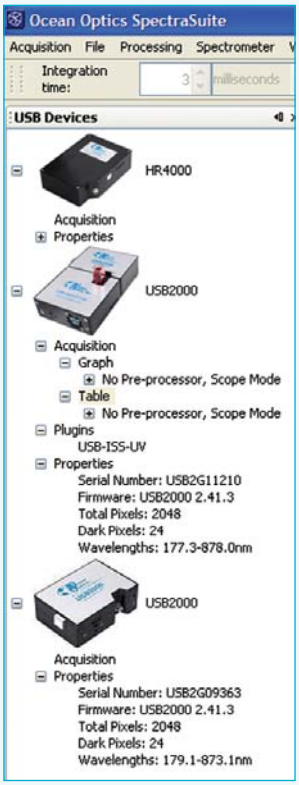


Ocean Optics data acquisition options allow you to interface your spectrometer to any desktop or notebook PC, whether it operates in Mac, Linux or Windows operating systems. Our plug-and-play spectrometers connect directly to the USB port of any desktop or notebook PC. We also offer external analog-to-digital converters, including USB and PCI-bus cards.

Real-time data acquisition for almost any type of application is made possible by our new operating, application and software development packages. We also offer custom software-development services.

The Joys of Java

SpectraSuite and OmniDriver: Multi-platform Marvels



You spoke, we listened. After nearly 15 years and thousands of spectroscopy applications, we've taken the best of your suggestions -- and added a few clever wrinkles of our own -- to create the industry's first modular, operating system-independent spectroscopy software platform and driver. SpectraSuite, a Java-based spectroscopy software that operates on Windows, Macintosh and Linux operating systems, offers a host of robust features for remarkable power and flexibility.

Like SpectraSuite, OmniDriver is cross-platform, Java-based software. It combines the best of our earlier device driver packages -- high-speed data acquisition, customization of acquisition and processing parameters, and so on -- with additional features to make it the only spectroscopy driver you'll ever need.

There's much more on SpectraSuite and OmniDriver in the next few pages -- so prepare to be dazzled.

More About Java

One of the most important decisions in developing SpectraSuite and OmniDriver was the selection of Java as the programming language. Java is an object-oriented programming language, developed in the mid-'90s by Sun Microsystems, Inc., that was designed as a robust, platform-independent programming environment that manages memory on its own. (When it comes to distributed applications, nothing beats Java. For additional information, visit java.sun.com.) We've taken Java a step further by making it platform- and spectrometer-independent -- i.e., the same code works for all of our USB-based spectrometers.

Overview: Software & Data Acquisition

It's long been a goal of ours to create one hardware device driver program that would control all of our hardware as well as other manufacturers' devices, from any type of computer operating system environment and from which all software applications would run. The answer was to use Java as the programming language. Java was designed to be platform-neutral, making it the perfect programming language for our customers around the globe. Aside from the additional power and flexibility our software packages provide, SpectraSuite and OmniDriver will affect customers in two significant ways. First, there is a $199 charge for SpectraSuite, a price that's comparable to what our competitors offer. Second, all existing Ocean Optics software will no longer be upgraded -- supported, yes; upgraded, no. Here's some additional important information about the transition to SpectraSuite and OmniDriver:

Q Did SpectraSuite replace OOIBase32? Is there a charge for SpectraSuite?

A Yes, SpectraSuite replaced OOIBase32, and yes, there is a charge for SpectraSuite -- $199. OOIBase32 is no longer being upgraded and does not work with spectrometers developed after August 2005. If you purchase a spectrometer today, you should include SpectraSuite in your order.

Q Can I upgrade from OOIBase32 to SpectraSuite?

A Absolutely. Upgrade to SpectraSuite for $199. Be sure to check with an Application Sales Engineer to make sure your spectrometer will work with SpectraSuite.

Q Which Ocean Optics software did SpectraSuite and OmniDriver replace?

A OOIBase32 Spectrometer Operating Software, OOIBase32 Platinum Script-writing Software, OOIChem Software for Education and OOIIrrad Irradiance Software; plus the OOIWinIP Windows Interface Package, OOILVD LabVIEW Software Device Driver Package, OOIHSD High-speed Driver Library and OOISPM Spectral Processing Module. Windows CE tools such as OOIPS2000-S Operating Software and OOIHIP Handheld Interface Package have become obsolete.

Q What about existing applications software?

A SpectraSuite is the platform for all future Ocean Optics application software development. At press time, OOISensors and OOILIBS Software are scheduled to migrate to the SpectraSuite platform later in 2007.

Q Will Ocean Optics continue to support earlier versions of its software?

A Yes, we will continue to technically support old versions of all of our software products and, if necessary, post software fixes on our website. In fact, we still occasionally get support questions about SpectraScope -- our original spectrometer operating software, which is older than dirt in software years. What we won't do is upgrade any older software with new features, nor will we upgrade older software to work with Ocean Optics hardware developed after August 2005.

UV-VIS Spectral Database

Ocean Optics has teamed with science-softCon to present the 4th edition of the science-softCon UV-Vis Spectral Database. This is one of the most extensive UV-Vis databases now available, with nearly 3,000 entries (in ASCII format) for some 400 substances. The database includes the following substance groups:

- Alkali Compounds
- Aromatic Compounds
- Dyes
- Halogenated Alkanes, Alkenes
- Halogenated Carbonyl Compounds
- Halogenated Nitrogen Compounds
- Halogens/Halogenoxides
- Hydrocarbons
- Hydrogenhalides/Hypohalides
- Nitrogen Acids
- Nitrogen/Nitrogen Oxides
- Organic Acids/Esters
- Organic Carbonyl Compounds
- Organic Nitrogen Compounds
- Other Oxygenated Organics
- Oxygen Hydrogen Compounds
- Pesticides
- Sulfur Compounds

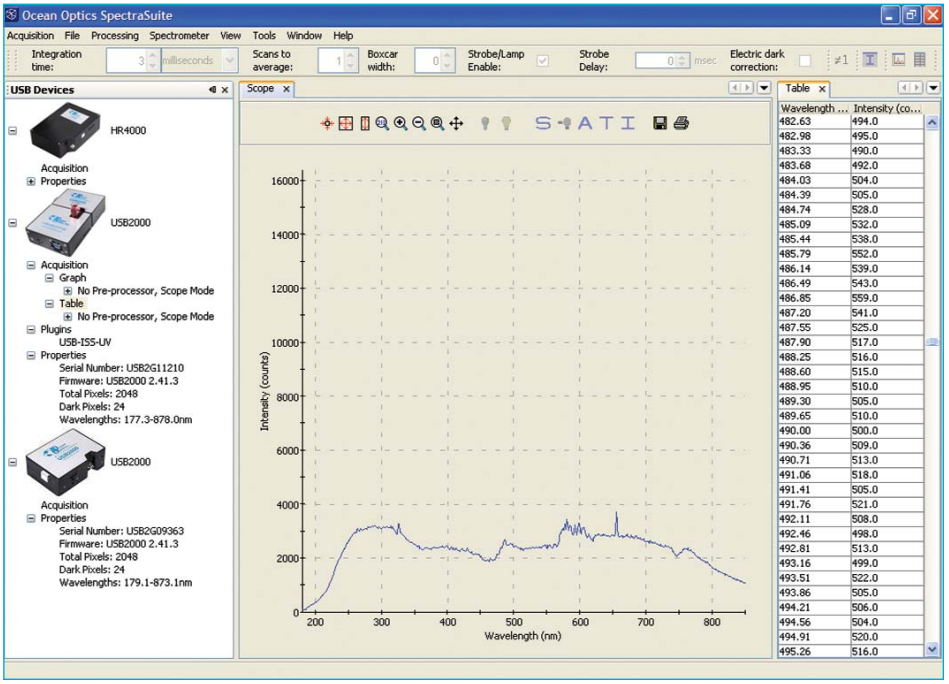
This price of the database includes a CD with science-softCon's UV/Vis Spectral Database and a one year unlimited online free subscription to the most up-to-date and comprehensive spectral data available.

CD-SPECTRA: $195

SpectraSuite Spectroscopy Software

The New Revolution

In 1992, we revolutionized the optical sensing industry when we introduced the first-ever modular, miniature spectrometer. Now, with more than 85,000 spectrometers sold and the experience of thousands of applications, we're kick-starting the market again with SpectraSuite, the first modular, OS-independent spectroscopy software platform.



SpectraSuite is a platform-independent application that provides graphical and numeric representation of spectra in one window.

Spectroscopy on any Operating System

SpectraSuite is a completely modular, Java-based spectroscopy software platform that operates on Windows, Macintosh and Linux operating systems. The software can control any Ocean Optics USB spectrometer and device, as well as any other manufacturer's USB instrumentation (using the appropriate drivers). The SpectraSuite interface looks and feels the same on all operating systems yet retains the familiar appearance of an application native to each OS. Ocean Optics is the first to offer such a flexible, feature-packed application with this level of cross-platform capability.

Our Platform for the Future

SpectraSuite is the platform for all future Ocean Optics application software development. Software applications including OOIChem, OOIColor and OOIIrrad-C have been migrated to the SpectraSuite platform, with applications such as OOISensors and OOILIBS coming in the near future.

Ultimate USB Spectrometer & Device Control

SpectraSuite easily manages multiple USB spectrometers -- each with different acquisition parameters -- in multiple windows or on the same graph in a single window -- and provides graphical and numeric representation of spectra from each spectrometer. Using SpectraSuite, you can combine data from multiple sources for applications that include upwelling/downwelling measurements, dual-beam referencing and process monitoring.

Modular Framework Lets SpectraSuite Work The Way You Work

The SpectraSuite framework is modular, so that every function in it can be altered or replaced. For instance, the data acquisition functions, the scheduling functions, the data processing functions and the rendering functions are all separate modules. You can add or delete modules to create a proprietary user interface or functionality, create modules to perform calculations, automate experiment routines and more. You or your Ocean Optics application developer can easily customize SpectraSuite through Java code.

SpectraSuite

Can be used with these Ocean Optics products when interfacing to a computer via USB port:

Spectrometers

HR2000
HR2000+
HR4000
MMS-Raman
NIR256-2.1
NIR256-2.5
NIR512
QE65000
USB2000
USB2000+
USB2000-FLG
USB4000

Other Devices

ADC1000-USB A/D Converter
SHA-1 Spectral Hyper Adapter

SpectraSuite Spectroscopy Software

Original Equipment Manufacturers

OEMs in particular will find SpectraSuite's modularity most beneficial, as all visual aspects of the program's user interface can be altered to create a fully branded application.

Advanced Data Capture Control

SpectraSuite provides the user with advanced control of episodic data capture attributes. For instance, a user can acquire data for a fixed number of spectra or for a specific interval. Initiation of each spectrum can be externally triggered or event-driven. Captured data is quickly stored into system memory at speeds as fast as one spectrum per millisecond, with speeds limited by hardware performance.

SpectraSuite in the Future

SpectraSuite is constantly evolving. Be sure to check for updates via SpectraSuite's Update Center. With the purchase of SpectraSuite, you are entitled to one year of free, web-based automatic upgrades. Future enhancements include:

- SpectraSuite will soon be 21 CFR Part 11 compliant with an encoded binary file. This binary data format will track the complete history of all processing steps that are performed on your data.
- SpectraSuite will allow users "process do-overs." A user will be able to change the values of various parameters in a process and apply those changes to data without having to recreate an entire process.
- SpectraSuite will store and provide data in new formats, such as JCAMP.
- SpectraSuite will offer a database module where arbitrary data can be stored in any user-selectable format.
- SpectraSuite will be fully "internationalized." All of the software's menus, dialog boxes, prompts, messages and files will be able to reflect a native language by simply changing a single file.

SpectraSuite Pricing

Item	Description	Price
SPECTRASUITE	One copy of SpectraSuite	$199
SPECTRASUITE-U	Annual upgrade subscription fee	$99
SPECTRASUITE-20	Site license for SpectraSuite allows up to 20 copies	$1,499
SPECTRASUITE-E	Site license for SpectraSuite allows up to 40 copies for educational institutions only	$2,499
SPECTRASUITE-S	Site license for SpectraSuite allows unlimited copies	$4,999

All-In-One SpectraSuite

Check out our long list of new SpectraSuite features. Note that most of the features from our other Application Software Packages, such as OOIIrrad Software for Color & Irradiance and OOIChem Software for the Teaching Lab, have migrated to SpectraSuite.

General Features

- Allows users to annotate graphs and to specify format and precision of displayed values
- Displays a color spectrum behind graphs
- Corrects for non-unity for reflection measurements
- Performs reference monitoring
- Displays x-axis in GHz, microns, pixel number, Raman shifts, wavenumbers or nanometers
- Provides an Experiment Wizard that guides users on configuring common experiments
- Acquires data from one spectrometer using different parameters to run multiple experiments
- Stores data in other formats such as tab-delimited ASCII (for Excel or other analysis packages) and GRAMS SPC

Features for Reflective & Emissive Color & Absolute Irradiance

- Provides dominant wavelength and wavelength purity
- Provides radiometric and color analysis
- Analyzes peak wavelength, full width at half max, centroid and central wavelength
- Measures absolute spectral intensity of light and other emission sources
- Calculates integrated intensity between user-specified wavelengths
- Obtains photopic or scotopic data calculated in lumen, lux and candela based on CIE standards
- Provides microjoules, microwatts, number of photons and much more
- Calculates reflective or emissive color
- Provides chromaticity diagram of color-space values
- Offers CIE standard illuminants for reflective color (A, B, C, D50, D55, D65, D75, E, F1-F12, etc.)
- Calculates L*a*b*, XYZ, xyz, u'v'w', hue, chroma, CCT (correlated color temperature), saturation, and more

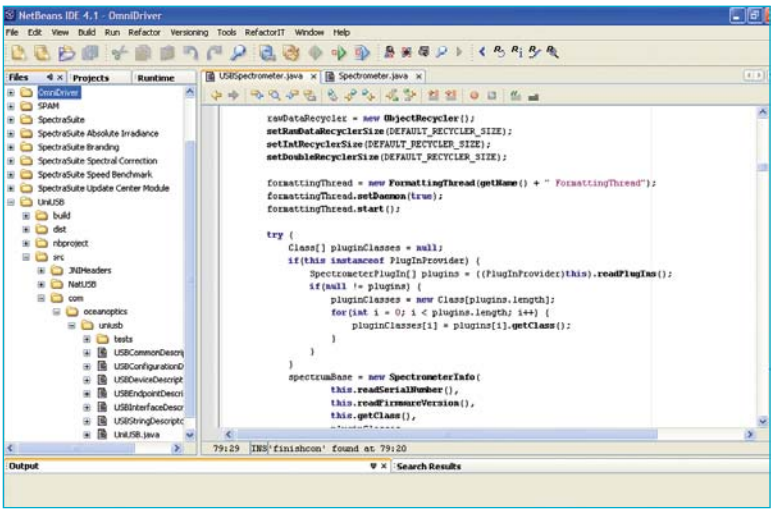
Features for Chemistry Teaching Labs

- Provides an easy-to-follow format ideal for undergraduate-level students and beginning spectroscopists
- Contains five modes of operation: Scope, Absorbance, Transmission, Relative Irradiance and Concentration
- Includes a Beer's Law spreadsheet for performing calibrations from standard solutions
- Adds into the spectral window previously saved overlay spectra
- Performs kinetics experiments
- Saves data as ASCII files and stores and retrieves sample spectra

OmniDriver Development Platform

More Than a Device Driver

OmniDriver is the culmination of our best software driver packages. It allows you to harness the power of high-speed data acquisition, spectral processing, data analysis, visual data representation and data flow in a single cross-platform driver. Integrate OmniDriver into your own software application for complete control over USB spectrometers and devices in virtually any environment.



Developed in Java

It's long been a goal of ours to create one hardware device driver program that would control all of our hardware as well as other manufacturers' devices, from any type of computer operating system environment and from which all software applications would run. The answer was to use Java as the programming language. Java was designed to be platform-neutral, making it the perfect programming language for our customers around the globe. OmniDriver was created in the Java environment and includes native libraries for select Windows, Macintosh and Linux operating systems. Using OmniDriver, you can develop robust applications to control multiple Ocean Optics USB spectrometers and direct-attach devices across these different operating systems. Ocean Optics is the first and only provider in the optical sensing industry to offer this level of cross-platform compatibility.

OmniDriver

Can be used with these Operating Systems

Windows	**Windows 2000 or later**
Macintosh	**OSX 10.2 or later**
Linux*	**RedHat 9 or later**
	Fedora Core, any version
	Debian 3.1 (Sarge)
	Suse, 9.0 or later

** OmniDriver will work with any Linux OS with a kernel 2.4.27 or later and libstdc ++ version 5.*

Complete Platform & Device Independence

Applications written in Java are environment-independent; they can work across all operating systems. This is an advantageous feature for product developers and OEMs wanting to expand their product offering with systems that work on multiple operating platforms. In developing OmniDriver, we took the Java philosophy a step further to create a device driver that is not only platform-independent, but also spectrometer-independent; the same Java code works with all Ocean Optics USB spectrometers and direct-attach devices. Plus, OmniDriver can control any manufacturer's USB spectrometer and supports any USB device.

"I don't know how to program in Java"

Chances are you know how to program in C, C++, Pascal, Visual Basic, Delphi, C++ Builder or one of many Microsoft Office Applications. You don't need to know Java to use OmniDriver. Our wrapper libraries take care of the Java code; we provide Framework (Mac), Dynamic Link Library (Windows), Shared Object (Linux), .NET object (Windows) and LabVIEW 7.0.

OmniDriver Components

OmniDriver is a fully functional cross-platform USB device driver library. It allows software to communicate with any USB device on any Windows, Macintosh or Linux operating system. What does it take to make such a robust driver? OmniDriver offers these components:

- **HighResTiming:** Time stamping that is accurate to sub-microsecond performance; great for chemical kinetics and other applications that require complex time accountability.
- **SPAM:** You'll want this SPAM. Spectral Processing and Manipulation performs all spectral processing math from subtracting dark to radiometric color analysis. SPAM provides you with the ability to harness spectral processing commands for your own applications but does not require you to use Ocean Optics spectrometers or hardware. SPAM is available as a stand-alone module or as part of the OmniDriver package (OMNI+SPAM).

OMNIDRIVER:	$399
SPAM:	$199
OMNI+SPAM:	$499

SpecLine Software for Compound ID

Identifies Elements & Compounds

SpecLine Software is a powerful new tool designed for identifying atomic emission lines and molecular bands in spectral data. SpecLine's advanced evaluation, search, compare and identify functions -- and its extensive library of over 100 elements and over 400 compounds -- enable you to quickly identify unknown lines, peaks and bands. SpecLine was designed for scientists, engineers and researchers using emission spectroscopy in fields such as astrophysics, the plasma sciences, and plasma processing.

Searching and Comparing Data

In the Line Identification window, you can define all the parameters for your search in a Periodic Table screen (top right), and begin the process with just a single click. SpecLine can analyze even the most complex spectral data, including spectra with double lines, line shoulders and complex band structures. Up to 12 separate spectra, even if they are in different file formats, can be combined for comparative purposes.

Identification

SpecLine applies a variety of sophisticated filter functions such as Wiener-Fourier and polynomial noise removal to identify the elements and compounds in your spectra. After SpecLine applies comparative searches to its extensive atomic, ionic and molecular database of over 100 elements in several ionization states and over 400 elemental compounds, it provides detailed data on each identified peak and line, such as the name of the element, the peak's wavelength, the electron voltage and its transition state and quantum number.

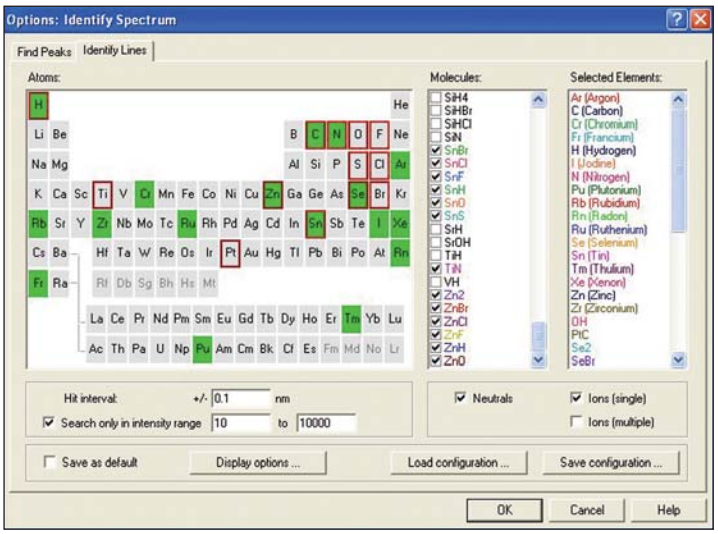
Opening Spectra & Saving Data

SpecLine can analyze spectral data from various spectroscopy software applications; it also can open all Ocean Optics software file formats as well as SPC and ASCII file formats. In addition, you can save all of SpecLine's identification data in its native file format or export it into various applications, such as Excel.

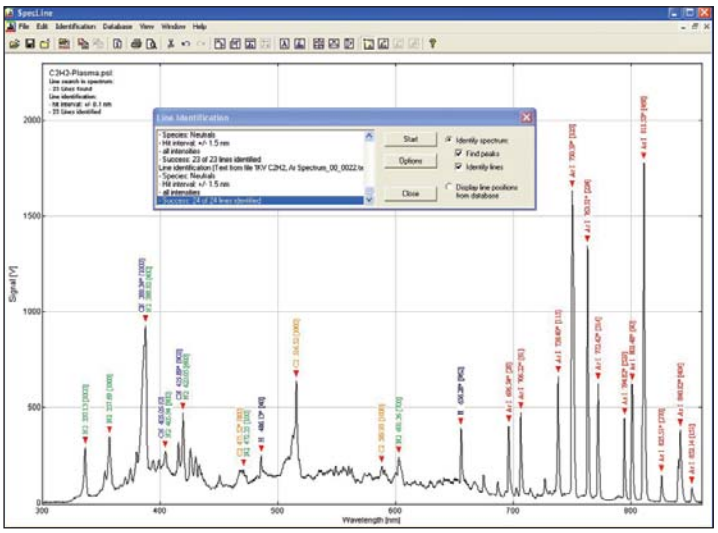
Hardware Keys

SpecLine Software comes with a USB or parallel-port (printer port) hardware key. The key is a security device to protect against unlicensed copies. It connects to an input/output port on your computer and must be used to run the software. SpecLine-U comes with a USB hardware key for use with Windows 98/2000/ME/XP operating systems (but not Windows 95 or NT). SpecLine-P comes with a feed-through parallel port hardware key.

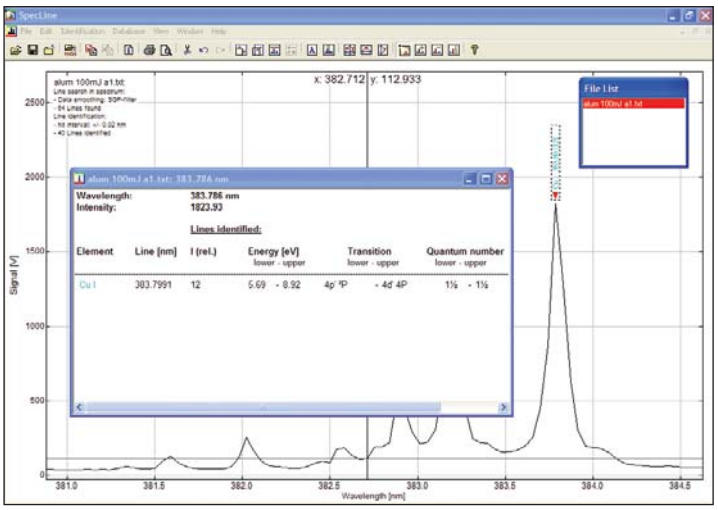
OOISPECLINE-P: $3,510
OOISPECLINE-U: $3,510



In the Identify Lines window, you can search atoms from a Periodic Table, molecules from an extensive list, and elements in single or multiple ionization states.



In this window, a search on the peaks and lines in a spectrum has been completed and identified successfully.



This window demonstrates SpecLine's ability to provide detailed data on just one emission line.

Analog-to-Digital Converters

ADC2000-PCI+ for PCI-bus

- This A/D card has 2 MHz sampling frequency for data acquisition within 2 milliseconds
- Channel rotator function acquires data from up to eight spectrometer channels simultaneously
- Has standard modes for free-running operation and external trigger modes for synchronizing external events
- Processes full spectrum into memory every 5 milliseconds
- Half-length, 12-bit A/D card fits easily into a PCI-bus slot in a PC and connects to the spectrometer via a 1-meter CBL-2 cable (included)
- Additional PC slot protector provides eight digital inputs/outputs and eight analog outputs (analog outputs incur additional fees)
- Provides advanced features such as pixel rotation with no loss of resolution

ADC2000-PCI+: $699
CBL-2 Cable: $50 (included)

ADC1000-USB for External USB

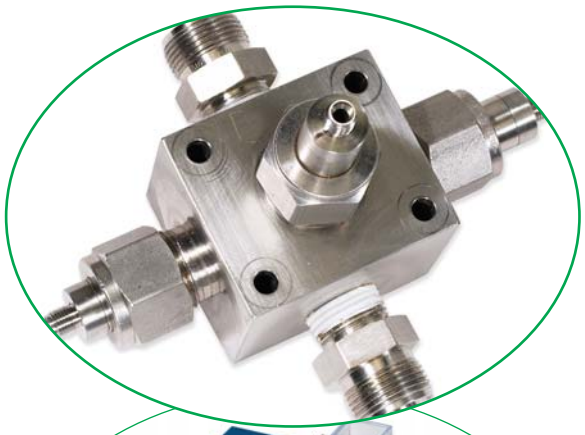
- Easily connects to PCs via USB port or serial port
- 1 MHz sampling frequency enables acquisition of data in 3 ms
- Plugs directly into back of your existing spectrometer (as in the main picture at right), or can be stacked or rack-mounted with the spectrometer in the same housing (see insets, one with housing and one without)
- Channel rotator function enables simultaneous acquisition of data from up to eight spectrometer channels
- Has standard modes for free-running operation and external trigger modes for synchronization of external events
- Provides D-Sub-15 pass-through for triggering the spectrometer and other accessories

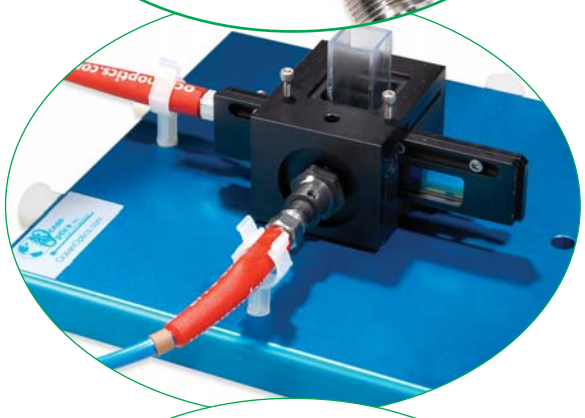
ADC1000-USB: $599
USB-CBL-1 USB Cable: $25 (included)
ADC-USB-SER Serial Cable: $49 (not included)

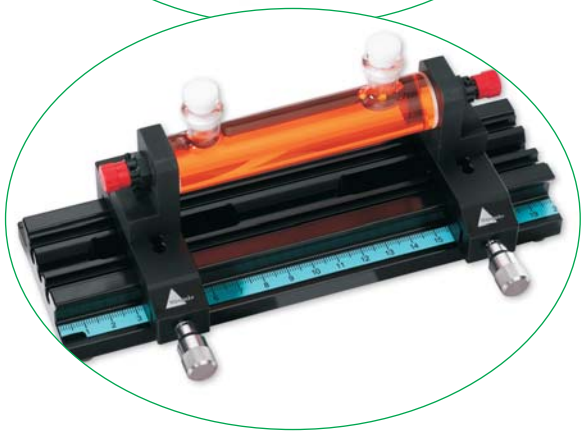
Specifications

	ADC2000-PCI+	ADC1000-USB
Dimensions:	168.8 mm x 127.9 mm x 18.3 mm	105.83 mm x 104.9 mm x 40.9 mm
Weight:	90 g	230 g
Power consumption:	250 mA @ 5 VDC	150 mA @ 5 VDC
Sampling frequency:	2 MHz (maximum)	1 MHz (maximum)
Integration time:	2 milliseconds to 60 seconds	3 milliseconds to 60 seconds
Data transfer rate:	Full spectrum into memory every 4 milliseconds; software time acquisition ~25 ms	Via USB port, full spectrum into memory every 14 milliseconds; via RS-232, full spectrum into memory every 300 milliseconds
Programmable flash delay:	0-65 seconds	0-255 milliseconds
Inputs/Outputs:	8 digital I/Os	8 analog outputs, requires ADC-1000-DAC
Shutdown S2000 power:	Yes	No
Spectrometer compatibility:	Supports S2000 Spectrometers	Supports S2000 and S1024DW Spectrometers
Board architecture/design:	32 bit/PCI bus	USB and RS-232 interface external A/D board
Operating systems:	Any 32-bit Windows operating system	Via USB port, Windows 98/Me/2000/XP, Mac OS X and Linux Via RS-232, any 32-bit Windows operating system
Interface cable:	Comes with a 25-pin, 1-meter cable for connecting the ADC2000-PCI+ to the spectrometer	Via USB port, comes with 1-meter cable (USB-CBL-1) to connect ADC1000-USB to PC Via RS-232, requires serial cable (not included, order ADC-USB-SER)
Software compatibility:	All 32-bit Ocean Optics software, except SpectraSuite and OmniDriver	All 32-bit Ocean Optics Software
Multiple-channel capability:	Up to eight spectrometer channels	
A/D resolution/channels:	12 bit/up to 8 spectrometer channels	
Rotator capability:	yes	
Trigger modes:	3	

Sampling Accessories







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Overview: Sampling Accessories

Sampling Accessories for Every Application

Ocean Optics provides modular components that can be configured easily for absorbance, transmission, reflectance, fluorescence, emission or scattering experiments. Often the sampling accessory is where light or excitation energy is collected from the light source, interacts with the sample, and sends the absorbed/transmitted, reflected or emitted light to the spectrometer. Sampling accessories also include the fixtures, such as collimating lenses, that provide specific sampling geometries. Accessories and fibers can be combined in an almost endless variety of configurations.

What's Your Field of View?

Four of our devices are used to control field of view (FOV) and aperture:

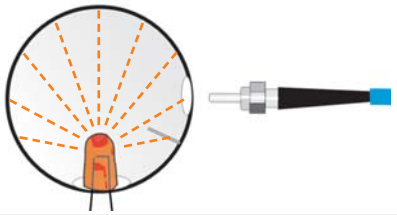
- Optical Fiber (25° FOV, aperture = fiber diameter)
- Collimating Lens (0°-45° FOV, aperture = 3 mm)
- Cosine Corrector (180° FOV, aperture = 3.9 mm)
- Integrating Sphere (360° FOV, aperture = 25 mm)

Optical Fiber: 25°

Adjustable Collimating Lens: ~0-45°

Cosine Corrector: ~180°

Integrating Sphere: 360°



Partner Spotlight: FIAlab Instruments

In 1987, Alitea USA was a distributor of Alitea AB peristaltic pumps. However, after demand for complete flow injection systems quickly grew, Alitea USA began to manufacture their own instruments. These early instruments are still widely used, evident by frequent mentions in scientific papers and conferences. In 1989, Alitea USA changed its name to FIAlab Instruments and have since introduced seven new state-of-the-art flow injection and sequential injection analysis systems, as well as a line of flow cells, sample changers and syringe pumps.

Innovative technology, top quality components, and the highest level of experience make FIAlab's FIA and SIA instruments the most advanced, precise, compact and economical available. Automation of reagent-based assays is critical to laboratory research in chemistry, biotechnology, drug screening and environmental studies, as well as in process control in industry. FIAlab brings quality and precision to this automation. The technical staff of FIAlab Instruments have a unique level of expertise in flow injection and sequential injection analyses with more than 20 years of direct research.

All of FIAlab's instruments are constructed with the best components available. Alitea peristaltic pumps ensure precise dispensing of fluids. Cavro microsyringe pumps offer a wide range of speeds and volumes. Valco "intelligent" valves are robust and highly reliable, and Upchurch fittings come in a large variety of chemically resistant and biocompatible materials.

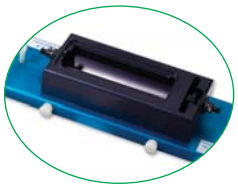
For more information on FIAlab Instruments' products, see pages 43-44, 94-95, and 100-101. You can contact them directly at 800-963-1101 or visit their web site at www.flowinjection.com.

Sampling Accessories by Measurement Type

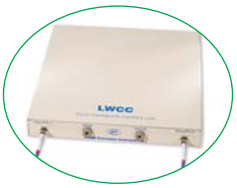
Our fiber optic sampling accessories create the optical interface part of our modular spectrometer systems. With so many sampling accessories from which to choose, you can meet the demands of a variety of experiments for absorbance, transmission, fluorescence, reflectance and emission.

Absorbance/Transmission

1-cm Cuvette Holder, p. 90



10-cm Cuvette Holder, p. 90



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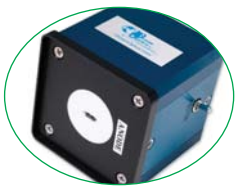

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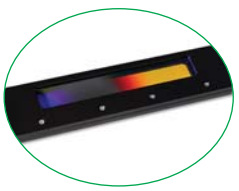

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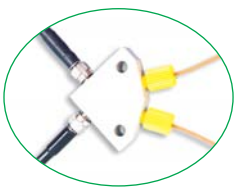

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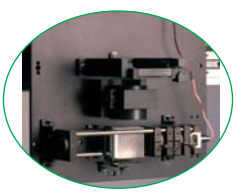
Integrating Spheres, p. 106



Long Trace Profilometer, p. 112

Reflection Stage, p. 109

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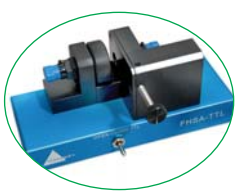
Modifying Light

Variable Attenuator, p. 117



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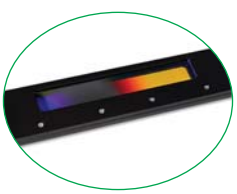

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Collimating Lenses

74-series Lens Fixtures

The 74-series Collimating Lenses are the common fiber optic-coupled lens fixture used throughout our extensive line of sampling accessories. The 74-series Collimating Lenses have an inner barrel threaded for SMA 905 Connectors. (FC barrels are available for $29; see page 158 for more.) The inner barrel slides relative to the lens fixture for adjusting the focus; a setscrew secures the barrel. Adjustment from a converging to diverging field of view (~45°) is possible.

74-UV Collimating Lens (200-2000 nm)
The 74-UV has an f/2 fused silica lens for 200-2000 nm. When focused for collimation, beam divergence is 2° or less, depending on fiber diameter. The 74-UV can be adjusted for UV-VIS or VIS-NIR setups.

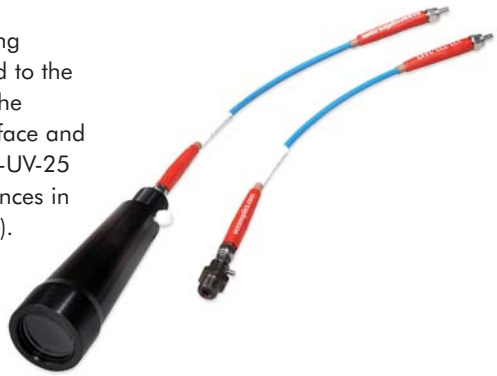
74-VIS Collimating Lens (350-2000 nm)
The 74-VIS -- the basic lens fixture in an LS-1 Light Source -- has a BK7 lens suitable for the VIS-NIR. These single-lens systems have the disadvantage of chromatic aberration, due to dispersion or variation in refractive index with wavelength.

74-ACR Collimating Lens (350-2000 nm)
The 74-ACR has two optical elements cemented together to form an achromatic doublet, optimized to correct for the spherical and chromatic aberrations inherent to single-lens systems.

74-DA Collimating Lens (200-2000 nm)
The 74-DA screw-in lens attaches directly to spectrometers for increased light throughput.

84-series Lens Fixture

The 84-series Collimating Lens is designed for coupling larger free-space beams to fibers. The fiber is coupled to the assembly with an inner 17.85-mm threaded barrel. The barrel positions the fiber ~100 mm from the lens surface and is adjusted to achieve a fine focus. The lens of the 84-UV-25 is especially suitable for collimating light at long distances in open air (it's been tested to distances of up to 40 feet). The 84-UV-25 has an 8-32 tapped hole for attaching to an optical post mount and then installing the mount in an optical breadboard or other fixture (at left).



Item	Diameter	Focal Length	Material	Wavelength	Operating Temp.	Connector	Price
74-UV	5 mm	10 mm	f/2 fused silica Dynasil	200-2000 nm	120 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$159
74-VIS	5 mm	10 mm	f/2 BK7 glass	350-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$159
74-DA	5 mm	10 mm	f/2 fused silica Dynasil	200-2000 nm	70 °C	SMA 905, 1/4-36 internal thread, 3/8-24 external thread	$159
74-ACR	5 mm	10 mm	BaF10 and FD10	350-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$199
84-UV-25	25.4 mm	100 mm	f/2 fused silica Dynasil	200-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$499

Collimating Lens Accessories

Right-angle Collimating Lens Holder

The 74-90-UV is an assembly for mounting lenses at right angles, and is especially useful for applications involving awkward optical fiber routing. It is temperature rated to 120 °C and has a mirror located under its cap that reflects light from the collimating lens to 90°. Two ports accommodate 74-series Collimating Lenses (not included) and an included adapter allows you to mount the 74-90-UV in male or female ports.

74-90-UV: $139

The 74-90-UV comes with a threaded adapter. It can be used for routing light around corners.

Adjustable Collimating Lens Holders

The 74-ACH Adjustable Collimating Lens Holder consists of adjustable bars with several threaded holes for collimating lenses. The bars can be set far enough apart to accept samples up to ~100 mm thick, making the 74-ACH a convenient option for transmission measurements of large samples. (Collimating lenses are not included.)

The ACH-CUV-VAR Adjustable Collimating Lens and Cuvette Holder is two products in one: a fixture for positioning collimating lenses at various heights or for holding extra-large or especially thick samples, and a holder for accepting cuvettes for transmission measurements. Its adjustable mount bars accept samples up to ~150 mm thick and its threaded holes hold collimating lenses. (Two 74-UV Collimating Lenses are included.)

74-ACH: $299
ACH-CUV-VAR: $1,439

74-ACH Adjustable Collimating Lens Holder

ACH-CUV-VAR Adjustable Collimating Lens and Cuvette Holder

Optical Post-mount Assembly

Also available is the OPM-M, which is a post-mount assembly for optical tables with metric M6 grids. The OPM-M has a lens holder (for a 74-UV Collimating Lens), an M4 metric optical post and an M6 metric post holder.

OPM-M: $180

OPM-M Optical Post Mount Assembly

OPM-1, OPM-2 and OPM-4 Optical Posts

OPM-SMA Optical Post Mount

Optical Post Mount & Optical Posts

The OPM-SMA is a fixture for mounting 74-series Collimating Lenses and SMA 905-terminated optical fibers. The OPM-SMA consists of a 1.5" OD disk with 3/8-24 threads to accommodate the lenses. You can use the OPM-SMA with SMA 905-terminated optical fibers. The OPM-SMA includes 8-32 (Imperial) and M6 (metric) threads for attaching to an optical post.

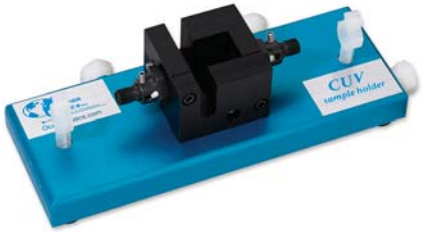
We offer four optical posts (in 25.4-mm, 50.8-mm, 76.2-mm and 101.6-mm heights) to attach to the OPM-SMA. These posts screw into optical bread-boards via a 1/4-20 tapped hole in the bottom of each post.

OPM-SMA: $149
OPM-1, -2, -3, -4: $15 each

Specifications

	74-90-UV	74-ACH	ACH-CUV-VAR	OPM-SMA	OPM-M
Dimensions (in mm):	16.5 x 16.5 x 19.9	152.4 x 76.2 x 152.4	200 x 67 x 157	38.1 OD x 10.2 width	30 mm OD x 6.5 width
Weight:	11.3 g	890.2 g	1,000 g	130 g (including post)	220 g (including post)
Threads:	3/8-24 (ports) 9.525 x 25.4 mm (nipple)	3/8-24 (mounting bars) 10-32 (setscrews for base)	3/8-24 (mounting bars) M6 (setscrews for base)	3/8-24 (lens holder) 8-32 (bore for mounting)	3/8-24 (lens holder) M4 (bore for mounting)
Material:	Black anodized Al	Blue anodized Al (base) Black anodized Al (bars)	Black anodized Al (base) Black anodized Al (bars)	Black anodized Al (mount) Stainless steel (post)	Black anodized Al (mount) Stainless steel (post)
Collimating lens included:	No	No	(2) 74-UV Lenses	No	No

Cuvette Holders



CUV-UV Cuvette Holder

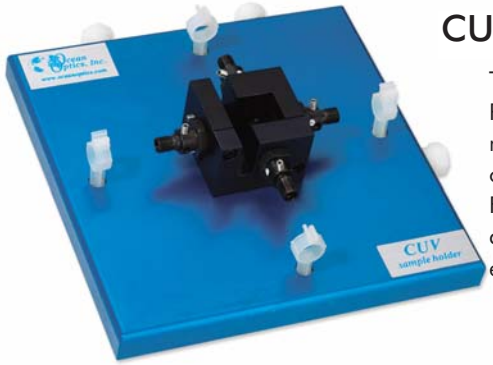
The CUV-UV (200-2000 nm) couples to lamps and spectrometers to create absorbance or transmission measurement systems. Two 74-UV lenses are mounted across a cell holder for square 1-cm cuvettes. The base includes channels for connection to a water bath for temperature regulation. The unit also accepts filters. An optional cover (CUV-COVER) excludes ambient light.

CUV-UV: $399

CUV-UV-10 Cuvette Holder

The CUV-UV-10 (200-2000 nm) accepts 10-cm cylindrical or flat-bottomed cuvettes. The CUV-UV-10 has two 74-UV Collimating Lenses that couple to light sources and spectrometers via optical fiber to make absolute absorbance systems for solutions and gases. Included is a shutter, a clamp for filters, water channels for temperature regulation, and a cover to exclude ambient light.

CUV-UV-10: $549



CUV-ALL-UV 4-way Cuvette Holder

The CUV-ALL-UV provides ports for 1-cm cuvettes from four directions. Position two collimators at 180° for absolute absorbance and transmission measurements, position two collimators at 90° for fluorescence or scattering, or use all four for simultaneous absorbance and fluorescence measurements. For fluorescence applications, increase the signal by replacing collimators with 74-MSP Mirror Plugs (see inset), which redirect energy back to the sample or back into a collimating lens.

CUV-ALL-UV: $809
74-MSP: $99

CUV-FL-DA Direct-attach Cuvette Holder

The CUV-FL-DA attaches to our light sources and couples via fibers to our spectrometers, creating systems for fluorescence and relative absorbance. The holder has a collimating lens and two mirrored screw plugs (74-MSP), which can be positioned per your application. A 6.35-mm slot is included for filters.

CUV-FL-DA: $399

CUV-VAR Variable Pathlength Cuvette Holder

The CUV-VAR has three functions: use its cuvette holder insert to create a 1-10 cm pathlength cuvette holder, create a 2-mm pathlength filter holder, or position its two 74-UV collimators to accept a flow cell. The included collimators are screwed into fixtures that slide along the base and can be set to create pathlengths up to 10 cm. Also available is a flow-cell adapter option (CUV-VAR-OPTION) for the CUV-VAR.

CUV-VAR: $1,291
CUV-VAR-OPTION: $399

Specifications

	CUV-UV	CUV-UV-10	CUV-ALL-UV	CUV-FL-DA	CUV-VAR
Dimensions:	58 mm x 140 mm x 38 mm	97 mm x 248 mm x 50 mm	147 mm x 147 mm x 40 mm	57 mm x 61 mm x 29 mm	200 mm x 67 mm x 70 mm
Weight:	230 g	1,040 g	540 g	80 g	726 g
Pathlength:	1 cm	10 cm	1 cm	1 cm	1 cm up to 10 cm
Filter slot:	Up to 6 mm, screw clamp	Up to 6 mm, wheel clamp	Up to 6 mm, screw clamp	Up to 6 mm, screw clamp	none
Water input fittings:	3.175-mm (1/8") NPT	3.175-mm (1/8") NPT	3.175-mm (1/8") NPT	none	none
Collimating lenses:	2 each 74-UV	2 each 74-UV	4 each 74-UV	2 each 74-UV	2 each 74-UV
Fiber termination:	SMA 905	SMA 905	SMA 905	SMA 905	SMA 905
"Z" dimension:	15 mm	15 mm	15 mm	15 mm	15 mm

Temperature-regulated Cuvette Holder

Precise Temperature Control

The CUV-TLC-50F Temperature-regulated Cuvette Holder is a high-quality, versatile sample chamber with a Peltier temperature controller calibrated against a NIST-traceable thermometer. The device controls the temperature of the holder from -55 °C to +105 °C and maintains a constant temperature to within ± 0.02 °C. The CUV-TLC-50F includes the cuvette holder and the external temperature controller box. To run the thermoelectric cooler efficiently, we offer a simple water pump and a water container.

Absorbance or Fluorescence

The CUV-TLC-50F (200-2000 nm) provides ports for viewing or illuminating 1-cm square cuvettes from four directions. Lenses are purchased separately to allow you to choose the best lenses for your application. For absorbance and transmission measurements, position two CUV-TLC-CL Collimating Lenses at 180°. For fluorescence applications, position two CUV-TLC-IL Imaging Lenses at 90° and position two CUV-TLC-MP Mirror Plugs in the remaining two collimator positions for increasing light throughput.

Additional Features

- A dry gas purge rids the chamber of condensation when operating at low temperatures or excludes O_2 (tubing for water and gas connections are included)
- Variable-speed magnetic stirring (a stir bar is included)
- Several removable optical slits included for modifying light entering and/or leaving the sample chamber
- Slots for removable slits at each collimating lens port

PC Adapter Package

An optional CUV-TLC-ADP adapter package comes with Windows-compatible software that allows you to remotely start a test sequence, operate the controller box and monitor experiments. Without the CUV-TLC-ADP, you can control the holder's temperature mechanically from the controller box.

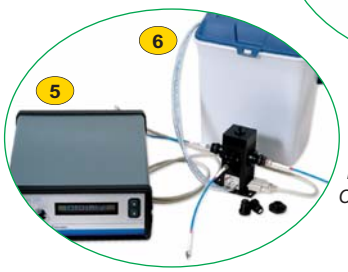
Specifications	
Full (maximum) temperature range:	-55 °C to +105 °C
Normal temperature range:	0 °C to 85 °C
Precision:	±0.02 °C
Reproducibility:	±0.05 °C
Maximum illuminated area:	12 x 10 mm
"Z" dimension:	8.5 mm

A Collimating Lens (far left) and Mirror Plug.

The CUV-TLC-IJ Insulation Jacket.

Another option is the CUV-TLC-FH Filter Holder.

An absorbance setup might include the USB2000 or USB4000 Spectrometer, an LS-1 Light Source and two optical fibers.



The CUV-TLC-50F includes the controller box and the cuvette holder. Optical fibers and the CUV-TLC-BATH are separate.

	Item	Description	Price
1	CUV-TLC-50F	Fiber optic temperature-controlled cuvette holder and controller box with slits, magnetic stirrer and tubing	$3,820
2	CUV-TLC-FH	Filter holder for the CUV-TLC-50F	$470
3	CUV-TLC-CL	AR-coated fused-silica collimating lens with SMA 905 Connector (comes with steering plate)	$180
4	CUV-TLC-MP	Mirror plug for use with CUV-TLC-IL when conducting fluorescence measurements	$70
5	CUV-TLC-ADP	Optional PC adapter package for remotely operating the cuvette holder (serial cable included)	$95
6	CUV-TLC-BATH	Water pump and bucket for running the thermoelectric cooler efficiently	$99
7	CUV-TLC-IJ	Insulating jacket for the CUV-TLC-50F	$175
	CUV-TLC-IL	Imaging or focusing lens snaps onto CL collimating lens with SMA 905 Connector (comes with steering plate)	$290
	CUV-TLC-SP	Steering plate that mounts a lens or mirror plug onto the cuvette holder	$50
	CUV-TLC-ABSKIT	A kit for absorbance/transmission; contains CUV-TLC-50F, CUV-TLC-ADP, two CUV-TLC-CL, CUV-TLC-BATH	$4,374
	CUV-TLC-FLKIT	A kit for fluorescence; contains the CUV-TLC-50F, the CUV-TLC-ADP, two CUV-TLC-IL, two CUV-TLC-MP, two CUV-TLC-SP, CUV-TLC-BATH	$4,834
	CUV-TLC-MPKIT	A kit with all of the items necessary for absorbance/transmission and fluorescence	$4,964

Integrated Sampling Systems

An Integrated Sampling System is a spectroscopy accessory where the light source and sample compartments have been integrated into one package. These systems perform the same function as our cuvette holders, but have an advantage in that one or both fibers are eliminated from the setup.

USB-ISS-UV-VIS Integrated Sampling System

The USB-ISS-UV-VIS Integrated Sampling System is a direct-attach sample holder and deuterium tungsten halogen light source for 1-cm square cuvettes. The USB-ISS-UV-VIS attaches directly to USB2000 and USB4000 Spectrometers. The sampling system allows you to adjust the intensity of the bulb via software. The sampling system has an electronic shutter for taking dark measurements and comes with a 5-volt power supply.

USB-ISS-UV-VIS: $1,499

USB-ISS-VIS Integrated Sampling Systems

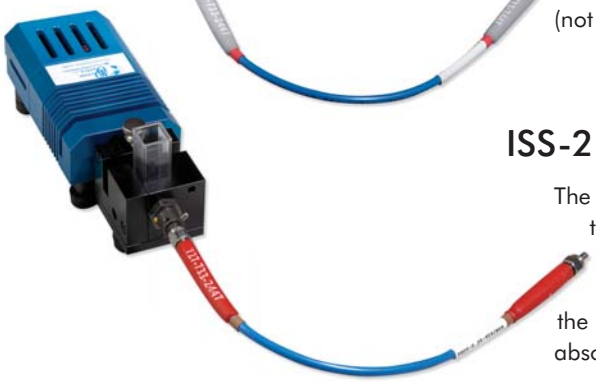
The USB-ISS-VIS and USB-ISS-T both have a violet LED-boosted tungsten source and a sample holder that bolts to the front of a USB2000 or USB4000 Spectrometer, which provides the power and control signals for the light source. The USB-ISS-VIS holds 1-cm cuvettes while the USB-ISS-T holds 12-mm OD test tubes. Both sampling systems cover the 390-900 nm range.

USB-ISS-VIS: $499
USB-ISS-T: $499

ISS-UV-VIS Integrated Sampling System

The ISS-UV-VIS combines a light source with a 1-cm cuvette holder for absorbance measurements. The ultraviolet light is provided by a deuterium bulb; visible light from a tungsten halogen bulb is focused through the deuterium lamp onto a diffuser. Solarization-resistant fiber (not included) is recommended. A 12 VDC wall transformer is included.

ISS-UV-VIS: $1,599



ISS-2 Integrated Sampling System

The ISS-2 Integrated Sampling System is a 1-cm cuvette holder and tungsten halogen light source. The ISS-2 combines the light source with a diffuser on the illumination side and a collimating lens on the receiving side of the cuvette holder. A fiber (not included) connects the ISS-2 to a spectrometer to create a small-footprint system for VIS-NIR absorbance measurements. A 12 VDC wall transformer is included.

ISS-2: $799

Specifications

	USB-ISS-UV-VIS	USB-ISS-VIS	USB-ISS-T	ISS-UV-VIS	ISS-2
Dimensions (mm):	198 x 105.1 x 40.6	40.7 x 88.8 x 34.1	40.7 x 88.8 x 34.1	198 x 104.9 x 40.9	155 x 50 x 53.3
Weight:	200 g	130 g	130 g	400 g	240 g
Power consumption:	1.8 A @ 5 VDC	160 mA @ 5 VDC	160 mA @ 5 VDC	420 mA @ 12 VDC	600 mA @ 12 VDC
Wavelength range (source)*:	200-2000 nm	390-2000 nm	390-2000 nm	200-2000 nm	400-2000 nm
Pathlength:	1 cm	1 cm	12 mm OD	1 cm	1 cm
Cuvette shape:	Square	Square	Round test tube	Square	Square
Light source:	Deuterium tungsten	Tungsten and violet LED	Tungsten and violet LED	Deuterium tungsten	Tungsten
Bulb life (hours):	800 (deut.); 2,000 (tung.)	45,000	45,000	800 (deut.); 2,000 (tung.)	900
Time to stabilized output:	~30 minutes	~5 minutes	~5 minutes	~30 minutes	~30 minutes
Filter slot:	None	None	None	None	6.35 mm
Recommended optical fibers:	None	None	None	QP400-025-SR	QP400-2-UV-VIS
Spectrometers:	USB2000 and USB4000	USB2000 and USB4000	USB2000 and USB4000	All	All
"Z" dimension:	15 mm	15 mm	15 mm	15 mm	15 mm

* *The wavelength range of the source may exceed the wavelength range of your spectrometer.*

Cuvettes & Sample Cells

Disposable UV & VIS Cuvettes

Our CVD-series Disposable Cuvettes are a low-cost, no-maintenance alternative to quartz cuvettes. All cuvettes have a 1-cm pathlength, 220-900 nm or 350-900 nm wavelength range coverage, and various filling volumes.

CVD-UV1S

CVD-UV1U

CVD-VIS1S

CVD-VIS1M

Item	Range	Material	Volume	Window in mm	Clear Sides*	Cover Needed	Price
CVD-UV1S (100 pk)	220-900 nm	Plastic	1.5-3.0 mL	4.5 x 23	4*	square	$63
CVD-UV1S-SAM (8 pk)							$10
CVD-UV1U (100 pk)	220-900 nm	Plastic	70 µL-1.8 mL	2 x 3.5	2	round	$63
CVD-UV1U-SAM (8 pk)							$10
CVD-VIS1S (100 pk)	350-900 nm	Polystyrene	1.5-3.0 mL	5 x 23	4*	square	$13
CVD-VIS1M (100 pk)	350-900 nm	Polystyrene	2.5-4.0 mL	10 x 35	2	square	$14

** Cuvettes with 4 clear sides are suitable for fluorescence measurements. Cuvettes with 2 clear sides are for "straight-through" absorbance and transmission measurements.*

Cuvette Covers

Disposable cuvette covers (top) come in packs of 100.

CVD-ROUND-RB:	$20
CVD-ROUND-RG:	$20
CVD-ROUND-RO:	$20
CVD-ROUND-RY:	$20
CVD-COVER (square):	$20

To block ambient light, use one of our black anodized covers.

CUV-COVER:	$25
CUV-COVER-TALL:	$30

Quartz Cuvette Cells

We offer several popular Suprasil quartz cuvettes made by Starna, including macro, semi-micro, flow and cylindrical cells. If you need a cell not listed here, you can order it through Ocean Optics using the Starna catalog number (see Starna.com for details). The cells listed here are suitable for use from 200-2700 nm.

CV-Q-10

CVFL-Q-10

CVS-Q-10

CVF-Q-10

CV-Q-100

Item	Description	Windows	Path	Lid	Exterior (mm)	Volume	Price
CV-Q-10	Standard	2 clear	10 mm	Teflon cover	12.5 x 12.5 x 45	3.5 mL	$75
CVFL-Q-10	Fluorescence	4 clear	10 mm	Teflon stopper	12.5 x 12.5 x 45	3.5 mL	$149
CVS-Q-10	Self-masking	2 clear	10 mm	Teflon stopper	12.5 x 12.5 x 48	1.4 mL	$219
CVF-Q-10	Flow cell	2 clear	10 mm	M6 screws	12.5 x 12.5 x 35	0.42 mL	$369
CV-Q-100	Cylindrical	2 clear	100 mm	Teflon stoppers	22 OD x 102.5	28.2 mL	$165

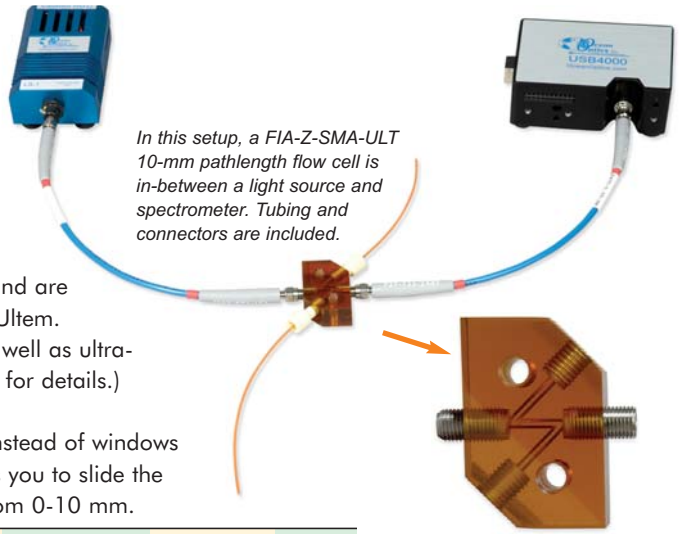
Photometric Absorbance Standards

STAN-ABS Absorbance Standards are used to check the photometric accuracy of spectrophotometer systems. Data charts and NIST-traceable certificates of analysis come with each kit. Each kit consists of a background reference and low, medium and high absorbance solutions, each 125 mL in volume. These polymer-based standards utilize submicron, non-surface charged, solid spheres in ultrapure water. The STAN-ABS-UV is certified for wavelengths from 200-450 nm, while the STAN-ABS-VIS covers wavelengths from 400-900 nm.

STAN-ABS-UV: $370
STAN-ABS-VIS: $370

Flow Cells for Flow Injection Analysis

We offer several optical flow cells with a "Z" configuration, to measure the optical absorbance of fluids. Couple them to our spectrometers to monitor chemical or biological processes, and immunoassays.

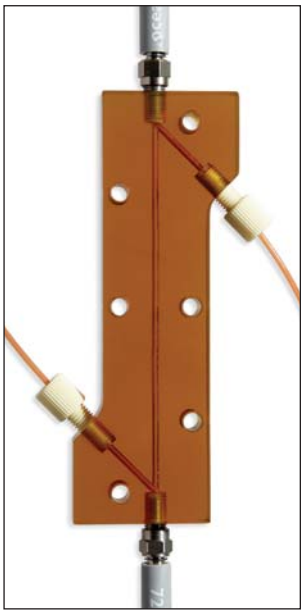


In this setup, a FIA-Z-SMA-ULT 10-mm pathlength flow cell is in-between a light source and spectrometer. Tubing and connectors are included.

In the FIA-Z-SMA Flow Cells, standard optical fibers (available separately) connect to SMA 905 fittings to transmit and receive light through the central axis of the Z. The FIA-Z-SMA Cells use silica windows as wetting surfaces at each fiber optic junction, and are available in PEEK polymer, Plexiglas, stainless steel, Teflon and Ultem. Common optical pathlengths are listed below. (Microvolume as well as ultra-short pathlength cells are also available. Contact Ocean Optics for details.)

The FIA-Z-CELL Flow Cells are different from the FIA-Z-SMAs; instead of windows they use optical fibers in 1.58-mm ferrules, a design that allows you to slide the ferrules in and out of the cell to adjust the optical pathlength from 0-10 mm.

Item	Description	Path-length	Cell Material	Fiber Type Needed	Price
FIA-Z-SMA-PEEK	Z Flow Cell with SMA 905 Connectors	10 mm	PEEK	Standard	$529
FIA-Z-SMA-PLEX	Z Flow Cell with SMA 905 Connectors	10 mm	Plexiglas	Standard	$529
FIA-Z-SMA-SS	Z Flow Cell with SMA 905 Connectors	10 mm	Stainless steel	Standard	$529
FIA-Z-SMA-TEF	Z Flow Cell with SMA 905 Connectors	10 mm	Teflon	Standard	$529
FIA-Z-SMA-ULT	Z Flow Cell with SMA 905 Connectors	10 mm	Ultem	Standard	$529
FIA-Z-SMA-20-PE	Z Flow Cell with SMA 905 Connectors	20 mm	PEEK	Standard	$529
FIA-Z-SMA-20-PLE	Z Flow Cell with SMA 905 Connectors	20 mm	Plexiglas	Standard	$529
FIA-Z-SMA-20-SS	Z Flow Cell with SMA 905 Connectors	20 mm	Stainless steel	Standard	$529
FIA-Z-SMA-20-TEF	Z Flow Cell with SMA 905 Connectors	20 mm	Teflon	Standard	$529
FIA-Z-SMA-20-ULT	Z Flow Cell with SMA 905 Connectors	20 mm	Ultem	Standard	$529
FIA-Z-SMA-50-PE	Z Flow Cell with SMA 905 Connectors	50 mm	PEEK	Standard	$629
FIA-Z-SMA-50-PLE	Z Flow Cell with SMA 905 Connectors	50 mm	Plexiglas	Standard	$629
FIA-Z-SMA-50-SS	Z Flow Cell with SMA 905 Connectors	50 mm	Stainless steel	Standard	$629
FIA-Z-SMA-50-TEF	Z Flow Cell with SMA 905 Connectors	50 mm	Teflon	Standard	$629
FIA-Z-SMA-50-ULT	Z Flow Cell with SMA 905 Connectors	50 mm	Ultem	Standard	$629
FIA-Z-SMA-100-PE	Z Flow Cell with SMA 905 Connectors	100 mm	PEEK	Standard	$729
FIA-Z-SMA-100-PLE	Z Flow Cell with SMA 905 Connectors	100 mm	Plexiglas	Standard	$729
FIA-Z-SMA-100-SS	Z Flow Cell with SMA 905 Connectors	100 mm	Stainless steel	Standard	$729
FIA-Z-SMA-100-TEF	Z Flow Cell with SMA 905 Connectors	100 mm	Teflon	Standard	$729
FIA-Z-SMA-100-ULT	Z Flow Cell with SMA 905 Connectors	100 mm	Ultem	Standard	$729
FIA-Z-CELL-PEEK	Z Flow Cell with ferrules	10 mm	PEEK	Ferruled	$365
FIA-Z-CELL-PLEX	Z Flow Cell with ferrules	10 mm	Plexiglas	Ferruled	$365
FIA-Z-CELL-SS	Z Flow Cell with ferrules	10 mm	Stainless steel	Ferruled	$365
FIA-Z-CELL-TEF	Z Flow Cell with ferrules	10 mm	Teflon	Ferruled	$365



This FIA-Z-SMA-100-ULT is a 100 mm pathlength cell made out of Ultem.

Specifications

Cell materials:	PEEK, Plexiglas, Teflon, stainless steel or Ultem	Wavelength range:	200-2000 nm
		FIA connectors:	1/4-28 fittings (included)
Inner diameter:	1.5 mm	Tubing:	1/16" Teflon, ~3 m
Window material:	UV-grade fused silica	Fiber connectors:	SMA 905 for FIA-Z-SMA cells; 1.58-mm stainless steel ferrules for FIA-Z-CELL cells
Window thickness:	1 mm		

Our standard fibers are designed for the FIA-Z-SMA cells.

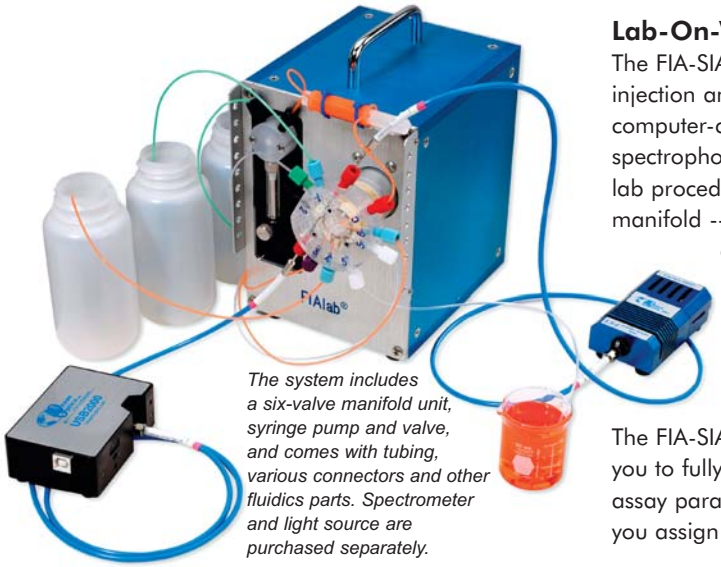
Fibers for Use with FIA Cells

An FIA-Z-SMA requires two 200 µm or 400 µm diameter fiber assemblies like the ones listed below. (Your application may require optical fibers optimized for a specific wavelength range. See pages 142-146 for more choices.) The FIA-ZCELL requires two fiber assemblies with ferrule terminations. Each price below is for one assembly (two are required).

The FIA-P400-SR and FIA-P200-SR fiber assemblies have ferrules for use with the FIA-Z-CELL cells.

Item	Description	For Use With	Price
P400-2-UV-VIS	(1) 400 µm fiber assembly with SMA 905 Connectors	FIA-Z-SMA	$119
P200-2-UV-VIS	(1) 200 µm fiber assembly with SMA 905 Connectors	FIA-Z-SMA	$99
FIA-P400-SR	(1) 400 µm fiber assembly with ferrule terminations	FIA-Z-CELL	$215
FIA-P200-SR	(1) 200 µm fiber assembly with ferrule terminations	FIA-Z-CELL	$210

Sequential Injection System



The system includes a six-valve manifold unit, syringe pump and valve, and comes with tubing, various connectors and other fluidics parts. Spectrometer and light source are purchased separately.

Lab-On-Valve Technology

The FIA-SIA-LOV Lab-On-Valve System is a compact sequential injection analyzer for all-in-one chemical analyses. It combines a computer-controlled six-position valve, precision syringe pump, and spectrophotometric flow cell that can automate many wet-chemistry lab procedures. All of the chemistry takes place within the valve manifold -- eliminating the need for additional tubing and connectors. All of the ports are interconnected by microchannels, and a built-in flow cell interfaces to optical fiber probes for spectral analyses in either absorbance or fluorescence mode.

Automate Wet Lab Procedures

The FIA-SIA-LOV includes software and interfaces to a PC, allowing you to fully automate wet lab procedures with precise control of assay parameters such as flowrates and volumes. Via the software, you assign each of the Lab-On-Valve's ports a specific function.

Control many assay parameters including:

- Bead trapping
- Flow injection
- Flow through
- Holding coil
- Mixing
- Reagent aspiration
- Sample dilution
- Sample aspiration
- Sequential injection
- Waste elimination

Cost-effective Methodology

The FIA-SIA-LOV offers a cost-effective, microliter-volume methodology -- it produces less waste, saves money and introduces fewer chemicals into the environment than other wet chemistry technologies. The unit weighs 3.6 kg, making it portable and easy to install in small incubators for temperature and humidity control. Also, the FIA-SIA-LOV can easily be positioned near ETAAS and MS systems so that samples are not transported through long conduits, which can cause sample degradation.

Modular Chemical Analyzer

The FIA-SIA-LOV unit was developed by flow injection system specialist and Ocean Optics partner FIAlab Instruments. It is compatible with our spectrometers and accessories for dynamic spectral analyses of absorbance or fluorescence of fluids. The FIA-SIA-LOV consists of the FIA-SIA Micro Sequential Injection Analyzer unit and the FIA-LOV Lab-on-a-Valve Manifold, each of which can be purchased separately.

FIA-SIA-LOV: $13,450
FIA-SIA: $10,950
FIA-LOV: $1,275

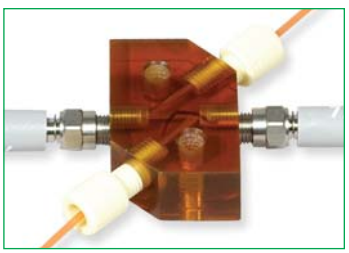
Specifications	
Dimensions:	12.7 cm x 15.3 cm x 15.3 cm
Weight:	3.6 kg
Spectral range:	260-2000 nm
Cell materials:	PEEK, Plexiglas, Teflon, stainless steel or Ultem
Inner diameter:	1.5 mm
Window material:	UV-grade fused silica
Window thickness:	1 mm
Pathlength:	10 mm
Fiber connectors:	SMA 905
Tubing:	1/16" Teflon, ~3 m
Tubing connectors:	1/4-28
Pump dimensions:	105 mm x 105 mm x 185 mm
Pump weight:	2.1 kg
Flow rate:	200 mL/minute/channel (depends on RPM an tubing diameter)
Pressure rating:	25 psi

Flow Cell Kit for Flow Injection Analysis

FIA-PUMP-C 2-channel peristaltic pump.

The FIA-1000-Z Flow Cell Kit is a fluid sampling system that couples to our spectrometers and light sources for rapid, quantitative analysis of solutions. The kit consists of an FIA-Z-SMA flow cell (see page 94 for details), tubing and fittings, the FIA-PUMP-C (a computer-controlled 2-channel peristaltic pump), and software to control the pump via a PC's serial port. Two optical fibers (not included) are required. You can also purchase the FIA-PUMP-C pump separately.

FIA-1000-Z: $1,470
FIA-PUMP-C: $974



FIA-Z-SMA "Z"-type flow cell in Ultem.

Specifications			
Spectral range:	260-2000 nm	Pathlength:	10 mm
Cell materials:	PEEK, Plexiglas, Teflon, stainless steel or Ultem (shown)	Tubing:	1/16" Teflon, ~3 m, with 1/4-28 connectors
Inner diameter:	1.5 mm	Pump:	105 mm x 105 mm x 185 mm; 2.1 kg
Window:	1 mm thick, UV-grade fused silica	Flow rate:	200 mL/minute/channel, depends on RPM and tubing diameter
Pathlength:	10 mm	Pressure rating:	25 psi

Process Flow Cells

About Custom Sensors & Technology

Custom Sensors & Technology, Inc. is a full-service designer and manufacturer of photometric transmitters, fiber optic probes and flow cells, oxygen transmitters, sampling handling systems and other products for process applications. In addition, Custom Sensors & Technology offers applications assistance, product validation and other services. Their process flow cells can easily be connected to our spectrometers for spectral analysis of samples in online process applications.

Cross Process Flow Cells

The Adjustable-pathlength Cross Process Flow Cells are used in a variety of demanding online flow analysis applications in industrial gas or liquid stream environments. The 1/2" and 3/8" cells are available in various materials and have adjustable pathlengths.

The 1/2" version has a pathlength that can easily be adjusted from 0.1-2.5 cm. This version comes with two Optical Interface Couplers that collimate light and easily connect optical fiber assemblies to the flow cell, spectrometer and light source. Also available is a version that has a viewport; call for details.

The 3/8" version has a pathlength that can be adjusted from 0.1-1.5 cm. It does not include Optical Interface Couplers but they can be purchased separately. The PRO-CFC-3/8's titanium body (standard) allows the cell to be used in highly aggressive process streams such as those often encountered in pulp and paper applications.

PRO-CFC-1/2: $3,250
PRO-CFC-3/8: $3,096

Micro Process Flow Cells

Process-ready Micro Flow Cells are useful for online measurements in gas or liquid streams in demanding industrial environments The cells provide extremely small pathlengths (to 0.02 mm) without restricting sample flow. Micro Flow Cells are available in 1/8" and 3/8" sizes and have adjustable pathlengths.

The PRO-MFC-OIC-VP includes a viewport for viewing the sample as it flows through the cell. See a close-up of the viewport below.

The PRO-MFC is a 3/8" Micro Flow Cell. The PRO-MFC-OIC is a 1/8" Micro Flow Cell that can be used in a variety of online flow analysis applications. The PRO-MFC-OIC-VP includes a quartz port that allows the user to view the setting and the sample as it flows through the cells. The PRO-MFC-S Sanitary Micro Flow Cell is designed for online flow analysis applications to 200 AU/CM and has high absorption characteristics from 200-2000 nm. Constructed of 316 stainless steel, the cell is available with outer diameters from 0.5" to 2.0".

PRO-MFC: $2,675
PRO-MFC-OIC: $5,400
PRO-MFC-OIC-VP: $6,000
PRO-MFC-S: $5,250

Specifications

	PRO-CFC-1/2	PRO-CFC-3/8	PRO-MFC	PRO-MFC-OIC	PRO-MFC-OIC-VP	PRO-MFC-S
Pathlength:	Adjustable 0.1-2.5 cm	Adjustable 0.1-2.5 cm	Adjustable 0.02-2.0 mm	Adjustable 0.02-2.0 mm	Adjustable 0.02-2.0 mm	0.02-2.0 mm
Body & barrel:	316 stainless steel (Hastelloy C, Titanium and Monel available)	316 stainless steel (Hastelloy C, Titanium and Monel available)	Titanium (316 stainless steel, Hastelloy C and Monel available)	316 stainless steel	316 stainless steel	316 stainless steel; wetted body
Sample inlet/outlet:	1/2" compression fittings	3/8" compression fittings	3/8" compression fittings	1/8" compression fittings	1/8" compression fittings	1/8" compression fittings
Window materials:	Quartz (Sapphire available)	Quartz (Sapphire available)	Quartz (Sapphire available)	Quartz	Quartz	Quartz
Seals:	Viton (Chemraz and Kalrez available)	Viton (Chemraz and Kalrez available)	Viton (Chemraz, Kalrez, TFE, Buna-N available)	Viton (Chemraz, Kalrez, TFE, Buna-N available)	Viton (Chemraz, Kalrez, TFE, Buna-N available)	Sample end: B-type VCO L-Ring Face Seal Fitting; Process end: Tri-Clamp
Temperature limit:	204 °C (400 °F)	204 °C (400 °F)	121 °C (250 °F)	121 °C (250 °F)	121 °C (250 °F)	149-232 °C (300-450 °F) depending on gasket
Pressure limit:	2000 psig	2000 psig	1000 psig	250 psig	250 psig	2500 psig (137 Bar)
Fiber connections:	SMA 905	SMA 905	SMA 905	SMA 905	SMA 905	SMA 905
Wavelength range:	UV-NIR	UV-NIR	UV-NIR	UV-NIR	UV-NIR	UV-NIR

Process Flow Cells

Fluorescence Process Flow Cells

The PRO-FC-FL+TR Fluorescence Flow Cell is an adjustable-pathlength fluorescence flow cell that can be used for fluorescence and transmission measurements in a variety of industrial online flow analysis applications. The PRO-FC-FL+TR can be configured with Optical Interface Couplers (three OICs included) at 90° for fluorescence applications. Add a third OIC at 180° to make transmission and fluorescence measurements simultaneously. The cell's pathlength can easily be adjusted from 0.5-15.0 mm.

PRO-FC-FL+TR: $3,750

End-of-Column Process Flow Cells

The Biotech End-of-Column Flow Cell is an adjustable-pathlength flow cell for optical measurements in a variety of industrial online flow analysis applications. The stainless steel PRO-FC-BIO is a Titanium cell body that features an electropolished (RA 12 or better) interior and two fiber-lensed Optical Interface Couplers (included). OICs and sample inlet/outlet are secured in the cell body with standard Upchurch fittings. The cell's pathlength can easily be adjusted from 0.02-10.0 mm.

PRO-FC-BIO: $2,572

Long Pathlength Process Flow Cells

The PRO-FC-LP Long Pathlength Process Flow Cell can be used in a variety of online flow analysis applications when longer pathlengths are required. The PRO-FC-LP is available in pathlengths from 50-500 mm. Contact an Applications Scientist for detailed ordering information. Two Optical Interface Couplers (included) collimate light and easily connect fiber optic cables to the flow cell, spectrometer and light source.

PRO-FC-LP: $3,145

Specifications

	PRO-FC-LP	PRO-FC-FL+TR	PRO-FC-BIO
Pathlength:	50-500 mm	0.5-15.0 mm	0.02-10.0 mm
Body & barrel material:	316 stainless steel (Hastelloy C, Titanium and Monel available)	316 stainless steel (Hastelloy C, Titanium and Monel available)	316 stainless steel (Hastelloy C, Titanium and Monel available)
Sample inlet/outlet:	3/4" compression fittings	1/2" compression fittings	1/8" Upchurch compression fittings
Window materials:	Quartz (Sapphire available)	Quartz (Sapphire available)	Quartz (Sapphire available)
Seals:	Viton (Chemraz, Kalrez, TFE, Buna-N available)	Viton (Chemraz, Kalrez, TFE, Buna-N available)	Viton (Chemraz, Kalrez, TFE, Buna-N available)
Temperature limit:	400 °F, 205 °C	400 °F, 205 °C	200 °F, 93 °C
Pressure limit:	2500 psig	2500 psig	250 psig
Fiber connections:	SMA 905	SMA 905	SMA 905
Wavelength range:	UV-NIR	UV-NIR	UV-NIR

SpectroPipetter Microcell

Easy to Use -- Just Pipette and Measure

The PIP-10-2 SpectroPipetter Microcell is a combination micropipetter and 10-mm pathlength microcell for low-volume sampling. Samples are loaded into a capillary tube with an optical fiber plunger, which is activated by depressing the thumbpad and releasing it to draw in the fluid. A mirror on the distal side of the capillary completes the optical path.

Requires 2 µL of Sample

The pipetter is equipped with a bifurcated fiber, which couples to our spectrometers and compact light sources to create low-volume absorbance systems. The SpectroPipetter requires only 2 µL of sample for a spectral measurement.

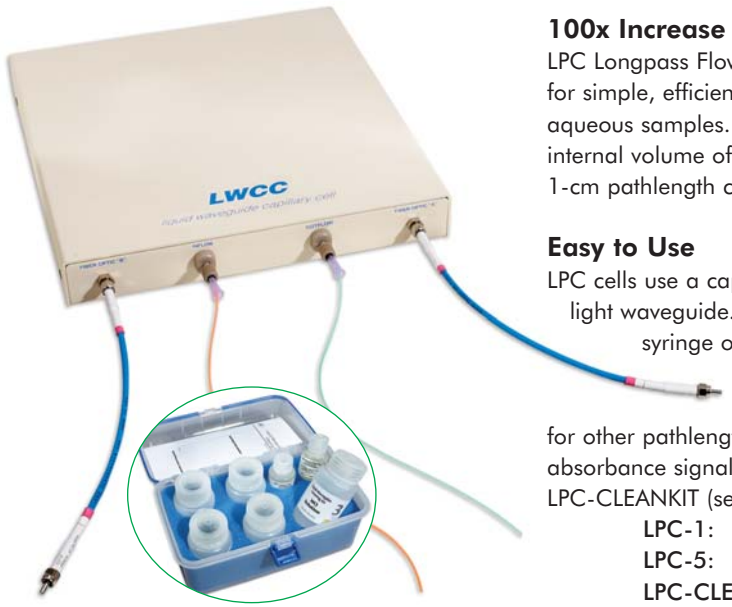
Cleaning Kit

To remove fluid or dye from the cell, use the PIP-UCK Cleaning Kit. It contains an ultrasonic cleaning bath (at right) and a bottle of cleaning solution. Additional PIP-UCK-CS Cleaning Solution (below right) is also available.

PIP-10-2: $1,995
PIP-UCK: $165
PIP-UCK-CS: $25

Specifications	
Wavelength range:	230-850 nm
Sample volume:	2 µL
Light pathlength of cell:	10 mm
Temperature range:	4 °C to 99 °C
Optical fiber length:	1.3 m
Core diameter of launch fibers:	Bundle of (3) 200 µm optical fibers
Core diameter of return fiber:	200 µm

Longpass Flow Cells



100x Increase in Sensitivity

LPC Longpass Flow Cells couple to our spectrometers and light sources for simple, efficient measurements of low-volume, low-concentration aqueous samples. With the LPC-1, you have a 1-meter cell with an internal volume of only 240 µL, giving you 100x the sensitivity over a 1-cm pathlength cuvette holder as your sampling device.

Easy to Use

LPC cells use a capillary tube as both the sample compartment and the light waveguide. You inject the sample into the fluidic ports with a syringe or pump; optical fibers connect to SMA 905 Connectors to deliver and return light to the spectrometer. We offer these cells in 1- and 5-meter pathlengths (call for other pathlengths). A 5-meter cell (250 µL/meter) increases the absorbance signal 500x more than a 1-cm cuvette. Also available is the LPC-CLEANKIT (see inset), a waveguide cleaning kit for the LPCs.

LPC-1: $1,695
LPC-5: $3,350
LPC-CLEANKIT: $59

Specifications			
Dimensions:	254 mm x 279 mm	Maximum sample temperature:	160 °C
Weight:	140 g	Tubing inner diameter:	550 µm
Wavelength range:	230-800 nm for LPC-1, 325-700 nm for LPC-5	Tubing:	Fused silica inner tubing coated with Teflon AF
Tubing volume:	250 µL/meter	Fluid fittings:	1/16", 1/32" compression fittings
Fiber connectors:	SMA 905	Maximum pressure:	2000 psi
Fiber core diameter:	400 µm	Chemical resistance:	Most organic and inorganic solvents

Cell for Capillary Electrophoresis

Solutions Absorbance

The CUV-CCE Electrophoresis Sample Cell is an optical fixture for measuring the absorbance of solutions in chromatography or capillary electrophoresis systems. The cell's design -- light projects through the sides of the silica tubing -- eliminates pressure limits commonly associated with tubing breakdown in electrophoresis systems.

Excellent Chemical Resistance

The CUV-CCE cell, fixtures and fittings are made of robust PEEK material. The cell, which can be purchased separately as CUV-CCE-CROSS, has a through-hole of 0.51 mm and comes with 10-32 coned female threads and four fittings. Two fibers (included) face each other across the sample tubing. To complete the system, we recommend a spectrometer and a DH2000-BAL Light Source (see page 122).

Fibers & Tubing Sleeves Included

The CUV-CCE comes with two 300-µm solarization-resistant fibers and tubing sleeves to connect tubing to the threaded ports. You can also purchase the CUV-CCE-CROSS tubing sleeves separately. Other sleeve sizes are available.

CUV-CCE: $599
CUV-CCE-CROSS: $65
CUV-CCE-TUBING: $15

Specifications	
Dimensions:	28.6 mm x 28.6 mm (cross); 50.8 mm x 50.8 mm (cross with fittings)
Weight:	9.4 g
Cell material:	PEEK polymer
Fixtures & fittings material:	PEEK polymer
Threads:	10-32
Through-hole:	0.51 mm
Fittings:	(4) F-300 double-winged nuts with F-142 ferrule
Swept volume:	0.721 µL
Tubing sleeve diameter:	0.41 mm inner diameter, 1.57 mm outer diameter
Tubing sleeve length:	31.8 mm
Tubing size accommodated:	350-390 µm outer diameter
Pressure rating (tubing):	6,000 psi (414 bar)

Positive Displacement Pump

Displaces Volumes from 1 µL

The PUMP-IT-1000 Positive Displacement Pump Kit is a pulsed pump that displaces from 1 µL to 250 µL of fluid with each pump or cycle. The amount of fluid displaced with each cycle is set via software. The amount pumped is precise to 0.3% with repeatability of better than 0.5%. The pump provides a ripple-free and bubble-free flow. For accurate mixing and/or dilution of fluids, the pump has upper and lower limits that can be set mechanically and via the software (included), which also allows you to select the displacement amount and the speed of the displacement.

Applications

The PUMP-IT-1000 Kit is useful for those wanting to automate the delivery of reagents into accurate flow setups. Typical applications include blood chemistry, blood analysis, particle sizing, in vitro diagnostics and biopharmaceutical analysis. The PUMP-IT-1000 comes with everything needed for a flow setup; you can also purchase the pump separately (PUMP-IT-PUMP).

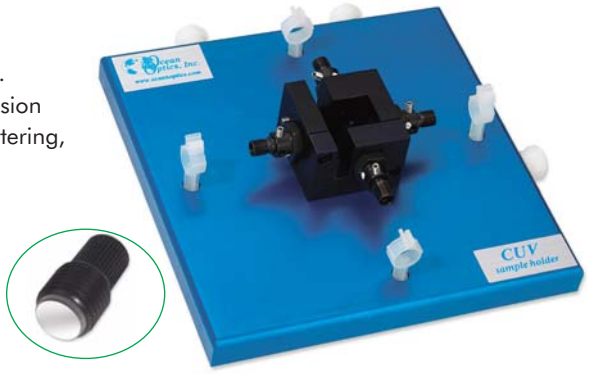
PUMP-IT-1000: $999
PUMP-IT-PUMP: $565

Specifications	
Volume:	250 µL full scale; 0.028 µL volume per full step
Throughput:	>60% (based on 400 µm optical fiber)
Actuator:	5 VDC, 0.49 amp/phase, 10.2 ohm/phase, 9.6 mHz/phase
Accuracy:	<0.5% repeatability; <0.3% precision
Pump head:	Acrylic (custom options include polycarbonate and PEEK)
Pump piston:	PEEK (custom options include stainless steel, ceramic and glass)
Pump body:	Aluminum (custom options include stainless steel and acrylic)
Dimensions (in cm):	Pump: 3.50 x 3.50 x 16.94; Controller: 11.93 x 11.93 x 6.35
Controller:	Unipolar/Bipolar dual stepper motor control PCB, 7.5 VAC, 1 A
Baud rate:	2400 or 9600 baud serial connection
AC adapter:	7.5 VAC, 1 A
Tubing:	10 feet of Tygon tubing
Nylon fittings:	10 female Luer fittings, 1/4 hex to 10-32 thread; 10 1/16" ID elbow fittings; 10 male Luer fittings, 1/4 hex to 10-32 thread; 10 Luer plugs and 10 caps; 10 1/16" ID barbed fittings with10-32 thread; and 10 1/16" ID barbed tee fittings

The PUMP-IT-1000 Kit comes with the Positive Displacement Pump, a 250-µL sample bottle, 10 feet of tubing, various nylon fittings, controller box and power supply, RS-232 cable and software.

Fluorescence Sampling Tools

CUV-ALL-UV 4-way Cuvette Holder



The CUV-ALL-UV provides ports for 1-cm cuvettes from four directions. Position two collimators at 180° for absolute absorbance and transmission measurements, position two collimators at 90° for fluorescence or scattering, or use all four for simultaneous absorbance and fluorescence measurements. For fluorescence applications, increase the signal by replacing collimators with 74-MSP Mirror Plugs (see inset), which redirect energy back to the sample or back into a collimating lens.

CUV-ALL-UV: $809
74-MSP: $99

CUV-FL-DA Direct-attach Cuvette Holder

The CUV-FL-DA attaches to our light sources and couples via fibers to our spectrometers, creating systems for fluorescence and relative absorbance. The holder has a collimating lens and two mirrored screw plugs (74-MSP), which can be positioned per your application. A 6.35-mm slot is included for filters.

CUV-FL-DA: $399

Fluorescence Standard

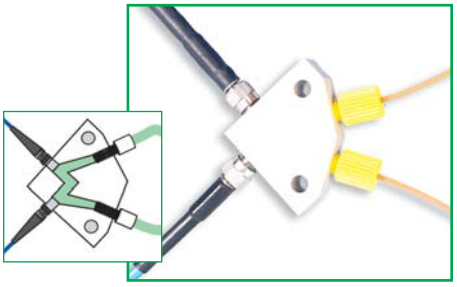
For quickly and easily checking the calibration, stability, and performance of your fluorescence system, use this Solid Secondary Fluorescence Standard.

STAN-FL-RED: $179

Linear Variable Filters

We've combined our patented high-pass and low-pass Linear Variable Filters to create the world's first bandpass filter with an adjustable center wavelength and adjustable bandpass. Each filter features an excellent transmission band (~90%) and blocking band (99.8%). These filters are especially useful for spectrally shaping the excitation energy from broadband sources used for fluorescence. The filters are epoxied into slide carriers that allow you to move the transmission or blocking band throughout the filter's wavelength range. The LVF filters and slide carriers can be inserted easily into spectrometer setups. For details, see page 114.

Fluorescence Flow Cell for Flow Injection



With the FIA-SMA-FL Fluorescence Flow Cell, a fiber sends excitation energy via a window into a sample compartment. A second fiber, oriented at 90° and connected to a spectrometer, collects the emitted energy. Each cell has two optical windows and SMA 905 Connectors (which do not contact the fluids). Also included are Teflon tubing and chemically-resistant tubing connectors and seals. Two 600 μm fibers are required. See the bottom of page 94 for fiber details.

FIA-SMA-FL: $435

Fluorescence Process Flow Cells

The PRO-FC-FL+TR Fluorescence Flow Cell is an adjustable-pathlength fluorescence flow cell that can be used for fluorescence and transmission measurements in a variety of industrial online flow analysis applications. The PRO-FC-FL+TR can be configured with Optical Interface Couplers (three OICs included) at 90° for fluorescence applications. Add a third OIC at 180°s to make transmission and fluorescence measurements simultaneously. The cell's pathlength can easily be adjusted from 0.5-15.0 mm.

PRO-FC-FL+TR: $3,750

Fluorescence Flow Analysis PMT

Parts-per-trillion Sensitivity

The FIA-PMT-FL Photomultiplier Flow-through Detection System provides parts-per-trillion sensitivity for ultra-low fluorescence, chemiluminescence and bioluminescence measurements.

Modular Design

The FIA-PMT-FL is built to order with either an internal excitation lamp or with an optical fiber interfacing to an external lamp. Excitation source options include tungsten, mercury vapor, LEDs and laser diodes. Emission and excitation filters are mounted in slots in the system, allowing for easy removal. Though the system uses a 25 µL flow-through cuvette, you can also use standard 1-cm pathlength cuvettes for manual measurements.

Easy PC Interface & Optimized Software

Included with the system is Windows-based software that allows you to set the integration time and voltage counts, and to obtain time histories of the measurements, both plotted and tabulated. The software can also automatically create calibration curves and control additional devices such as certain syringe and peristaltic pumps, injection valves, selection valves and autosamplers. ActiveX control is included for controlling the FIA-PMT-FL from your own software. The FIA-PMT-FL plugs into the RS-232 serial port of a PC.

FIA-PMT-FL: $6,495

Specifications	
Dimensions:	~13 cm x 18 cm x 25.4 cm
Spectral range:	310-750 nm (filter/lamp selection dependent)
Detector:	Photo-counting photomultiplier tube
PMT dynamic range:	2 x 10^6
Responsivity:	5 x 10^{17} cps/watt (@ 400 nm)
Detection limits:	10 parts per trillion measured with fluorescein @ 200 msec integration time and internal LED
Pulse-pair resolution:	10 ns
Flow cell :	10 mm path, 25 µL volume with flow-through cuvette
Filters:	Your waveband choice of 1 excitation filter and 1 emission filter (call for options)
Computer interface:	RS-232 to Windows 98/Me/2000/XP OS

Fiber Optic Scanning Monochromator

Monochromator Allows 2 nm Bandwidth

The MonoScan2000 is a computer-controlled scanning monochromator with a 300-700 nm wavelength range. It takes the MonoScan2000 only three seconds to scan from 300-700 nm. To scan only one nanometer takes about 15-20 milliseconds. The MonoScan2000 is compatible with all Ocean Optics spectrometers, light sources, accessories and optical fibers.

Use as a Tunable Light Source or Excitation for Fluorescence

In this setup, a broadband light source provides light via optical fiber to the MonoScan2000. You select a 2-to-3 nm bandpass in which the light passes before exiting the MonoScan, interacting with a sample and passing to a spectrometer. In this situation, the MonoScan takes the place of a filter. A scanning monochromator is better able to provide excitation intensity than a filter because of the monochromator's ability to reject out-of-band illumination. Filters can provide adequate excitation intensity but at reduced optical transmittance because they typically have a wider bandpass. You often sacrifice dynamic range with filters.

Use with Single-element Detector

A light source provides light via optical fiber to a sample, interacts with the sample, and sends light to the MonoScan2000. The monochromator captures the incoming light, transmits it via fiber to a single-element detector, such as a photodiode, one wavelength at a time. The MonoScan2000 allows a high optical throughput and provides an intense spectral signal. The MonoScan has the ability to scan through a wavelength range you select via software. Because the MonoScan has no slit, the diameter size of the optical fiber determines the optical resolution of the system. When using 200 µm fibers, for example, optical resolution is <3 nm (FWHM).

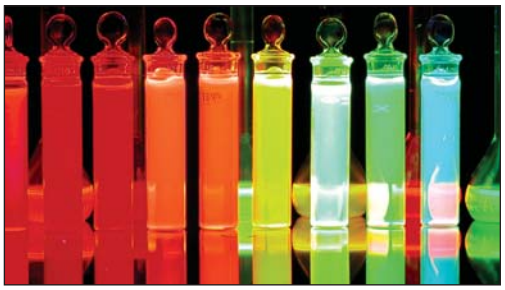
MonoScan2000: $5,219

Specifications	
Dimensions:	112 mm x 132 mm x 145 mm
Weight:	1.1 kg
Wavelength range:	300-700 nm
Optical resolution:	Fiber diameter dependent; ~4 nm (FWHM) using a 400 µm fiber
Holographic grating:	1250 l/mm, blazed at 350 nm
Accuracy:	<0.5 nm
Repeatability:	0.2 nm
Transition speed:	From wavelength to wavelength is ca 3s 300-700 nm 1 nm step ~ 15 ms
Dispersion:	~10 nm per mm
Optical throughput:	>50% with a 1000 µm fiber at 350 nm >30% with a 1000 µm fiber at 500 nm
Grating scan angle:	14.8° (300-700 nm)
Computer interface:	USB and RS-232
Power requirement:	12 VDC max. 1.2A (WT-12V-E)
Gearbox ratio:	1:261

Semiconductor Nanocrystals

Evident Technologies, an Ocean Optics partner, develops extremely high-quality, low-cost semiconductor nanocrystals. These quantum dots are nanometer-scale materials that have properties between that of molecules and bulk materials. This enables Evident to produce "designer atoms" through atomic-level manipulation. When combined with our spectrometers and excitation sources, these nanocrystals have been used in biology applications as fluorescent tags to measure and quantify biological phenomena, and in photonics as tunable colors for light-emitting diodes. EviTags are an ideal tagging tool for high-throughput screening in micro-fluidic systems, as well as cell imaging and pathogen detection. For most applications, we recommend our USB2000-FLG Spectrometer and some combination of our light sources and filters to excite EviDots and EviTags. Contact one of our Applications Scientists for details.

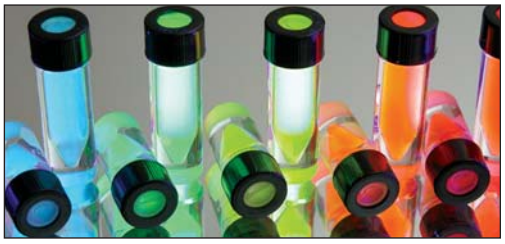
EviDot Core & Core-shell Nanocrystals



EviDot Core Nanocrystals are manufactured quantum dots ranging in size from 2-10 nm with fewer than 1,000 atoms. Each Core type is made of the same material but exhibits different emission properties based on size. Cores produce high quantum yields with intense fluorescence at targeted peak wavelengths. EviDot Core-shell Nanocrystals are Core Nanocrystals with a zinc sulfide coating that stabilizes the Core, improves quantum yield and reduces photodegradation.

Item Code	Description	Semiconductor Nanocrystals	Vials	Volume per Vial	Price
QD-CS-VIS	Core Shell EviDot Kit. Choose 6 vials from the following: • 490 nm • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	Cadmium selenide nanocrystals with zinc sulfide shell (CdSe/ZnS)	6	0.5 mg dots in 4 mL of toluene solvent	$699
QD-CS-1V	Core Shell EviDots. Specify 1 vial only from the following: • 490 nm • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	Cadmium selenide nanocrystals with zinc sulfide shell (CdSe/ZnS)	1	50 mg dots in 5 mL of toluene solvent	$449

EviTag Core-shell Nanocrystals



EviTag Nanocrystals are Core-shell Nanocrystals with an additional proprietary coating that makes the Core shells water-stable. These EviTags are cadmium selenide nanocrystals with a zinc sulfide shell. Carboxyl ligands are attached to the proprietary coating so that they can easily be bound to nucleic acids, antibodies and proteins, making the EviTag technology available to life science applications.

Item Code	Description	Volume per Vial	Price
QD-T2-MP-1V	Single vial of cadmium selenide nanocrystal compound with a zinc sulfide shell (CdSe/ZnS) and a proprietary coating containing carboxyl terminal groups; specify one of the following • 490 nm • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	6 nanomoles of EviTags per 0.5 milliliters of deionized water	$399
QD-T2-MP-A-1V	Single vial of cadmium selenide nanocrystal compound with a zinc sulfide shell (CdSe/ZnS) and a proprietary coating containing amine terminal groups; specify one of the following • 490 nm • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	6 nanomoles of EviTags per 0.5 milliliters of deionized water	$399

FluoroVette Micro-volume Cells

Fluorescence Cells for Nano-molar Detection

The FluoroVettes are ultra low-volume, disposable cells for nano-molar range fluorescence detection. Only 50 µL of fluid fills the microfluidic channel of a FluoroVette, which then slides into a 1-cm cuvette adapter for use in a fluorescence setup with a spectrometer and cuvette holder.

Advantages Versus Cuvettes

For only $125, you receive 10 disposable FluoroVettes with a Cuvette Adapter, making these cells a great alternative to expensive quartz cuvettes. For the price of one micro-volume quartz cuvette, you could use over 30 disposable FluoroVettes with no risk of sample contamination.

Two Types of Disposable 50 µL FluoroVettes

There are two types of FluoroVettes. The CFV-PIP-SP has an inlet port for loading the sample into the FluoroVette with a standard 20-200 µL pipetter and ordinary tips, making it a snap to fill and perform measurements. The CFV-PUMP-SP has tubing barbs at the inlet and outlet ports so the FluoroVette can be used in continuous or flow injected measurements using a syringe or peristaltic pump. Each type of FluoroVette slips easily into the Cuvette Adapter for using with a standard 1-cm cuvette holder, such as our CUV-ALL-UV 4-way Cuvette Holder. The Cuvette Adapter's two ports are positioned at 90° for fluorescence measurements. (See complete setup below.)

In this setup, the CFV-PUMP-SP FluoroVette and Cuvette Adapter sit in a CUV-ALL 4-way Cuvette Holder. A pump circulates the sample through the FluoroVette.

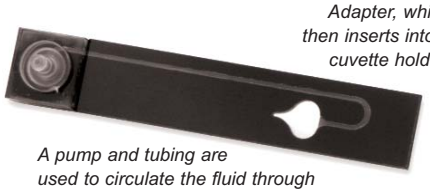
High-sensitivity Applications of Precious Samples

FluoroVettes are easy to fill and empty, making it possible to perform a dilution series to optimize data from scarce samples. The FluoroVettes are ideal for a variety of real-time high-sensitivity fluorescence applications, such as

- Assay development with quantum dots
- GFP-based assays
- Protein conformation analysis
- DNA quantification via Pico-Green assay reagent
- Cell marker identification
- Enzyme inhibitors using FRET Assays

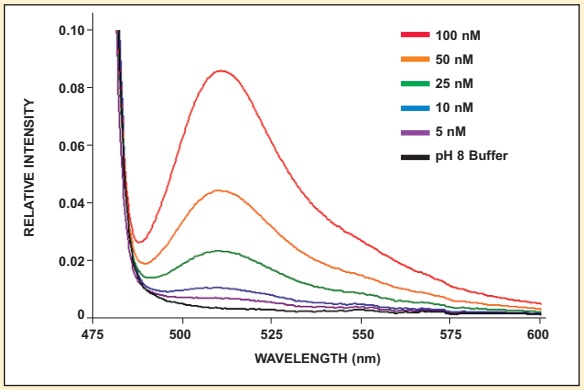
A pipetter is used to inject fluid into the CFV-PIP-SP FluoroVette.

A FluoroVette slides into the top of the Cuvette Adapter, which then inserts into a cuvette holder.



A pump and tubing are used to circulate the fluid through the CFV-PUMP-SP FluoroVette.

Fluorescein Spectra in pH 8 Buffer



Detection of fluorescein in the nanomolar range (nM) is typical with FluoroVettes. These spectra were made with a CFV-PIP-SP, USB2000-FLG Spectrometer, LS-450 Blue LED, CUV-ALL-UV Cuvette Holder, 1000 µm illumination fiber and 600 µm read fiber. The integration time was 1000 msec; a longer integration time provides even lower detection limits.

Specifications	
Size:	50 mm tall, 9 mm wide, and 1 mm thick
Volume:	50 µL
Pathlength:	0.75 mm
Detection limit:	5 nM detection limit of fluorescein with pH 8 buffer and 1000 msec integration time
Dead volume:	1 µL for pipette interface; for tubing interface, dead volume depends on tubing length
Wavelength range:	220-2500 nm
Accuracy:	FluoroVettes are linear over the concentration range, typical error is less than 5%

Item	Description	Price
CFV-PIP-SP	Pack of 10 FluoroVettes with pipetter interface (for use with a pipetter) and one FluoroVette Cuvette Adapter Assembly for 1-cm standard cuvette holders	$125
CFV-PUMP-SP	Pack of 10 FluoroVette Flow Cells with tubing interface (for use with pump and tubing, neither included) and one FluoroVette Cuvette Adapter Assembly for 1-cm standard cuvette holders	$125

Cosine Correctors: Emission Collection

Collect Radiation from 180°

Our Cosine Correctors couple to optical fibers and spectrometers for relative and absolute spectral intensity measurements, for emissive color applications, and for evaluation of light sources such as LEDs and lasers.

Probe Option

When the CC-3 and CC-3-UV are screwed onto the end of an optical fiber, the cosine corrector and optical fiber become an irradiance probe. The probe couples to one of our spectrometers to measure the intensity of light normal to the probe surface.

The CC-3-DA (above left) attaches directly to an SMA 905 Connector on a spectrometer, creating a spectroradiometer. The CC-3 and CC-3-UV (above, right) attach to fibers, creating Irradiance Probes.

Direct-attach Option

The CC-3-DA screws directly onto the SMA 905 Connector of an Ocean Optics Spectrometer, creating a complete spectroradiometric system and eliminating the need for an optical fiber.

Diffusing Material: UV-VIS or VIS-NIR

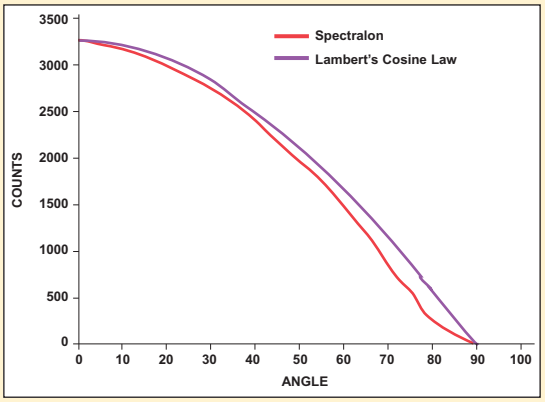
The diffusing material used in the cosine corrector is a thin disk of opaline glass (350-1100 nm) or Spectralon (200-1100 nm) that sits at the end of a stainless steel barrel.

CC-3:	$99
CC-3-UV:	$129
CC-3-DA:	$299

Specifications

	CC-3	CC-3-UV	CC-3-DA
Diffusing material:	Opaline glass	Spectralon	Spectralon
Wavelength range:	350-1000 nm	200-1100 nm	200-1100 nm
Dimensions:	6.35 mm OD	6.35 mm OD	12.7 mm OD
Field of view:	180°	180°	180°

CC-3-UV Angular Response



The response of the Spectralon disc (red trace) used in the CC-3-UV closely matches that of Lambert's Cosine Law.

Power Supply & Controller for LEDs

Measuring LEDs

The LED-PS Power Supply works with our spectrometers and the FOIS-1 Fiber Optic Integrating Sphere (see page 105) for spectroradiometric and color measurements of LEDs. The LED-PS unit has easy-to-reach electrical connectors for mounting LEDs that are 9.52-mm diameter or smaller with 2.77-mm lead spacing.

Adjustable Drive Current

The LED-PS holds the LED in place, powers the LED, and displays the LED's drive current. The drive current is adjustable, with a digital display to indicate the current level. With the LED-PS-NIST, the current meter is calibrated against a NIST-traceable standard. For more on LED measurements, see page 56.

LED-PS:	$499
LED-PS-NIST:	$749
LED-PS-RECAL:	$199

Specifications

Dimensions:	56.8 mm x 56.8 mm x 56 mm
Weight:	170 g
Power consumption:	Up to 100 mA @ 12 VDC; depends on setting
LED drive current:	12-50 mA with 0.1 mA resolution
Drive current accuracy:	±1.0%
LED mount:	2.77 mm lead spacing, PTFE base

Integrating Spheres: Irradiance/Emission

ISP-I Integrating Spheres

Specifications	
Weight:	330 g (ISP-30); 730 g (ISP-50); 1,650 g (ISP-80)
Spectral range:	200-2500 nm
Sphere coating:	Proprietary PTFE-based diffusing material
Reflectivity:	>98% (400-1500 nm); >95% (250-2000 nm)

Emission Collection

ISP-I Integrating Spheres are convenient sampling optics that couple to our spectrometers via optical fibers to measure the spectral output from 200-2500 nm of LEDs, lasers and other light sources. Each integrating sphere consists of a proprietary PTFE-based, sintered diffusing material -- in diameters of 30 mm, 50 mm or 80 mm -- that provides a Lambertian surface for irradiance measurements.

LED Measurement & Direct-attach Option

An ISP-LED-ADP adapter holds in place 3 mm, 5 mm or 8 mm LEDs and screws into the sample port of the ISP-50-8-I Integrating Sphere for measuring LEDs. The adapter ensures reproducibility. Other options are the USB-ISP-50 or USB-ISP-80, which directly attach to a USB2000 and USB4000 Spectrometer, eliminating the need for a read fiber. If the sample ports are too small, we offer custom sample port sizes for all ISPs. Custom machining for ports in diameters of 8, 10, 12, 14, 16 or 20 mm is available (see below).

Item	Description	Sample Port	Max. Fiber	Price
ISP-30-6-I	Integrating sphere, 59 mm diameter, 58 mm high	6 mm	800 µm	$1,337
ISP-50-8-I	Integrating sphere, 80 mm diameter, 78 mm high	8 mm	600 µm	$1,741
ISP-80-8-I	Integrating sphere, 107 mm diameter, 117 mm high	8 mm	400 µm	$2,156
ISP-LED-ADP	Holds in place 3, 5 or 8 mm LED for reproducibility; for use with ISP-50-8-1	N/A	N/A	$202
USB-ISP-50-I	ISP-50-8-I designed to directly attach to a USB2000 or USB4000 Spectrometer	8 mm	600 µm	$2,217
USB-ISP-80-I	ISP-80-8-I designed to directly attach to a USB2000 or USB4000 Spectrometer	8 mm	600 µm	$2,632
ISP-PORT-1	Custom sample port machining of 8, 10, or 12 mm diameter	8, 10 or 12 mm	400 µm	$172
ISP-PORT-2	Custom sample port machining of 14,16 or 20 mm diameter	14, 16 or 20 mm	400 µm	$335
HL-2000-CAL-ISP	NIST-traceable radiometric standard for use with ISP-50-8-I; see page 133	N/A	N/A	$883

FOIS-1 Fiber Optic Integrating Sphere

In the picture top right, the FOIS-1 is being used to measure LEDs. In the picture bottom right, the FOIS-1 is attached to a 74-ACH, a setup often used when making transmission measurements of curved optics. An optic is set between the FOIS-1 and the right arm of the 74-ACH.

Specifications			
Dimensions:	56.8 mm x 62.4 mm (housing) 38.1 mm diameter (sphere)	Weight:	240 g
		Spectral range:	200-2500 nm
Top mounts:	(2) 6-32; (2) 8-32; (1) 1/4-20	Sample port:	9.5 mm aperture
Side mounts:	SMA 905 Connector; (1) 8-32	Sphere coating:	Spectralon

360° Emission Collection

The FOIS-1 is a compact sampling optic that collects light from emission sources such as LEDs and lasers, or that measures light fields with a 360° field of view.

Principle of Operation

At the heart of the FOIS-1 is Spectralon, a white diffusing material with a highly Lambertian surface. Light enters the sphere via a 9.5-mm diameter port while a fiber -- oriented at 90° to the sample port -- collects the light. The size of the FOIS-1 and its three mounting holes make it easy to connect the sphere to other items, such as the 74-ACH Adjustable Collimating Lens Holder (at left).

Use with Calibrated Light Source

Before measuring the absolute spectral intensity of emission sources, use the LS-1-CAL-INT Calibrated Light Source to calibrate the absolute spectral response of your spectroradiometric system. For more on the LS-1-CAL-INT, see page 133.

FOIS-1: $499

Integrating Spheres for Reflectance

ISP-REF Illuminated Integrating Sphere

The ISP-REF Illuminated Integrating Sphere couples to our spectrometers to measure the total integrated reflectance of surfaces placed against the sphere's sample port. The ISP-REF can measure variegated and opaque samples.

The ISP-REF measures the reflectance from flat surfaces pressed against its 10.3-mm diameter sample port. Illumination is provided by an internal tungsten halogen lamp powered with a 12 VDC wall transformer. The lamp is baffled so that all light that strikes the sample has been reflected from the sphere walls. The sphere's highly Lambertian interior provides a uniform 180° illumination field. The sample is viewed from 8° from normal by a lens system that couples to the fiber optic sample port. The field of view is restricted to the sample area, and has a divergence of ~2°. A simple switch allows you to open or close a gloss trap opposite the lens for the inclusion or exclusion of specular reflectance. A reference fiber port is provided to connect to a second spectrometer channel to monitor the output of the light source during long experiments, or for bringing external light into the sphere.

ISP-REF: $1,599
ISP-REF-B Bulb: $40

ISP-R Integrating Spheres

The ISP-Rs are distinguished by their compact size and sturdy design. Each has SMA 905 fiber ports at 90° (to connect to a spectrometer) and 8° (to connect to a light source for direct illumination).

Each sphere is made of a sintered PTFE, which is >98% reflective in the visible. The spheres are available in diameters of 30 mm, 50 mm and 80 mm. Sample port diameters are 6 mm for the 30-mm sphere and 8 mm for the 50-mm and 80-mm spheres. If the 6-mm or 8-mm diameter sample ports are too small, custom sample port sizes for all ISP-Rs are available. For sample ports in diameters of 8, 10, or 12 mm, select ISP-PORT-1. To custom machine a 14,16 or 20 mm sample port, order an ISP-PORT-2.

The gloss-trap version (see inset, far right) comes with two cylindrical pieces -- one is made of black absorbing material and the other of white reflecting material -- that fit into a hole at the top of the sphere. When using the white gloss trap, you can make specular and diffuse measurements. When using the black gloss trap, you can use the ISP-Rs for diffuse measurements.

ISP-30-6-R: $1,739
ISP-50-8-R: $2,009
ISP-80-8-R: $2,424
ISP-50-8-R-GT: $2,163
ISP-PORT-1: $172
ISP-PORT-2: $335

Specifications

	ISP-REF	ISP-30-6-R	ISP-50-8-R	ISP-80-8-R	ISP-50-8-R-GT
Dimensions:	54 mm x 57 mm x 83 mm	59 mm dia., 58 mm high	80 mm dia., 78 mm high	107 mm dia., 117 mm high	80 mm dia., 78 mm high
Weight:	864.7 g	330 g	730 g	1,650 g	743.3 g
Power consumption:	600 mA @ 12 VDC (lamp)	None	None	None	None
Spectral range:	360-2000 nm	200-2500 nm	200-2500 nm	200-2500 nm	200-2500 nm
Sphere diameter:	38.1 mm	30 mm	50 mm	80 mm	50 mm
Sample port diameter:	10.32 mm	6 mm	8 mm	8 mm	8 mm
Sphere coating:	Spectralon	PTFE material	PTFE material	PTFE material	PTFE material
Reflectance:	Diffuse or specular and diffuse	Specular and diffuse	Specular and diffuse	Specular and diffuse	Diffuse
Reflectivity:	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)
Bulb:	900-hour bulb; 3100 K color temp.	None	None	None	None

Diffuse Reflectance Standards

WS-1

WS-1 Diffuse Reflectance Standard

The WS-1 Diffuse Reflectance Standard (at left) is made of PTFE, a diffuse white plastic that provides a Lambertian reference surface for reflectance experiments. The WS-1 comes in an anodized aluminum housing, and is hydrophobic, chemically inert and very stable, even in deep-ultraviolet applications. It is >98% reflective from 250-1500 nm and >95% reflective from 250-2200 nm.

WS-1: $299

WS-1-SL

WS-1-SL White Reflectance Standard with Spectralon

The WS-1-SL is a diffuse reflectance standard from Labsphere and is made from their patented diffuse reflectance material, Spectralon. Spectralon is hydrophobic and is thermally stable to 350 °C. The durable material provides highly accurate, reproducible data. Unlike all the other PTFE-based standards on this page, the WS-1-SL often can be smoothed, flattened and cleaned if nicked or soiled.

WS-1-SL: $329


WS-1-SS

WS-1-SS Includes Stainless-steel Housing

The WS-1-SS comes in a stainless steel housing and has the same properties as the WS-1. In addition, the surface of the WS-1-SS is slightly recessed to allow the RPH-1 Reflection Probe Holder to sit on the standard without coming in direct contact with the standard's surface.

WS-1-SS: $396

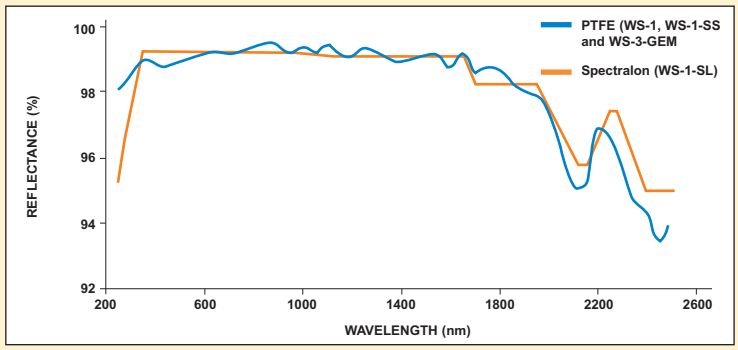

WS-3-GEM

WS-3-GEM White Reference Tile

Conceived for use in colorimetric applications involving diamonds and other gems, the WS-3-GEM White Reference Tile consists of a diffuse PTFE material, shaped to form a holder within its stainless steel receptacle. Because of its concave shape, the WS-3-GEM becomes an integrating sphere when illuminated. The WS-3-GEM has >98% reflectivity from 250-1500 nm and >95% reflectivity from 250-2200 nm. Like the WS-1, the WS-3-GEM's reflectance material is hydrophobic, chemically inert and very stable, even in deep-UV applications.

WS-3-GEM: $530

Reflectivity of the White Standards



Specifications

	WS-1	WS-1-SL	WS-1-SS	WS-3-GEM
Dimensions:	38 mm diameter (housing) 32 mm OD, 10 mm thick (tile)	38 mm diameter (housing) 32 mm OD, 10 mm thick (tile)	38 mm diameter (housing) 32 mm OD, 10 mm thick (tile)	38 mm diameter (housing) 31 mm OD, 10 mm thick (tile)
Weight:	30 g	30 g	30 g	30 g
Spectral range:	250-2000 nm	250-2500 nm	250-2000 nm	250-2000 nm
Housing:	Aluminum	Delrin holder, protective cover	Stainless steel	Stainless steel
Reflectivity:	>98% (250-1500 nm) >95% (250-2200 nm)	99% (400-1500 nm) >96% (250-2000 nm)	>98% (250-1500 nm) >95% (250-2200 nm)	>98% (250-1500 nm) >95% (250-2200 nm)

Specular Reflectance Standards

Versatile & Durable Standards

We offer three specular reflectance standards for use as references when measuring the reflection of surfaces with high or low specular reflectivity. Each standard consists of a 31.7-mm outer diameter optical reflectance material in a protective aluminum receptacle with screw-on top. The superior coatings on the substrates are environmentally stable; they are able to withstand high temperatures and mechanical stresses.

Software Referencing & Calibration

Reflectivity values for the standards are built into our Spectroscopy Operating Software to provide a reference for any specular measurement. You simply choose the standard from a software menu and the software reads data from the electronic file shipped with the standard.

With the STAN-SSH High-reflectivity Specular Reflectance Standard (above), you receive a certificate of calibration in paper and electronic formats.

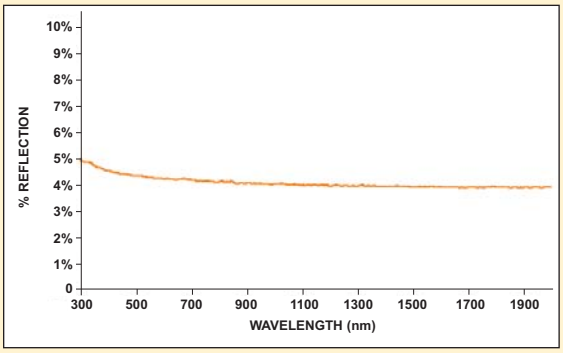
For High Reflectivity

The STAN-SSH High-reflectivity Specular Reflectance Standard is a fused-silica substrate coated with aluminum and protected by a thin layer of magnesium fluoride. This standard is typically used for measuring high-reflectance surfaces of optical substrates and coatings, machined metals and semiconductor materials. Values for the STAN-SSH are calculated for any angle from 0-45°.

For Calibrated High Reflectivity

Also available is a calibrated version of the STAN-SSH. The STAN-SSH-NIST is calibrated at a 6° angle traceable to NIST and is accurate to ±0.1% from 250-2500 nm. The STAN-SSH-NIST comes with calibrated reflectivity values (from a 6° angle) in both paper and electronic formats. We recommend a periodic recalibration of the STAN-SSH-NIST, which costs $149. Should the calibrated surface become corrupted, a recoat and calibration service is available for $299.

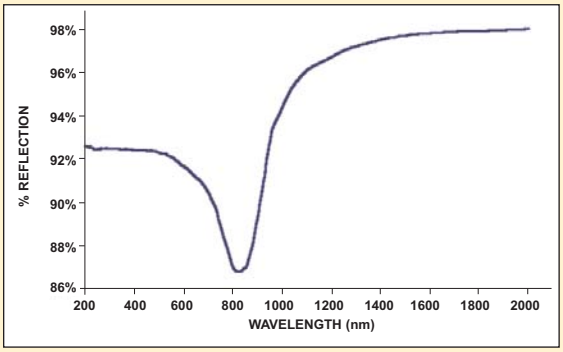
Reflectance of STAN-SSL at 6°



For Low Reflectivity

The STAN-SSL Low-reflectivity Specular Reflectance Standard is a black glass standard that can be used as a reference when measuring the low-reflectance surfaces of samples such as thin film coatings, anti-reflective coatings, blocking filters and substrates.

Reflectance of STAN-SSH at 6°



Holder Protects Standards

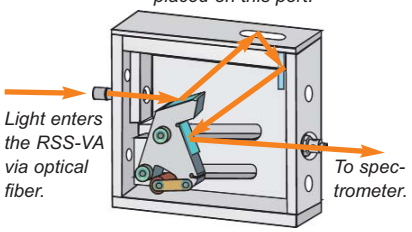
We also offer a holder for use with our reflectance standards. The STAN-HOLDER supports a standard during measurements, which helps to preserve its coating.

STAN-SSH:	$499
STAN-SSH-NIST:	$999
STAN-SSL:	$499
STAN-HOLDER:	$75

Specifications

	STAN-SSH	STAN-SSH-NIST	STAN-SSL
Substrate dimensions:	31.75 mm outer diameter x 6.35 mm height	31.75 mm outer diameter x 6.35 mm height	31.75 mm outer diameter x 6.35 mm height
Housing dimensions:	38 mm outer diameter x 19 mm height	38 mm outer diameter x 19 mm height	38 mm outer diameter x 19 mm height
Weight:	40 g	40 g	40 g
Reflectance material:	Front-surface protected aluminum mirror on fused silica substrate	Front-surface protected aluminum mirror on fused silica substrate	Schott ND9 glass
Reflectivity:	~87-93% (200-1000 nm) ~93-98% (1000-2500 nm)	~87-93% (200-1000 nm) ~93-98% (1000-2500 nm)	~5% (200-950 nm) ~4% (950-2500 nm)

Variable-angle Reflection Sampling System



Measure Optical Substrates at Different AOI

The RSS-VA Variable-angle Reflection Sampling System is a cleverly designed opto-mechanical device for measuring specular reflection of optical substrates at varying angles of incidence (AOI). When coupled to our spectrometers and light sources, the RSS-VA becomes a compact alternative to unwieldy, high-priced systems typically used to characterize optical substrates.

Opto-Mechanical Design

The RSS-VA has two ports for SMA 905-terminated optical fibers: one to illuminate the optical substrate, the other to collect the reflectance and send it to the spectrometer (see drawing). This fiber-in/fiber-out design takes advantage of a sophisticated optical train that allows users to change the angle of incidence (AOI) from 10° to 50° simply by manipulating the carriage inside the black anodized stainless steel device housing. Also included is a three-point surface mount for holding the sample in a fixed position. To normalize measurements taken with the RSS-VA, you will need a reflectance standard such as the Specular Reflectance Standards on page 108.

RSS-VA: $1,400
RSS-VA-ADP: $99

Specifications

Dimensions:	114.3 mm x 41.3 mm x 101.6 mm
Weight:	980 g
Sample port:	19.0 mm x 6.4 mm
Connectors:	(2) SMA 905 Connectors (for illumination fiber & read fiber)
Surface mount:	3-point
Angles of incidence:	~10° to ~50° (user-adjusted)
Recommended fibers:	100 µm (illumination and read)
Material:	Black anodized aluminum

Reflection & Transmission Stages

The Single-Point Reflection Stage (at right) is a probe holder for reflection measurements of optical layers and other substrates up to 150 mm in diameter. The probe holder accommodates fiber optic probes up to 6.35 mm in diameter, and slides up and down a stainless steel post for adjustment to heights as great as ~63.5 mm. The Stage has an anodized base plate scored in concentric circles of varying diameters, to act as a guide when positioning round samples.

The Stage-RTL-T is a novel sampling system for analysis of substrate materials such as silicon, metals, glass and plastics. The RTL-T couples to our spectrometers and light sources, and can be used in a variety of setups for reflection and transmission measurements. The Stage-RTL-T consists of a variable rail attached to a base plate, with three devices that attach to the rail with a thumbscrew. These devices are a fiber holder with collimating lens, a sample holder for reflection or transmission, and a light trap to mitigate the effects of back reflection and ambient light. The STAGE-RTL-T is remarkably versatile: perform reflection measurements with the probe positioned above or below the sample (measuring from below maintains a constant distance between probe and sample); make reflection measurements with the light trap in place; or measure transmission of samples using two fibers.

STAGE: $631
STAGE-RTL-T: $2,303

Specifications

	STAGE	STAGE-RTL-T
Dimensions:	152.4 mm diameter (base)	206.3 mm diameter (base)
Dimensions:	101.6 mm diameter* (sample area)	152.4 mm diameter (sample area)
Weight:	620 g	4.5 kg
Height:	Rail height adjustable to 63.5 mm	Rail height adjustable to 400 mm
Materials:	Anodized aluminum plate, stainless steel post and post holder	Anodized aluminum

** Represents the area of scored concentric circles. You could use the entire base plate area, which is larger, for your sample.*

Optical Flats

Visual Reference

Each Optical Flat is a finely polished optical reference surface that can be used to visually inspect the flatness of optical components such as mirrors, filters, prisms and windows. Flats can also be used as windows for interferometry applications.

What to Select

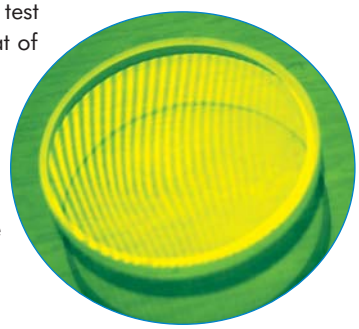
We offer single-sided flats made from either fused silica or Zerodur, each of which can be enhanced with an aluminum coating to increase contrast and improve the visual reference. We manufacture flats ranging from 1" to 6" in diameter and with flatness accuracies as precise as 1/20 wave.

Fused Silica or Zerodur

Your selection of fused silica or Zerodur flats depends on the application. Fused silica has a low thermal expansion and is highly resistant to abrasion. Zerodur is a glass ceramic that exhibits an even lower thermal expansion, making it useful for applications with significant temperature fluctuations.

How Flats Work

The choice of flatness accuracy depends on the application. For example, if the test surface is flatter than 1/4 wave, a more precise 1/10 wave flat is required to display the interference pattern change. When an Optical Flat is placed in contact with a test surface and illuminated with monochromatic light, an interference pattern of light and dark bands forms. A curved interference pattern like the one shown here indicates that the flatness of the test surface is less than that of the reference. Evenly spaced patterns indicate that the flatness of the test surface is equal to or higher than that of the reference.



Fused Silica Optical Flats

Item	Diameter	Center Thickness	Aluminum Coating	Flatness	Price
FLS-10-SS	1.0"	0.5"	No	1/10λ	$200
FLS-10-SSM	1.0"	0.5"	Yes	1/10λ	$250
FLS-12-SS	1.0"	0.5"	No	1/20λ	$225
FLS-12-SSM	1.0"	0.5"	Yes	1/20λ	$270
FLS-14-SS	1.0"	0.5"	No	1/4λ	$170
FLS-14-SSM	1.0"	0.5"	Yes	1/4λ	$210
FLS-20-SS	2.0"	0.5"	No	1/10λ	$290
FLS-20-SSM	2.0"	0.5"	Yes	1/10λ	$330
FLS-22-SS	2.0"	0.5"	No	1/20λ	$350
FLS-22-SSM	2.0"	0.5	Yes	1/20λ	$400
FLS-24-SS	2.0"	0.5"	No	1/4λ	$230
FLS-24-SSM	2.0"	0.5"	Yes	1/4λ	$255
FLS-40-SS	4.0"	0.75"	No	1/10λ	$650
FLS-40-SSM	4.0"	0.75"	Yes	1/10λ	$765
FLS-42-SS	4.0"	0.75"	No	1/20λ	$765
FLS-42-SSM	4.0"	0.75"	Yes	1/20λ	$875
FLS-60-SS	6.0"	1.0"	No	1/10λ	$1,200
FLS-60-SSM	6.0"	1.0"	Yes	1/10λ	$1,325
FLS-62-SS	6.0"	1.0"	No	1/20λ	$1,395
FLS-62-SSM	6.0"	1.0"	Yes	1/20λ	$1,665

Zerodur Optical Flats

Item	Diameter	Center Thickness	Aluminum Coating	Flatness	Price
FLZ-10-SS	1.0"	0.5"	No	1/10λ	$200
FLZ-10-SSM	1.0"	0.5"	Yes	1/10λ	$250
FLZ-12-SS	1.0"	0.5"	No	1/20λ	$225
FLZ-12-SSM	1.0"	0.5"	Yes	1/20λ	$270
FLZ-14-SS	1.0"	0.5"	No	1/4λ	$170
FLZ-14-SSM	1.0"	0.5"	Yes	1/4λ	$210
FLZ-20-SS	2.0"	0.5"	No	1/10λ	$290
FLZ-20-SSM	2.0"	0.5"	Yes	1/10λ	$330
FLZ-22-SS	2.0"	0.5"	No	1/20λ	$350
FLZ-22-SSM	2.0"	0.5"	Yes	1/20λ	$400
FLZ-24-SS	2.0"	0.5"	No	1/4λ	$230
FLZ-24-SSM	2.0"	0.5"	Yes	1/4λ	$255
FLZ-40-SS	4.0"	0.75"	No	1/10λ	$650
FLZ-40-SSM	4.0"	0.75"	Yes	1/10λ	$765
FLZ-42-SS	4.0"	0.75"	No	1/20λ	$765
FLZ-42-SSM	4.0"	0.75"	Yes	1/20λ	$875
FLZ-60-SS	6.0"	1.0"	No	1/10λ	$1,200
FLZ-60-SSM	6.0"	1.0"	Yes	1/10λ	$1,325
FLZ-62-SS	6.0"	1.0"	No	1/20λ	$1,395
FLZ-62-SSM	6.0"	1.0"	Yes	1/20λ	$1,665

Specifications

	FLS (Fused Silica)	FLZ (Zerodur)
Surface quality:	60-40	60-40
Wedge:	< 5 minutes	< 5 minutes
Tolerance:	± 1 mm on CT ± 0.25 mm on diameter	± 1 mm on CT ± 0.25 mm on diameter
Refractive index:	1.458 n_d	1.542 n_d
Abbe #:	67.7 v_d	56.2 v_d
Thermal expansion:	0.55 x 10^{-6} °C^{-1}	0.10 x 10^{-6} °C^{-1}

Shear-plate Collimation Testers

Applications Versatility

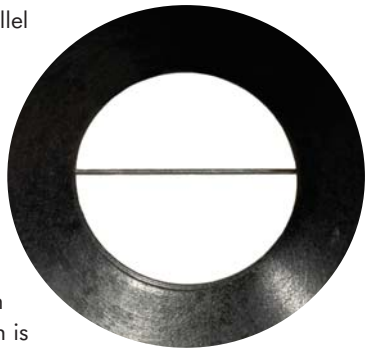
Use Shear-plate Collimation Testers to examine and adjust the collimation of laser light, or to measure the wavefront curvature and divergence/convergence magnitude of large-radius optical components.

Various Aperture Sizes from 350-2500 nm

Each tester is useable from 350-2500 nm, and is available in apertures ranging from 10-200 mm. Each tester consists of a wedged, high-quality optical flat housed in a heavy-duty anodized aluminum frame.

Basic Operation with Interferometric Design

The testers are remarkably easy to use: When a planar wavefront is incident at an angle of 45°, two reflected wavefronts result. The lateral separation of these wavefronts is referred to as shear. Fringes -- parallel patterns of light and dark areas -- will be seen in the overlapping region of the two images. Collimating the laser beam is a matter of adjusting the collimating system until the fringe pattern is parallel to the shadow of the collimation tester's reference wire.



Collimation Testers

Item Code	Aperture Size	Price
CT-10	10 mm	$600
CT-20	20 mm	$700
CT-50	50 mm	$800
CT-75	75 mm	$950
CT-100	100 mm	$1,200
CT-125	125 mm	$1,700
CT-150	150 mm	$2,800
CT-200	200 mm	$4,800

Thin Film Reference Wafer

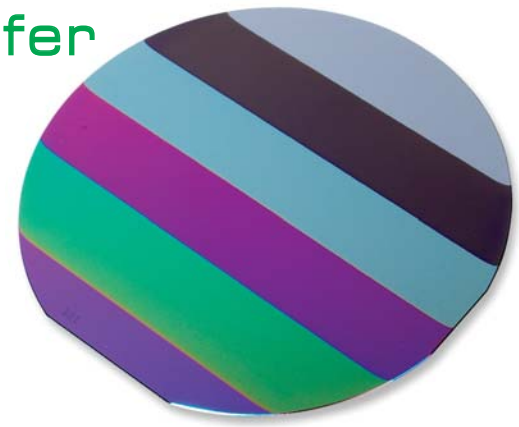
5-step Wafer

When measuring the thickness of substrates such as silicon wafers or optical layers, consider our Silicon-Silicon Dioxide (Si-SiO_2) Reference Wafer. This 9.8-cm (4") diameter, 5-step wafer has a calibrated thickness range of 0-500 nm, and is ideal for use as a reference standard when measuring the thickness of thin, transparent layers on various substrates.

Calibrated

The Reference Wafer consists of a thin wafer of silicon dioxide on silicon, with each transparent step numbered and etched on the wafer surface. A calibration data sheet -- the wafer is calibrated using an ellipsometer -- includes information for each step such as the X and Y positions, δ (Psi), ψ (Delta), period (in nm) and thickness (in nm).

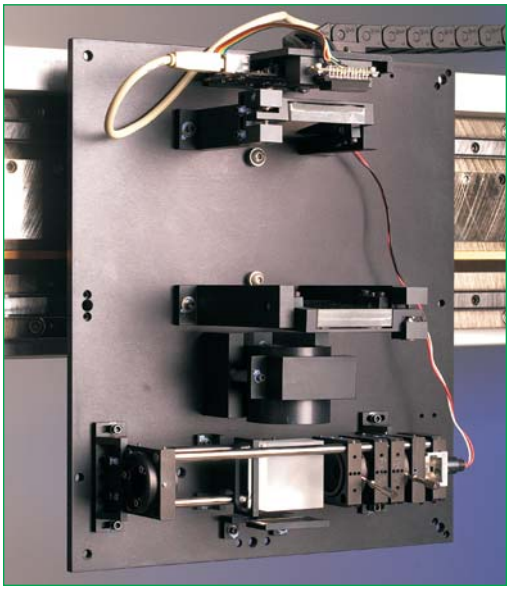
REFERENCE: $669



Step Sizes
0-500 nm with 100 nm steps:

0 nm (uncoated)
100 nm (±20 nm)
200 nm (±20 nm)
300 nm (±20 nm)
400 nm (±20 nm)
500 nm (±20 nm)

Long Trace Profilometer



The LTP-V has a linear servomotor that's so accurate it can position itself within 0.5 mm. The streamlined optical head design (shown above) is temperature-insensitive and has only two optical controls -- beam amplitude and sample-versus-reference balance. A polarizing beamsplitter is accurate to 1/20 wave. Included is a miniature CCD-array system that interfaces to PCs via a USB cable.

Specifications	
Scan length:	1500 mm
Scan velocity:	3 mm/second (assuming 1-mm steps, 1 sample)
Position accuracy:	± 0.5 µm
Slope accuracy:	<1 microradian
Height accuracy:	<50 nm; 10-nm variations have been measured
Slope measurement range:	±5.0 milliradian

Unique Optical Profiling Tool

The LTP-V Long Trace Profilometer is an interferometric optical profiling instrument for absolute figure measurement of flats, spheres and aspheres up to 1500 mm in diameter. The LTP-V characterizes the figure and mid-frequency errors on cylindrical aspheres over one meter in length, and excels at measuring the shape of exotic aspheric optics, adaptive optics and mirror-bending mechanisms. With the LTP-V, optical surfaces can be measured quickly, easily and with nanometer precision and accuracy -- without the need for null corrector lenses or external reference surfaces. It is the only instrument now available for absolute figure measurement of optics as large as 150 cm in diameter.

About the Instrument

Conceived at Brookhaven National Laboratory and commercialized by Continental Optical in the early 1990s, the Long Trace Profilometer has been completely redesigned since our acquisition of Continental Optical in 2000. The LTP-V is a slope-measuring interferometer that measures the phase difference between two co-linear probe beams as they move across the sample surface. It is extremely insensitive to vibrations, which makes it suitable for use in laboratory environments.

Absolute Accuracy

What sets the LTP-V apart from other profile-measuring instruments is its ability to correct for real-time probe beam angular errors during the traverse of the linear beam, without the need for a calibrated external reference standard. Variations in the probe beam pointing direction are measured and subtracted from the test surface slope, resulting in the absolute slope profile and measurement of the absolute radius of curvature of the test surface.

Pricing

A great deal of care and consultation is required before the purchase of an LTP-V. The cost for the LTP-V includes these consultations, shipping of the instrument, installation of the instrument, and training in its operation. The LTP-VMIR is an additional attachment for taking vertical and inverted mirror scans. The LTP-CALSTD is a calibrated standard mirror for use as a reference source.

LTP-V:	$120,000
LTP-VMIR:	$1,500
LTP-CALSTD:	$1,000

Filter Sample Holders

In-line Filter Holder

The FHS-UV In-line Filter Holder is a dual-purpose fixture for projecting a collimated beam of light through a flat optical filter. The FHS-UV can measure the transmission of filters, or provide a location in an optical system for inserting filters. It has two 74-UV Collimating Lenses mounted across a filter holder, which holds round filters up to 25 mm in diameter and samples up to six millimeters thick. (For large filters and other samples, see the 74-ACH Adjustable Collimating Lens Holder.) A bushing keeps the filter against the reference surface. A shutter facilitates taking dark measurements.

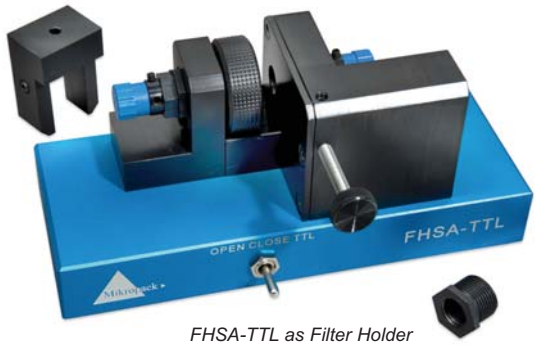
FHS-UV: $399

FHS-UV In-line Filter Holder

Filter & Cuvette Holders

What's unique about the FHSA Filter/Cuvette Holders is you can configure the holders to sample either cuvettes or filters. Use the FHSAs to measure transmission of 1-cm square cuvettes or filters up to seven millimeters thick. In addition, FHSAs interface via RS-232 bus to PCs, allowing you to control some functions of the FHSAs via software, which is included. With the FHSA-TTL, you have manual control of attenuation (adjustable from 0-100%), and manual or software control of a shutter. With the FHSA-RS232, you have software control of both the attenuation and shutter functions. Both versions include a 12 VDC power supply.

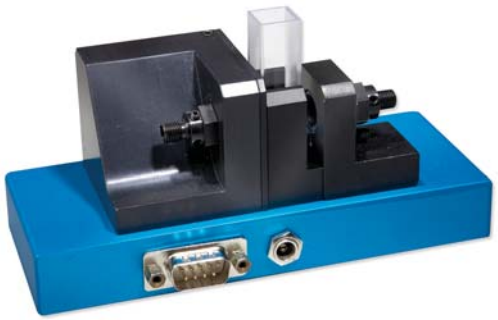
FHSA-TTL: $1,332
FHSA-RS232: $2,349



FHSA-TTL as Filter Holder

Specifications

	FHSA-TTL	FHS-UV
Dimensions:	140 mm x 50 mm x 50 mm	50.6 mm x 140 mm x 43.1 mm
Weight:	490 g	240 g
Power consumption:	100 mA @ 12 VDC	None
Filter size (maximum):	Any sample up to 7 mm thick	25-mm diameter round; any sample up to 6-mm thick
Light source:	None	None
Wavelength range:	200-2000 nm	200-2000 nm
Optical fibers required:	Yes	Yes
Cuvette dimensions:	10 mm x 10 mm	None
Shutter frequency:	5 Hz/60 dB (maximum)	None
Shutter response time:	7 µsec	None



FHSA-TTL as Cuvette Holder

Filter Holders for Optical Fibers

The INLINE-FH In-line Filter Holder (top photos) holds INLINE-OF Filters or other filters 8 mm in diameter and 2-5 mm thick. The Filter Holder includes two collimating lenses and connects to two fibers for in-line filtering. The FH-SMA (bottom photos) allows you to mount filters or diffusers at the end of SMA 905-terminated optical fibers. The FH-SMA accepts 8-mm diameter filters in thicknesses of 1-7 mm. See page 164 for information on available filters for the INLINE-FH or FH-SMA.

INLINE-FH: $436
INLINE-OF: $102
FH-SMA: $142

Specifications

	FH-SMA	INLINE-FH
Dimensions:	16 mm diameter	15 mm diameter
Weight:	10 g	20 g
Filter size:	8 mm diameter, 1-7 mm thick	8 mm diameter, 2-5 mm thick
Material:	Anodized aluminum	Stainless steel (collimating lenses have anodized housings)

Linear Variable Filters

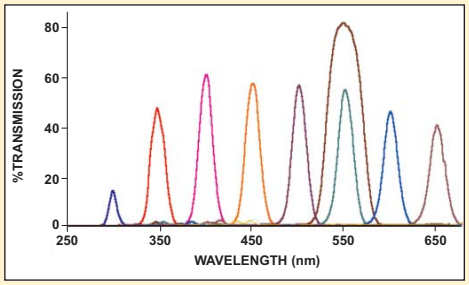
Novel Filtering Technology

We've combined our patented high-pass and low-pass Linear Variable Filters to create the world's first bandpass filter with an adjustable center wavelength and adjustable bandpass. Each filter features an excellent transmission band (~90%) and blocking band (99.8%). These filters -- with interference coatings applied to 57 mm x 10 mm quartz substrates -- are especially useful for spectrally shaping the excitation energy from broadband sources used for fluorescence.

Slide Carriers

These off-the-shelf filters are epoxied into slide carriers that allow you to move the transmission or blocking band throughout the filter's wavelength range.

LVF-HL Variable Bandwidth Filter



These spectra were taken with an LVF-HL to show how a transmission bandwidth can be set throughout the filter's range (300-750 nm).

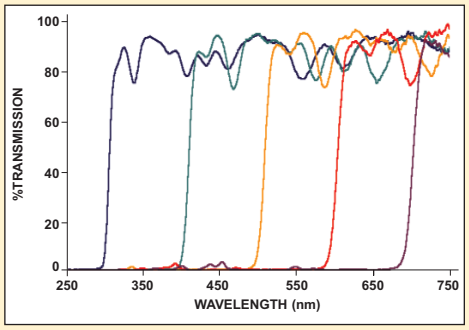
Single High-pass & Single Low-pass Filter

The LVF-H High-pass Filter is a single filter that blocks light at 98.8% up to a transition wavelength that varies along its length. At that point, the LVF-H passes light better than 90%. The LVF-L Low-pass Filter is a single filter that passes light at 88% up to a transition wavelength that varies along its length. At that point, the LVF-L blocks light better than 98.8%.

Double High-pass & Double Low-pass Filters

We take two identical LVF-H or LVF-L filters, align them so that the transition wavelengths of both filters are matched, and then epoxy them together in their slide carriers. The benefit of having double filters versus a single filter is that the optical density of the blocking band increases to 99.96%. However, the transmission band is reduced to 80%.

LVF-H High-pass Filter



The transition wavelength from blocking to transmission band varies according to the filter's position in front of the collimating lens.

High-pass & Low-pass Variable Bandpass Filters

By fastening together a high-pass filter and a low-pass filter, we created a variable bandpass filter that allows you to adjust the center wavelength and the bandwidth. We preset the transmission bandwidth at ~25 nm FWHM, but adjusting four screws allows you to slide the filters against one another to create a transmission bandwidth as wide as ~100 nm and as narrow as ~20 nm.

LVF Accessories

The LVF filters and slide carriers can be inserted easily into spectrometer setups with our LVF accessories. See the next page for details.

Item	Description	Price
LVF-H	A single high-pass filter for 300-750 nm	$249
LVF-L	A single low-pass filter for 300-750 nm	$249
LVF-HH	Two LVF-H high-pass filters epoxied together for 300-750 nm	$499
LVF-LL	Two LVF-L low-pass filters epoxied together for 300-750 nm	$499
LVF-HL	An LVF-H high-pass filter and LVF-L low-pass filter fastened together to create an adjustable bandpass linear variable filter	$499
LVF-UV-H	A single high-pass filter for 230-500 nm	$249
LVF-UV-L	A single low-pass filter for 230-500 nm	$249
LVF-UV-HH	Two LVF-UV-H high-pass filters epoxied together for 230-500 nm	$499
LVF-UV-LL	Two LVF-UV-L low-pass filters epoxied together for 230-500 nm	$499
LVF-UV-HL	An LVF-UV-H high-pass filter and LVF-UV-L low-pass filter fastened together to create an adjustable bandpass linear variable filter	$499

Accessories for Linear Variable Filters

LVF Accessories in Setups

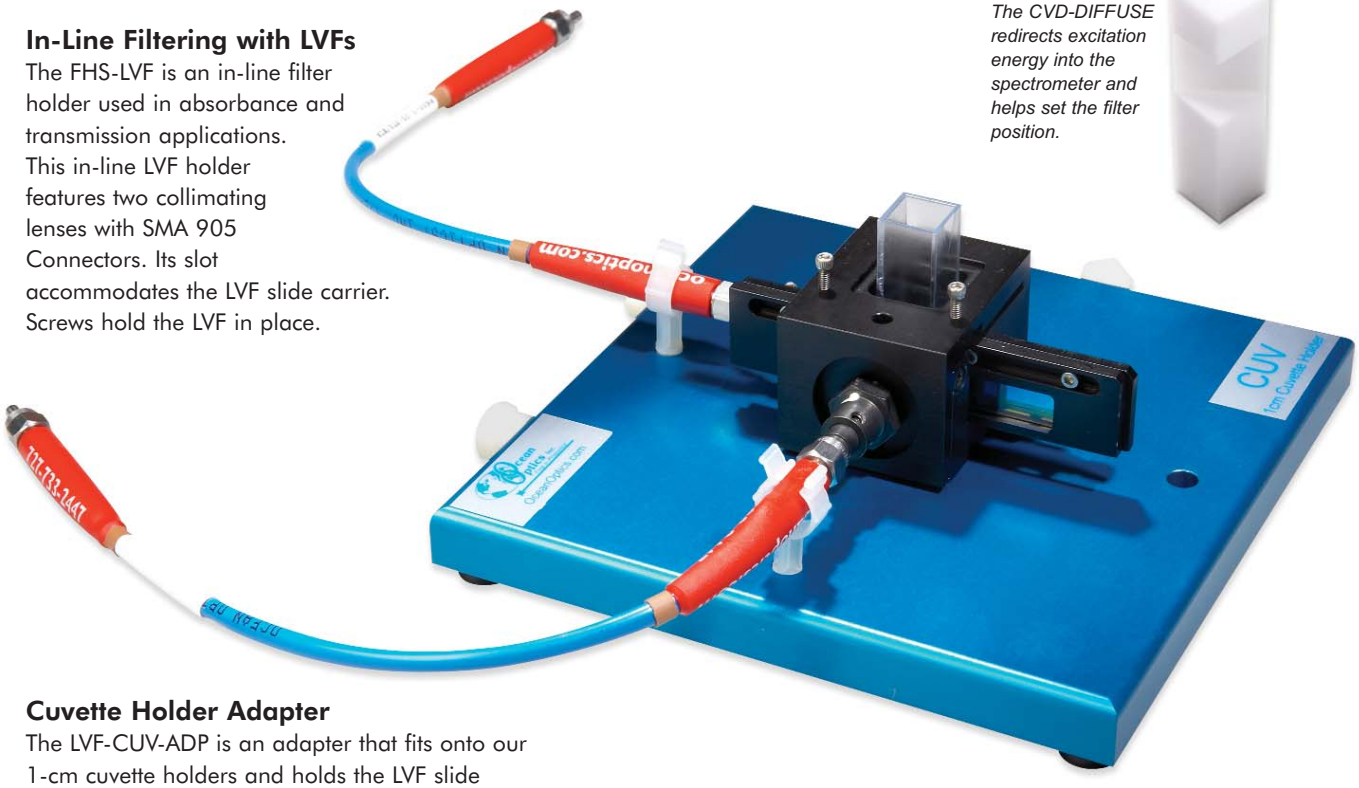
We offer several LVF Linear Variable Filters as either high-pass, low-pass or, when we use them as pairs -- as we do for the LVF-HL -- variable bandwidth filters. These filters are installed into slide carriers, which can accommodate both the single-filter and double-filter configurations. The slide carriers fit into our slide carrier accessories, which make it possible to integrate LVFs with our spectrometers and accessories into fluorescence and absorbance setups.

The LVF is epoxied into a slide carrier, which fits into such LVF accessories as the FH-LVF Filter Holder.

In-Line Filtering with LVFs

The FHS-LVF is an in-line filter holder used in absorbance and transmission applications. This in-line LVF holder features two collimating lenses with SMA 905 Connectors. Its slot accommodates the LVF slide carrier. Screws hold the LVF in place.

The CVD-DIFFUSE redirects excitation energy into the spectrometer and helps set the filter position.



Cuvette Holder Adapter

The LVF-CUV-ADP is an adapter that fits onto our 1-cm cuvette holders and holds the LVF slide carrier. The cuvette adapter slides over the top of the cuvette holder and includes screws to clamp the LVF's slide carrier into place. The LVF-CUV-ADP comes with a cover to block out ambient light.

Diffuser for Redirecting Excitation Light

The CVD-DIFFUSE, a 1-cm cuvette-shaped piece of PTFE material, has a 45° surface at the measurement height and is used with an LVF in a fluorescence cuvette holder to redirect excitation energy 90° into the spectrometer. This facilitates setting the filter position -- i.e., while the CVD-DIFFUSE is inserted in the cuvette holder, you position the LVF to select the wavelength region passed by the filter.

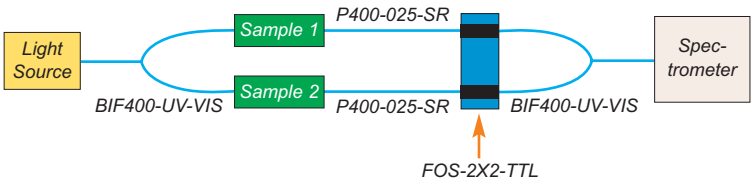
When using an LVF with a cuvette holder like our CUV-ALL 4-way Cuvette Holder, you will need the LVF-CUV-ADP Cuvette Holder Adapter. The LVF (in a slide carrier) is inserted in front of the sample and held in place by the LVF-CUV-ADP (shown at right), with a cover to block ambient light.

Item	Description	Price
LVF-CUV-ADP	An adapter for a 1-cm pathlength cuvette holder that holds the slide carriers in place	$99
CVD-DIFFUSE	A 1-cm cuvette-shaped PTFE for redirecting excitation energy	$99
FHS-LVF	In-line filter holder for LVFs	$399
LVF-KIT	Consists of the LVF-HL, LVF-CUV-ADP, FHS-LVF and CVD-DIFFUSE	$999
LVF-UV-KIT	Consists of the LVF-UV-HL, LVF-CUV-ADP, FHS-LVF and CVD-DIFFUSE	$999

Fiber Optic Dual Switch with TTL Line

The FOS-2X2-TTL Fiber Optic Dual Switch was designed to provide you with flexibility in routing, splitting and controlling light. The FOS has two light channels. You can opt to have one light channel open at a time or have both closed. The FOS is useful for monitoring the drift of the light source or for measuring two samples with one spectrometer channel and one light source. The diagram below is an example of how the FOS can be utilized. In this setup, the FOS eliminates the need for a second spectrometer channel.

FOS-2X2-TTL: $1,664



In this setup, light enters a Bifurcated Optical Fiber Assembly and then splits into two arms, one for each sample. Light interacts with each sample and travels through another fiber assembly, each into its own port in the FOS. Another Bifurcated Assembly collects the light from the FOS and sends it to the spectrometer. Here you would switch the shutter on the FOS from one light channel to another in order to get clean data from each sample. Without the FOS, you would need another spectrometer channel to monitor the two samples.

Specifications	
Dimensions:	100 mm x 70 mm x 70 mm
Weight:	455 g
Material:	Anodized aluminum
Switch frequency:	Maximum of 5 Hz
Power:	12 VDC
Operation:	Manual switch or TTL input signal

Electronic TTL Shutter

In spectrometer setups, the INLINE-TTL TTL-driven shutter allows you to block the light path without disturbing the experiment -- for example, by turning the light source on and off. The laser-cut shutter is installed between two collimating lenses, which attach to two optical fibers. The INLINE-TTL is driven by a small board with a TTL input. Included is a cable for interfacing to a spectrometer.

INLINE-TTL-S: $1,076

Specifications	
Dimensions:	140 mm x 50 mm x 50 mm
Weight:	~600 g
Shutter-Input:	TTL maximum 5 Hz
Power requirements:	12 VDC (power supply included)
Power consumption:	100 mA maximum
Maximum frequency:	5 Hz

Field of View Control

The Gershun Tube Kit (GER-KIT) controls the field of view of our SMA 905-terminated optical fiber. It also directly attaches to a spectrometer with an SMA 905 Connector. User-interchangeable apertures provide many different fields of view from 1° to 28°. (When the GER-KIT is used with our optical fiber, the field of view cannot exceed the optical fiber's 25° field of view if you are measuring radiance.)

GER-KIT: $499

Specifications	
Material:	Black anodized aluminum
Interior:	Bead-blasted surface to reduce off-axis reflections
Connection:	Directly attaches to one of our spectrometers or couples to an SMA 905-terminated optical fiber with included adapter barrel
Apertures:	1°, 3°, 8°, 10° and 14° apertures included, providing 1°, 2°, 3°, 6°, 8°, 10°, 14°, 16°, 20° and 28° fields of view

Optical Multiplexer

An MPM-2000-2x8 has two input ports and 16 outputs. Here, we used a USB2000 Spectrometer and an LS-1 Light Source as the input ports.

Flexibility for Multipoint Sampling

Our MPM-2000 Fiber Optic Multiplexers take light to a spectrometer or from a light source connected to one of the input ports and distribute it to either 8 or 16 outputs. The light is distributed through the output ports in sequential order, with switching times between channels of less than 150 milliseconds. Multiplexers often are found in process industries, where multiple locations need to be measured with one spectrometer channel and/or light source.

High-precision Instrument

All versions of the MPM-2000 include a DC motor, which has excellent speed control without sacrificing power. The motor is on a rotator block and includes an encoder, which converts movement into a digital pulsed output. Each channel in the multiplexer has a collimating lens connecting to an internal optical fiber system. The MPM-2000 provides accurate measurements with an excellent repeatability of 99%.

Multiple Versions

The MPM-2000 comes with either two input channels -- with each input channel corresponding to eight output channels -- or with one input channel and 16 output channels. Choose either a UV-VIS (250-800 nm) or VIS-NIR (350-2000 nm) multiplexer.

Software-controlled

The multiplexers interface to a PC via an RS-232 port and come with software and a driver for complete PC control. The software allows you full control of the switching order, switching delay time and system calibration.

MPM-2000-1X16-UV:	$8,401
MPM-2000-1X16-VIS:	$8,401
MPM-2000-2X8-UV:	$8,736
MPM-2000-2X8-VIS:	$8,736

Specifications	
Dimensions:	230 mm x 200 mm x 150 mm (fits into 19" system: 33TE, 3HE, etc.)
Wavelength range:	250-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
Optical throughput:	> 60% when using standard 400 µm fibers @ 650 nm
Motor:	Direct-current motor
Optical fibers:	400 µm diameter optical fibers
Repeatability:	> 99%
Switching time:	150 milliseconds between adjacent positions
Interface:	RS-232 (optional USB)
Power requirement:	24 VDC, 1.2 A (includes WT-24V-E power supply)
Connectors:	SMA 905

Fiber Optic Variable Attenuator

The FVA-UV Fiber Optic Variable Attenuator is an opto-mechanical device that helps control the amount of light transmitted between two fibers. Two fibers screw into either side of the FVA-UV via SMA 905 Connectors with collimating lenses, which project light across a metal disc in which a slit has been cut. The width of the slit varies as a function of radial position, which is adjusted manually. Rotating the disc varies the attenuation from 0-100% uniformly across a 200-2000 nm wavelength range. An FVA-ADP attaches the FVA-UV directly to a light source.

FVA-UV:	$499
FVA-ADP:	$99

Specifications	
Dimensions:	38.1 mm x 59.4 mm x 40 mm
Weight:	90 g
Assembly ports:	3/8-24 threads for collimating lenses
Wheel lock:	6-32 nylon thumbscrew
ADP adapter:	Directly attaches to a light source with a collimating lens
Connector:	SMA 905

XYZ Mapping Tables

Versatile Design

We offer four high-precision linear XYZ Mapping Tables. The mapping table -- with a linear axis resolution of 1 µm and an accuracy of ±5 µm -- is ideal for spatial mapping of spectral features or for multisampling in microwell plates. See the table below for table options and prices.

Additional Functions

The XYZ Table comes with an electric motor and encoder to drive each axis, along with a CNC Controller and a portal for the vertical (Z-axis) stage. The table makes it possible to measure every sample within an X-Y range of 150 mm x 150 mm or 200 mm x 150 mm. With the 100-mm vertical (Z-axis) stage, you can attach holders for probes and other sampling devices, which are purchased separately.

PC Control

The system requires 110-240 VAC to operate (included) and interfaces via RS-232 bus to PCs. Computer-controlled operation of the motors is available. Contact an Applications Scientist for details.

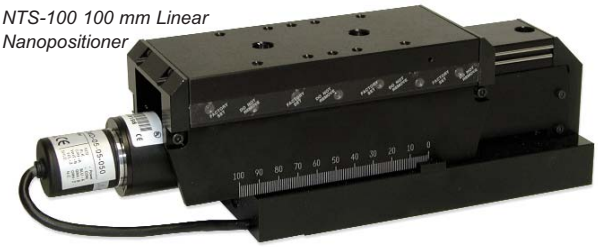
Item	X-axis	Y-axis	Z-axis	Price
XY(Z)-150 X150+	150 mm	150 mm	Optional	$12,650
XY(Z)-200X150+	200 mm	150 mm	Optional	$13,119
XYZ-150 X150X100	150 mm	150 mm	100 mm	$15,397
XYZ-200X150X100	200 mm	150 mm	100 mm	$15,866
Z-AXIS-100+	None	None	100 mm	$2,896

Specifications	
Dimensions base:	476 x 375 x 89 mm
Dimensions rail:	508 x 38 x 165 mm
Weight:	14.7 kg
Power input:	110-240 VAC
Travel range:	150 mm x 150 mm (minimum)
Controller:	CNC Controller (2-3 axes)
Interface:	RS-232

NTS-series Linear Nanopositioners

NTS-25 25 mm Linear Nanopositioner

NTS-100 100 mm Linear Nanopositioner



NTS-ND-3 Controller

Item	Description	Price
NTS-10	Nanopositioner, 10 mm travel	$3,500
NTS-25	Nanopositioner, 25 mm travel	$3,800
NTS-100	Nanopositioner, 100 mm travel	$4,950
NTS-ND-1	NTS Controller, 1 axis	$2,000
NTS-ND-2	NTS Controller, 2 axes	$2,500
NTS-ND-3	NTS Controller, 3 axes	$3,000
NTS-NJ	Joystick controller	$400
NTS-SOFTWARE	NTS Operating Software	Free

LabVIEW software available; contact an Applications Scientist for details.

The NTS-series Linear Nanopositioners are software-controlled linear nanopositioning systems that combine superior 0.4 nm high-resolution incremental movement and extended travel range (10 mm, 25 mm and 100 mm). Competing technologies are limited in that they provide either high resolution or extended travel range, but not both. What's more, the systems offer long-term stability in open loop mode of less than 2 nm drift per hour for high repeatability and accuracy. The NTS-series Nanopositioners can be used in applications including metrology, semiconductor analysis, microscopy, cell manipulation, microlithography and fiber optic alignment.

The nanopositioners feature piezoelectric motors that have high torque (0.2 Newton meter), variable speeds and high angular resolution. Additionally, the motor uses a shaft-mounted 4000 counts/revolution optical encoder. These features enable both continuous or step operation modes to provide accurate angular positioning. For details on the NTS Nanopositioners and Controllers, visit www.oceanoptics.com/products/nts10.asp.

Features include:

- Resolution of 1 nm and wide velocity range (5 orders)
- Acceleration time to maximum velocity less than 0.3 ms
- Continuous or stepping modes
- Self-locking technology, eliminated "stick-slip" effect
- DSP Controllers for 1-, 2- or 3-channel configurations enable wide dynamic range and high accuracy
- Stages support loads up to 3 kg

Light Sources

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Overview: Light Sources

Sources for Illumination, Excitation, Calibration

The development of Ocean Optics miniature fiber optic spectrometers created the need for comparably sized and priced accessories, including light sources. Since no such sources existed, we developed our own -- compact, modular sources complemented by the best bulbs for spectroscopy that our vendor partners can provide.

Sources for illumination cover various wavelength ranges to enable absorbance, reflectance and fluorescence measurements from the deep UV to the NIR. Compact light-emitting diodes produce output for fluorescence measurements. For fast, reliable spectrometer wavelength calibrations, we offer Mercury and Argon sources. Design features such as built-in filter slots, combined with optional accessories such as direct-attach cuvette holders, make sampling simple.

Ocean Optics Modular Light Source Options

Deuterium Light Sources: Used most often for UV absorbance and reflectance measurements.

Combination Deuterium and Tungsten Light Sources: Used as single illumination sources for measurements across broad wavelength ranges.

Pulsed Xenon Lamps: Used as long-life sources for absorbance, reflectance and fluorescence measurements, and for measuring optically or thermally labile samples.

Calibrated Light Sources: Used to calibrate the absolute spectral intensity of a system in irradiance applications.

Tungsten Halogen Light Sources: Used most often as standard VIS-NIR light sources for absorbance, reflectance of solid objects, and color measurement.

Light-emitting Diodes: Used as excitation sources for fluorescence. Feature minimal warm-up and high stability. Power is lower and spectral width is wider than with lasers.

Wavelength Calibration Sources: Used to calibrate the wavelength of spectrophotometric systems. The mercury argon source is for UV-NIR and the argon source is for VIS-NIR.

Type	Product	Wavelength Range	Output	Measurement Type	Page
Deuterium Tungsten Halogen	DH2000-BAL DH2000	~230-2000 nm	Continuous	Absorbance, Reflectance, Fluorescence, Transmission	122 123
Miniature Deuterium Tungsten Halogen	DT-MINI-2 DT-MINI DT-MINI-2-GS USB-DT	~200-2000 nm	Continuous	Absorbance, Transmission, Reflectance	125 125 125 124
Deuterium	D2000	~215-400 nm	Continuous	Absorbance, Reflectance, Fluorescence, Transmission	126
Xenon	PX-2 HPX-2000	220-750 nm 185-2000 nm	Pulsed Continuous	Absorbance, Reflectance, Fluorescence, Transmission	127
LEDs	LEDs (several wavelengths)	380, 395, 470, 475, 518, 590, 640 and 450-630 nm	Pulsed or Continuous	Fluorescence	130-131
Tungsten Halogen	LS-1 HL-2000	360-2000 nm 360-2000 nm	Continuous	Absorbance, Reflectance, Transmission	128 129
Calibrated Deuterium Tungsten Halogen	DH2000-CAL	~220-1050 nm	Continuous	Calibration (Radiometric)	132
Calibrated Tungsten Halogen	LS-1-CAL HL-2000-CAL	300-1050 nm 300-1050 nm	Continuous	Calibration (Radiometric)	133
Mercury Argon	HG-1 CAL-2000	253-1700 nm 253-1700 nm	Continuous	Calibration (Wavelength)	134
Argon	AR-1	700-1700 nm	Continuous	Calibration (Wavelength)	135

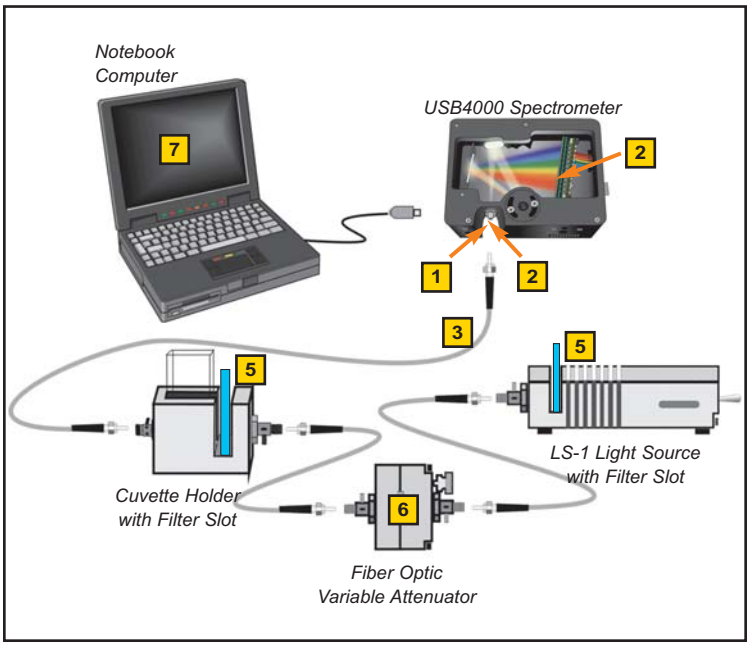
Overview: Light Sources

Ways to Modify Light

Our products provide you with many options for modifying the light transmitted to the spectrometer's detector. The illustration here is a fabricated configuration -- as few would have a setup exactly like it -- to demonstrate several ways in which you can modify light.

For high-intensity light-level applications such as laser characterization, more light will reach the spectrometer than likely can be detected successfully by the high-sensitivity CCD-array detector used in most of our spectrometers. Also, some absorbance experiments may require signal attenuation; too much light can saturate the reference measurement.

In some instances, saturation is avoided by using a different grating, changing the optical bench entrance aperture or adding neutral-density filters to the optical path. Another option is to adjust (via software) the spectrometer integration time to limit the interval during which the detector collects light.

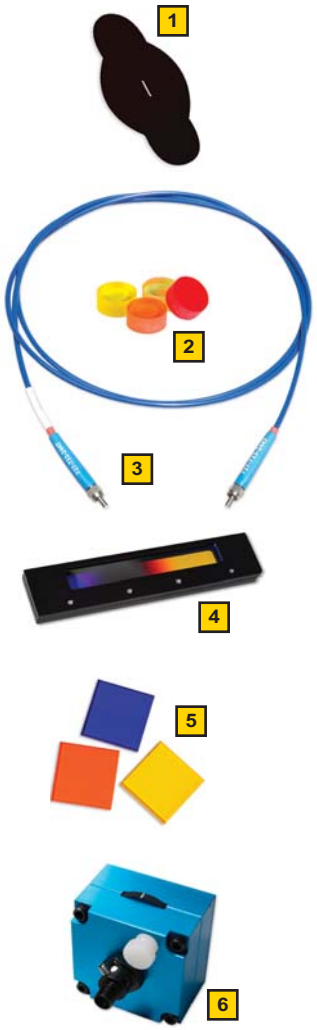


1 **Entrance Aperture: Slit**
An installed slit acts as the entrance aperture to the optical bench and regulates the amount of light entering the optical bench. The slit size is specified by the user. Slits are optional, and range in size from 5 µm to 200 µm.

2 **Installed Filters**
In addition to the variable longpass OFLV Filter -- an order-sorting filter applied to the detector's window -- we offer optional bandpass and longpass blocking filters to restrict radiation in certain wavelength regions.

3 **Optical Fiber**
Our optical fibers are available from 8 µm to 1000 µm in diameter. If you need a great deal of light for your application, you should select a large-diameter fiber. Also, in the absence of a slit, the fiber connected to the spectrometer acts as the optical bench entrance aperture.

4 **Linear Variable Filters**
Our high-pass, low-pass and adjustable-bandpass filters have excellent blocking characteristics and resistance to heat, making these filters ideal for spectrally shaping the light emitted from broadband sources.



5 **Loose Filters**
Our loose filters fit into our light sources, cuvette holders and in-line filter holders. High-pass Filters eliminate second- and third-order effects, test for stray light, and block excitation energy. Balancing Filters absorb energy in some regions while transmitting in others. Bandpass Filters pass energy in one region and block light above and below that region.

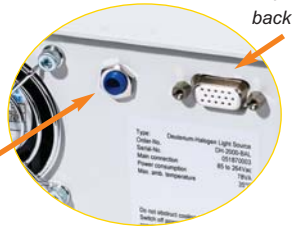
6 **Fiber Optic Variable Attenuator**
The FVA-UV Fiber Optic Variable Attenuator is an opto-mechanical device that helps control the amount of light transmitted between two fibers. The FVA-UV attenuates light uniformly at all wavelengths from the ultraviolet through the near-infrared.

7 **Integration Time**
Integration Time is a setting in our software and is specified by the user. The integration time of the spectrometer is analogous to the shutter speed of a camera. The higher the value specified for the integration time, the longer the detector "looks" at the incoming photons. For more information about integration time, see any of our software manuals.

Balanced Deuterium Tungsten Source

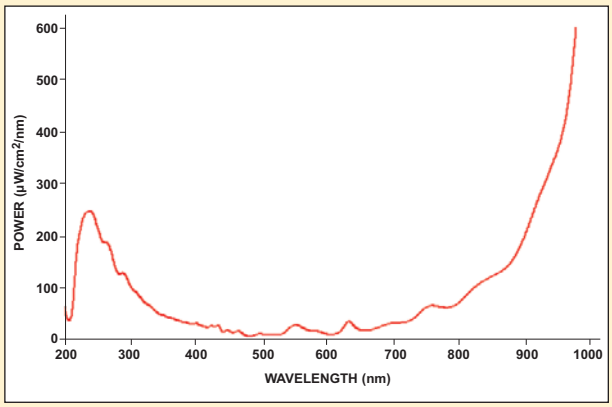
You can operate the shutter via a switch on the front of the light source . . .

. . . or via a TTL line from the back of the lamp.



Here, you can adjust the power for the tungsten bulb.

DH2000-BAL Spectral Output



Specifications	
Dimensions:	150 mm x 135 mm x 319 mm
Weight:	3.8 kg
Wavelength range:	230-400 nm (deuterium); 360-2000 nm (tungsten halogen)
Power consumption:	25 W (deuterium); 20 W (tungsten halogen); 190 W maximum
Power requirements:	85-264 V 50/60 Hz
Voltage:	Ignition 350 V/20°; tungsten bulb voltage is adjustable from 4.5 to 11.5 volts
Current:	Operating 85 V/0.3A
Stability:	<5 x 10^{-6} peak-to-peak (0.1-10.0 Hz)
Drift:	<0.01% per hour
Time to stable output:	20 minutes
Bulb life:	1,000 hours
Operating temperature:	5 °C - 35 °C
Humidity:	5-95% non-condensing at 40 °C
Electronic certifications:	CE; VDI/VDE 0160; EN 61010

UV-NIR Spectral Range with Balanced Output

We've applied our expertise in patterned dichroic filters to an innovation in light source technology to create the only combined-spectrum illumination source available that eliminates saturation and signal-to-noise problems associated with the D-alpha line in the deuterium source. The DH2000-BAL Deuterium Tungsten Halogen Light Source combines deuterium and tungsten halogen light sources in a single optical path, producing a powerful, stable output from 230-2000 nm.

About the D-alpha Line

All deuterium sources have a D-alpha line, revealed as a sharp peak in the visible portion of the spectrum, that produces "unbalanced" output in the deuterium and tungsten halogen sources. Correcting for this peak -- a sharp spectral feature near 655 nm -- is difficult. For example, if you adjust spectrometer integration time to reduce the intensity of this saturated peak, the efficiency of the system at ultraviolet wavelengths drops significantly, compromising the signal-to-noise of the spectrum. Also, spectrometer efficiency is typically greatest in the same general spectral range as the 655 nm line, exaggerating its effects.

Proprietary Filtering Technology

Using the same high-precision patterned dichroic filter technology that distinguishes our Linear Variable Filters (page 114), the DH2000-BAL:

- balances the intensity of the deuterium and tungsten halogen sources
- eliminates the D-alpha, D-beta and Fulcher lines
- eliminates problems associated with saturation
- produces a "smoother" spectrum across the entire wavelength range.

Upgrading Existing DH2000s with Kits

If you own a DH2000 and would like to upgrade the light source with the filtering technology used in the DH2000-BAL, but don't wish to purchase a new light source, you can order a DH-BAL-KIT (at left) and install the upgrade yourself.

For those owning a DH2000-S shuttered version of the lamp, specify the DH-BAL-KIT-S.

Optical Fibers

We recommend using our solarization-resistant optical fibers with the DH2000-BAL. See page 146 for details.

DH2000-BAL:	$3,588
DH-BAL-KIT:	$1,761
DH-BAL-KIT-S:	$1,761

Deuterium Tungsten Halogen Sources

UV-NIR Spectral Range

The DH2000 Deuterium Tungsten Halogen Light Source combines the continuous spectrum of deuterium and tungsten halogen light sources in a single optical path. The combined-spectrum light source produces a powerful, stable output from 215-2000 nm. In addition, deep-UV versions of the DH2000 are available, with a 190-2000 nm range.

Options & Accessories: Shutter & Filter Holder

Integrated shutters are available and can be driven either by a switch or by a TTL signal. Another option is to include a filter holder with the source (see inset), which accepts filters up to four millimeters in thickness and as large as 25-mm square or 25-mm round in diameter. All versions of the DH2000 have an SMA 905 Connector for easy coupling to our spectrometers and accessories via optical fiber.

Adjustable Power

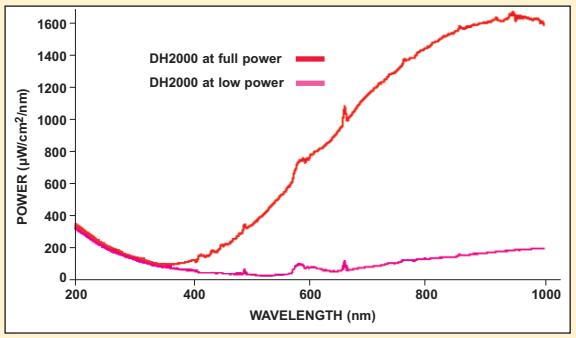
All versions of the DH2000 have a potentiometer on the back of the light source to adjust the intensity of the tungsten halogen output. This potentiometer allows you to adjust the optical power of the tungsten halogen light from 10-100%.

Optical Fibers

We recommend using our solarization-resistant optical fibers with all versions of the DH2000. See page 146 for details.

DH2000: $2,421

DH2000 Spectral Output



The spectral output of the DH2000 at full power is in red and the tungsten halogen bulb at low power is in pink.

Additional DH2000 Light Sources and Accessories

Item	Description	Price
DH2000-DUV	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range	$2,907
DH2000-S	Comes with a shutter controlled via a TTL signal or a manual switch up to 5 Hz	$3,049
DH2000-S-DUV	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range and comes with a shutter (controlled via a TTL signal or a manual switch up to 5 Hz)	$3,330
DH2000-FHS	Comes with a filter holder for filters up to 25-mm square or 25-mm round and 4-mm thick	$3,328
DH2000-FHS-DUV	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range; comes with a filter holder for filters up to 25-mm square or 25-mm round and 4-mm thick; and has a shutter controlled via TTL	$3,752
DH2000-S-DUV-TT	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range and comes with a shutter (controlled via an included external TTL line) for remote on/off of the deuterium and halogen bulbs	$3,755
DH2000-BH	Replacement tungsten halogen bulb for all versions of the DH2000	$158
DH2000-BD	Replacement deuterium bulb for DH2000, DH2000-S, DH2000-FHS	$649
DH2000-DUV-B	Deep-UV replacement deuterium bulb for DH2000-DUV, DH2000-S-DUV, DH2000-FHS-DUV	$775

Specifications

Dimensions:	150 mm x 135 mm x 319 mm	Stability:	<5 x 10^{-6} peak-to-peak (0.1-10.0 Hz)
Weight:	3.8 kg	Drift:	<0.01% per hour
Wavelength range:	190-2000 nm (deep-UV deuterium bulb & tungsten halogen bulb) or 215-2000 nm (standard deuterium bulb & tungsten halogen bulb)	Time to stable output:	20 minutes deuterium; 20 minutes tungsten halogen
		Bulb type:	Deuterium and tungsten halogen
		Bulb life:	1,000 hours
Power consumption:	25 W (deuterium); 20 W (tungsten halogen); 190 W maximum	Bulb aperture:	0.5 mm
Power requirements:	85-264 V 50/60 Hz	Operating temperature:	5 °C - 35 °C
Output:	100 W	Humidity:	5-95% without condensation at 40 °C
Voltage:	Ignition 350 V/20°; tungsten bulb adjustable 4.5-11.5 volts	Electronic certifications:	CE; VDI/VDE 0160; EN 61010
Current:	Operating 85 V/0.3A	Connector:	SMA 905

USB-DT Mini Deuterium Tungsten Source

Most Versatile Lamp We Offer

The USB-DT Deuterium Tungsten Light Source is our most versatile combination UV-VIS light source. There are several ways to use the USB-DT: as a stand-alone source, stacked atop the USB2000 or USB4000 Spectrometer via the USB-ADP-DT2 adapter, or connected to a spectrometer via a Breakout Box. Though the USB-DT can be stacked on top of the USB2000 or USB4000, it is not the kind of direct-attach source that eliminates fibers; the USB-DT requires fibers. This compact source is about the size of a deck of cards, provides stable, broadband output from 200-2000 nm, and requires a 5-volt wall transformer for power.

Software Control

When the USB-DT is stacked with the USB2000 or USB4000 or used with an HR2000+, HR4000 or QE65000 and the Breakout Box, you can control the following lamp functions through software:

- adjusting the intensity of the tungsten source
- activating the internal shutter to block the light path
- controlling on/off switch of each source independently
- utilizing a low-power shutdown mode
- saving settings in memory

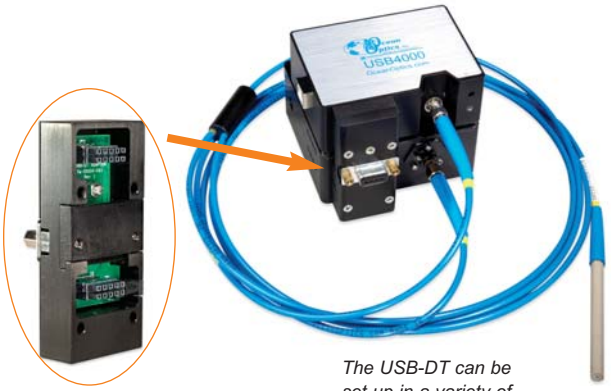
The USB-DT has a 15-pin connector for interfacing to the spectrometer.

Novel Deuterium Tungsten Halogen Sources

Our deuterium tungsten halogen sources combine the continuous spectrum of deuterium and tungsten halogen lamps in a single optical path. These combined-spectrum sources produce stable, continuous UV-VIS output that make them ideal for applications such as absorbance spectroscopy.

USB-DT:	$1,499
USB-DT-B Bulb:	$399
USB-ADP-DT2:	$75
HR4-BREAKOUT:	$199

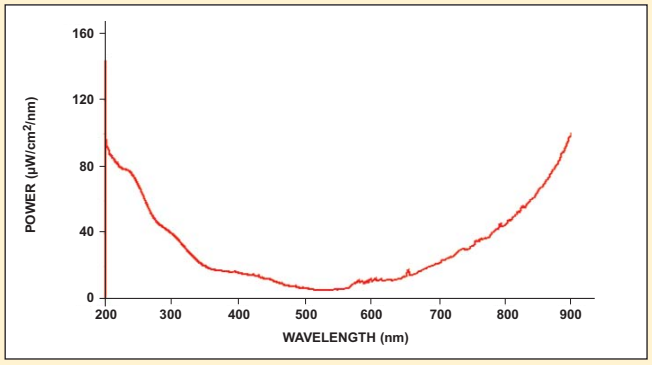
Spectrometer With USB-DT	Directly Stackable	Software Control of all USB-DT Functions
USB2000	Yes, with USB-ADP-DT2	Yes, when stacked atop the USB2000 with a USB-ADP-DT2
USB4000	Yes, with USB-ADP-DT2	Yes, when stacked atop the USB4000 with a USB-ADP-DT2
HR2000	No	No
HR2000+	No	Yes, when used with HR4-BREAKOUT
HR4000	No	Yes, when used with HR4-BREAKOUT
QE65000	No	Yes, when used with HR4-BREAKOUT



USB-ADP-DT2 Connector.

The USB-DT can be set up in a variety of ways. It can be stacked with the USB4000 via the USB-ADP-DT2 connector (above), or used as a stand-alone component with an Ocean Optics spectrometer.

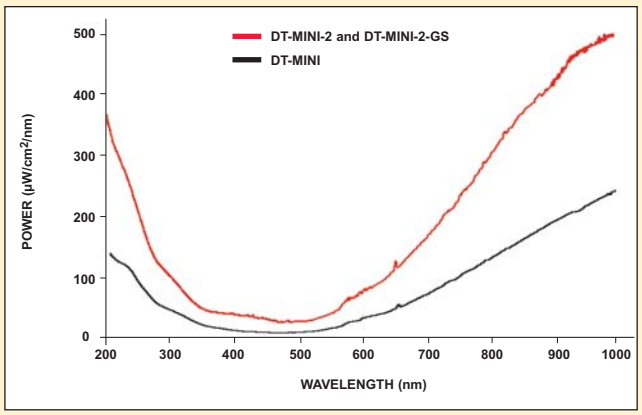
USB-DT Spectral Output



Specifications	
Dimensions:	81 mm x 90 mm x 37 mm
Weight:	260 g
Wavelength range:	200-2000 nm
Power consumption:	1.5 A @ 5 VDC
Output:	see Spectral Output graph at left
Stability:	0.5% peak-to-peak (after warm-up)
Time to stable output:	15 minutes
Bulb life:	800 hours for deuterium; 2,000 hours for tungsten
Connector:	SMA 905

Mini Deuterium Tungsten Sources

Spectral Output: DT-MINI-2 vs. DT-MINI



~200-2000 nm Spectral Range

Our DT-MINI-series Deuterium Tungsten Halogen Light Sources combine the continuous spectrum of a high-powered, RF-excited deuterium light source and a tungsten halogen light source in a single optical path. The combined-spectrum sources produce stable spectral output from ~200-2000, nm in a compact package.

0.5 mm Aperture: More Powerful Output

The original DT-MINI was our first foray into a compact and versatile UV-NIR light source, and is still a great choice for a range of applications and measurements. The advantage of the newer DT-MINI-2 is that it uses a bulb with a 0.5 mm diameter aperture, which results in more focused, uniform beam coupling to our optical fibers. Also, the DT-MINI-2 is only $100 more than the DT-MINI, which we will continue to offer.

Shutter Version

The DT-MINI-2-GS Deuterium Tungsten Halogen Light Source (lower left) also utilizes the bulb with the 0.5-mm diameter aperture. Its added feature is a shutter for blocking the light path, which can be controlled via a manual switch or TTL. There is also a switch for turning the deuterium source on and off, and one for turning the tungsten halogen source on and off (this can also be accomplished via TTL); each switch can be used independently of the other.

Rack-mount Version

Rack-mount versions of DT-MINI-series lamps are available. These sources can be hard-wired to a spectrometer channel and racked into a Dual Box, Rack Box or Desktop Box with other accessories. For more on rack-mount systems and enclosures, see page 62.

DT-MINI-2:	$1,499
DT-MINI-2-GS:	$1,754
DT-MINI:	$1,399
DT-MINI-2-B Bulb*:	$526
DT-MINI-B Bulb*:	$487

** The DT-MINI-2-B Bulb can only be used in the DT-MINI-2 and DT-MINI-2-GS sources. Likewise, the DT-MINI-B Bulb can only be used in the DT-MINI and DT-MINI-GS.*

Specifications

	DT-MINI-2	DT-MINI-2-GS
Dimensions:	153.4 mm x 104.9 mm x 40.9 mm	140 mm x 50 mm x 125 mm
Weight:	330 g	475 g
Wavelength range:	200-410 nm (deuterium); 360-2000 nm (tungsten halogen)	200-410 nm (deuterium); 360-2000 nm (tungsten halogen)
Power consumption:	350 mA @ 12 VDC	350 mA @ 12 VDC
Output:	3.8 watts (deuterium); 1.2 watts (tungsten halogen)	3.8 watts (deuterium); 1.2 watts (tungsten halogen)
Stability:	0.3% peak-to-peak (over 4 hours) after 30-minute warm-up	0.3% peak-to-peak (over 4 hours) after 30-minute warm-up
Time to stable output:	10 minutes (deuterium); 1 minute (tungsten halogen)	10 minutes (deuterium); 1 minute (tungsten halogen)
Bulb life:	~800 hours (deuterium); 2,000 hours (tungsten halogen)	~800 hours (deuterium); 2,000 hours (tungsten halogen)
Ignition delay:	<2.0 seconds (delay for cold start-up may be longer)	<2.0 seconds (delay for cold start-up may be longer)
Connector:	SMA 905	SMA 905

D2000 Deuterium Light Sources

UV Range + Great Performance

The D2000 Deuterium Light Source produces a powerful, stable output from 215-400 nm. A deep-UV version is available for wavelength coverage of 190-400 nm. The D2000 is an extremely stable source, with peak-to-peak stability of <0.005% and drift of only ±0.5% per hour.

Options & Accessories

All versions of the D2000 have an SMA 905 Connector for easy coupling to our spectrometers and fiber optic accessories, as well as safety goggles and a cover for blocking the light when the fiber is not attached. The 1,000-hour deuterium bulb used in the D2000 can be replaced easily.

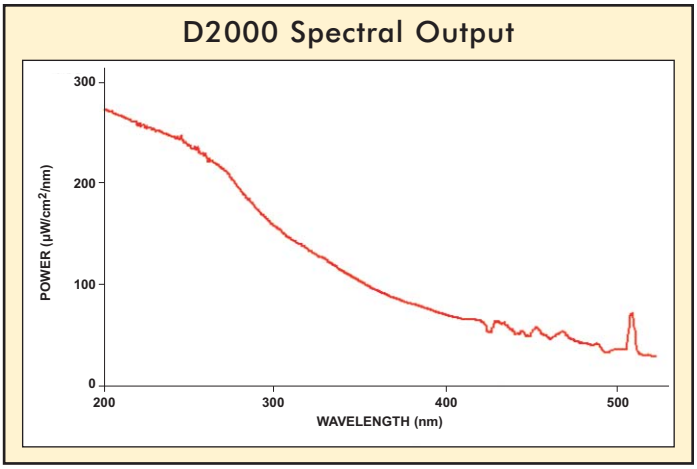
Shutter Option

The D2000 is available with an optional integrated shutter. You can operate the shutter via a manual switch on the front of the lamp. In addition, you can control the shutter electronically via software or a TTL signal from an output port on the back of the lamp.

Optical Fibers

We recommend using our solarization-resistant optical fibers with all versions of the D2000. See page 146 for details.

D2000: $2,003



Additional D2000 Light Sources and Accessories

Item	Description	Price
D2000-DUV	Uses a deep-UV deuterium bulb, which provides a 190-400 nm wavelength range	$2,475
D2000-S	Comes with a shutter (controlled via a TTL signal or switch)	$2,580
D2000-S-DUV	Uses a deep-UV deuterium bulb, which provides a 190-400 nm wavelength range, and comes with a shutter (controlled via a TTL signal or switch)	$2,873
DH2000-BD	Replacement deuterium bulb for the D2000 and the D2000-S	$649
DH2000-DUV-B	Replacement deuterium bulb for the D2000-DUV and the D2000-S-DUV	$775

Specifications

Dimensions:	150 mm x 135 mm x 319 mm	Voltage:	Ignition 350V/20°; operating 85 V/0.3A
Weight:	3.8 kg	Bulb life:	1,000 hours for standard or deep-UV bulb
Wavelength range:	215-400 nm (standard bulb); 190-400 nm (deep-UV bulb)	Bulb aperture:	Aperture 0.5 mm, numerical aperture 26°
Power consumption:	830 mA @ 230 VDC or 1660 mA @ 115 VDC	Operating temperature:	5 °C - 35 °C
Power requirements:	85-264 V 50/60 Hz	Humidity:	5-95% without condensation at 40 °C
Stability:	<0.005% at 250 nm peak-to-peak	Electronic certifications:	CE; VDI/VDE 0160; EN 61010
Drift:	±0.5% per hour at 250 nm	TTL-shutter input:	Up to 5 Hz maximum (shutter versions only)
Time to stable output:	20 minutes	Shutter speed:	10 millisecond minimum

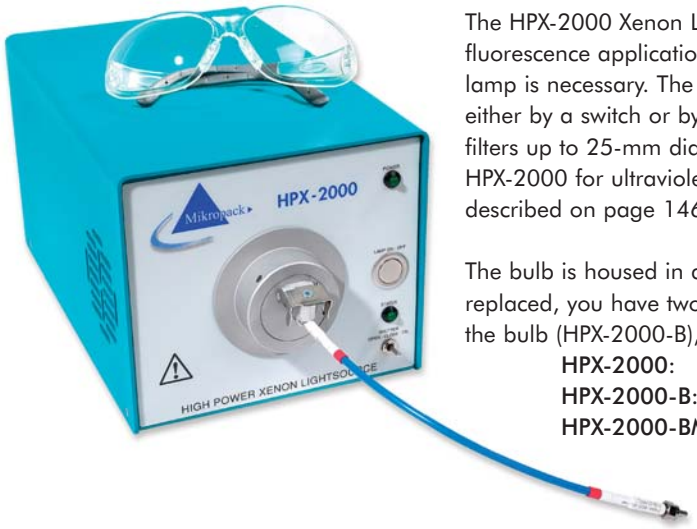
Xenon Pulsed & Continuous Sources

Pulsed & Continuous Xenon Light Source

The PX-2 Pulsed Xenon Lamp is a high flash rate, short-arc xenon lamp from 220-750 nm. The PX-2 is a great source for applications requiring absorbance, reflectance or fluorescence measurements, and is especially useful for measuring optically or thermally labile samples. The PX-2 is a low-power lamp with excellent pulse-to-pulse stability. It provides two trigger modes for software control of the flash rate. It comes with a regulated power supply and an interface cable to connect to the spectrometer.

PX-2: $769
PX-2-B Bulb: $379
USB-ADP-PX2: $50

High-powered Continuous-wave Xenon Source

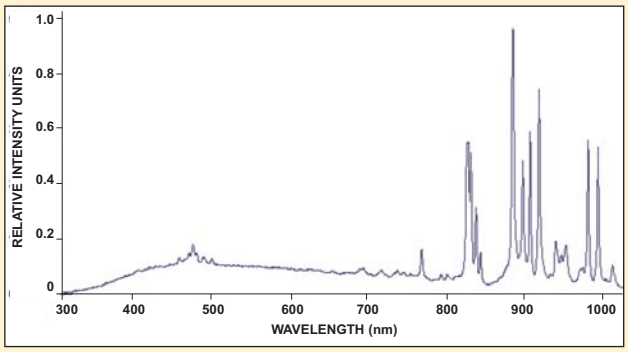


The HPX-2000 Xenon Light Source (185-2000 nm) is especially useful for fluorescence applications, and for other applications where a high-intensity lamp is necessary. The HPX-2000 has an integrated shutter, which can be driven either by a switch or by a TTL signal. It also comes equipped with a slot for filters up to 25-mm diameter or square, and up to 9-mm thick. (If operating the HPX-2000 for ultraviolet applications, use the solarization-resistant fiber described on page 146.)

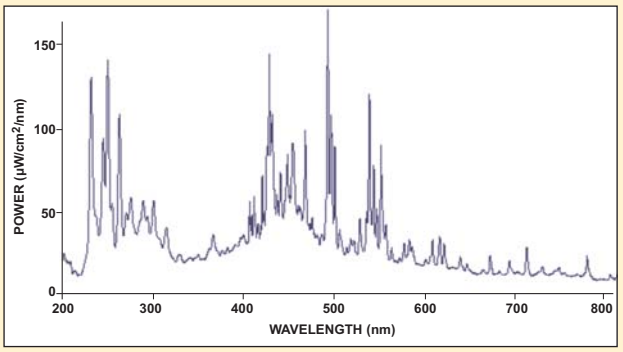
The bulb is housed in an easy-to-remove bulb module. If your bulb needs to be replaced, you have two options. You can send the module back to us to replace the bulb (HPX-2000-B), or you can order another bulb module (HPX-2000-BM).

HPX-2000: $6,006
HPX-2000-B: $1,158
HPX-2000-BM: $2,692

HPX-2000 Spectral Output



PX-2 Spectral Output



Specifications

	HPX-2000	PX-2
Dimensions:	145 mm x 165 mm x 260 mm	153.4 mm x 104.9 mm x 40.9 mm
Weight:	4.3 kg	370 g
Wavelength range:	185-2000 nm	220-750 nm
Power consumption:	50 W AC; 50/60 Hz; 110	1 A @ 12 VDC
Output*:	35 watts	45 microjoules per pulse maximum; 9.9 watts average power; 220 Hz pulse rate maximum
Bulb life:	1,000 hours minimum; 2,000 hours typical	10^9 pulses (estimated 230 days continuous operation at 50 Hz pulse rate)
Connector:	SMA 905	SMA 905
Trigger input:	External TTL positive pulse via 15-pin connector (shutter)	External TTL positive pulse via 15-pin connector
Pulse duration:	Not applicable	5 microseconds (at 1/3 height of pulse)

** Power output is measured with an integrating sphere. Power out of a fiber depends on fiber size.*

LS-1 Tungsten Halogen Sources

360-2000 nm Spectral Range

The LS-1 Tungsten Halogen Light Source is a versatile white-light source useful for absorbance, reflectance and color measurements for the VIS-NIR (360-2000 nm). The lamp offers high color temperature and efficient output.

Long Life

The LS-1 comes with a 900-hour bulb. Also available is the LS-1-LL, which comes with a 10,000-hour bulb for extra-long life bulb performance. LS-1 Light Sources come with a 12 VDC power supply (WT-12V).

Color-correcting & Signal-attenuating Accessories

The LS-1 is one of the most popular miniature spectroscopy light sources ever. As a result of customer feedback, we've enhanced our LS-1 offering to include components -- at no extra charge -- that allow users to modify the light source output:

- a 12.7-mm diameter color-correcting filter that can be installed into the light source to enhance the signal in the blue and NIR regions
- three PTFE discs of various thickness to create a diffuse source -- by attenuating the light 50%, 75% or 99% -- when spectrometer saturation is an issue

Maximum Flexibility

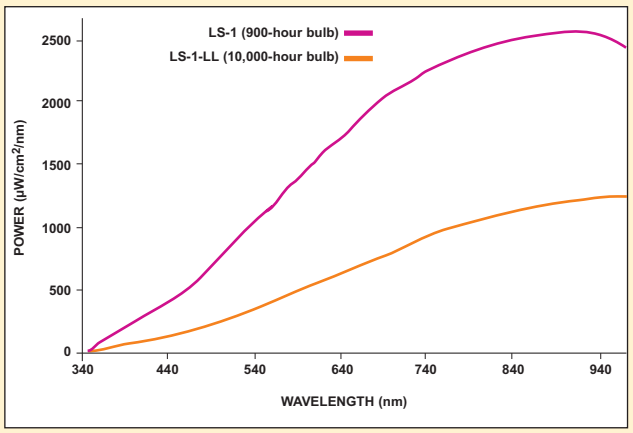
The LS-1 has an SMA 905 Connector for easy coupling to our spectrometers and accessories, including optical fibers, cuvette holders and probes. A built-in slot accepts optical filters up to three millimeters in thickness.

Rack-mountable

Install sources with spectrometers and other devices into a Rack Box or Desktop Box. For details, see page 62.

LS-1: $499
LS-1-LL: $549

LS-1 and LS-1-LL Spectral Output



Additional LS-1-series Light Sources and Accessories

Item	Description	Price
R-LS-1	Rack-mounted LS-1 with color-correcting filter and diffusers	$499
R-LS-1-LL	Rack-mounted LS-1-LL with color-correcting filter and diffusers	$549
LS-1-B	900-hour replacement bulb for LS-1	$45
LS-1-LL-B	10,000-hour replacement bulb for LS-1-LL	$55
OF2-LS	Additional filter set for use with LS-1 source includes: BG 34, GG 395 and OG 550 filters, as well as PTFE diffusing discs	$100

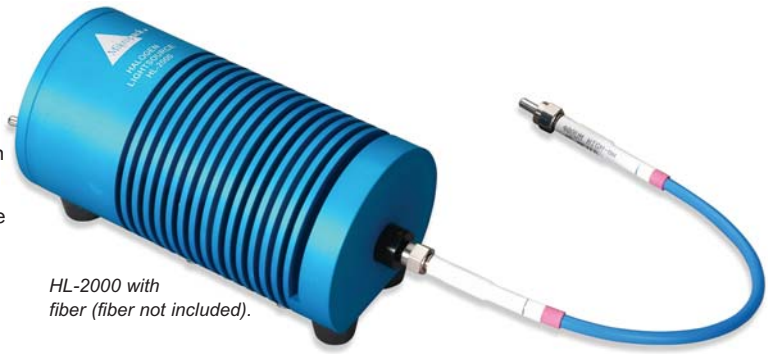
Specifications

Dimensions:	113.5 mm x 50.8 mm x 31.6 mm	Bulb type:	Tungsten halogen
Weight:	140 g	Bulb life:	900 hours (LS-1); 10,000 hours (LS-1-LL)
Wavelength range:	360-2000 nm	Bulb color temperature:	3100 K (900-hour bulb); 2800 K (10,000-hour bulb)
Power consumption:	600 mA @ 12 VDC	Connector:	SMA 905
Output:	6.5 watts (without a fiber)	Internal filter accessory:	BG 34 balancing filter
Current:	5 V, 1.3 A	External filter slot:	Accepts filters up to 3-mm thickness
Time to stable output:	~10 minutes	Spectral attenuation:	50%, 75% and 99% with PTFE disc accessories

HL-2000 Tungsten Halogen Sources

Great Versatility

The HL-2000 Tungsten Halogen Light Sources are versatile sources optimized from 360-2000 nm. The lamps feature adjustable focusing of the SMA 905 Connector to maximize light coupling into a fiber. A fan keeps the light sources cool and stable. The HL-2000 comes with a 1,500-hour bulb. A 10,000-hour long-life version is also available.



HL-2000 with fiber (fiber not included).

Filter Slot

A built-in filter slot on all standard HL-2000s accepts optical filters up to 25.4-mm round or up to 50.8-mm square and three millimeters thick. The HL-2000-LVF-HP version also accepts our LVF Linear Variable Filters (for more on the LVFs, see page 114.)

High-power Version

For applications requiring large-diameter optical fibers or fiber and probe bundles, a special high-power version of the HL-2000 is available. The bulb used in the HL-2000-HP is a 20-watt bulb. We recommend 1000 μm diameter optical fiber for use with the high-power versions of the HL-2000.

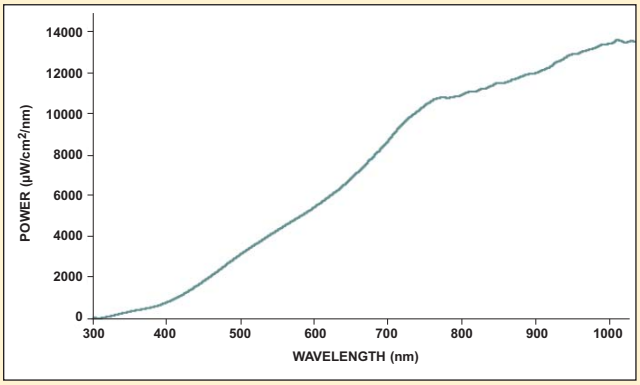
Attenuator & Shutter Option

The HL-2000-FHSA version of the HL-2000 includes a shutter and an attenuator that allows you to control the intensity of the light source from 0-100%. A locking screw allows you to manually fix the intensity position for the long term. In addition, you can opt to control the attenuator and the TTL shutter via RS-232 with the HL-2000-HP-232.

HL-2000: $635

HL-2000-HP-232 is being used to measure adaptive optics in observatories.

HL-2000 Spectral Output



Additional HL-2000 Light Sources & Bulbs

Item	Description	Price
HL-2000-LL	Long-life version (10,000-hour)	$688
HL-2000-FHSA	Includes filter holder, attenuator and shutter	$1,342
HL-2000-FHSA-LL	Includes filter holder, attenuator, shutter and long-life 10,000-hour bulb	$1,389
HL-2000-HP	High-powered, 20 W version	$1,089
HL-2000-HP-FHSA	High-powered, 20 W version with filter holder, attenuator and shutter	$1,655
HL-2000-HP-232	High-powered, 20 W version with RS-232 control in rack mount housing; comes with script for software control	$2,350
HL-2000-LVF-HP	High-powered, 20 W version with filter slot for Linear Variable Filters; comes with shutter and attenuator	$1,719
HL-2000-B	Standard 1,500-hour spare bulb	$83
HL-2000-B-LL	Long-life 10,000-hour spare bulb	$96
HL-2000-HP-B	High-power 1,000-hour spare bulb	$132

Specifications

	HL-2000	HL-2000-LL	HL-2000-HP	HL-2000-HP-232
Dimensions:	62 mm x 60 mm x 150 mm	62 mm x 60 mm x 150 mm	62 mm x 60 mm x 150 mm	70 mm x 100 mm x 160 mm
Weight:	500 g	500 g	500 g	600 g
Wavelength range:	360-2000 nm	360-2000 nm	360-2000 nm	360-2000 nm
Power consumption:	1.2 A @ 12 VDC	1.0 A @ 12 VDC	1.2 A @ 24 VDC	1.2 A @ 24 VDC
Output:	7 watts	7 watts	20 watts	20 watts
Stability:	0.5%	0.5%	0.5%	0.5%
Drift:	<0.3% per hour	<0.3% per hour	<0.3% per hour	<0.3% per hour
Time to stable output:	~5 minutes	~5 minutes	~5 minutes	~5 minutes
Bulb life:	1,500 hours	10,000 hours	1,000 hours	1,000 hours
Bulb color temperature:	2,960 K	2,800 K	3,000 K	3,000 K
Operating temperature:	5 °C - 35 °C	5 °C - 35 °C	5 °C - 35 °C	5 °C - 35 °C
Humidity:	5-95% at 40 °C	5-95% at 40 °C	5-95% at 40 °C	5-95% at 40 °C

Light Emitting Diodes

Choose your LED in a stand-alone housing (above) or mounted with a spectrometer and other accessories. We also sell the LEDs listed below individually in a 12.7-mm barrel (right) for easy installation and alignment.

Excellent Excitation Sources for Fluorescence

Our LED Light Sources produce either pulsed or continuous output for high-sensitivity fluorescence measurements. They were designed for use with our fluorescence spectrometers, such as the USB4000-FLG and USB4000-FL (pages 46-47), sensors and other accessories.

Software Operation & Synching with Detector

The LED Sources can be turned on/off through manual or software operation via SpectraSuite Spectroscopy Operating Software (page 80).

Stand-alone and Rack-mount Versions

Each LED Source connects to a spectrometer via an interface cable. First, decide if you want an LED in its own stand-alone housing (see top left) or if you want the LED racked with a spectrometer. Then, choose the LED distinguished by wavelength to install in the housing. For those with limited space, we can install two LEDs on one rack-mount card. You can also purchase just the LED; they come in easy-to-install barrels.

LED with Housing:	$499
LED Rack-mounted:	$499
LED Bulb alone:	$100

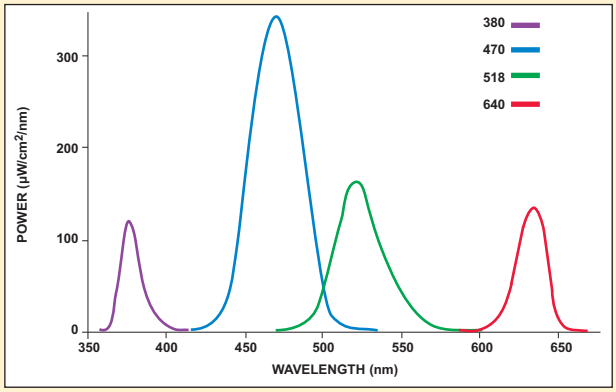
Additional LED Light Sources

You can order one of the LEDs listed below, either alone or installed in a housing/rack mount. We offer seven LEDs that can be used in the same housing. All LEDs can be used in pulsed or continuous mode through manual or software operation.

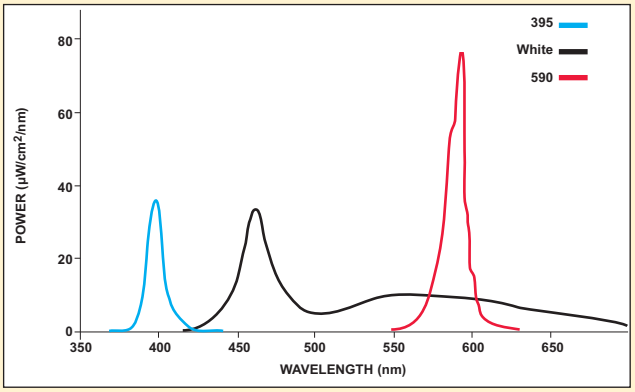
Item	Description	Color	Power*	Price of LED Alone	Price of LED with Housing
LED-380	380 nm wavelength UV LED	UV	45 µW	$100	$499
LED-395	395 nm wavelength VIS LED	Light Blue	25 µW	$100	$499
LED-470	470 nm wavelength VIS LED	Blue	35 µW	$100	$499
LED-518	518 nm wavelength VIS LED	Green	35 µW	$100	$499
LED-590	590 nm wavelength VIS LED	Yellow	40 µW	$100	$499
LED-640	640 nm wavelength VIS LED	Red	50 µW	$100	$499
LED-WHITE	450-630 nm wavelength VIS LED	White	50 µW	$100	$499
LED-KIT	Set of 6 LEDs: LED-380, LED-395, LED-518, LED-590, LED-640, LED-WHITE	Mixed	Mixed	$499	$998

** Power into a 600 µm Patch Cord Optical Fiber Assembly*

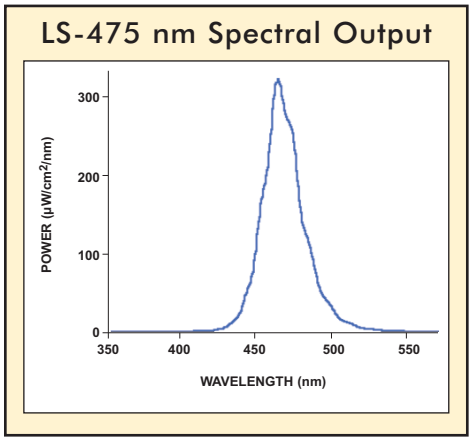
Spectral Output for LED Bulbs: 380 nm, 470 nm, 518 nm and 640 nm



Spectral Output for LED Bulbs: 395 nm, White, 590 nm



Pulsed Blue LED Light Source



Lamp Available for All Spectrometers

The LS-475 Blue LED Light Source produces pulsed or continuous spectral output centered at 475 nm. The LS-475 is designed as an excitation source for fluorescence measurements. The LS-475 often is paired with one of our preconfigured fluorescence spectrometers (pages 46-47).

Specifications	
Dimensions:	62 mm x 60 mm x 150 mm
Wavelength range:	460-490 nm
Power consumption:	25 mA @ 12 VDC
Output:	50 µW with a 600 µm optical fiber
Stability:	±1.0% drift after 2-minute warm-up
Connector:	SMA 905

High-stability & Fan-cooled

The LS-475 has a very stable output and keeps cool with a built-in fan. The lamp provides better than ±1.0% drift after a 2-minute warm-up time. It has an SMA 905 Connector for coupling to optical fiber assemblies and a filter slot that accepts 25.4-mm round or 50.8-mm square filters up to 3-mm thick. An 800 mA, 12 VDC power supply comes with the unit.

LS-475: $774

Direct-attach LED Light Source

Direct-attach Lamp for USB4000 Spectrometer

The USB-LS-450 and USB-LS-395 Pulsed LED Light Sources are designed as a direct-attach excitation source for USB2000 and USB4000 Spectrometers. The USB-LS-450 is an LED that produces either pulsed or continuous output centered at 470 nm -- the blue region. The USB-LS-395 is an LED that produces either pulsed or continuous output centered at 395 nm. Each LED connects to the spectrometer via a 10-pin connector. The USB2000 and USB4000 provide power to the LEDs and also enable synchronization functions. These sources are primarily used in fluorescence measurements and in our oxygen sensing systems. The 470 nm LED is great for exciting the FOXY and HIOXY oxygen sensing formulations, while the 395 nm LED is used for exciting the FOSPOR oxygen sensing formulation (pages 65-71).

Benefit for O_2 Sensor Users

The sources features a built-in, 24-bit A/D converter that is configured for a 100 ohm platinum temperature probe (The USB-LS-450-TP is seen at right with a direct-attach LED and a spectrometer.) These excitation sources have onboard memory that can be programmed to store temperature and oxygen calibration coefficients. If neither the 450 nor 395 LED fits your needs, you can purchase the USB-LS-LED and then specify one of the other LEDs we offer on page 130.

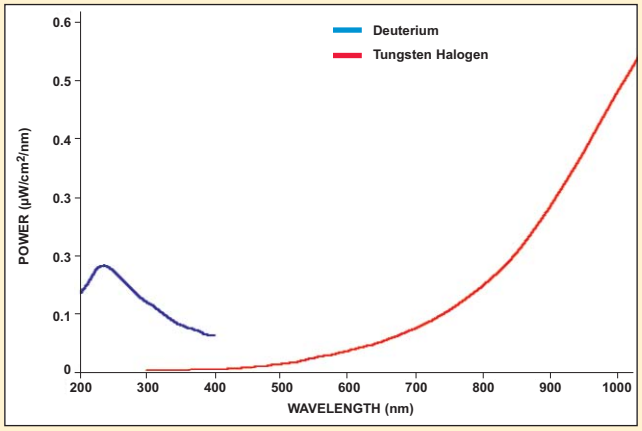
USB-LS-450: $549
USB-LS-395: $549
USB-LS-LED: $549
USB-LS-450-TP: $99

Specifications			
Dimensions:	89 mm x 57 mm x 34.5 mm	Wavelength range:	460-490 nm
Weight:	120 g	Power consumption:	60 mA @ 5 VDC
Stability:	±1.0% drift after 2-minute warm-up period	Output:	60 µW (minimum) into a 600 µm optical fiber

Radiometric Calibration Standards: UV-NIR

The DH2000-CAL is calibrated for use with either a CC-3-UV Cosine Corrector or with an optical fiber. The lamp comes with a CC-3-UV.

DH2000-CAL Spectral Output



These spectral output graphs were taken separately for the deuterium (200-400 nm) and the tungsten halogen bulbs (400-1100 nm).

Calibrated from 220-1050 nm

The DH2000-CAL Deuterium Tungsten Halogen Calibration Standard is a UV-NIR light source used to calibrate the absolute spectral response of a radiometric system. With the DH2000-CAL and our SpectraSuite Spectroscopy Operating Software, you can determine known absolute intensity values at wavelengths from 220-1050 nm.

Calibrated for Bare Fiber & Cosine Corrector

The DH2000-CAL is calibrated for use with optical fibers or a cosine corrector; the calibration data includes absolute intensities for wavelengths between 220-1050 nm at the fiber entrance port for both a bare fiber and an included CC-3-UV Cosine Corrector (page 104).

NIST-traceable Calibration Certificate

The DH2000-CAL is calibrated with a NIST-traceable standard. The DH2000-CAL comes with a calibration certificate and a diskette with a data file compatible with our software. The calibration data -- absolute spectral intensity values in $\mu W/cm^2/nm$ measured at the fiber port -- is provided for use with our SpectraSuite software (not included, see pages 80-81).

Recalibration of Your DH2000-CAL

The DH2000-CAL typically provides 50 hours of operation before recalibration is necessary. We recalibrate these lamps in-house. (For more information on the DH2000-RECAL service, contact an Applications Scientist.)

DH2000-CAL: $3,275
DH2000-RECAL: $399

In-house Calibration Service

Also, you don't need a DH2000-CAL to take advantage of our in-house SPEC-CAL-UV radiometric calibration service for UV spectrometers. The calibration is good for about one year, provided the optical fiber is not removed from the setup, as the system is calibrated for use with a specific fiber.

SPEC-CAL-UV: $499

Radiometric Calibration Sources are not illumination sources for spectroscopic measurements. Use the DH2000-BAL (page 122) for illumination.

Specifications

Dimensions:	150 mm x 135 mm x 319 mm	Stability:	<5 x 10^{-6} peak-to-peak (0.1-10.0 Hz)
Weight:	3.8 kg	Drift:	<0.01% per hour
Wavelength range:	220-1050 nm calibrated	Time to stable output:	20 minutes
Power consumption:	25 W (deuterium); 20 W (tungsten halogen); 190 W maximum	Operating temperature:	5 °C - 35 °C
		Humidity:	5-95% without condensation at 40 °C
Power requirements:	85-264 V 50/60 Hz	Electronic certifications:	CE; VDI/VDE 0160; EN 61010
Output:	100 watts	Connector:	SMA 905
Voltage:	350 V	Calibration accuracy:	±5%
Current:	Operating 85 V/0.3A	Calibration valid for:	50 hours

Radiometric Calibration Standards: VIS-NIR

Calibrated with Fiber & Cosine Corrector

The LS-1-CAL is designed for calibrating the absolute spectral response of a complete system consisting of a spectrometer and an optical fiber and/or a CC-3-UV Cosine Corrector (page 104). The HL-2000-CAL is also designed for calibrating a system consisting of a spectrometer and a cosine corrector. The calibration data for both the LS-1-CAL and the HL-2000-CAL includes absolute intensities for wavelengths between 300-1050 nm.

LS-1-CAL:	$749
HL-2000-CAL:	$871

The LS-1-CAL is calibrated for use with a fiber and/or a CC-3-UV Cosine Corrector (not included).

Calibrated for Use with Integrating Sphere

The LS-1-CAL-INT is designed for calibrating the absolute spectral response of a system that uses the FOIS-1 Fiber Optic Integrating Sphere (page 105) as the sampling optic. The LS-1-CAL-INT comes with a diffuser plug that fits into the sample port of the FOIS-1 to measure absolute spectral intensities of LEDs and other emission sources. The HL-2000-CAL-ISP is designed for calibrating the absolute spectral response of your system when using the ISP-50-8-I Integrating Sphere (page 105) as your sampling optic.

LS-1-CAL-INT:	$749
HL-2000-CAL-ISP:	$882

The LS-1-CAL-INT is calibrated specifically for use with the FOIS-1 Integrating Sphere. Notice the PTFE diffuser plug that's seated where an SMA 905 Connector is usually installed. This plug fits snugly into the sample port of the FOIS-1.

What's Included

Each of these radiometric sources comes with a regulated 12 VDC power supply. Also included is a calibration certificate and electronic files for use with our irradiance functions in SpectraSuite Spectroscopy Operating Software. Neither the LS-1-CAL nor the HL-2000-CAL lamps comes with a CC-3-UV Cosine Corrector.

Recalibrating Your Source

These calibrated sources provide 50 hours of operation before an in-house recalibration (called the LS-1-RECAL and the HL-2000-RECAL) is necessary.

LS-1-RECAL:	$199
HL-2000-RECAL:	$199

The HL-2000-CAL is used for calibrating most radiometric systems, while the HL-2000-CAL-ISP is used with ISP Integrating Spheres.

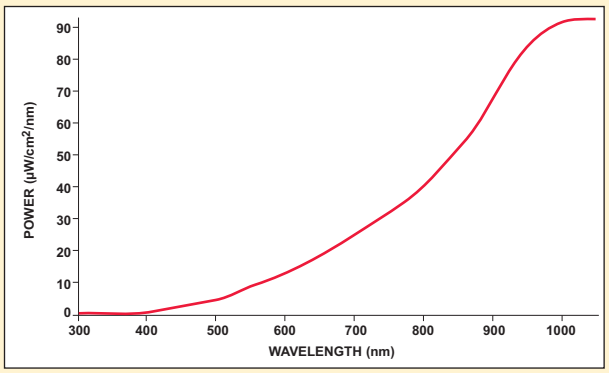
In-house Calibration

If you do not want to purchase one of these calibration sources, we offer in-house radiometric calibration services that calibrate the absolute spectral response of your system. The SPEC-CAL service is for 300-1050 nm and the SPEC-CAL-NIR service is for 900-2400 nm.

SPEC-CAL:	$499
SPEC-CAL-NIR:	$499

Specifications	
Power consumption:	600 mA @ 12 VDC
Wavelength range:	300-1050 nm (calibrated)
Output:	6.5 watts
Recalibration:	Required after 50 hours of operation
Time to stable output:	~20 minutes
Bulb color temperature:	3100 K for LS-1-CALs, 2800 K for HL-2000-CALs
Connector:	SMA 905 for fiber; 6.35-mm barrel for cosine corrector; PTFE plug for integrating sphere

LS-1-CAL Spectral Output



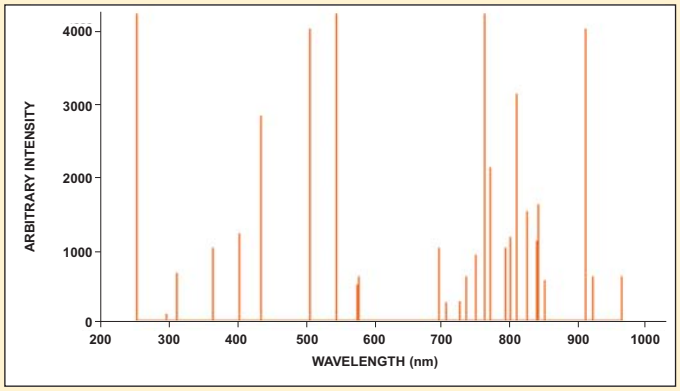
Above is the typical calibration output when using the LS-1-CAL or HL-2000-CAL with a CC-3 Cosine Corrector.

Wavelength Calibration Standards: UV-VIS

The HG-1.

The CAL-2000.

HG-1 & CAL-2000 Spectral Output



Mercury emission lines are <600 nm. Argon emission lines are >600 nm, and are shown on an exaggerated amplitude scale.

Wavelength Calibration Sources

The HG-1 and CAL-2000 Mercury Argon Calibration Sources are spectral wavelength calibration sources for spectrometer systems. The HG-1 and the CAL-2000 produce low-pressure mercury and argon atomic emission lines from 253-1700 nm for use in performing fast, reliable spectrometer wavelength calibrations. A list of mercury and argon spectral emission lines is printed on each lamp's housing.

Drift Occurs in all Spectrometers

Our spectrometers are carefully calibrated as part of our standard quality assurance process. However, as is the case with all optical benches, slight drifts in wavelength occur due to time and environmental conditions. If wavelength accuracy is an important part of your application, consider including calibration spectra with every experiment.

Convenient Operation

Wavelength calibration with the HG-1 or the CAL-2000 requires a power supply (included) and an optical fiber to connect from the source to your spectrometer. You will need a spreadsheet program such as Microsoft Excel or a calculator that performs third-order polynomial regressions.

Convenient Portability

Both calibration sources operate with a 12 VDC power supply (included) or a 9V battery (not included) for field use. Both sources feature an SMA 905 Connector for interfacing to optical fiber assemblies and have bulbs with a 3,500-hour lifetime. You can replace the bulb in the CAL-2000, but not in the HG-1.

HG-1:	**$399**
CAL-2000:	**$475**
CAL-2000-B Bulb:	**$191**

For as low as $250 per spectrometer channel, you can purchase the ASP Annual Service Package, which entitles you to a yearly spectrometer inspection, wavelength calibration, optical alignment, linearity calibration, signal-to-noise analysis and much more.

Specifications

	HG-1	CAL-2000
Dimensions:	125.7 mm x 70 mm x 25.8 mm	130 mm x 125 mm x 50 mm
Weight:	40 g	410 g
Wavelength range*:	253-1700 nm	253-1700 nm
Power consumption:	250 mA @ 12 VDC	250 mA @ 12 VDC
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (not included)	12 VDC wall transformer (included) or 9 VDC battery (not included)
Voltage:	600 volts at 30 kHz	600 volts at 30 kHz
Bulb life:	~3,500 hours (at 20 mA)	~3,500 hours (at 20 mA)
Time to stable output:	1 minute	1 minute
Connector:	SMA 905	SMA 905

** For performing wavelength calibrations for spectrometers in the VIS-NIR, consider using the AR-1 Argon Calibration Source on page 135.*

Wavelength Calibration Standard: NIR

Calibration Source for NIR Spectrometers

The AR-1 Argon Calibration Source is a spectral wavelength calibration source specifically designed for NIR spectrometers like our NIR256 and NIR-512 (see pages 30-31). The AR-1 produces low-pressure argon atomic emission lines from 696-1704 nm for use in performing fast, reliable spectrometer wavelength calibrations. The spectral emission lines are printed on the lamp's housing.

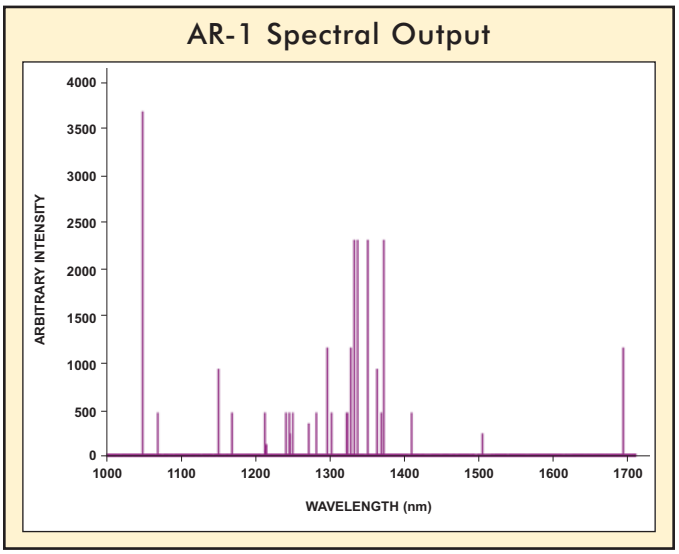
Convenient Operation

Our spectrometers are carefully calibrated as part of our standard quality assurance process. However, as is the case with all optical benches, slight drift in wavelength occurs due to time and environmental conditions. With the AR-1, you can recalibrate your spectrometer using a spreadsheet program such as Microsoft Excel or a calculator that performs third-order polynomial regressions.

Conveniently Portable

The AR-1 operates with a 12 VDC power supply (included) or a 9V battery (not included) for field use. The AR-1 features an SMA 905 Connector for interfacing to optical fiber assemblies.

AR-1: $399



Specifications	
Dimensions:	125.7 mm x 70 mm x 25.8 mm
Weight:	40 g
Wavelength range:	696-1704 nm
Power consumption:	250 mA @ 12 VDC
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (not included)
Voltage:	600 volts at 30 kHz
Bulb life:	~3,500 hours (at 20 mA)
Time to stable output:	~1 minute
Connector:	SMA 905

Cuvette Wavelength Calibration Adapter

The PS-HG1-ADP Wavelength Calibration Adapter is a 1-cm square fixture that fits into a 1-cm pathlength sample chamber and then connects to the HG-1 Mercury Argon Calibration Standard or the AR-1 Argon Wavelength Calibration Standard via optical fiber. (Neither Wavelength Calibration Standard nor optical fiber is included.) The adapter is designed for performing a wavelength calibration for a USB2000 or USB4000 Spectrometer and a direct-attach sampling system. However, the adapter can be used with any post-dispersive spectrometer and 1-cm cuvette holder, whether it's designed by Ocean Optics or another manufacturer.

PS-HG1-ADP: $259

Bulbs, Power Supplies & Accessories

Power Supplies*

Item	Description	Plug Style	Current	Regulated	Price
WT-12V	12-volt power supply, 110/220	Americas/Japan	800 milliamps	Yes	$25
WT-12V-R	12-volt power supply, 110/220	Americas/Japan	2.5 Amps	Yes	$100
WT-12V-E	12-volt power supply, 110/220	European	800 milliamps	Yes	$20
WT-12V-R-E	12-volt power supply, 110/220	European	2.5 Amps	Yes	$100
WT-24V	24-volt power supply, 110/220	Americas/Japan	2.5 Amps	Yes	$50

** Each Ocean Optics Sales, Service & Support location sells power supplies that best serves its region.*

WT-12V-E European Power Supply.

Bulbs for Ocean Optics Light Sources

Item	Description	Price
DH2000-BD	Spare or replacement deuterium bulb for D2000, DH2000 and DH2000-BAL sources	$650
DH2000-DUV-B	Spare or replacement deep-UV deuterium bulb for D2000-DUV and DH2000-DUV sources	$776
DH2000-BH	Spare or replacement tungsten halogen bulb for DH2000 and DH2000-BAL sources	$158
DT-MINI-B	Spare bulb for DT-MINI and DT-MINI-GS (white or blue bulb housing)	$487
DT-MINI-2-B	Spare bulb for DT-MINI-2 and DT-MINI-2-GS (yellow bulb housing)	$526
HL-2000-B	Spare or replacement tungsten halogen bulb for the HL-2000 (1,500-hour, 2,960 K)	$83
HL-2000-B-LL	Spare or replacement long-life tungsten halogen bulb for the HL-2000-LL (10,000-hour, 2,800 K)	$96
HL-2000-HP-B	Spare or replacement tungsten halogen bulb for all HL-2000-HPs	$132
HPX-2000-BM	Spare or replacement xenon bulb module for the HPX-2000	$2,692
HPX-2000-B	Spare or replacement xenon bulb for the HPX-2000	$1,158
LED-380	Interchangeable, 380-nm LED for LS-450	$100
LED-395	Interchangeable, 395-nm LED for LS-450	$100
LED-518	Interchangeable, 518-nm LED for LS-450	$100
LED-590	Interchangeable, 590-nm LED for LS-450	$100
LED-640	Interchangeable, 640-nm LED for LS-450	$100
LED-WHITE	Interchangeable, white LED for LS-450	$100
LED-KIT	LED kit with 380-nm, 395-nm, 518-nm, 590-nm, 640-nm and white LEDs, for LS-450	$499
LS-1-B	Spare or replacement tungsten halogen bulb for LS-1 (900-hour, 3100 K bulb)	$45
LS-1-LL-B	Spare or replacement long-life tungsten halogen bulb for LS-1 or LS-1-LL (10,000-hour, 2800 K bulb)	$55
PX-2-B	Spare or replacement xenon bulb for the PX-2	$379
USB-ISS-UV-B	Spare or replacement deuterium and tungsten bulb for USB-ISS-UV-VIS	$399
USB-ISS-VIS-B	Spare or replacement tungsten bulb for the USB-ISS-VIS source	$199
D-1000-B	Spare or replacement deuterium bulb for the D-1000	$525
D-1000-REM-B	Spare or replacement bulb for D-1000-REM systems	$425
DT-1000-B	Spare or replacement deuterium bulb for the DT-1000	$595
DT-1000-BT	Spare or replacement tungsten halogen bulb for the DT-1000	$135
DT-1000-REM-B	Spare or replacement bulb for DT-1000-REM systems	$485
DT-1000-BT-CE	CE-certified tungsten halogen bulb for the DT-1000	$135

The DH2000-BD deuterium bulb used in all D2000s and DH2000s.

The CAL-2000-B.

The DH2000-BH tungsten halogen bulb used in all DH2000s.

Bulb for the HL-2000.

The DT-MINI bulb unit.

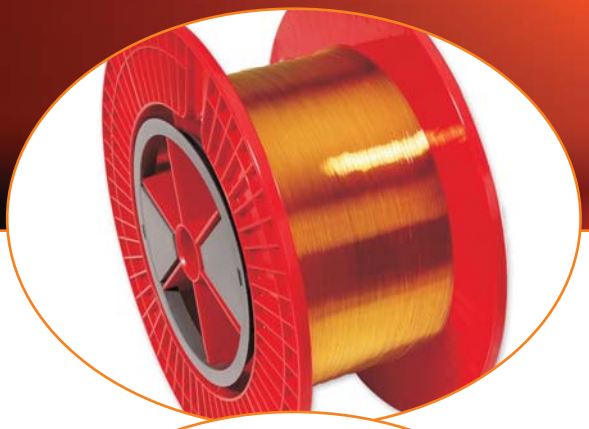
The LS-1-B replacement bulb for the LS-1.

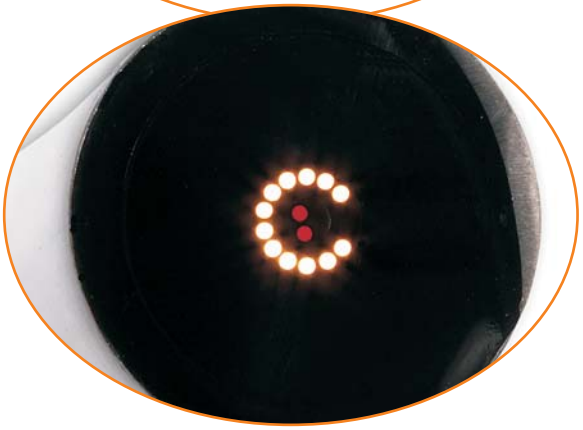
Other Light Source Accessories

Item	Description	Price
CBL-PX-2	Cable for connecting PX-2 to S2000 Spectrometer	$25
FCBARREL	6.35-mm outer diameter stainless steel barrel threaded for FC connectors that inserts into our 74-series Collimating Lenses	$29
FOT-SMA WRENCH	SMA wrench for easily attaching Laboratory-grade optical fibers to SMA 905 Connectors on Ocean Optics products	$10

Bulb module for the HPX-2000.

Fibers & Probes





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Overview: Fibers & Probes

The Most Flexible Line in the Industry

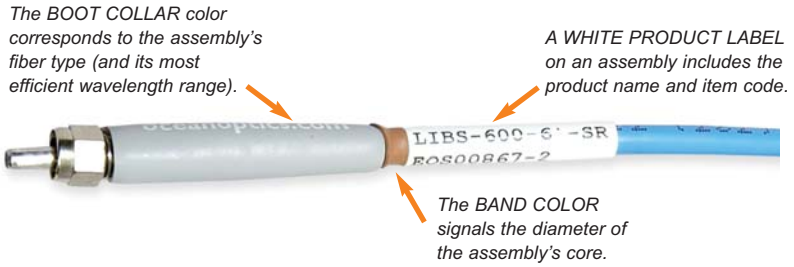
Ocean Optics is the most versatile supplier of optical fibers and accessories for spectroscopy in the industry. We offer everything from one-off patch cords and custom assemblies, to OEM builds for all sorts of applications. Our fiber accessories, fixtures and fiber assembly kits allow you to easily connect or manipulate fibers, and integrate them into tricky experiment set-ups. Optical fiber technology has been paramount to our success and makes possible our "take the instrument to the sample" maxim. Fiber is the nucleus of our analytical instrumentation and accessory design philosophy. And it's optical fiber technology that helped us create the world's most flexible line of sensing instruments.

Anatomy of an Assembly

At the fiber's core is pure silica; it's the diameter of the core that you need to consider when purchasing an optical fiber assembly. (The core diameter is often in the product's item code. For example, the P600-UV-VIS has a 600 µm diameter silica core.) Surrounding the core is a doped-fluorine silica cladding. A buffer material is then applied. A buffer coats the core and cladding , strengthens the fiber and reduces stray light even further. In most assemblies polyimide is used as the buffer; other assemblies use aluminum or acrylate. Then a jacketing is applied over the core, cladding and buffer to protect the fiber and provide strain relief. For off-the-shelf Premium-grade "Q" Optical Fiber Assemblies, the standard jacketing is stainless steel silicone monocoil. For off-the-shelf the Laboratory-grade Optical Fiber Assemblies, the standard jacketing is zip tube blue PVDF. (There are several other jacketing options when creating a custom assembly.) Precision SMA 905 Connectors terminate the assembly and are precisely aligned to the spectrometer's slit to ensure concentricity of the fiber. Finally, captive end caps protect the fiber tips against scratches and contaminants.

Assembly Identifiers

Our optical fiber and probe assemblies are clearly and cleanly labeled in three ways so that you always know the following about your assembly: its name, its core diameter, and its most efficient wavelength region.



BOOT COLLARS

The assembly's boot color lets you know the fiber type and the most efficient wavelength range in which your fiber will work.

BAND COLORS

A color band tells you the diameter fiber with which you are working.

8 µm	Purple
50 µm	Blue
100 µm	Green
200 µm	Yellow
300 µm	Gray
400 µm	Red
500 µm	Orange
600 µm	Brown
1000 µm	Clear

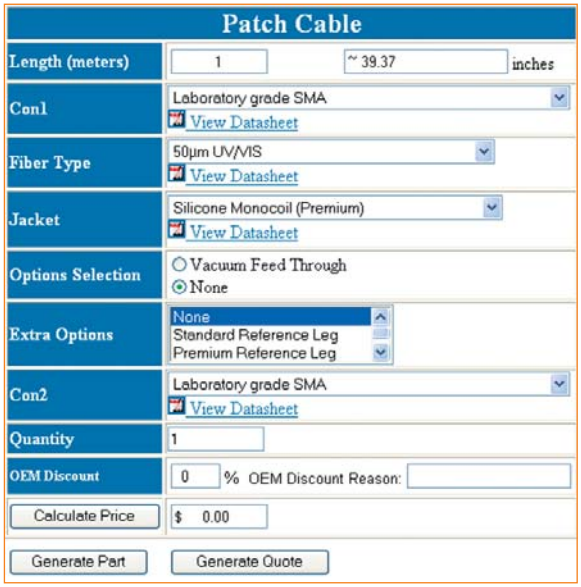
Boot Color	Fiber Type	Most Efficient Wavelength Range	Premuim-grade Optical Fiber Assembly for each Fiber Type
Gray	UV-VIS XSR Solarization-resistant	180-900 nm	
Gray	UV/SR-VIS High OH content	200-1100 nm	
Blue	UV-VIS High OH content	300-1100 nm	
Red	VIS-NIR Low OH content	400-2500 nm	

Custom Fiber & Probe Assemblies

Custom Fiber & Probe Quoting Website

Continuous innovation is a critical ingredient for our growth. Our parent company, Halma p.l.c., believes that innovation is not just the responsibility of our development departments but is integral to all commercial activities within the business. Halma's successful Innovation Initiative allows all employees to deliver innovative ideas to help their companies achieve growth objectives. In 2006, Halma awarded Ocean Optics employees for our Custom Fiber Assembly Quoting and CAD Design website, designed to rapidly create quotations and CAD drawings of custom optical fiber assemblies.

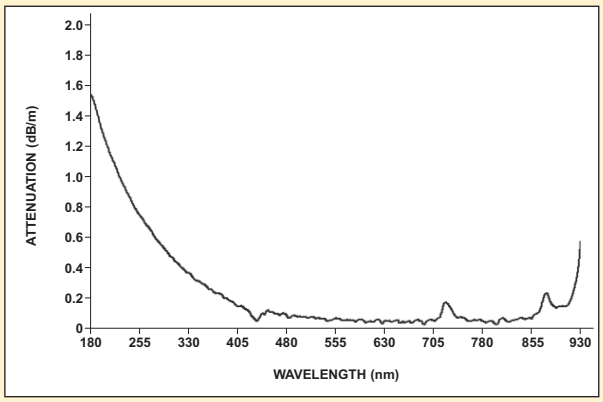
The website allows our application sales scientists and customer service and support personnel to custom-create an optical fiber or probe assembly that automatically generates quotes and drawings for customers to view, modify and approve. Customers have hundreds of options available to them when creating a custom assembly. Our team of engineers uses our award-winning site to help guide you through choosing the best options for your unique application.



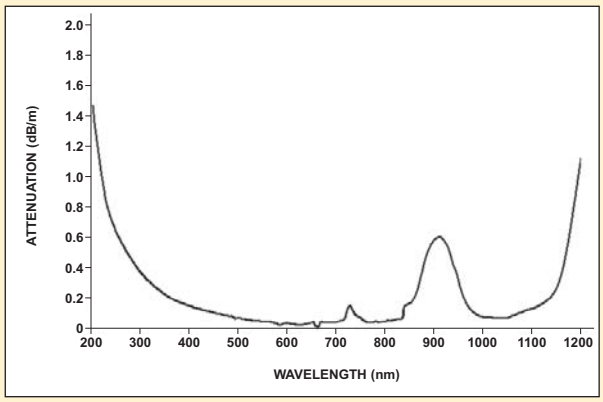
Custom Option: Fiber Type

One important consideration in building a custom assembly is which fiber type you should specify for your application. Typically, the wavelength range needed for your application should match the wavelength range of the fiber type. Here are the attenuation spectra for each fiber type we offer.

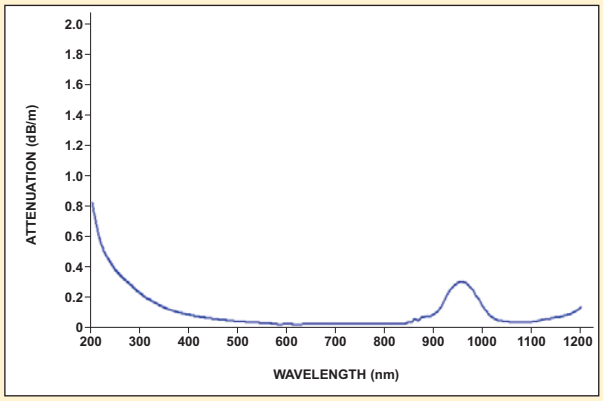
XSR Solarization-resistant: 180-900 nm



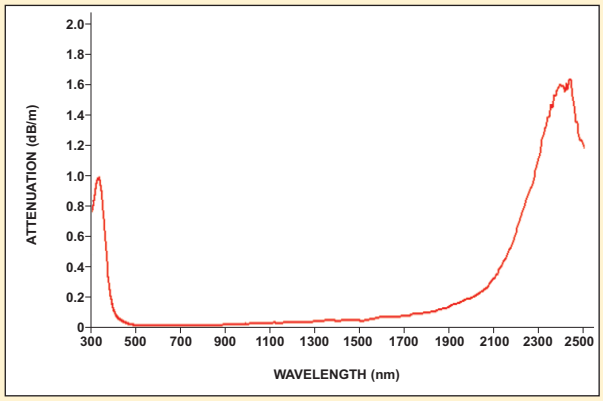
UV/SR-VIS Fibers: 200-1100 nm



UV-VIS High OH Fibers: 300-1100 nm



VIS-NIR Low OH Fibers: 400-2500 nm



Custom Fiber & Probe Assemblies

Custom Option: Optical Fiber Diameter Sizes

After selecting the best Fiber Type, you should consider the diameter size of the pure silica core needed inside of your assembly. We offer several diameter sizes, and can recommend the appropriate assembly based on these criteria:

1. How much light do you need for your application? Reflection and fluorescence applications generally need more light, and larger diameter fibers are often better choices than smaller diameter fibers. For a laser application, however, we may suggest a smaller diameter fiber.
2. What is the entrance aperture size of your spectrometer? Make sure that your fiber diameter size and the entrance aperture to your spectrometer are compatible and are configured properly for your application needs.
3. If you have too much light in your setup, are there ways you can attenuate the light? We believe that it's better to have too much light than not enough.

Optical Fiber Diameter Sizes Available for Custom Assemblies

- 8 µm
- 50 µm
- 115 µm
- 200 µm
- 230 µm
- 300 µm
- 320 µm
- 400 µm
- 455 µm
- 500 µm
- 550 µm
- 600 µm
- 800 µm
- 1000 µm

Custom Option: Jacketing Options

The fiber assembly jacketing is designed to protect the fiber and provide strain relief. But we have jacketing options that can do so much more. We offer over 15 different jacketing options; our most popular selections are listed below. With options from PEEK polymer jacketing (No. 3) designed for environments with temperatures up to 260 °C to stainless-steel BX cable with neoprene synthetic rubber (No. 8) designed for excellent mechanical tolerance, we are sure to have the right jacketing for your application environment. Each jacketing has a set of specifications so that you and one of our Applications Scientists can choose the best option for your setup.

Item		Description	Temp. Limits	Chemical Resistance	Steam Sterilizable	Mechanical Tolerance	Length Limits
1	PVC Monocoil	OEM applications only	70 °C	Poor	No	Good	6 m
2	Zip Tube Blue PVDF	Best for budget-conscious applications; standard in Laboratory-grade Assemblies	100 °C	Poor	No	Good	50 m
3	PEEK	Good for hydrogen peroxide applications	260 °C	Excellent	Yes	Good	10 m
4	Zip Tube Blue PVDF	Best for budget-conscious applications; larger diameter than #2	100 °C	Poor	No	Good	50 m
5	PVC over Brass BX Tube	Glossy PVC covered over brass BX tube	100 °C	Good	No	Good	20 m
6	Silicone Monocoil	High-end jacketing; standard in Premium-grade Assemblies	250 °C	Good	Yes	Good	20 m
7	Stainless-steel BX	OEM applications only; optional polyolefin heatshrink overcoat	250 °C	Good	Yes	Poor	4 m
8	Stainless-steel fully interlocked BX	Excellent stainless steel jacketing supports longer lengths of fiber; optional polyolefin heatshrink overcoat	250 °C	Good	Yes	Excellent	40 m
9	Brake cable	OEM applications only	120 °C	Good	No	Good	20 m
10	Stainless-steel BX with heat shrink	Neoprene synthetic rubber over stainless steel; resists heat	120 °C	Good	No	Excellent	10 m
11	Large-diameter stainless-steel BX	OEM applications only; optional polyolefin heatshrink overcoat	250 °C	Good	Yes	Poor	4 m

** Custom printing available for OEMs.*

Custom Fiber & Probe Assemblies

Custom Option: Connectors & Connector Adapters

Our fiber assemblies are available with several connector options. For an upgrade fee that includes the cost of the custom connector and labor, we will replace the standard SMA 905 Connector (included in the assembly price) with any custom connector from the list below (priced separately). When ordering custom connectors, please specify the diameter size of the optical fiber to which it will be attached. You also can order connectors separately.


CONN-QSMA


CONN-SMA

Item	Description	Connector Price
CONN-ST	Stainless-steel ST Connector	$20
CONN-FC	Stainless-steel FC Connector	$18
CONN-QSMA	Premium-grade SMA 905 Connector (standard in Premium-grade assemblies)	$16
CONN-SMA	Laboratory-grade SMA 905 Connector (standard in Laboratory-grade assemblies)	$13
CONN-PSMA	Process-grade SMA 905 Connector used with an assembly with Tefzel jacketing	$23
CONN-QSMA-O	Premium-grade SMA 905 Connector with O-ring	$26
CONN-SMA-O	Laboratory-grade SMA 905 Connector with O-ring	$23
CONN-PSMA-O	Process-grade SMA 905 Connector with O-ring	$33
CONN-LSMA	Laser SMA 905 Connector for use during laser or other high-intensity applications	$30

Custom Option: Connector Adapters

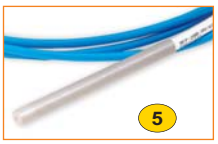
Connector adapters allow you to mate an item with an SMA 905 Connector to an item with either an ST or FC Connector.


SMA-ST-ADP


SMA-FC-ADP

Item	Description	Price
SMA-ST-ADP	SMA-to-ST Adapter for interfacing an item with an SMA 905 Connector to an item that has an ST Connector	$50
SMA-FC-ADP	SMA-to-FC Adapter for interfacing an item with an SMA 905 Connector to an item that has an FC Connector	$50

Custom Option: Ferrules for Probe Assemblies



	Description
1	1/4" diameter stainless-steel ferrule often used in solution transmission measurements
2	1/4" diameter PEEK ferrule used in harsh environments for solution transmission measurements
3	1/4" diameter stainless-steel ferrule used in reflection measurements
4	1/4" diameter Torlon ferrule with cap
5	1/4" diameter PEEK ferrule used in harsh environments
6	1/8" diameter stainless-steel ferrule
	1/16" diameter stainless-steel ferrule
	1/4" diameter stainless-steel ferrule with the tip angled to 30°
	Fiber-to-lens ferrule that comes with a collimating lens

Custom Option: Epoxy

Item	Description	Operating Temp. Continuous	Operating Temp. Intermittent	Chemical Compatibility
EPO-TEK 353ND	Standard epoxy in all fiber assemblies	220 °C	350 °C	Good
EPO-TEK 354ND	Slightly lower curing stress on the fiber than 353ND	200 °C	300 °C	Good
EPO-TEK OM125	Lowest curing stress on the fiber of the three epoxies	150 °C	250 °C	Fair
EPOXY-TEST	Free sample slide of all epoxies for compatibility testing	NA	NA	NA

Premium-grade Assemblies

Premium-grade Patch Cord Assemblies

Our Premium-grade Optical Fiber Assemblies are durable, high-quality assemblies that consistently deliver uniform results with minimal signal variance. These assemblies are available in a wide variety of off-the-shelf configurations. With every order, you receive a Quality Control Report that includes both the serial number and transmission curve of the assembly. Our 2-meter Premium-grade Patch Cord Assemblies are terminated with precision SMA 905 Connectors. They connect easily to spectrometers, light sources and sampling accessories and are available in standard lengths or can be ordered in custom lengths.

Premium-grade Assemblies have a silicone-coated steel monocoil jacketing with a Nomex braid for superior strain relief and protection.

Item Code	Wavelength Range	Core Diameter	Buffer/ Coating	Assembly Length	Jacketing	LTBR*	STBR**	Price
QP8-2-SMA	400-2500 nm	8 µm ± 0.5 µm	acrylate	2 meters	silicone monocoil	4 cm	2 cm	$159
QP50-2-UV/BX	300-1100 nm	50 µm ± 5 µm	polyimide	2 meters	stainless-steel BX	4 cm	2 cm	$149
QP50-2-UV-VIS	300-1100 nm	50 µm ± 5 µm	polyimide	2 meters	silicone monocoil	4 cm	2 cm	$150
QP50-2-VIS-NIR	400-2500 nm	50 µm ± 5 µm	polyimide	2 meters	silicone monocoil	4 cm	2 cm	$150
QP100-2-UV/BX	300-1100 nm	100 µm ± 3 µm	polyimide	2 meters	stainless-steel BX	4 cm	2 cm	$149
QP100-2-UV-VIS	300-1100 nm	100 µm ± 3 µm	polyimide	2 meters	silicone monocoil	4 cm	2 cm	$150
QP100-2-VIS/BX	400-2500 nm	100 µm ± 3 µm	polyimide	2 meters	stainless-steel BX	4 cm	2 cm	$149
QP100-2-VIS-NIR	400-2500 nm	100 µm ± 3 µm	polyimide	2 meters	silicone monocoil	4 cm	2 cm	$150
QP200-2-SR/BX	200-1100 nm	200 µm ± 4 µm	polyimide	2 meters	stainless-steel BX	8 cm	2 cm	$179
QP200-2-UV/BX	300-1100 nm	200 µm ± 4 µm	polyimide	2 meters	stainless-steel BX	8 cm	4 cm	$149
QP200-2-UV-VIS	300-1100 nm	200 µm ± 4 µm	polyimide	2 meters	silicone monocoil	8 cm	4 cm	$150
QP200-2-VIS/BX	400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	stainless-steel BX	8 cm	4 cm	$149
QP200-2-VIS-NIR	400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	silicone monocoil	8 cm	4 cm	$150
QP230-0.25-XSR	180-900 nm	230 µm ± 10 µm	aluminum	25 centimeters	stainless-steel BX	4 cm	2 cm	$149
QP230-1-XSR	180-900 nm	230 µm ± 10 µm	aluminum	1 meter	stainless-steel BX	4 cm	2 cm	$179
QP230-2-XSR	180-900 nm	230 µm ± 10 µm	aluminum	2 meters	stainless-steel BX	4 cm	2 cm	$199
QP300-1-SR	200-1100 nm	300 µm ± 6 µm	polyimide	1 meter	silicone monocoil	12 cm	6 cm	$150
QP400-025-SR	200-1100 nm	400 µm ± 8 µm	polyimide	25 centimeters	silicone monocoil	16 cm	8 cm	$119
QP400-025-SR/BX	200-1100 nm	400 µm ± 8 µm	polyimide	25 centimeters	stainless-steel BX	16 cm	8 cm	$119
QP400-1-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	1 meter	silicone monocoil	16 cm	8 cm	$150
QP400-2-SR	200-1100 nm	400 µm ± 8 µm	polyimide	2 meters	silicone monocoil	16 cm	8 cm	$179
QP400-2-SR/BX	200-1100 nm	400 µm ± 8 µm	polyimide	2 meters	stainless-steel BX	16 cm	8 cm	$179
QP400-2-UV/BX	300-1100 nm	400 µm ± 8 µm	polyimide	2 meters	stainless-steel BX	16 cm	8 cm	$169
QP400-2-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	2 meters	silicone monocoil	16 cm	8 cm	$169
QP400-2-VIS/BX	400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	stainless-steel BX	16 cm	8 cm	$169
QP400-2-VIS-NIR	400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	silicone monocoil	16 cm	8 cm	$169
QP450-0.25-XSR	180-900 nm	455 µm ± 10 µm	aluminum	25 centimeters	stainless-steel BX	8 cm	4 cm	$159
QP450-1-XSR	180-900 nm	455 µm ± 10 µm	aluminum	1 meter	stainless-steel BX	8 cm	4 cm	$199
QP450-2-XSR	180-900 nm	455 µm ± 10 µm	aluminum	2 meters	stainless-steel BX	8 cm	4 cm	$239
QP600-025-SR	200-1100 nm	600 µm ± 10 µm	polyimide	25 centimeters	silicone monocoil	24 cm	12 cm	$129
QP600-025-SR/BX	200-1100 nm	600 µm ± 10 µm	polyimide	25 centimeters	stainless-steel BX	24 cm	12 cm	$119
QP600-025-UV	300-1100 nm	600 µm ± 10 µm	polyimide	25 centimeters	silicone monocoil	24 cm	12 cm	$119
QP600-025-VIS-N	400-2500 nm	600 µm ± 10 µm	polyimide	25 centimeters	silicone monocoil	24 cm	12 cm	$119
QP600-1-SR	200-1100 nm	600 µm ± 10 µm	polyimide	1 meter	silicone monocoil	24 cm	12 cm	$179
QP600-1-SR/BX	200-1100 nm	600 µm ± 10 µm	polyimide	1 meter	stainless-steel BX	24 cm	12 cm	$179
QP600-1-UV-VIS	300-1100 nm	600 µm ± 10 µm	polyimide	1 meter	silicone monocoil	24 cm	12 cm	$179
QP600-2-SR	200-1100 nm	600 µm ± 10 µm	polyimide	2 meters	silicone monocoil	24 cm	12 cm	$219
QP600-2-SR/BX	200-1100 nm	600 µm ± 10 µm	polyimide	2 meters	stainless-steel BX	24 cm	12 cm	$219
QP600-2-UV/BX	300-1100 nm	600 µm ± 10 µm	polyimide	2 meters	stainless-steel BX	24 cm	12 cm	$209
QP600-2-UV-VIS	300-1100 nm	600 µm ± 10 µm	polyimide	2 meters	silicone monocoil	24 cm	12 cm	$209
QP600-2-VIS/BX	400-2500 nm	600 µm ± 10 µm	polyimide	2 meters	stainless-steel BX	24 cm	12 cm	$209
QP600-2-VIS-NIR	400-2500 nm	600 µm ± 10 µm	polyimide	2 meters	silicone monocoil	24 cm	12 cm	$209
QP1000-2-UV/BX	300-1100 nm	1000 µm ± 20 µm	acrylate	2 meters	stainless-steel BX	30 cm	15 cm	$359
QP1000-2-UV-VIS	300-1100 nm	1000 µm ± 20 µm	acrylate	2 meters	silicone monocoil	30 cm	15 cm	$359
QP1000-2-VIS/BX	400-2500 nm	1000 µm ± 20 µm	acrylate	2 meters	stainless-steel BX	30 cm	15 cm	$359
QP1000-2-VIS-NI	400-2500 nm	1000 µm ± 20 µm	acrylate	2 meters	silicone monocoil	30 cm	15 cm	$359

* *LTBR stands for Long Term Bend Radius, the bend radius allowed long term (such as for storage) before damaging the fiber.*

** *STBR stands for Short Term Bend Radius, the momentary bend radius allowed before damaging the fiber.*

Premium-grade Assemblies

Premium-grade Bifurcated Optical Fiber Assemblies

Our 2-meter Premium-grade Bifurcated Optical Fiber Assemblies are Y-shaped assemblies with two fibers of the same diameter side-by-side in the common end of the assembly. From the breakout of the assembly, the two fibers diverge into two legs, which can be UV-VIS, VIS-NIR or one of each -- a "mixed" assembly. Premium-grade assemblies feature premium SMA 905 Connectors (at right).

Item Code	Wavelength Range	Core Diameter	Buffer/ Coating	Assembly Length	Jacketing	LTBR*	STBR**	Price
QBIF50-UV-VIS	300-1100 nm	50 µm ± 5 µm	polyimide	2 meters	silicone monocoil	4 cm	2 cm	$299
QBIF200-UV-VIS	300-1100 nm	200 µm ± 4 µm	polyimide	2 meters	silicone monocoil	8 cm	4 cm	$299
QBIF200-VIS/BX	400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	stainless-steel BX	8 cm	4 cm	$299
QBIF200-VIS-NIR	400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	silicone monocoil	8 cm	4 cm	$299
QBIF400-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	2 meters	silicone monocoil	16 cm	8 cm	$329
QBIF400-VIS-NIR	400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	silicone monocoil	16 cm	8 cm	$329
QBIF600-UV-VIS	300-1100 nm	600 µm ± 10 µm	polyimide	2 meters	silicone monocoil	24 cm	12 cm	$369
QBIF600-VIS/BX	400-2500 nm	600 µm ± 10 µm	polyimide	2 meters	stainless-steel BX	24 cm	12 cm	$369
QBIF600-VIS-NIR	400-2500 nm	600 µm ± 10 µm	polyimide	2 meters	silicone monocoil	24 cm	12 cm	$369
QBIF200-MIXED	300-1100 nm & 400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	silicone monocoil	8 cm	4 cm	$299
QBIF400-MIXED	300-1100 nm & 400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	silicone monocoil	16 cm	8 cm	$329

Unjacketed Bulk Optical Fiber

We offer spooled, unjacketed optical fiber primarily for those interested in making their own assemblies. We offer various core diameters from 50 µm to 600 µm. To improve the fiber's strength and flexibility, we triple-coat it with a polyimide buffer before spooling. We offer all types of unjacketed optical fiber: High OH (high hydroxyl content for UV-VIS), Low OH (very low hydroxyl content for VIS-NIR) and Solarization-resistant (for UV-VIS). Each fiber type is optimized for use in a particular wavelength range.

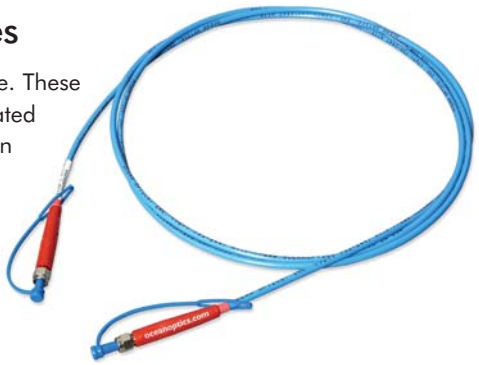
Item Code	Wavelength Range	Core Diameter	Buffer/ Coating	Fiber Type	Length	LTBR*	STBR**	Price/ Meter
FIBER-50-UV	300-1100 nm	50 µm ± 5 µm	polyimide	UV-VIS	specify meter length	4 cm	2 cm	$15.78
FIBER-50-VIS	400-2500 nm	50 µm ± 5 µm	polyimide	VIS-NIR	specify meter length	4 cm	2 cm	$15.78
FIBER-100-UV	300-1100 nm	100 µm ± 3 µm	polyimide	UV-VIS	specify meter length	4 cm	2 cm	$15.78
FIBER-100-VIS	400-2500 nm	100 µm ± 3 µm	polyimide	VIS-NIR	specify meter length	4 cm	2 cm	$15.78
FIBER-200-SR	200-1100 nm	200 µm ± 4 µm	polyimide	UV/SR-VIS	specify meter length	4 cm	2 cm	$15.00
FIBER-200-UV	300-1100 nm	200 µm ± 4 µm	polyimide	UV-VIS	specify meter length	8 cm	4 cm	$12.63
FIBER-200-VIS	400-2500 nm	200 µm ± 4 µm	polyimide	VIS-NIR	specify meter length	8 cm	4 cm	$12.63
FIBER-300-SR	200-1100 nm	300 µm ± 6 µm	polyimide	UV/SR-VIS	specify meter length	12 cm	6 cm	$19.38
FIBER-300-UV	300-1100 nm	300 µm ± 6 µm	polyimide	UV-VIS	specify meter length	12 cm	6 cm	$18.75
FIBER-300-VIS	400-2500 nm	300 µm ± 6 µm	polyimide	VIS-NIR	specify meter length	12 cm	6 cm	$18.75
FIBER-400-SR	200-1100 nm	400 µm ± 8 µm	polyimide	UV/SR-VIS	specify meter length	16 cm	8 cm	$28.75
FIBER-400-UV	300-1100 nm	400 µm ± 8 µm	polyimide	UV-VIS	specify meter length	16 cm	8 cm	$23.38
FIBER-400-VIS	400-2500 nm	400 µm ± 8 µm	polyimide	VIS-NIR	specify meter length	16 cm	8 cm	$23.38
FIBER-500-SR	200-1100 nm	500 µm ± 10 µm	polyimide	UV/SR-VIS	specify meter length	20 cm	10 cm	$40.00
FIBER-500-UV	300-1100 nm	500 µm ± 10 µm	polyimide	UV-VIS	specify meter length	20 cm	10 cm	$31.25
FIBER-500-VIS	400-2500 nm	500 µm ± 10 µm	polyimide	VIS-NIR	specify meter length	20 cm	10 cm	$31.25
FIBER-600-SR	200-1100 nm	600 µm ± 10 µm	polyimide	UV/SR-VIS	specify meter length	24 cm	12 cm	$20.34
FIBER-600-UV	300-1100 nm	600 µm ± 10 µm	polyimide	UV-VIS	specify meter length	24 cm	12 cm	$36.88
FIBER-600-VIS	400-2500 nm	600 µm ± 10 µm	polyimide	VIS-NIR	specify meter length	24 cm	12 cm	$36.88
FIBER-1000-UV	300-1100 nm	1000 µm ± 20 µm	acrylate	UV-VIS	specify meter length	30 cm	15 cm	$96.25
FIBER-1000-VIS	400-2500 nm	1000 µm ± 20 µm	acrylate	VIS-NIR	specify meter length	30 cm	15 cm	$96.25

* *LTBR stands for Long Term Bend Radius, the bend radius allowed long term (such as for storage) before damaging the fiber.*

** *STBR stands for Short Term Bend Radius, the momentary bend radius allowed before damaging the fiber.*

Laboratory-grade Assemblies

Laboratory-grade Patch Cord Optical Fiber Assemblies



Our Laboratory-grade Optical Fiber Assemblies offer high quality at an affordable price. These off-the-shelf assemblies come in various lengths and wavelength ranges, and in bifurcated and splitter designs. Our standard Laboratory-grade Assemblies act as both illumination and read fibers and connect easily to our spectrometers, light sources and accessories. Solarization-resistant Assemblies (these have -SR in the item code) are for applications below 300 nm. UV radiation below 300 nm degrades transmission in standard silica fibers, resulting in solarization (increased light absorption in the UV fiber that can invalidate data). For applications below 200 nm, we recommend our Premium-grade Xtreme Solarization-resistant Fiber and Probe Assemblies (see page 146).

Item Code	Wavelength Range	Core Diameter	Buffer/ Coating	Assembly Length	LTBR*	STBR**	Price
P8-2-SMA	400-2500 nm	8 µm ± 0.5 µm	acrylate	2 meters	4 cm	2 cm	$99
P50-2-UV-VIS	300-1100 nm	50 µm ± 5 µm	polyimide	2 meters	4 cm	2 cm	$99
P50-2-VIS-NIR	400-2500 nm	50 µm ± 5 µm	polyimide	2 meters	4 cm	2 cm	$99
P100-2-UV-VIS	300-1100 nm	100 µm ± 3 µm	polyimide	2 meters	4 cm	2 cm	$99
P100-2-VIS-NIR	400-2500 nm	100 µm ± 3 µm	polyimide	2 meters	4 cm	2 cm	$99
P100-5-UV-VIS	300-1100 nm	100 µm ± 3 µm	polyimide	5 meters	4 cm	2 cm	$149
P100-5-VIS-NIR	400-2500 nm	100 µm ± 3 µm	polyimide	5 meters	4 cm	2 cm	$149
P100-10-UV-VIS	300-1100 nm	100 µm ± 3 µm	polyimide	10 meters	4 cm	2 cm	$199
P100-10-VIS-NIR	400-2500 nm	100 µm ± 3 µm	polyimide	10 meters	4 cm	2 cm	$199
P200-2-UV-VIS	300-1100 nm	200 µm ± 4 µm	polyimide	2 meters	8 cm	4 cm	$99
P200-2-VIS-NIR	400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	8 cm	4 cm	$99
P200-5-UV-VIS	300-1100 nm	200 µm ± 4 µm	polyimide	5 meters	8 cm	4 cm	$149
P200-5-VIS-NIR	400-2500 nm	200 µm ± 4 µm	polyimide	5 meters	8 cm	4 cm	$149
P200-10-UV-VIS	300-1100 nm	200 µm ± 4 µm	polyimide	10 meters	8 cm	4 cm	$199
P200-10-VIS-NIR	400-2500 nm	200 µm ± 4 µm	polyimide	10 meters	8 cm	4 cm	$199
P300-1-SR	200-1100 nm	300 µm ± 6 µm	polyimide	1 meter	12 cm	6 cm	$99
P400-025-SR	200-1100 nm	400 µm ± 8 µm	polyimide	25 centimeters	16 cm	8 cm	$99
P400-1-SR	200-1100 nm	400 µm ± 8 µm	polyimide	1 meter	16 cm	8 cm	$119
P400-1-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	1 meter	16 cm	8 cm	$109
P400-2-SR	200-1100 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$129
P400-2-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$119
P400-2-VIS-NIR	400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$119
P400-5-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	5 meters	16 cm	8 cm	$179
P400-5-VIS-NIR	400-2500 nm	400 µm ± 8 µm	polyimide	5 meters	16 cm	8 cm	$179
P400-10-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	10 meters	16 cm	8 cm	$279
P400-10-VIS-NIR	400-2500 nm	400 µm ± 8 µm	polyimide	10 meters	16 cm	8 cm	$279
P600-025-SR	200-1100 nm	600 µm ± 10 µm	polyimide	25 centimeters	24 cm	12 cm	$109
P600-025-VIS-NIR	400-2500 nm	600 µm ± 10 µm	polyimide	25 centimeters	24 cm	12 cm	$99
P600-1-SR	200-1100 nm	600 µm ± 10 µm	polyimide	1 meter	24 cm	12 cm	$119
P600-2-SR	200-1100 nm	600 µm ± 10 µm	polyimide	2 meters	24 cm	12 cm	$169
P600-2-UV-VIS	300-1100 nm	600 µm ± 10 µm	polyimide	2 meters	24 cm	12 cm	$159
P600-2-VIS-NIR	400-2500 nm	600 µm ± 10 µm	polyimide	2 meters	24 cm	12 cm	$159
P600-5-UV-VIS	300-1100 nm	600 µm ± 10 µm	polyimide	5 meters	24 cm	12 cm	$249
P600-5-VIS-NIR	400-2500 nm	600 µm ± 10 µm	polyimide	5 meters	24 cm	12 cm	$249
P600-10-UV-VIS	300-1100 nm	600 µm ± 10 µm	polyimide	10 meters	24 cm	12 cm	$349
P600-10-VIS-NIR	400-2500 nm	600 µm ± 10 µm	polyimide	10 meters	24 cm	12 cm	$349
P1000-2-UV-VIS	300-1100 nm	1000 µm ± 20 µm	acrylate	2 meters	30 cm	15 cm	$299
P1000-2-VIS-NIR	400-2500 nm	1000 µm ± 20 µm	acrylate	2 meters	30 cm	15 cm	$299

* *LTBR stands for Long Term Bend Radius, the bend radius allowed long term (such as for storage) before damaging the fiber.*

** *STBR stands for Short Term Bend Radius, the momentary bend radius allowed before damaging the fiber.*

Specifications

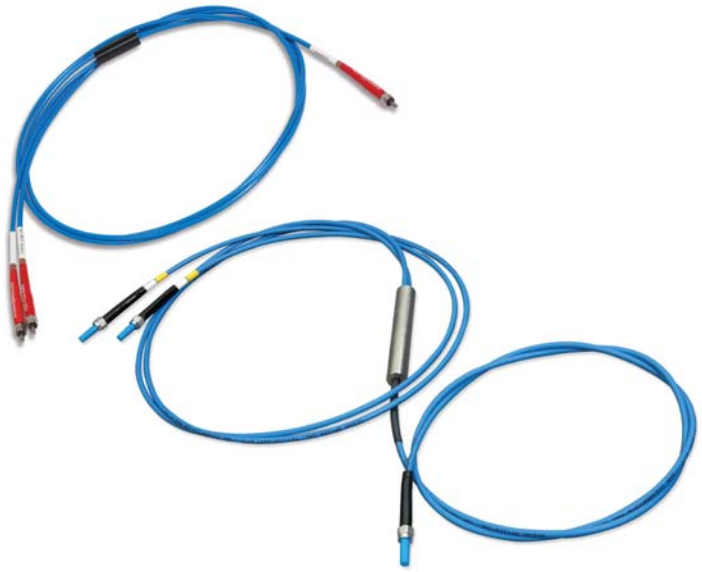
Type:	Laboratory-grade Patch Cord Optical Fiber Assemblies	Connector(s):	Laboratory-grade SMA 905 Connectors
Fiber profile:	Step-index multimode (all diameter assemblies except for (8 µm) and Step-index single mode (8 µm diameter assemblies)	Assembly jacketing	zip tube blue PVDF
		Temperature range:	-20 °C to 80 °C
Fiber core:	Pure silica core	Numerical aperture:	Multimode: 0.22 ± 0.02 (yields acceptance angle of 24.8° in air);
Fiber cladding:	Fluorine-doped silica cladding		Single mode: 0.14 ± 0.02 (yields acceptance angle of 14.94° in air)

Laboratory-grade Assemblies

Laboratory-grade Bifurcated and Splitter Optical Fiber Assemblies

These 2-meter Bifurcated Optical Fiber Assemblies (right, top) are Y-shaped assemblies that have two fibers of the same diameter side-by-side in the common end, or the tail of the assembly. From the nexus or breakout of the assembly, the two fibers diverge into two separate legs. You may specify that both fibers in the assembly are UV-VIS, VIS-NIR or one of each -- a "mixed" bifurcated assembly.

A splitter (right, bottom) is a 2-meter, Y-shaped assembly with a stainless steel breakout located midway from the ends of the assembly. Each splitter is made up of three separate optical fibers, all of the same diameter, and epoxied at the nexus of the Y-shaped assembly. A splitter can route light from two different sources to illuminate one sample or from one source to illuminate two samples. Splitters have lower transmission efficiency than other fiber assemblies due to their design.



Item Code	Wavelength Range	Core Diameter	Buffer/ Coating	Assembly Length	LTBR*	STBR**	Price
Bifurcated Optical Fiber Assemblies							
BIF50-UV-VIS	300-1100 nm	50 µm ± 5 µm	polyimide	2 meters	4 cm	2 cm	$249
BIF50-VIS-NIR	400-2500 nm	50 µm ± 5 µm	polyimide	2 meters	4 cm	2 cm	$249
BIF200-UV-VIS	300-1100 nm	200 µm ± 4 µm	polyimide	2 meters	8 cm	4 cm	$249
BIF200-VIS-NIR	400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	8 cm	4 cm	$249
BIF400-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$279
BIF400-VIS-NIR	400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$279
BIF400-MIXED	300-1100 nm & 400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$279
BIF600-UV-VIS	300-1100 nm	600 µm ± 10 µm	polyimide	2 meters	24 cm	12 cm	$329
BIF600-VIS-NIR	400-2500 nm	600 µm ± 10 µm	polyimide	2 meters	24 cm	12 cm	$329
Splitter Optical Fiber Assemblies							
SPLIT200-UV-VIS	300-1100 nm	200 µm ± 4 µm	polyimide	2 meters	8 cm	4 cm	$499
SPLIT200-VIS-NIR	400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	8 cm	4 cm	$499
SPLIT400-UV-VIS	300-1100 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$499
SPLIT400-VIS-NIR	400-2500 nm	400 µm ± 8 µm	polyimide	2 meters	16 cm	8 cm	$499
Keyed SMA Optical Fiber Assemblies, Round to Keyed Linear							
PL100-2-UV-VIS	300-1100 nm	100 µm ± 3 µm	polyimide	2 meters	4 cm	2 cm	$299
PL100-2-VIS-NIR	400-2500 nm	100 µm ± 3 µm	polyimide	2 meters	4 cm	2 cm	$299
PL100-2-MIXED	300-1100 nm & 400-2500 nm	100 µm ± 3 µm	polyimide	2 meters	4 cm	2 cm	$299
PL200-2-MIXED	300-1100 nm & 400-2500 nm	200 µm ± 4 µm	polyimide	2 meters	8 cm	4 cm	$299

* *LTBR stands for Long Term Bend Radius, the bend radius allowed long term (such as for storage) before damaging the fiber.*

** *STBR stands for Short Term Bend Radius, the momentary bend radius allowed before damaging the fiber.*

Specifications

Type:	Laboratory Grade Bifurcated, Splitter and Keyed Optical Fiber Assemblies
Fiber profile:	Step-index multimode
Fiber core:	Pure silica core
Fiber cladding:	Fluorine-doped silica cladding
Connector(s):	Laboratory-grade SMA 905 Connectors
Assembly jacketing:	zip tube blue PVDF
Breakout:	Midway of assembly at 1 meter
Operating temp. range:	-20 °C to 80 °C
Numerical aperture:	0.22 ± 0.02 (yields acceptance angle of 24.8° in air)

Xtreme Solarization-resistant Assemblies

High Transparency and Durability

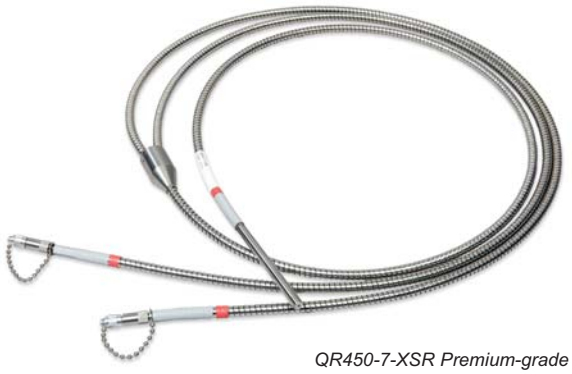
Xtreme Solarization-resistant Optical Fiber and Probe Assemblies for spectroscopy are manufactured using a proprietary process that provides enhanced UV transmission -- signal will transmit to 180 nm -- and remarkable resistance to UV degradation, making it ideal for deep-UV applications (<300 nm). Ocean Optics is the only spectroscopy manufacturer to offer XSR Fiber.

Solarization in Typical Fibers

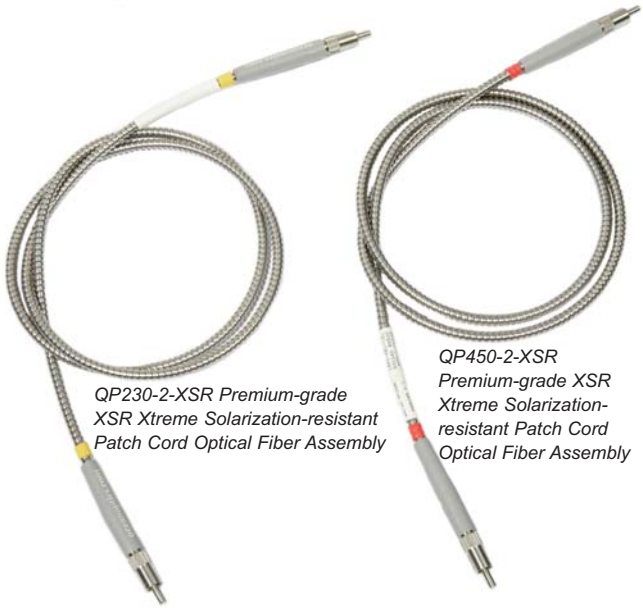
UV radiation below 300 nm degrades transmission in standard silica fibers, resulting in solarization (increased light absorption in the UV fiber that can invalidate data). For applications below 300 nm, we recommend Premium-grade XSR Xtreme Solarization-resistant Fiber and Probe Assemblies, which are available for immediate delivery in standard lengths. Shorter lengths for solarization-resistant assemblies maximize UV throughput. Custom lengths are available; however, we recommend speaking with our Applications Scientists before ordering.

High Production Values

Our XSR products are part of our high-quality Premium-grade line of optical fibers and probes. XSR Fiber and Probe Assemblies are robust and durable; each assembly has an aluminum coating, a stainless-steel BX jacketing, and our high-quality SMA 905 Connectors with captive end cap that protects fiber tips against scratches and contaminants. And like all of our optical fibers, the XSR assemblies are precisely polished to work with our miniature fiber optic spectrometers and accessories.



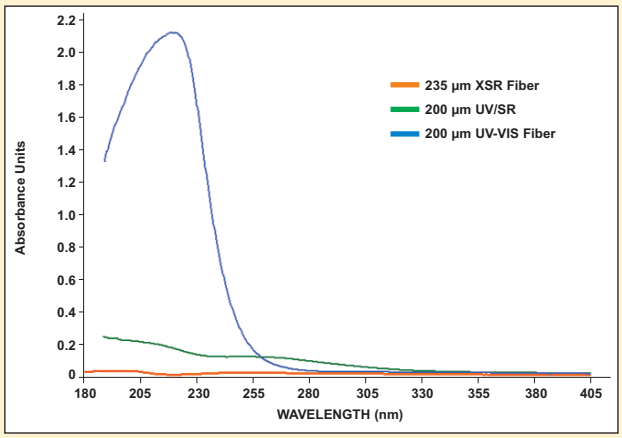
QR450-7-XSR Premium-grade XSR Xtreme Solarization-resistant Reflection Probe Assembly



QP230-2-XSR Premium-grade XSR Xtreme Solarization-resistant Patch Cord Optical Fiber Assembly

QP450-2-XSR Premium-grade XSR Xtreme Solarization-resistant Patch Cord Optical Fiber Assembly

Absorbance Spectra of Various Fiber Types after 72 Hours of UV Exposure



Specifications

Type:	Premium Grade Xtreme XSR Solarization-resistant Optical Fiber Assemblies and Reflection/Backscattering Probes
Wavelength range:	180-900 nm
Fiber profile:	Step-index multimode
Fiber core:	Pure silica core
Fiber cladding:	Fluorine-doped silica cladding
Fiber buffer/coating:	Aluminum
Operating temp. range:	-50 °C to 250 °C
Numerical aperture:	0.22 ± 0.02 (yields acceptance angle of 24.8° in air)
Connector(s):	Premium-grade SMA 905 Connectors
Assembly jacketing	Stainless-steel BX

Item Code	Product Type	Assembly Length	Core Diameter	LTBR*	STBR**	Price
QP230-0.25-XSR	Optical Fiber Assembly	25 centimeters	230 µm	4 cm	2 cm	$149
QP230-1-XSR	Optical Fiber Assembly	1 meter	230 µm	4 cm	2 cm	$179
QP230-2-XSR	Optical Fiber Assembly	2 meters	230 µm	4 cm	2 cm	$199
QP450-0.25-XSR	Optical Fiber Assembly	25 centimeters	450 µm	8 cm	4 cm	$159
QP450-1-XSR	Optical Fiber Assembly	1 meter	450 µm	8 cm	4 cm	$199
QP450-2-XSR	Optical Fiber Assembly	2 meters	450 µm	8 cm	4 cm	$239
QR230-7-XSR/BX	Reflection/backscattering Probe	2 meters	230 µm	4 cm	2 cm	$599
QR450-7-XSR	Reflection/backscattering Probe	2 meters	450 µm	8 cm	4 cm	$999

* *LTBR stands for Long Term Bend Radius, the bend radius allowed long term (such as for storage) before damaging the fiber.*

** *STBR stands for Short Term Bend Radius, the momentary bend radius allowed before damaging the fiber.*

Flame Loop Fiber Optic Probe

Heat-resistant Fiber Optic Probe

The FL-400 Flame Loop Fiber Optic Probe couples to our spectrometers to measure in situ emission spectra of samples such as dissolved metals and high-temperature plasmas. The FL-400 consists of a high-temperature 400 µm gold-jacketed UV-VIS optical fiber in an 8-inch-long nickel sleeve. The assembly operates in temperatures up to 700 °C. The probe connects to the 21-02 Splice Bushing and a P400-2-UV-VIS Optical Fiber, which couples to a spectrometer to measure emission spectra. (Components are sold separately.)

Use as a Flame Loop Probe or Use as a Heat-resistant Fiber Probe

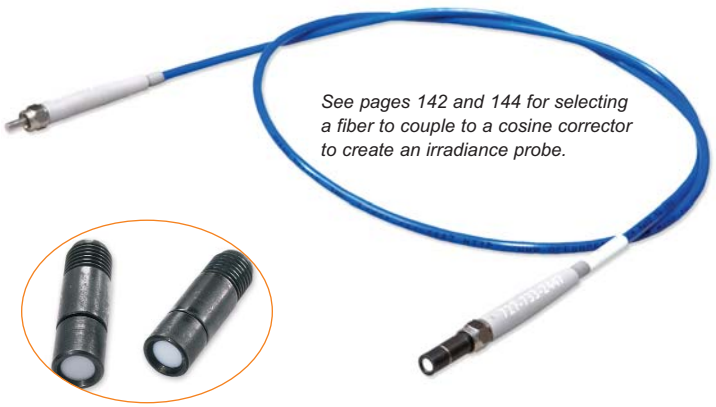
The FL-400 is especially beneficial as an emission spectroscopy teaching tool to observe atomic emission lines of dissolved metals. You simply dip the loop in your sample material and pass the loop over an open flame to take emission measurements. To use the FL-400 as a heat-resistant emission probe, remove the flame loop and insert the FL-400 into a high-temperature environment to monitor emission.

FL-400: $499
P400-2-UV-VIS: $119
21-02: $13

Probe Assembly Specifications

Fiber diameter:	400 µm core diameter
Fiber core/cladding:	Fused silica core and doped, fused silica cladding
Fiber jacketing:	Gold
Fiber type:	1 single-strand, multimode fiber
Wavelengths covered:	300-1100 nm
Probe sleeve (ferrule):	Nickel
Probe dimensions:	17.78 cm length, 20-gauge probes with 0.902 mm OD
Temperature range:	-269 °C to 700 °C
Numerical aperture:	0.22
Connector:	SMA 905

Cosine-corrected Irradiance Probe

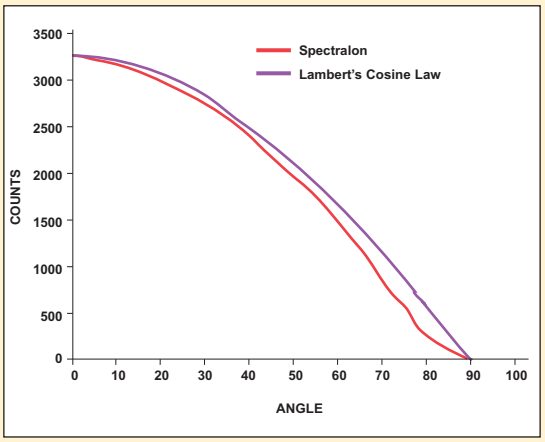


See pages 142 and 144 for selecting a fiber to couple to a cosine corrector to create an irradiance probe.

CC-3 and CC-3-UV Cosine Correctors collect radiation from a 180° solid angle. When screwed onto the end of an optical fiber, the cosine corrector and optical fiber become an irradiance probe, measuring the intensity of light normal to the probe surface defined by the diffusing material. The probe then couples to one of our spectrometers to make a complete spectroradiometer for relative and absolute spectral intensity measurements, such as measuring UV-A and UV-B in natural solar environments, evaluating emissive color sources and analyzing light sources such as LEDs and lasers. The CC-3 has an opaline glass diffuser for VIS-NIR; the CC-3-UV utilizes Spectralon for UV-NIR. Each disc sits flush at the end of 6.35-mm outer diameter barrel, which is threaded on one side for SMA 905 Connectors.

CC-3: $99
CC-3-UV: $129

CC-3-UV Angular Response



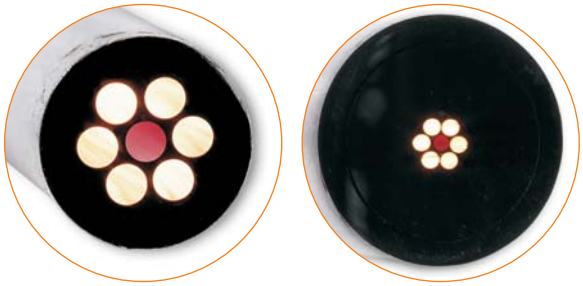
The response of the Spectralon (red trace) used in the CC-3-UV nearly matches that of Lambert's Cosine Law.

Specifications

	CC-3	CC-3-UV
Diffusing material:	Opaline glass	Spectralon
Wavelength range:	350-1000 nm	200-1100 nm
Disc thickness:	7.9 mm	7.9 mm
Dimensions:	6.35 mm OD	6.35 mm OD
Field of view:	180°	180°
Connector:	SMA 905	SMA 905

Reflection/Backscattering Probes

Our R-series Fiber Optic Reflection Probes are used for measuring specular or diffuse reflectance from a surface, fluorescence from solid surfaces, or backscattering and fluorescence in solutions and powders. These probes come in all four fiber types (XSR, UV/SR, UV-VIS and VIS-NIR), or a combination of fiber types. (See page 139 for more on each fiber type.)



Our standard reflection probes use a 6-around-1 close-packing design to ensure parallel orientation of the fibers.

Standard Reflection/Backscattering Probes

Stainless Steel Ferrule

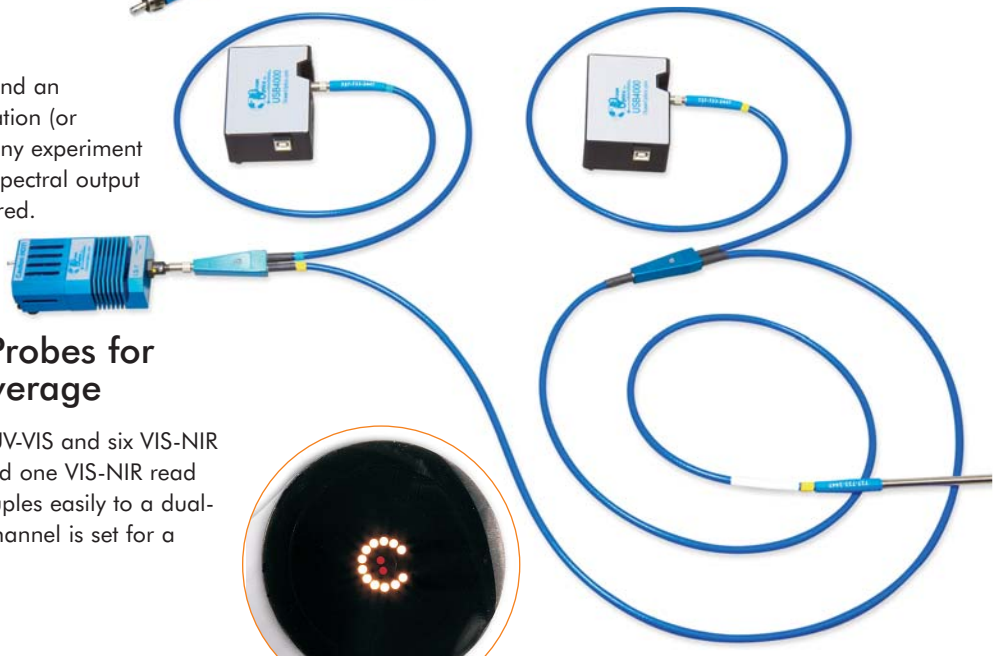
Our Standard Reflection/Backscattering Probes are based on a natural close-packing arrangement of optical fibers. Typically, the arrangement is a tight bundle of seven optical fibers -- six illumination fibers around one read fiber. This arrangement ensures parallel orientation of the fibers. The center or read fiber splits from the other six fibers and couples to a spectrometer. The outer six illumination fibers connect to the light source.

PEEK Probe Ferrule

The RP200-7-UV-VIS consists of a bundle of 200-µm fibers in a six-around-one design, but has a PEEK ferrule for applications where samples may be corrosive to the standard stainless-steel ferrule.

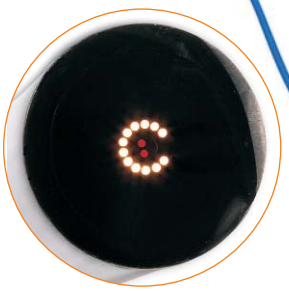
Reflection/Backscattering Probes with Reference Leg

The R200-REF consists of an R200-7 and an additional fiber to monitor the illumination (or reference) source, which is useful for any experiment in which variation or instability in the spectral output of the light source needs to be monitored.



Reflection/Backscattering Probes for Expanded Wavelength Coverage

The R200-MIXED has 14 fibers -- six UV-VIS and six VIS-NIR illumination fibers, plus one UV-VIS and one VIS-NIR read fiber (see bundle photo at right). It couples easily to a dual-channel spectrometer in which each channel is set for a different wavelength range.



Angled Probes for Solutions & Powders

Our angled probes also have a six-around-one design, but employ a 30° window to remove specular reflection effects when the probe is immersed in dense solutions and powders. We offer the angled probe with two different diameter fibers, 200 µm and 400 µm. These backscattering probes are especially useful for fluorescence measurements.

Reflection/Backscattering Probes

Item Code	Wavelength Range	Core Diameter	Fiber Bundle	Fiber Jacketing	Probe Ferrule	LTBR*	STBR**	Price
Standard Reflection/Backscattering Probes								
QR200-7-UV-VIS	300-1100 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	8 cm	4 cm	$399
QR200-7-VIS-NIR	400-2500 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	8 cm	4 cm	$399
QR230-7-XSR/BX	180-900 nm	230 µm	6 illumination fibers around 1 read, with aluminum coating	stainless-steel BX	6.35 mm OD			$599
QR400-7-SR	200-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	16 cm	8 cm	$699
QR400-7-SR/BX	200-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	stainless-steel BX	6.35 mm OD	16 cm	8 cm	$549
QR400-7-UV/BX	300-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	stainless-steel BX	6.35 mm OD	16 cm	8 cm	$549
QR400-7-UV-VIS	300-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	16 cm	8 cm	$650
QR400-7-VIS/BX	400-2500 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	stainless-steel BX	6.35 mm OD	16 cm	8 cm	$549
QR400-7-VIS-NIR	400-2500 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	16 cm	8 cm	$649
QR450-7-XSR	180-900 nm	450 µm	6 illumination fibers around 1 read, with aluminum coating	stainless-steel BX	6.35 mm OD			$999
QR600-7-SR-125F	200-1100 nm	600 µm ± 10 µm	6 illumination fibers around 1 read	silicone monocoil	3.18 mm OD	24 cm	12 cm	$899
QR600-7-UV-125F	300-1100 nm	600 µm ± 10 µm	6 illumination fibers around 1 read	silicone monocoil	3.18 mm OD	24 cm	12 cm	$849
QR600-7-VIS-125	400-2500 nm	600 µm ± 10 µm	6 illumination fibers around 1 read	silicone monocoil	3.18 mm OD	24 cm	12 cm	$849
R200-7-UV-VIS	300-1100 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	8 cm	4 cm	$399
R200-7-VIS-NIR	400-2500 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	8 cm	4 cm	$399
R400-7-SR	200-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	16 cm	8 cm	$549
R400-7-UV-VIS	300-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	16 cm	8 cm	$499
R400-7-VIS-NIR	400-2500 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	16 cm	8 cm	$499
R600-7-SR-125F	200-1100 nm	600 µm ± 10 µm	6 illumination fibers around 1 read	zip tube blue PVDF	3.18 mm OD	24 cm	12 cm	$699
R600-7-UV-125F	300-1100 nm	600 µm ± 10 µm	6 illumination fibers around 1 read	zip tube blue PVDF	3.18 mm OD	24 cm	12 cm	$699
R600-7-VIS-125F	400-2500 nm	600 µm ± 10 µm	6 illumination fibers around 1 read	zip tube blue PVDF	3.18 mm OD	24 cm	12 cm	$699
RP200-7-UV-VIS	300-1100 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	zip tube blue PVDF	PEEK ferrule, 6.35 mm OD	8 cm	4 cm	$499
Reflection/Backscattering Probes with Reference Leg								
QR200-REF-UV-VI	300-1100 nm	200 µm ± 4 µm	6 illumination fibers around 1 read plus 1 fiber to monitor illumination	silicone monocoil	6.35 mm OD	8 cm	4 cm	$549
QR200-REF-VIS-N	400-2500 nm	200 µm ± 4 µm	6 illumination fibers around 1 read plus 1 fiber to monitor illumination	silicone monocoil	6.35 mm OD	8 cm	4 cm	$549
R200-REF-UV-VIS	300-1100 nm	200 µm ± 4 µm	6 illumination fibers around 1 read plus 1 fiber to monitor illumination	zip tube blue PVDF	6.35 mm OD	8 cm	4 cm	$549
R200-REF-VIS-NI	400-2500 nm	200 µm ± 4 µm	6 illumination fibers around 1 read plus 1 fiber to monitor illumination	zip tube blue PVDF	6.35 mm OD	8 cm	4 cm	$549
Reflection/Backscattering Probes for Expanded Wavelength Coverage								
QR200-12-MIXED	300-1100 nm & 400-2500 nm	200 µm ± 4 µm	6 UV-VIS & 6 VIS-NIR illumination fibers around 1 UV-VIS & 1 VIS-NIR fibers	silicone monocoil	6.35 mm OD	8 cm	4 cm	$749
R200-12-MIXED	300-1100 nm & 400-2500 nm	200 µm ± 4 µm	6 UV-VIS & 6 VIS-NIR illumination fibers around 1 UV-VIS & 1 VIS-NIR fibers	zip tube blue PVDF	6.35 mm OD	8 cm	4 cm	$749
Angled Probes for Solutions & Powders								
QR200-ANGLE-U	300-1100 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	8 cm	4 cm	$599
QR200-ANGLE-V	400-2500 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	8 cm	4 cm	$599
QR400-ANGLE-U	300-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	16 cm	8 cm	$749
QR400-ANGLE-V	400-2500 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	silicone monocoil	6.35 mm OD	16 cm	8 cm	$749
R200-ANGLE-UV	300-1100 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	8 cm	4 cm	$499
R200-ANGLE-VIS	400-2500 nm	200 µm ± 4 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	8 cm	4 cm	$499
R400-ANGLE-UV	300-1100 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	16 cm	8 cm	$599
R400-ANGLE-VIS	400-2500 nm	400 µm ± 8 µm	6 illumination fibers around 1 read	zip tube blue PVDF	6.35 mm OD	16 cm	8 cm	$599

* *LTBR stands for Long Term Bend Radius, the bend radius allowed long term (such as for storage) before damaging the fiber.*

** *STBR stands for Short Term Bend Radius, the momentary bend radius allowed before damaging the fiber.*

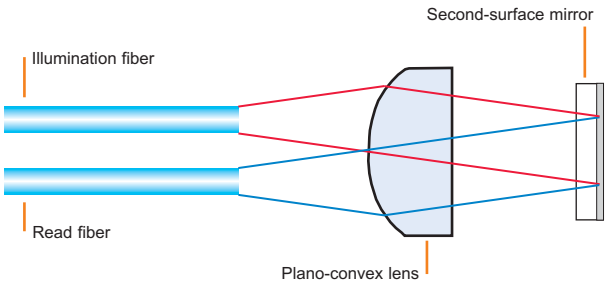
Specifications

Fiber profile:	Step-index multimode	Probe ferrule material:	Stainless steel except where noted
Fiber core:	Pure silica core	Probe connector(s):	Premium-grade SMA 905 Connectors for QR-series probes, Laboratory-grade SMA 905 Connectors for R-series probes
Fiber cladding:	Fluorine-doped silica cladding		
Fiber buffer/coating:	Polyimide coating except where noted	Breakout:	Midway of assembly at 1 meter
Operating temp. range:	-20 °C to 80 °C	Total probe length:	2 meters for fiber assembly, 76.2 mm long for probe ferrule = 2.076 meters; custom lengths available
Numerical aperture:	0.22 ± 0.02 (yields an acceptance angle of 24.8° in air)		

Transmission Dip Probes

The stainless steel RT-series tips screw onto the end of the T300-RT or T200-RT.

Transmission Dip Probe Operation



Specifications	
Fiber type:	T300: 300 µm UV/SR fiber type (200-1100 nm) T200: 200 µm VIS-NIR fiber type (400-2500 nm)
Pressure limit:	100 psi
Temperature limit:	100 °C without sleeve
Outer diameter:	6.35 mm
Probe length:	127 mm
Fiber length:	2 meters
Breakout:	1.5 meters from the end of the probe
Optics:	Fused silica
Probe wetted materials:	Stainless steel, fused silica, EPO-TEK 353ND
Pathlength:	2, 4, 5 or 10 mm
Fiber jacketing:	PVC Monocoil
Connector:	SMA 905
Probe sleeve:	Stainless steel

In Situ Monitoring

Our T300-RT and T200-RT Transmission Dip Probes couple to our spectrometers and light sources to measure absorbance and transmission in solutions. These probes are especially useful for embedding into process streams for in situ, real-time sample monitoring.

Theory of Operation

In transmission dip probes, light is transmitted from the illumination fiber through a plano-convex lens and through the sample compartment to a flat, second-surface mirror. The light reflects from this mirror and is focused by the lens onto the read fiber. The advantage of the transmission probe is its compact optical design, which fits into a 6.35-mm (1/4") outer diameter stainless steel body, or ferrule. The trade-offs with these probes are that they measure both transmitted light and backscattered light from the sample and have internal reflections that limit the dynamic range of the measurement. Still, at less than $1,000, transmission probes are a cost-effective option for many on-line and lab applications.

T300-RT Design

The T300-RT-UV-VIS Transmission Dip Probe consists of two 300-µm solarization-resistant optical fibers -- one illumination optical fiber and one read optical fiber -- in a 3.175-mm (1/8") outer diameter stainless steel assembly that slides into a 127-mm long, 6.35-mm (1/4") outer diameter stainless steel ferrule. Each leg of the assembly has an SMA 905 termination so that one leg can be attached to a light source and the other to a spectrometer.

T200-RT Design

The T200-RT-VIS-NIR Transmission Dip Probe has the same optical design as the T300-RT-UV-VIS, but is made with two 200-µm VIS-NIR optical fibers in its assembly.

Process Applications

Both probes fit into a standard 1/4" Swagelok fitting for installation into a pipe or reactor. Probe optics are mounted with an epoxy that offers superior chemical resistance to most solvents and can tolerate high temperatures.

Screw-on Tips: Choose Your Pathlength

Available separately are the screw-on, interchangeable probe tips necessary to use either probe. The RT-series tips come in pathlengths of 2 mm, 4 mm, 5 mm or 10 mm so that sampling setups can be configured for optically dense or dilute solutions.

T300-RT-UV-VIS:	$750
T200-RT-VIS-NIR:	$750
RT-2MM:	$240
RT-4MM:	$240
RT-5MM:	$240
RT-10MM:	$240

Transmission Dip Probes

Dip Probe for Hostile Environments

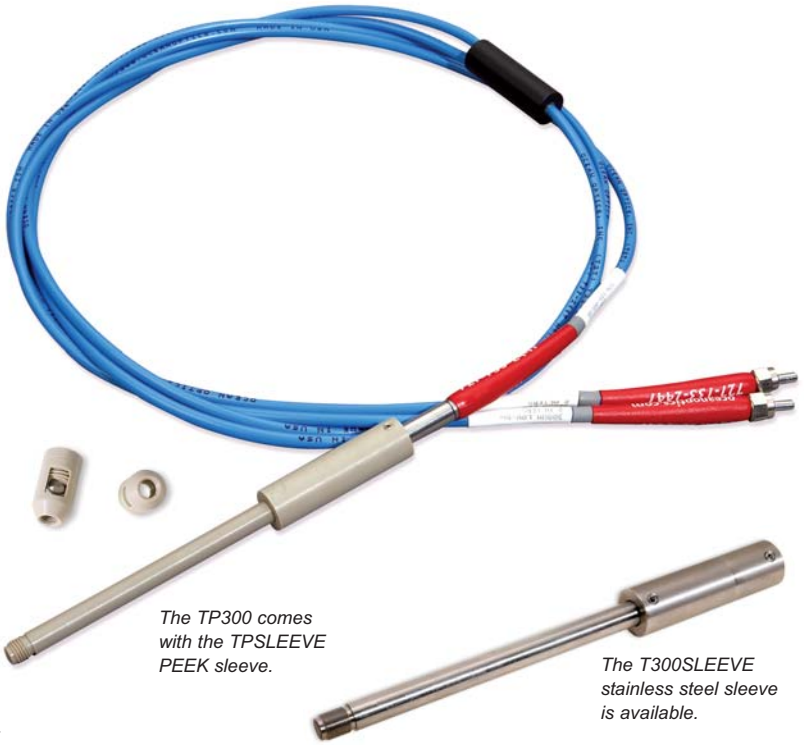
The TP300-UV-VIS Transmission Dip Probe couples to our spectrometers and light sources to measure the absorbance and transmission of solutions in harsh environments.

Probe Assembly

The TP300-UV-VIS consists of two 300-µm optical fibers -- one illumination optical fiber and one read optical fiber -- in a 3.175-mm (1/8") outer diameter stainless steel assembly sealed into a PEEK polymer sleeve. You have the option of choosing solarization-resistant fibers or VIS-NIR fibers for your assembly.

PEEK Polymer Sleeve

The sleeve is designed for environments with temperatures up to 200 °C. The PEEK material is also radiation-resistant and has low flammability and excellent chemical resistance. The PEEK sleeve (TPSLEEVE) comes with the TP300-UV-VIS. An additional stainless steel sleeve (T300SLEEVE) is available.



The TP300 comes with the TPSLEEVE PEEK sleeve.

The T300SLEEVE stainless steel sleeve is available.

Theory of Operation

The TP300 works the same way as the T300-RT and T200-RT probes. Light travels from the light source into the illumination leg of the probe and through a lens near the end of the probe. The light then transmits through the sample compartment to a second-surface mirror. The light reflects and travels back through the sample compartment a second time and is then focused by the lens onto the read fiber and through the read leg of the probe to the spectrometer.

Adjustable-pathlength Tips

There are two adjustable-pathlength tips (2-mm to 10-mm pathlengths or 10-mm to 20-mm pathlengths) available for the TP300-UV-VIS. Additionally, an RT-PH tip for mounting pH films in the optical path can be used for pH-sensing applications.

TP300-UV-VIS:	**$750**
TP300-VIS-NIR:	**$750**
T300SLEEVE:	**$250**
TPSLEEVE:	**$250**
RTP-2-10 Tip:	**$240**
RTP-10-20 Tip:	**$240**
RT-PH Tip:	**$240**

The RTP-series Tips (above) are for transmission and absorbance measurements. The RT-PH Tip (left) turns the TP300 Probe into a pH Sensor (see page 76).

Specifications

Fiber type:	TP300-UV-VIS -- 300 µm UV/SR fiber type (200-1100 nm) TP300-VIS-NIR -- VIS-NIRfiber type (400-2500 nm)	Pathlength:	Adjustable from 2-10 mm or from 10-20 mm RT-PH - fixed 16-mm pathlength
Outer diameter:	3.175 mm	Outer materials:	PVDF for jacketing, PEEK polymer for sleeve
Length:	107.9 mm for probe, 2 meters for fiber	Temperature limit:	200 °C with PEEK sleeve
Optics:	Fused silica	Pressure limit:	100 psi

Industrial Process Probes

Industrial Environments up to 250 psi, 300 °C

Our TI300-series Transmission Industrial Dip Probes can be used in environments with pressure limits up to 250 psi and at temperatures up to 300 °C. The TI300-UV-VIS uses 300 µm diameter solarization-resistant optical fiber (200-1100 nm), while the TI300-VIS-NIR uses 300 µm diameter VIS-NIR optical fiber (400-2200 nm). The TI300 probes couple to our spectrometers and light sources to measure solutions absorbance and transmission in industrial applications.

Sampling Tips Use O-rings, Replacing Epoxy

With our other transmission probe offerings, we use high-grade epoxy to adhere the sampling optics to the sampling tips. However, most epoxies lose their adhesive properties in continuous heat over 220 °C. With the TI300s, we mounted the probe optics into the sampling tips using Parker perfluoroelastomer (Parofluor ULTRA) O-ring seals. The material in these special O-rings offers broad chemical resistance, excellent thermal stability and temperature resistance up to 300 °C. The other materials in the screw-on, interchangeable sampling tips are grade 303 stainless steel, a back-coated quartz mirror and a quartz lens. The tips come in pathlengths of 2, 5, 10, 25 and 50 mm so that sampling setups can be configured for optically dense or dilute solutions.

Probe Ferrule & Jacketing

The TI300s use a fully interlocked stainless-steel jacketing over Teflon tubing and have an outer diameter of 0.68 cm. The immersible part of the probe, the ferrule, is also made from 303 stainless steel and measures 12.7 cm in length, with an outer diameter of 1.27 cm.

How it Works

In a TI300 probe, there are two 300-µm optical fibers -- one illumination optical fiber and one read optical fiber -- in a 12.7-mm diameter stainless-steel ferrule. Light transmits via the illumination fiber through a plano-convex lens and the sample compartment to a flat, second-surface mirror (see diagram on page 150). The light reflects from this mirror, travels back through the sample compartment and is focused by the lens onto the read fiber and through the read leg of the probe to the spectrometer. The trade-offs with these probes are that they measure both transmitted light and backscattered light from the sample and have internal reflections that limit the dynamic range of the measurement. But at less than $1,600 (for the TI300 probe and one sampling tip), a TI300 probe, with its high pressure and temperature limits, is a great option for many industrial applications.

TI300-UV-VIS:	**$1,299**
TI300-VIS-NIR:	**$1,299**
RT-TI-2MM:	**$299**
RT-TI-5MM:	**$299**
RT-TI-25MM:	**$299**
RT-TI-50MM:	**$299**

Specifications	
Fiber type:	TI300-UV-VIS -- 300 µm diameter UV/SR fiber type (200-1100 nm) TI300-VIS-NIR -- 300 µm diameter VIS-NIR fiber type (400-2500 nm)
Wavelength range:	TI300-UV-VIS -- 200-1100 nm TI300-VIS-NIR -- 400-2500 nm
Pressure limit:	250 psi
Temperature limit:	300 °C
Sampling tip body:	303 stainless steel
Sampling tip optics:	Quartz back-coated mirror and quartz lens
Sampling tip O-ring:	Parker perfluoroelastomer (Parofluor ULTRA) O-ring seal
Probe ferrule:	12.7 mm outer diameter 303 stainless steel
Probe jacketing:	Fully interlocked stainless-steel jacketing over Teflon tubing; total 6.8 mm outer diameter
Length:	Fiber -- 2 meters Ferrule -- 12.7 cm without tip Tips -- 2.6 cm to 4.99 cm, depending on tip
Breakout distance:	1 meter from the end of the probe
Immersible length:	12.7 cm
Optical pathlengths:	2, 5, 10, 25 and 50 mm pathlengths available
Connectors:	SMA 905

Vacuum Feedthroughs

Feedthroughs with Industry-standard Flanges

These Vacuum Feedthroughs are welded into industry standard flanges, and designed for monitoring high-vacuum applications from inside a vacuum system with external equipment, such as our spectrometers. The optical fiber inside of the VFT is hermetically sealed into a stainless steel shell. These VFTs come in two standard flange types: Conflat Flanges and ISO KF Flanges. The flanges use surgical-grade stainless steel with glass-ceramic seals. The flange-to-seal's metal-to-glass design allows the entire assembly to perform up to either 250 °C and 10^{-10} Torr for the Conflat Flanges or 150 °C and 10^{-8} Torr for the ISO KF Flanges.

VFT-1000-UV-133

VFT-1000-UV-275

VFT-1000-UV-16

VFT-1000-UV-40

Item	Fiber Type	Range	Flange Type	Price
VFT-200-UV-133	200-µm diameter UV-VIS	300-1100 nm	1.33" OD Conflat	$279
VFT-200-VIS-133	200-µm diameter VIS-NIR	400-2500 nm	1.33" OD Conflat	$279
VFT-400-UV-133	400-µm diameter UV-VIS	300-1100 nm	1.33" OD Conflat	$440
VFT-400-VIS-133	400-µm diameter VIS-NIR	400-2500 nm	1.33" OD Conflat	$440
VFT-600-UV-133	600-µm diameter UV-VIS	300-1100 nm	1.33" OD Conflat	$450
VFT-600-VIS-133	600-µm diameter VIS-NIR	400-2500 nm	1.33" OD Conflat	$450
VFT-1000-UV-133	1000-µm diameter UV-VIS	300-1100 nm	1.33" OD Conflat	$485
VFT-1000-VIS-133	1000-µm diameter VIS-NIR	400-2500 nm	1.33" OD Conflat	$485
VFT-200-UV-275	200-µm diameter UV-VIS	300-1100 nm	2.73" OD Conflat	$450
VFT-200-VIS-275	200-µm diameter VIS-NIR	400-2500 nm	2.73" OD Conflat	$450
VFT-400-UV-275	400-µm diameter UV-VIS	300-1100 nm	2.73" OD Conflat	$455
VFT-400-VIS-275	400-µm diameter VIS-NIR	400-2500 nm	2.73" OD Conflat	$455
VFT-600-UV-275	600-µm diameter UV-VIS	300-1100 nm	2.73" OD Conflat	$465
VFT-600-VIS-275	600-µm diameter VIS-NIR	400-2500 nm	2.73" OD Conflat	$465
VFT-1000-UV-275	1000-µm diameter UV-VIS	300-1100 nm	2.73" OD Conflat	$499
VFT-1000-VIS-275	1000-µm diameter VIS-NIR	400-2500 nm	2.73" OD Conflat	$499
VFT-200-UV-16	200-µm diameter UV-VIS	300-1100 nm	1.18" OD KF16 ISO	$430
VFT-200-VIS-16	200-µm diameter VIS-NIR	400-2500 nm	1.18" OD KF16 ISO	$430
VFT-400-UV-16	400-µm diameter UV-VIS	300-1100 nm	1.18" OD KF16 ISO	$435
VFT-400-VIS-16	400-µm diameter VIS-NIR	400-2500 nm	1.18" OD KF16 ISO	$435
VFT-600-UV-16	600-µm diameter UV-VIS	300-1100 nm	1.18" OD KF16 ISO	$445
VFT-600-VIS-16	600-µm diameter VIS-NIR	400-2500 nm	1.18" OD KF16 ISO	$445
VFT-1000-UV-16	1000-µm diameter UV-VIS	300-1100 nm	1.18" OD KF16 ISO	$480
VFT-1000-VIS-16	1000-µm diameter VIS-NIR	400-2500 nm	1.18" OD KF16 ISO	$480
VFT-200-UV-40	200-µm diameter UV-VIS	300-1100 nm	2.16" OD KF40 ISO	$445
VFT-200-VIS-40	200-µm diameter VIS-NIR	400-2500 nm	2.16" OD KF40 ISO	$445
VFT-400-UV-40	400-µm diameter UV-VIS	300-1100 nm	2.16" OD KF40 ISO	$450
VFT-400-VIS-40	400-µm diameter VIS-NIR	400-2500 nm	2.16" OD KF40 ISO	$450
VFT-600-UV-40	600-µm diameter UV-VIS	300-1100 nm	2.16" OD KF40 ISO	$460
VFT-600-VIS-40	600-µm diameter VIS-NIR	400-2500 nm	2.16" OD KF40 ISO	$460
VFT-1000-UV-40	1000-µm diameter UV-VIS	300-1100 nm	2.16" OD KF40 ISO	$495
VFT-1000-VIS-40	1000-µm diameter VIS-NIR	400-2500 nm	2.16" OD KF40 ISO	$495

VFT-series Feedthroughs

Our general-purpose VFT-series Vacuum Feedthroughs are designed to penetrate NEMA enclosures. The VFT screws into a 3/8-24 external threaded hole in the vacuum chamber, or bolts into a smooth hole with the provided nut and washer.

Item	Fiber Type	Range	Price
VFT-200-SR	200-µm diameter SR fiber	200-1100 nm	$299
VFT-200-VIS	200-µm diameter VIS-NIR fiber	400-2500 nm	$299
VFT-400-SR	400-µm diameter SR fiber	200-1100 nm	$299
VFT-400-VIS	400-µm diameter VIS-NIR fiber	400-2500 nm	$299
VFT-600-SR	600-µm diameter SR fiber	200-1100 nm	$299
VFT-600-VIS	600-µm diameter VIS-NIR fiber	400-2500 nm	$299
VFT-1000-UV	1000-µm diameter UV-VIS fiber	300-1100 nm	$299
VFT-1000-VIS	1000-µm diameter VIS-NIR fiber	400-2500 nm	$299

Specifications

	VFTs with Conflat Flanges	VFTs with KF ISO Flanges	VFT-Series
Temperature limit:	250 °C	150 °C	140 °C
Vacuum range:	1 x 10^{-10} Torr	1 x 10^{-8} Torr	1 x 10^{-9} Torr
Numerical aperture:	0.22, and acceptance angle of 24.8°	0.22, and acceptance angle of 24.8°	0.22, and acceptance angle of 24.8°

Bare Fiber Adapter Kit

The SMA-PUCK, sold separately from the BFA-KIT.

The BFA-KIT Bare Fiber Adapter Kit is for the fiber tinkerer who wants to polish bare (unjacketed) optical fiber. The kit comes with fiber polishing holders for various sizes of optical fibers.

The Bare Fiber Adapter Kit includes the following:

- 6 fiber polishing holders for various sizes of optical fiber: (1 each for 100 µm, 200 µm, 300 µm, 400 µm, 600 µm and 1000 µm optical fibers)
- a BFA-KIT-CHUCK connect-and-release adapter (which can be purchased separately as well) to fasten the SMAs onto bare optical fiber
- several pieces of wire for cleaning out the polishing holders and connect-and-release adapter

An SMA-PUCK polishing puck is not included with the BFA-KIT, but is available separately. The puck is used to polish the surface of an optical fiber.

Need a special SMA 905 Connector? We can drill out an SMA 905 Connector from 149 µm to 2705 µm. Custom-drilled connectors are available for $50 each.

BFA-KIT:	**$249**
BFA-KIT-CHUCK:	**$169**
SMA-PUCK:	**$129**

How to Use the BFA-KIT

Select the fiber polishing holder that corresponds to the diameter of your bare optical fiber.

Attach the fiber polishing holder to the front of the BFA-KIT-CHUCK connect-and-release adapter.

Thread your bare optical fiber through the back of the chuck and into the holder and fasten. The holder allows you to easily work with the fiber for various purposes, such as polishing.

Fiber Tinkerer's Kit

The FT-KIT Fiber Tinkerer Kit (left) includes an assortment of randomly selected, unterminated UV-VIS and VIS-NIR optical fibers. Each fiber included in the kit will be at least one meter in length. The Fiber Termination Kit (TERM-KIT) on the following page includes all the tools needed to terminate and polish fiber.

FT-KIT: $99

Fiber Termination Kit

Inspect & Repair Fibers

The TERM-KIT Termination Kit provides you with all the tools you need to properly polish and terminate an optical fiber. The TERM-KIT is great for inspecting, repairing and polishing optical fiber assemblies. If you would like unterminated fibers for use with the TERM-KIT, the FT-KIT Fiber Tinkerer Kit includes an assortment of optical fibers in lengths of at least one meter (see page 154 for details).

Included in Each TERM-KIT

- 4 SMA 905 Connectors for 50 µm or 100 µm fibers
- 4 SMA 905 Connectors for 200 µm optical fibers
- 4 SMA 905 Connectors for 400 µm optical fibers
- 4 SMA 905 Connectors for 600 µm optical fibers
- 4 SMA 905 Connectors for 1000 µm optical fibers
- polishing puck
- glass polishing plate (15 cm x 15 cm)
- dozens of polishing papers
- 5-cavity crimp tool (for 2.6, 3.4, 3.8, 4.5 and 6.4 mm cavities)
- scoring tool
- inspection scope
- 2-hour cure epoxy
- optical wipes

TERM-KIT: $599

Terminators

Our SMA 905 Connector Kits are an excellent complement to the standard Termination Kit (above). We offer six different kits, each with 10 SMA 905 Connectors of the same size, drilled for precise alignment with our optical fiber. The difference between each kit is the diameter size of the SMA 905 Connector. We offer 150 µm, 270 µm, 380 µm, 490 µm, 710 µm and 1300 µm diameter connectors.

TERMKIT-SMA-710

TERMKIT-SMA-270

TERMKIT-QSMA-710

TERMKIT-QSMA-270

Item	Fiber Type	For Use with Fiber Diameters of	Price
TERMKITSMA-150	10 SMA Connectors for 100-micron and 50-micron fibers	50 µm and 100 µm	$75
TERMKITSMA-270	10 SMA Connectors for 200-micron fibers	200 µm	$75
TERMKITSMA-380	10 SMA Connectors for 300-micron fibers	300 µm	$75
TERMKITSMA-490	10 SMA Connectors for 400-micron fibers	400 µm	$75
TERMKITSMA-710	10 SMA Connectors for 600-micron fibers	600 µm	$75
TERMKITSMA-130	10 SMA Connectors for 1000-micron fibers	1000 µm	$75
TERMKITQSMA-150	10 Premium SMA Connectors for 100-micron and 50-micron fibers	50 µm and 100 µm	$170
TERMKITQSMA-270	10 Premium SMA Connectors for 200-micron fibers	200 µm	$170
TERMKITQSMA-380	10 Premium SMA Connectors for 300-micron fibers	300 µm	$170
TERMKITQSMA-490	10 Premium SMA Connectors for 400-micron fibers	400 µm	$170
TERMKITQSMA-710	10 Premium SMA Connectors for 600-micron fibers	600 µm	$170
TERMKITQSMA-130	10 Premium SMA Connectors for 1000-micron fibers	1000 µm	$170

Optical Fiber Kits

Fiber Optic Kit -- UV-VIS

We've taken our most popular laboratory-grade optical fiber assemblies and accessories and combined them into cost-saving Optical Fiber Kits -- perfect for testing, teaching or just plain tinkering. The FOP-UV Optical Fiber Kit consists of five patch cord optical fiber assemblies, the Fiber Optic Variable Attenuator, a CC-3-UV Cosine Corrector, a fiber wrench and more. By buying a kit instead of each product separately, you save over $400. The table below lists the items in the kit.

FOP-UV KIT: $999

FOP-UV Items	Description	Price
P50-2-UV-VIS	(1) 50 µm diameter optical fiber; UV-VIS	$99
P200-2-UV-VIS	(1) 200 µm diameter optical fiber; UV-VIS	$99
P400-025-SR	(2) 400 µm diameter optical fibers; UV, SR	$198
P600-2-UV-VIS	(1) 600 µm diameter optical fiber; UV-VIS	$159
21-02	(2) Splice bushings	$26
21-01	(2) Bulkhead bushings	$18
FVA-UV	(1) Fiber Optic Variable Attenuator	$499
FOT-SMAWRENCH	(1) Fiber Wrench	$10
CC-3-UV	(1) Cosine Corrector	$129
FCBARREL	(2) 6.35-mm OD barrel for FC connectors	$58
FIBER-WRAP	(3) 2-foot-long pieces of fiber wrap	$10
74-UV	(1) Collimating Lens	$159
	Total, if purchased separately:	**$1,464**

The FVA-UV Fiber Optic Variable Attenuator helps control the amount of light transmitted between two fibers.

The 74-UV Collimating Lens can be screwed onto the end of a fiber to collimate light.

The FC-BARREL accepts FC-terminated fibers for use with our lenses, lamps and other fixtures.

The FIBER-WRAP is used to bundle and protect optical fibers.

The CC-3-UV Cosine Corrector attaches to optical fiber to create an irradiance probe.

The 21-01 SMA Bulkhead Bushing allows you to position an optical fiber on a through-panel such as a chamber wall.

The 21-02 Splice Bushing is an in-line adapter that mates two SMA 905 Connectors, such as those on optical fibers.

Fiber Optic Kit -- VIS-NIR

The FOP-VIS Optical Fiber Kit consists of five patch cord optical fiber assemblies, the Fiber Optic Variable Attenuator, CC-3 Cosine Corrector, fiber wrap, a fiber wrench and more. By buying a kit instead of each product separately, you save nearly $500. The table below lists the items included in the kit.

FOP-VIS KIT: $999

FOP-VIS Items	Description	Price
P50-2-VIS-NIR	(1) 50 µm diameter optical fiber; VIS-NIR	$99
P200-2-VIS-NIR	(1) 200 µm diameter optical fiber; VIS-NIR	$99
P400-2-VIS-NIR	(2) 400 µm diameter optical fibers; VIS-NIR	$238
P600-2-VIS-NIR	(1) 600 µm diameter optical fiber; VIS-NIR	$159
21-02	(2) Splice bushings	$26
21-01	(2) Bulkhead bushings	$18
FVA-UV	(1) Fiber Optic Variable Attenuator	$499
FOT-SMAWRENCH	(1) Fiber Wrench	$10
CC-3	(1) Cosine Corrector	$99
FCBARREL	(2) 6.35-mm OD barrel for FC connectors	$58
FIBER-WRAP	(3) 2-foot-long pieces of fiber wrap	$10
74-UV	(1) Collimating Lens	$159
	Total, if purchased separately:	**$1,474**

The FOT-SMAWRENCH slips over SMA 905 Connectors to secure fibers to spectrometers, collimating lenses and accessories.

The P400-2-UV-VIS Laboratory-grade Optical Fiber in the FOP-VIS Kit.

Fiber & Probe Fixtures & Holders

C-Mounts

Our C-MOUNT-MIC Adapter Assembly with adjustable focusing barrel has an SMA 905 Connector in its center for attaching to optical fibers. The internal C-mount threads of this assembly allow you to adapt fiber optic spectrometers to other optical devices such as microscopes and telescopes.

The MFA-C-MOUNT also connects to optical devices such as microscopes and telescopes, but its center connector is designed to accept probes with 6.35-mm (1/4") outer diameter ferrules.

C-MOUNT-MIC: $125
MFA-C-MOUNT: $458

The MFA-C-Mount.


The C-MOUNT-MIC Adapter Assembly.

Phototubus Microscope Adapter

The MFA-PT Phototubus Microscope Adapter adapts to a Phototubus outlet on microscopes and accepts SMA 905-terminated optical fibers.

MFA-PT: $424


The MFA-PT Phototubus Microscope Adapter.

Right-angle Collimating Lens Holder

The 74-90-UV is an assembly for mounting lenses at right angles, and is especially useful for applications involving awkward optical fiber routing. It has a mirror located under its cap bonded with high-temperature epoxy, and reflects light from the collimating lens to 90°. Two ports accommodate 74-series Collimating Lenses (not included).

74-90-UV: $139


The 74-90-UV Right-angle Collimating Lens Holder with collimating lenses and optical fiber (not included).

Reflection Probe Holders

The RPH-1 (far right) and RPH-2 (near right) are anodized aluminum platforms with holes drilled at 45° and 90° angles to the surface. The RPH-1 holds 6.35-mm (1/4") diameter probes but with the RPH-ADP -- an adapter that fits on the RPH-1 -- you can secure 3.17 mm (1/8") diameter probes as well. The RPH-2 is for use only with probes with SMA 905 Connectors. The Curved Surface Probe Holders accommodate 6.35-mm (1/4") outer diameter probes for measuring reflection of curved surfaces. The CSH (right) has a hole drilled at a 90° angle to the surface. The CSH-45 has a hole drilled at a 45° angle to the surface.

RPH-1: $75
RPH-ADP: $69
RPH-2: $102
CSH: $107
CSH-45: $122


RPH-2

RPH-1

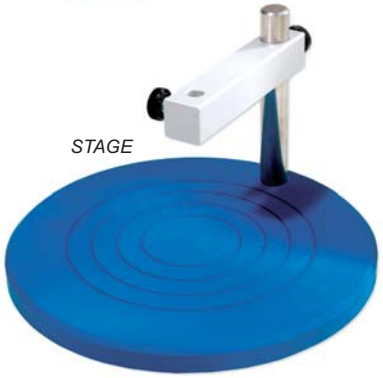
CSH

Optical Stages

The Single-Point Reflection Stage (at right) is a probe holder for reflection measurements of optical layers and other substrates up to 150 mm in diameter. The probe holder accommodates fiber optic probes and other sampling devices up to 6.35 mm in diameter.

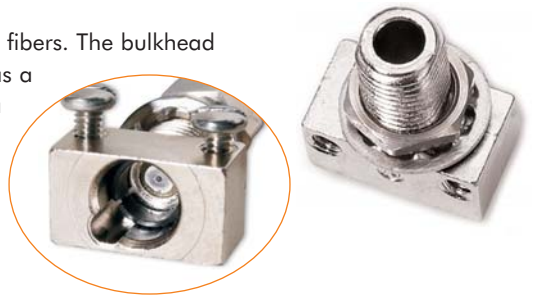
The Stage-RTL-T is also a sampling system for analysis of substrate materials. The STAGE-RTL-T can be configured for reflection and transmission measurements. For details on both stages, see page 109.

STAGE: $631
STAGE-RTL-T: $2,303


STAGE

Fiber & Probe Accessories

Bulkhead Bushing



The 21-01 SMA Bulkhead Bushing assembly is a device mount for optical fibers. The bulkhead bushing allows you to position an optical fiber on a through-panel such as a chamber wall. For example, to monitor a chamber, you could configure a sampling optic that consists of an SMA 905-terminated optical fiber screwed into the bulkhead bushing and mounted to a chamber window.

21-01: $9

Splice Bushings

The 21-02 SMA Splice Bushings are in-line adapters that connect SMA 905-terminated optical fibers (or any two objects with SMA 905 terminations). A splice bushing consists of a 0.75" screw with female ends. The standard 21-02 is made of nickel-plated brass while the 21-02-SS is made of stainless steel. They are useful for coupling patch cords to fiber optic probes and other devices, or for any multiple-fiber application where coupling our standard optical fibers and accessories is preferable to creating costly and complex fiber optic assemblies.

21-02: $13
21-02-SS: $49

Bulkhead & Splice Bushing Combo

The 21-02-BH SMA Bulkhead Splice Bushing is an in-line adapter that connects SMA 905-terminated optical fibers through a chamber wall or panel. The 21-02-BH features an O-ring for sealing against the inside of the panel wall and a nut and lockwasher for mounting to the outside of the panel wall.

21-02-BH: $23

FC Barrel

Our collimating lenses come standard with SMA 905 Connectors and interface to our SMA-terminated fibers. If you have FC-terminated fiber, you could remove the inner 6.35-mm OD SMA barrel and replace it with this FC Barrel to connect to our products.

FCBARREL: $29

Finger Fiber Wrench

The FOT-SMAWRENCH is a wrench that slips over the hex nut of the SMA 905 Connector used in Laboratory-grade Optical Fibers and helps to easily attach the fiber to connectors on spectrometers, light sources, collimating lenses and many other accessories.

FOT-SMAWRENCH: $10

Modemixer/Modestripper

The Modemixer/Modestripper is an in-line, 3-mm Suprasil rod that connects two SMA 905-terminated optical fibers to mix core modes and eliminate clad modes throughout 180-2100 nm.

ADP-SMA-SMA: $268

Fiber Wrap

Fiber Safety Wrap is a protective spiral wrap used to bundle and protect optical fibers. The durable wrap comes in 2-foot sections of red, yellow and green.

FIBER-WRAP: $10

Thin Films & Optics

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Overview: Thin Films & Optics

Precision, Experience & New Technology

The thin films and optics division that we established nearly five years ago provides the most versatile of in-house manufacturing arts: the innovation to create patented patterned dichroic filters for display and scientific applications, and the expertise to produce optics and coatings in OEM volumes. We are often our own best customer, applying the kind of spectroscopy-savvy insight that few optics suppliers can provide to the development of filters and optics that enhance our spectrometers and accessories. Our "colored light" products are among the most robust in the world, making them ideal for theatrical and architectural applications. One such product is the SeaChanger Color Engine, a color-changing device for stage lighting.

It all starts with a patented dichroic filter array process (see sidebar below), which creates patterns precise enough to project still images. There's much more, including both custom and off-the-shelf filters and precision optics for markets ranging from the entertainment industry to the military; optical metrology products such as laser-collimation testers and optical flats; and optical services from machining and microlithography to etching and QC testing.

Thin Films

Specifications

Substrates:
up to 455 mm diameter

Image size:
up to 250 mm square

Pattern resolution:
to 2 μm features

Spatial resolution:
to 1 μm

Temperature tolerance:
-80 °F to 700 °F

Coating wavelength range:
200-2500 nm

Coatings used in patterning:
see coating types below

Coating Types

- Antireflective
- Beamsplitter
- Dichroic, Dielectric, and Interference (UV to NIR)
- Fluorides
- High-reflective
- Metals
- Oxides
- Custom

Optics

Specifications

Curvature:
plano, concave, convex

Deviation/wedge:
<0.002 mm

Wavefront:
<1/20 wave

Flatness:
λ/10 at 633 nm

Irregularity:
<1/20 wave

Mechanical tolerance:
<0.010 mm

Parallelism:
<30 arc seconds

Surface quality:
better than $<10^{-5}$

Surface roughness:
<10 angstrom RMS

Size of finished optic:
1 mm to 200 mm

High-precision Optics

- Beamsplitters
- Collimation Testers
- Filters
- Flats
- Laser Mirrors and Optics
- Lenses and Windows
- Mirrors
- Prisms & Spheres
- Reticles

Patented Coating Technology

We have pioneered an optical coatings production method that combines optical thin film deposition techniques with microlithographic procedures. This patented process enables micron-scale precision patterning of optical thin film dichroic coatings -- which selectively transmit or reflect light according to its wavelength -- on a single substrate.

With this process, we create multipatterned arrays of optical filters for use in various products, including micromechanical and optical waveguide-based devices and dense wavelength division multiplexers. The process also can be applied to multipart bonded filter applications common to the manufacture of digital data projectors, LCD display panels and CCD camera detectors. In fact, many optical coatings can be patterned, including dielectric multiple-layer reflectors, bandpass filters, dichroic edge filters and broadband anti-reflection coatings. Our technique also is used to deposit enhanced metal reflectors, low-reflectivity opaque metals and electrically conductive transparent patterns.

Thin Films & Optics Capabilities

Our expertise in electro-optics, spectroscopy, optical fibers and precision optics offers great value to researchers and OEMs seeking a flexible, full-service supplier. We offer a range of skills, techniques and services to provide you with state-of-the-art, one-stop-shopping optical manufacturing. Since all grinding, polishing, coating and assembly operations are performed in-house, we have absolute control over the entire process, whether for prototype or production optics.

Raw Materials

We select only top-grade materials for machining into the optical component you need for your application. Glasses and ceramics include Borosilicate glass, fused quartz, Zerodur and ULE.

Machining & Finishing

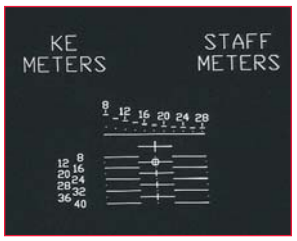
Our full-size machine shop creates metal components and assemblies with equipment such as CNC mills and lathes and other machine shop tools. Our shaping and finishing capabilities -- double-side grinding, cutting and polishing equipment for plano, concave and convex optics -- apply to materials up to 200 mm in diameter or 220 mm in length.

Reticles

Our etch-and-fill reticles can be fabricated with line widths from 0.005 mm to 0.5 mm. Etchings are available with black, white or red fill. The middle photo in the column at right is a close-up of a 0.015 mm line-width etching. In addition to etch & fill, reticles can be constructed of dielectric and metal vacuum deposited materials.

Assembly

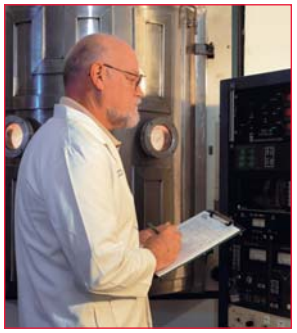
Our in-house machining capabilities allow us to provide a wide range of assembly services, including optical cementing, thin film and surface mounting, thin film bonding, soldering and wiring.



Coating & Microlithography

Our patented optical coating technology combines optical thin film deposition techniques with microlithographic procedures to provide a variety of precise, cost-effective, optical thin film coatings. This high-precision patterning can be applied to whatever filtering configuration the customer requests, and provides color filtering, spatial resolution, transmission efficiency and durability that's superior to dye-colored gels and other commonly used filtering technologies. All of the coatings listed below can be deposited onto optical substrates using this patented process.

- Dichroic, Dielectric, and Interference (UV to NIR)
- Oxides
- Beamsplitter
- Antireflective
- Fluorides
- High-reflective
- Metals

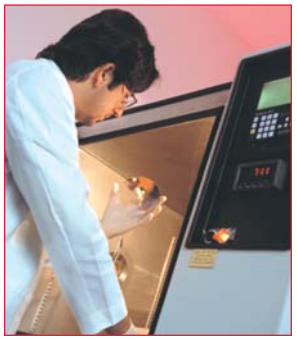


QC Standards

Our standards program adheres to ISO 9001 guidelines and strict quality control procedures. We meet military compliance requirements (MIL-PRF-13830) and adhere to SPC and Total Quality Management document control and manufacturing practices.

QC Testing

We perform optical-surface, spectral, environmental and mechanical testing on all products to ensure the highest quality. Our full-service metrology department has at its disposal equipment such as interferometers, a radius bench, alignment telescopes and spectrophotometers.



Thin Films & Optics Applications

Our expertise in a wide range of optical applications offers great value to researchers and OEMs seeking a flexible, full-service supplier. We offer applications know-how that few manufacturers can match. Because of our applications knowledge and our high manufacturing standards -- a surface accuracy to 1/20λ and a scratch-to-dig rating of 10:5 -- we can meet most any optical specification. Our custom products can be integrated into many applications, including those listed below.

Applications

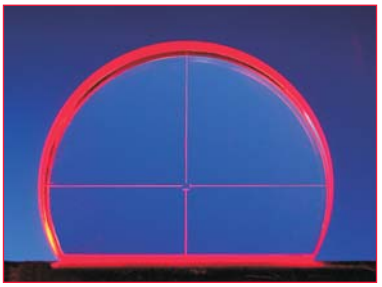
Entertainment/ Lighting	Consumer Electronics	Reticles	Instrumentation	Metrology	Optical Networking
AR coatings for GOBOs Broadband antireflection coated filters for entertainment lighting Coatings for light envelopes Dichroic filters for stage lighting Filters for special effects lighting Hot and cold mirrors for lighting fixtures Large-format still images	Dielectric coatings for personal digital assistant screens RGB filters for LCD and projection displays Patterned GOBOs for projection systems Color technology for HDTV, high-def monitors, and rear-projection TVs UVA-B-C filters in cameras	Binoculars Bore-sighting devices Fire control Precision optics for E-O systems	Bandpass filters for medical fiber optic instruments Hyper-spectral imaging filters for CCD cameras RGB color filters for CCD detectors Second- and third-order blocking filters for spectroscopy Spectroscopic kits for optics inspection Optics for optical benches in spectrometers	Flats for inspecting optics Collimation Testers for examining and adjusting the collimation of laser beams Spectroscopic kits for optics inspection Reflectance standards, NIST-traceable Long Trace Profilometer for large flats and aspheres	AR coatings for network components Bandpass filters, gain flatteners and rejection filters for DWDM Coatings for MEMS, waveguide relays and switches Filters for wavelength add/drop couplers Tunable filters for transmitters and receivers

Examples of Custom Products

Variable Saturation Filters

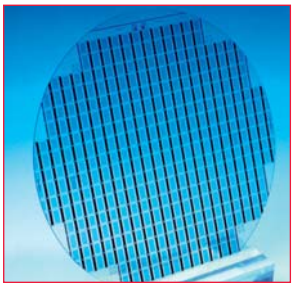
- Excellent optical transmission efficiency for superior brightness
- Temperature and humidity stability for consistent color
- Used in entertainment, display and lighting fixtures

Reticles



- Used for targeting systems, firearm scopes and binoculars
- Etch-and-fill or dielectric-and-metallic patterns
- Superior line and image quality

Patterned MEMs Windows



- Patterned MEMs Windows on a variety of custom-sized wafers
- Antireflective coatings available in ranges from 200-2500 nm
- Patterns aligned with great precision on both wafer surfaces

Technologies for Entertainment and Consumer Applications

Our patterned dichroic filters can be patterned with such precision that it's possible to project even large-format still images with remarkable resolution and clarity. With that same technology, we've developed a line of "colored light" products for theatrical, worship and architectural lighting installations, anchored by the award-winning SeaChanger Color Engine (at right). SeaChanger is a four-filter color changer designed as an accessory for ETC Source Four Ellipsoidals, the world's most popular stage lights. SeaChanger fills a niche between inexpensive but maintenance-intensive color gel scrollers -- the traditional color-changer technology for stage lighting -- and higher priced moving lights, and has appeared everywhere from church productions to Broadway musicals. We've also produced filters for the next generation of micro-mirror-based digital display technologies, as well as precision mirror coatings and optics designed to improve the safety and performance of a wide range of consumer products.

www.SeaChangerOnline.com

SEACHANGER

Specular Reflectance Standards

With the STAN-SSH High-reflectivity Specular Reflectance Standard (above), you receive a certificate of calibration in paper and electronic formats.

We offer three specular reflectance standards for use as references when measuring the reflection of surfaces with high or low specular reflectivity. The superior coatings on the substrates are environmentally stable; they are able to withstand high temperatures and mechanical stresses. Reflectivity values for the standards are built into our software to provide a reference for any specular measurement.

We offer a STAN-SSH High-reflectivity Specular Reflectance Standard designed as a standard reference when measuring the optical substrates, optical coatings, machined metals and semiconductor materials. (A NIST version of the STAN-SSH is also available.) The STAN-SSL Low-reflectivity Specular Reflectance Standard can be used as a reference when measuring samples such as thin film coatings, anti-reflective coatings, blocking filters and substrates. For details on the specular reflectance standards, see page 108.

STAN-SSH:	$499
STAN-SSH-NIST:	$999
STAN-SSL:	$499

Collimation Testers

Use Shear-plate Collimation Testers to examine the collimation of laser light, and as tools for measuring the wavefront curvature and divergence/convergence magnitude of optical components such as large-radius optics. Each tester consists of a wedged, high-quality optical flat housed in a heavy-duty anodized aluminum frame. Each tester is available in apertures ranging from 10 mm to 200 mm in diameter, and is useable from 350-2500 nm.

The testers are remarkably easy to use: When a planar wavefront is incident at an angle of 45°, two reflected wavefronts result. The lateral separation of these wavefronts is referred to as shear. Fringes -- parallel patterns of light and dark areas -- will be seen in the overlapping region of the two images. Collimating the laser beam is a matter of adjusting the collimating system until the fringe pattern is parallel to the shadow of the collimation tester's reference wire. See page 111 for details on all of our collimation testers.

Optical Flats

Each Optical Flat is a finely polished optical reference surface that can be used to visually inspect the flatness of optical components such as mirrors, filters, prisms and windows. We offer single-sided optical flats in either fused silica or Zerodur, each of which can be enhanced with an aluminum coating to increase contrast and improve the visual reference. There are nearly 50 different flats available, ranging from 1" to 6" in diameter and with flatness accuracies as precise as 1/20 wave. For a complete list of prices and specifications, see page 110.

Absorbing Glass Filters

Schott Standard Filters

Colored Glass					ND Filters
BG 3	BG 40	GG 420	OG 570	UG 11	D0.15
BG 4	BG 42	KG 1	OG 590	VG 3	D0.3
BG 7	FG 3	KG 2	RG 6	VG 4	D0.6
BG 12	FG 4	KG 3	RG 9	VG 6	D1.0
BG 13	FG 10	KG 4	RG 610	VG 9	D1.3
BG 14	FG 12	KG 5	RG 630	VG 9	D1.6
BG 18	FG 13	NG 1	RG 645	VG 10	D2.0
BG 20	FG 16	NG 3	RG 665	WG 225	D2.3
BG 23	FG 17	NG 4	RG 695	WG 280	D2.6
BG 24 A	GG 375	NG 5	RG 715	WG 295	D3.0
BG 25	GG 385	NG 9	RG 725	WG 305	D3.3
BG 26	GG 395	NG 10	RG 780	WG 320	D3.6
BG 28	GG 400	NG 11	RG 830	WG 335	D4.0
BG 34	GG 435	NG 12	RG 850	WG 345	D4.3
BG 36	GG 455	OG 515	RG 1000	WG 360	D4.6
BG 38	GG 475	OG 530	UG 1		D5.0
BG 39	GG 495	OG 550	UG 5		

Please check with us on filter availability.

High-pass Filters

OF2-WG305	pass >305 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-GG375	pass >375 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-GG395	pass >395 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-GG475	pass >475 nm	square 50.8 x 50.8 x 3 mm or square 25.4 x 25.4 x 3 mm	$50
OF2-OG515	pass >515 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-OG550	pass >550 nm	square 25.4 x 25.4 x 3 mm	$50

Balancing Filters

OF2-FG3	enhance blue and red	square 25.4 x 25.4 x 3 mm	$50
OF2-BG34R	enhance blue and red	round 12.7 mm OD	$50

Bandpass Filters

OF2-KG3	>325 nm and <700 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-U360	>340 nm and <380 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-RG780	>780 nm and 50% transmission <2.7 µm	square 25.4 x 25.4 x 3 mm	$50

Filter Kit for use with LS-1 Light Source

OF2-LS	BG34, GG395, OG550, Teflon diffusers	$100

Schott Glass Filters

Schott glass filters absorb light energy in certain regions of the spectrum. These filters fit easily into our light sources, cuvette holders and in-line filter holders. Please check for availability.

High-pass Filters

High-pass Filters are transmissive approximately 50% at the nominal cutoff wavelength, >99% at wavelengths 50 nm higher than the cutoff, and less than 0.1% at 50 nm lower than the cutoff. High-pass filters are used to eliminate second- and third-order effects, test for stray light, and block excitation energy in fluorescence experiments.

Balancing Filters

Balancing Filters absorb energy in some regions while transmitting in others. The BG 34 filter, for example, reduces the light's intensity at 600 nm from a tungsten bulb while transmitting all of the light at the blue and red regions, where detector sensitivity in our spectrometers is lower.

Bandpass Filters

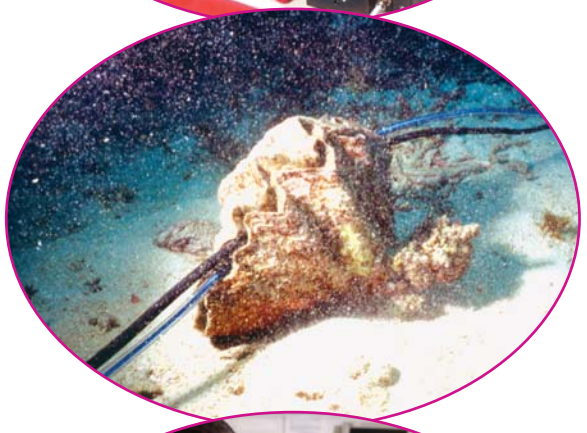
Bandpass Filters pass energy in a certain region and block energy above and below that region.

OF2, OF1 & Inline-OF Filters

We offer OF2 Filters (see top photo) for installing into the optical path of the spectrometer setup. We also offer OF1 Filters (see top photo in the column below) that are installed permanently in the SMA 905 Connector of the spectrometer. The OF1 filters are limited to the filters listed on page 16 and come in 4.75 mm diameter and 2 mm thickness.

In addition, our INLINE-FH Filter Holder (middle left) and FH-SMA Filter Holder (bottom left) also hold the filters listed in these tables, and are cut to 8 mm diameter and from 1 mm to 7 mm thick to fit these fixtures. Filters used in the INLINE-FH and FH-SMA Filter Holders are $100 each. See page 113 for details.

Resources



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Overview: Resources

Our Know-how = More Resources for You

Find out more about our products, experience and support through the following:

Live Demonstrations
Each year we exhibit at nearly 100 tradeshows around the world (OceanOptics.com/Tradeshows.asp). At home, we conduct formal seminars and can customize training sessions to your requirements.

Science Curricula
Our *Educational Spectroscopy Grant Program* rewards educators and researchers for their use of spectroscopy in curricula or research. Information about grant-winning projects is posted at OceanOptics.com/Applications/GrantWinners.asp.

R&D Services
Our Applications Group will take ownership of your most challenging application needs. The Group provides optical and electronic design services, software engineering and spectral modeling, testing and validation, and rapid prototyping capabilities.

Reference Library
We have amassed nearly 500 technical papers featuring our spectrometers and accessories. Citations are on our website at OceanOptics.com/Applications.asp.

Technical Information on the Web

We believe in easy access to information. That's why we don't hide our prices and that's why we provide easily accessible technical documentation on our website, so that you can view manuals before you buy the instrument. We also include the manufacturer's name and the model number for components that go into our instruments. We want to provide you with all of the information you need not only to make the right purchasing decision, but also to get the best performance out of your Ocean Optics products.

- **OceanOptics.com/Technical.asp.** Choose the TECHNICAL button on our website to view and download information about our products and technology, including manuals and operating instructions, software downloads and system specifications.
- **Operating Instructions.** We provide hundreds of pages of easy-to-access operating instructions and specifications of our products so that you can read before you buy at OceanOptics.com/Technical/OperatingInstructions.asp.
- **Software Downloads.** Easily download the latest operating and application software, device drivers and code, utility programs and microcode at OceanOptics.com/Technical/SoftwareDownloads.asp.
- **Spectrometer System Specifications.** Spectrometer system performance depends on a host of factors, such as the detector, optical bench, grating, entrance aperture size and sampling optics, just to list a few. To help you understand how to configure spectrometer systems, visit OceanOptics.com/Technical/SystemSpecifications.asp.
- **Applications Database.** Choose the APPLICATIONS button from any Ocean Optics webpage to view an up-to-date bibliographic listing of journal and magazine articles that reference our products. Visit OceanOptics.com/Applications/References.asp.

85,000+ Spectrometers, 1,000s of Applications

We've sold over 85,000+ Ocean Optics optical-sensing systems since 1992, which has provided us with a body of applications knowledge that is unmatched in the industry. Our spectrometers are used in applications such as these:

- Air and soil in situ monitoring
- Astronomy
- Biological and chemical warfare agent detection
- Biotechnology
- Blood oximetry
- Cancer detection
- Chemistry
- Color measurement
- Crystal growth
- Display technologies
- Dissolved oxygen
- Elemental analysis
- Endpoint detection
- Exhaust emission analysis
- Flow injection analysis
- Fluorescence of corals
- Food processing
- Forensics
- Gemstone grading
- General R&D
- Headspace monitoring
- Laser characterization
- LED quality control
- Life sciences
- Manufacturing
- Medical research
- Non-destructive testing
- Optical filter transmission
- pH monitoring
- Pharmaceuticals
- Physics/Optics
- Physiological applications
- Plasma monitoring
- Process control
- Radiometry
- Raman spectroscopy
- Reaction kinetics
- Semiconductor processing
- Shelf life of food and beverages
- Stack emissions
- Thin film thickness
- Tissue composition

The ABCs of Absorbance

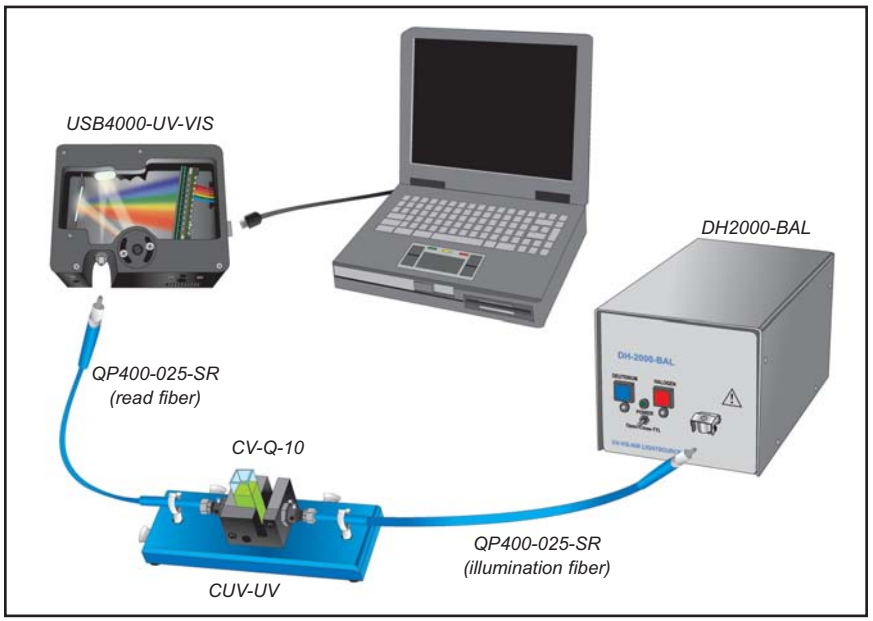
Like thousands of other educators, chemists at Miami (Ohio) University have equipped their labs with Ocean Optics spectrometers and accessories for basic spectroscopic measurements such as solutions absorbance.

Of particular interest is a PC-based setup for measuring the UV-VIS absorption spectrum of iodine crystals from 500-580 nm. This experiment is readily performed using an S2000 Spectrometer, LS-1 Tungsten Halogen Light Source, fiber optic patch cords and a 10-cm pathlength cuvette holder. Substitute a USB4000 Spectrometer (see drawing at right) to eliminate the external A/D card that completes the Miami University system.

Another option is the CHEM4-UV-VIS Lab Spectrophotometer, which consists of a 200-850 nm USB-interface spectrometer, a combination deuterium tungsten halogen light source and 1-cm cuvette holder, high-speed electronics and software.

Solutions absorbance experiments are not limited to cuvette holder setups. Flow cells, on-line dip probes and other sampling optics are available, with the latter especially useful for in situ applications. For example, one Ocean Optics customer uses a UV-VIS spectrometer and dip probe to measure the absorbance of vanadium oxytrichloride (VOCl3), a potentially toxic liquid used in the production of rubber (the absorptivity of VOCl3 relates to its stability). Because the VOCl3 reacts with moisture in the air and forms vanadic and hydrochloric acids, it must be measured in a moisture-free environment. In situ measurements eliminate the need for potentially risky sample collection.

Setup: Solutions Absorbance



Overview

Absorbance measurements are used to quantify the concentration of gases and solutions (the latter is described here) that absorb light in a media that transmits light. The signal in absorbance units is proportional to the molar absorptivity, pathlength and concentration of the sample (see Beer's Law, page 178).

Spectrometer

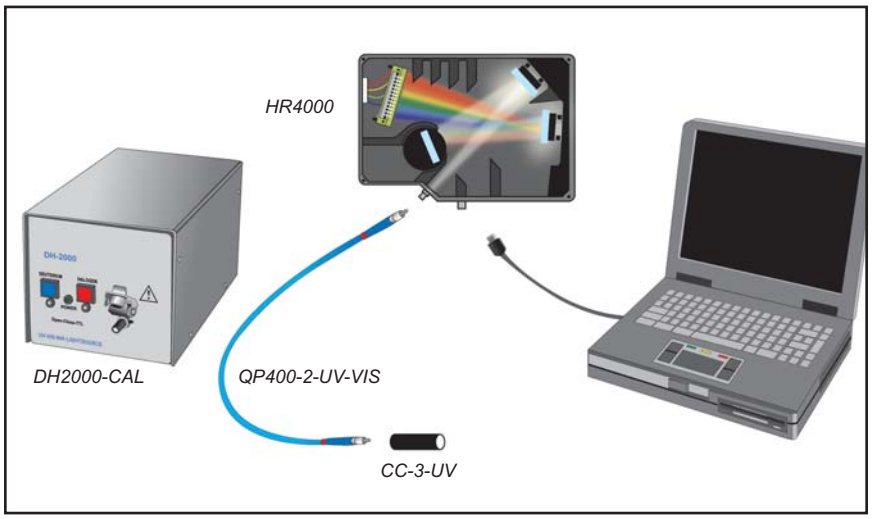
The USB4000-UV-VIS Spectrometer is ideal for absorbance measurements from 200-850 nm. The spectrometer is configured with Grating #1, which has peak efficiency at 300 nm. This configuration provides adequate resolution (~1.5 nm FWHM) for most solutions absorbance measurements. The built-in OFLV-200-850 Order-sorting Filter eliminates second-and third-order effects that otherwise yield false peaks in absorbance spectra. The preferred light source is the DH2000-BAL Deuterium Tungsten Halogen Light Source. The DH2000 is a less expensive source, but lacks the filtering technology that eliminates problems associated with the D-alpha line in the deuterium source.

Sampling Optics

For absolute absorbance measurements, use the 1-cm pathlength CUV-UV Cuvette Holder and the CV-Q-10 Quartz Cuvette. For relative absorbance, direct-attach USB accessories, dip probes and flow cells are available. We recommend QP400-025-SR Premium-grade Solarization-resistant Optical Fibers as illumination and read fibers. Use NIST-traceable STAN-ABS Photometric Absorbance Standards to provide certifiable results.

Components	Page	Price
1. USB4000-UV-VIS General Lab Spectrometer	34	$2,649
25 µm Slit as entrance aperture	15	included
Grating #1, 200-850 nm range	16	included
DET4-200-850 Detector with UV4 Detector Window Upgrade and OFLV-200-850 Order-sorting Filter	17	included
2. DH2000-BAL Deuterium Tungsten Halogen Light Source	122	$3,588
3. (2) QP400-025-SR Premium-grade SR Assemblies	142	$238
4. CUV-UV Cuvette Holder	90	$399
5. CV-Q-10 Quartz Cuvette	93	$75
6. STAN-ABS-UV Photometric Absorbance Standards	93	$370
7. SpectraSuite Spectroscopy Operating Software	80	$199
8. ASP Annual Service Package	62	$250
	Total:	**$7,768**

Setup: Upwelling/Downwelling



Overview

Upwelling radiation is radiation -- either reflected solar or emitted terrestrial -- that is directed upward from the earth's surface. Downwelling radiation is radiation that is directed toward the earth's surface from the sun or atmosphere. The relationship between the two (albedo) can be used to derive spectral information from vegetation, forest canopies, seabeds and more.

Spectrometer

An HR4000 Spectrometer with an HC-1 grating provides an elegant solution for upwelling and downwelling measurements. The HC-1 is a variable-blazed grating that covers the 200-1050 nm wavelength range; optical resolution is ~1.5 nm (FWHM) with a 50 µm slit as the entrance aperture. An OFLV-200-1100 Order-sorting Filter eliminates second- and third-order effects.

Sampling Optics

The spectrometer connects to a patch cord that screws into the CC-3-UV Cosine Corrector. The CC-3-UV can be used as part of a configuration for measuring absolute spectral irradiance. You'll need a DH2000-CAL (or LS-1-CAL for 300-1050 nm only) to calibrate the absolute spectral response of the system and SpectraSuite Spectroscopy Operating Software to calculate spectral intensity and photopic data in lumens, lux or candela. An alternative to the CC-3-UV is a Gershun tube, which has fixtures for adjusting the area of light from 1° to 28° and attaches directly to the spectrometer or to an optical fiber.

Components	Page	Price
1. HR4000 High-resolution Spectrometer	21	$3,999
50 µm Slit as entrance aperture	22	$150
Grating HC-1, 200-1050 nm range	23	$600
DET4-200-1100 Detector with OFLV-200-1100 Order-sorting Filter and UV4 Detector Window Upgrade	24	$400
2. QP400-2-UV-VIS Premium-grade Patch Cord Assembly	142	$169
3. CC-3-UV Cosine Corrector	104	$129
4. DH2000-CAL Radiometric Calibration Standard	132	$3,275
5. SpectraSuite Spectroscopy Operating Software	80	$199
6. ASP Annual Service Package	62	$250
	Total:	**$9,171**

Measuring Mining Effects

In the small Pacific island of New Caledonia, a multinational team of researchers has used Ocean Optics spectrometers to measure the effects of strip mining on coastal erosion, sea grass growth and coral reef health.

The team focused on the relationship between above-water reflectance and turbidity profiles. The latter relates to fluxes in the presence of metals and various pollutants -- and thus, to sea grass growth and coral reef health.

A USB4000 Spectrometer set from 360-1100 nm measures reflectance and irradiance. The USB4000 connects to a patch cord that screws into a Gershun Tube, which has fixtures for adjusting the area of light entering the fiber -- in this case, to reduce the field of view to 3°. Upwelling irradiance and downwelling radiance measurements -- the spectral distribution of the underwater light field -- add valuable data.

The researchers also have measured the concentration of chlorophyll pigment in coastal waters and the reflectance of sand and mud collected at Caribbean, Mediterranean and Pacific beaches. The sand application used a dual-channel spectrometer for visible (410-900 nm) reflectance measurements of various natural sands. Reflectance spectra were deduced from successive measurements of upwelling irradiance using a Spectralon plate and downwelling radiance captured under natural light.

Ultimately, researchers will use satellite monitoring, spectroradiometric measurements and numerical models to better understand the nature of particulate transport in coral reef lagoons, especially as it relates to erosion rates in coastal areas.

O_2 Medical Diagnostics

Researchers at two Irish universities have monitored dissolved oxygen in cellular media in order to validate the optimum gassing technique to induce hypoxia in irradiated cells.

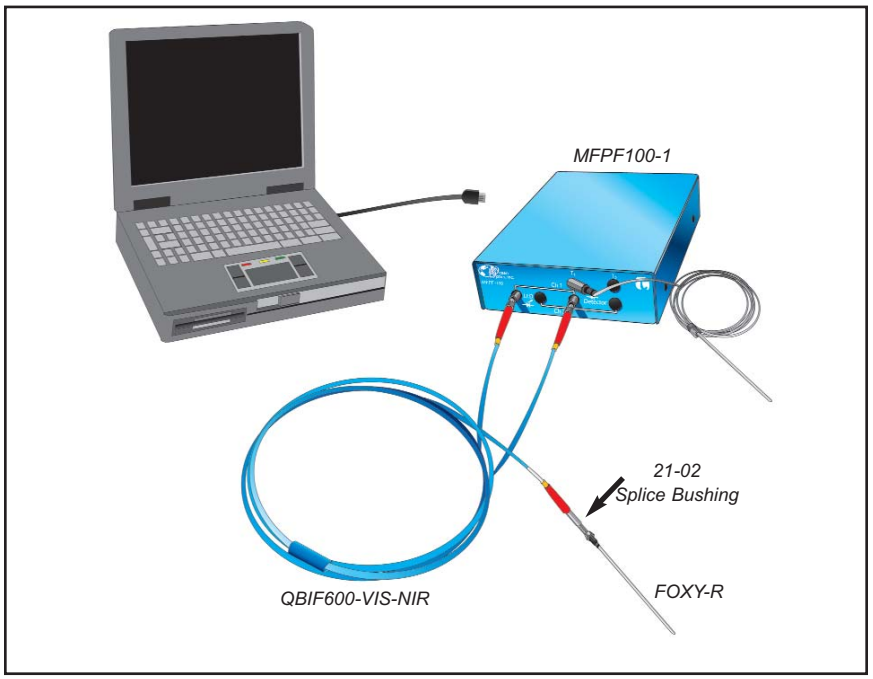
Scientists from University College Cork and Cork University Hospital measured irradiated HeLa cells -- a strain of human cells used for biological studies -- under both oxic (rich in oxygen) and hypoxic (lacking oxygen) conditions. With oxygen present, the irradiation injury to the cells was greater than when optimum levels of

hypoxia (~90%) were reached. To induce hypoxia, and thus mitigate any oxygen-enhancement injury, the cells were gassed with nitrogen. This hypoxia was confirmed with a FOXY Fiber Optic Oxygen Sensor and a USB2000 Spectrometer.

The FOXY Sensor has been used for other hypoxia experiments, including an application where clinicians determine how much of a diseased human limb targeted for amputation can be saved; the presence of oxygen correlates to tissue health. Monitoring dissolved oxygen in both human and animal tissue is a common application for the FOXY Sensor, which offers the advantages of being minimally invasive, not consuming the sample, and working well in viscous media.

Ultimately, the cellular hypoxia researchers determined that oxygen measurements of the cellular environment made with the FOXY Sensor matched the predicted hypoxic saturation values, depending on the amount and duration of nitrogen flushed through the sample chamber. The FOXY Sensor proved to be a valuable tool in confirming the desired level of hypoxia.

Setup: Oxygen Sensing



Overview

Oxygen is sensed by measuring the decrease in fluorescence intensity of a fluorophore bound to the tip of an optical fiber. The sensor responds to the partial pressure of oxygen in gases, liquids and even viscous samples.

Spectrometer

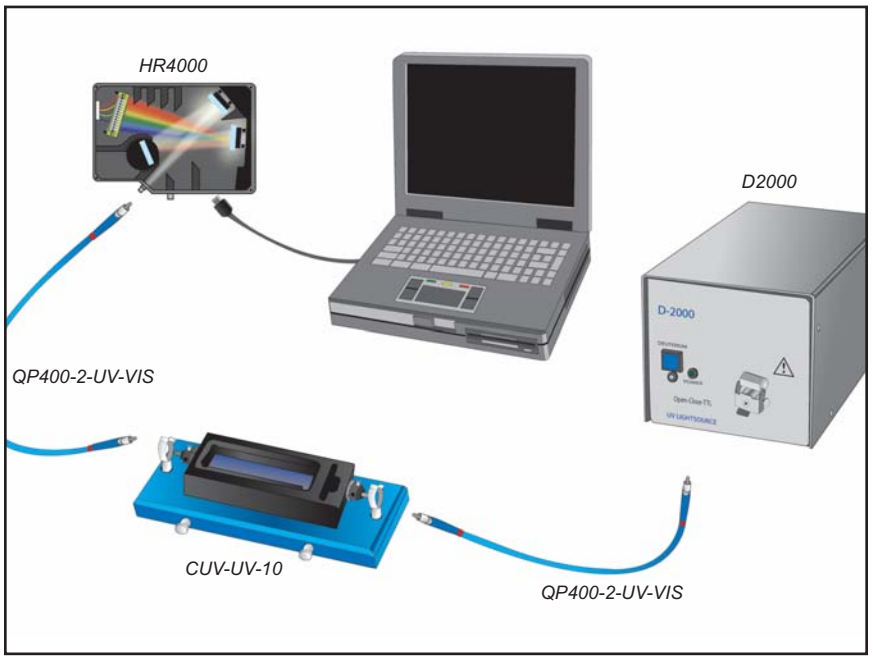
Used with Ocean Optics Fiber Optic Oxygen Sensors and custom probes, the MultiFrequency Phase Fluorometer (MFPF), manufactured by TauTheta, is a flexible platform for measurement of luminescence lifetime, phase and intensity. This frequency-domain luminescence monitor uses LED excitation and avalanche photodiode detection with filter-based wavelength selection for easy experimental set-up and control. The MFPF is especially useful for oxygen sensing applications where sensitivity to drift is important and where sample set-ups must be undisturbed for long periods of time. Because it utilizes phase-shift technology, it is invariant to fiber bending and stray light, has a wide dynamic range of optical intensity, and has low optical and electronic crosstalk as well as low drift and phase noise.

Sampling Optics

The MFPF is embedded with LED excitation sources and transmits light at ~475 nm to one leg of a QBIF600-VIS-NIR Bifurcated Optical Fiber Assembly. The bifurcated assembly connects to the oxygen sensor probe via a 21-02 SMA Splice Bushing. If the excited formulation at the probe tip encounters an oxygen molecule, the fluorescence signal decreases. The fluorescence is collected by the probe and is transmitted to the spectrometer via the other leg of the bifurcated assembly. OOISensors Software calculates partial pressure of the oxygen from this signal. For more on sensor operation, see page 65.

Components	Page	Price
1. MFPF100-1 MultiFrequency Phase Fluorometer	67	$5,000
2. QBIF600-VIS-NIR Premium-grade Bifurcated Fiber Assembly	72	$369
3. 21-02 Splice Bushing	72	$13
4. FOXY-R Fiber Optic Oxygen Sensor Probe	71	$499
5. OOISensors Software	75	$199
6. ASP Annual Service Package	62	$250
	Total:	**$6,330**

Setup: Gas Absorbance



Overview

Absorbance measurements are used to quantify the concentration of solutions and gases (as described here) that absorb light in a media that transmits light. The signal in absorbance units is proportional to the molar absorptivity, pathlength and concentration of the sample. (See more on Beer's Law on page 178.)

Spectrometer

A setup for measuring benzene gas, for example, would call for an HR4000 High-resolution Spectrometer with an H7 grating and a 200-300 nm wavelength range. Optical bench accessories include an L4 Detector Collection Lens for increased light throughput, and a UV4 Detector Upgrade to transmit light in the UV. With a 5 μm slit, optical resolution of ~0.07 nm (FWHM) is possible. The preferred light source for work in the ultraviolet is the D2000 Deuterium Light Source.

Sampling Optics

The 10-cm pathlength CUV-UV-10 Cuvette Holder, the CV-Q-10 Cylindrical Cell and QP400-025-SR Premium-grade Solarization-resistant Optical Fibers (one fiber illuminates, the other reads signal) comprise the system's sampling optics. For applications requiring shorter pathlengths or open-air monitoring (see sidebar), use an optical fibers-and-collimating lenses configuration.

Components	Page	Price
1. HR4000 High-resolution Spectrometer	21	$3,999
Grating H7, 2400 lines per mm, 200-300 nm range	23	included
5 µm Slit as entrance aperture	22	$150
L4 Detector Collection Lens	24	$150
DET4-UV Detector with UV4 Detector Upgrade	24	$150
2. D2000 Deuterium Light Source	126	$2,172
3. CUV-UV-10 Cuvette Holder	90	$549
4. CV-Q-100 Cylindrical Cell	93	$165
5. (2) QP400-2-UV-VIS Premium-grade Patch Cord Assemblies	142	$338
6. SpectraSuite Spectroscopy Operating Software	80	$199
7. ASP Annual Service Package	62	$250
	Total:	**$8,122**

Volcano Emissions

Active volcanoes emit various gases including sulphur dioxide (SO_2), a colorless, pungent gas that can irritate the skin and the mucous membranes of the eyes, nose and throat. Volcanologists regularly monitor SO_2, which absorbs in the UV.

For example, on the Caribbean island of Montserrat, researchers use three S2000 Spectrometers to collect UV absorbance (from 245-380 nm) of SO_2 in gas emissions. The spectrometers are set up at three plume sites, each of which is about 3.5 km from the volcano's dome. The spectrometers are small, making them simple to transport and deploy at the volcano site. The entire setup costs less than $10,000, within most budget limits and almost "disposable" (this is a volcano, after all).

The Montserrat researchers configured a system that makes efficient use of light-collection optics and provides good optical resolution (~3.5 nm FWHM). Each spectrometer is connected to a 1000 μm optical fiber, which screws into a telescope mount.

At the Montserrat Volcano Observatory (www.mvo.ms) sampling sites, spectra are collected every 4-6 seconds and transmitted to researchers at the observatory via modem; one complete scan of the plume takes 4-6 minutes. Depending on wind direction, data from two of the three spectrometers is used to calculate plume height, by comparing the angles at which peaks in the SO_2 plume are measured.

All That Glitters . . .

By some accounts, fluorescence of minerals has been observed for more than a century. For early miners, fluorescence of minerals such as calcite helped to target drilling operations to the richest bodies of ore. For amateur geologists, mineral fluorescence is a more esoteric pursuit: samples that fluoresce simply look really cool.

Consider genthelvite, an opaque mineral that fluoresces bright green under UV radiation and remains phosphorescent for a short period. In 2003, mineralogists Earl Verbeek and Herb Yeates measured fluorescence of both genthelvite and willemite (another fluorescent mineral) found in deposits at a site in New Jersey.

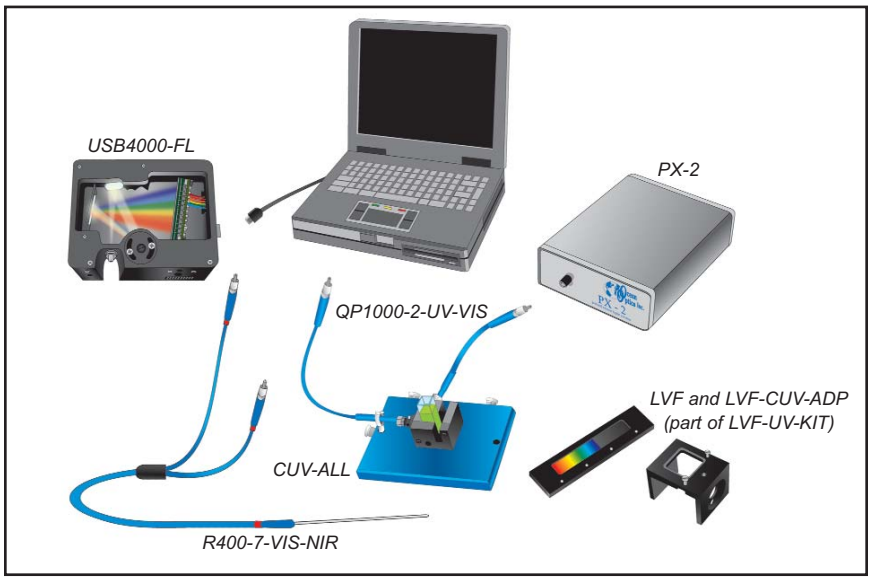
In a paper submitted to the Franklin-Ogdensburg Mineralogical Society, Verbeek and Yeates described using a USB2000-VIS-NIR Spectrometer (350-1000 nm), a high-power UV excitation source and a 600 μm probe to observe emission peaks of 511 nm for genthelvite and 528 nm for willemite.

Spectrometer integration times were set for 1000 ms to measure the dim (although visible to the naked eye) genthelvite fluorescence, compared with a 10 ms integration to measure the brighter willemite fluorescence.

To ensure that the light emitted from the samples came from the minerals themselves, Verbeek and Yeates measured the samples in a light-tight enclosure and filtered out excitation source wavelengths and ambient light.

Why does genthelvite fluoresce? Verbeek and Yeates identified the source as divalent manganese -- a substitute for zinc in the genthelvite structure that is also responsible for the color in amethyst.

Setup: Fluorescence



Overview

Fluorescence measurements require a sensitive detector and an effective filter for discriminating between powerful excitation source wavelengths and weak spectral emissions from the sample.

Spectrometer

We offer several spectrometers useful for fluorescence, but recommend the high-sensitivity, preconfigured USB4000-FL Spectrometer for most general fluorescence applications. The USB4000-FL is set to 360-1000 nm and comes with a 200-μm slit and an L4 Detector Collection Lens for increased light throughput.

Sampling Optics

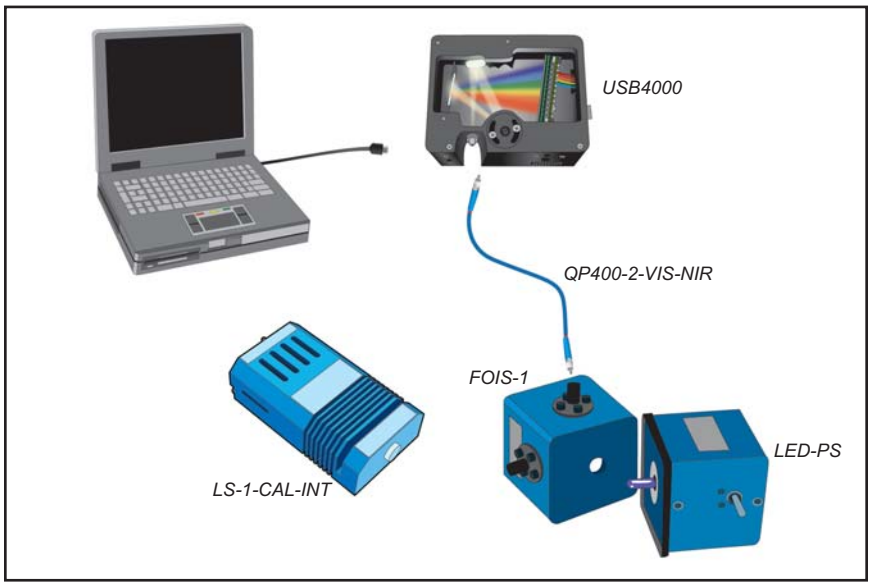
Your standard excitation source option is our PX-2 Pulsed Xenon Source. Our proprietary LVF Linear Variable Filters are excellent tools for spectrally shaping the excitation energy from broadband sources used for fluorescence. Various sampling optics are available for detecting picomolar-range concentrations of fluorophores from surfaces and in solutions and powders.

Spectrometer Components	Page	Price
1. USB4000-FL Spectrofluorometer	46	$2,499
200 µm Slit as entrance aperture	15	included
Grating #3, 380-1000 nm range	16	included
L4 Detector Collection Lens	17	included
SAG+UPG Mirrors	16	$250

Components for Use with Solutions	Page	Price
2. PX-2 Pulsed Xenon Source	127	$769
3. CUV-ALL-UV 4-way Cuvette Holder	90	$809
4. LVF-UV-KIT Linear Variable Filter Kit	114	$999
6. (2) QP1000-2-UV-VIS Premium-grade Patch Cord Assemblies	142	$718
7. (2) 74-MSP Mirrored Screw Plugs	90	$198
8. SpectraSuite Spectroscopy Operating Software	80	$199

Components for Use with Solids	Page	Price
2. PX-2 Pulsed Xenon Source	127	$769
3. R400-7-VIS-NIR Reflection/Backscattering Probe	148	$499
4. SpectraSuite Spectroscopy Operating Software	80	$199

Setup: LED Analysis



Overview

To measure the absolute spectral intensity and color of LEDs, specify the configuration described here or see page 56.

Spectrometer

We suggest a USB4000 Spectrometer with a 25 µm Slit and Grating #2 (350-1000 nm). An L4 Detector Collection Lens increases light-collection efficiency and reduces stray light. An OFLV-350-1000 Order-sorting Filter eliminates second- and third-order effects. This optical bench configuration maximizes system sensitivity, mitigating the light loss inherent with use of an integrating sphere -- the sampling optic of choice for most LED applications. (You also can collect LED signal with a CC-3-UV Cosine Corrector and fiber.)

Sampling Optics

The LED is mounted in the NIST-traceable LED-PS-NIST LED Power Supply, which provides a white background for the LED and a controlled drive current to characterize LED output. The FOIS-1 Integrating Sphere is placed over the LED-PS-NIST and collects the LED output. The attached optical fiber collects the light energy from the LED and transmits it to the spectrometer. The power and color of the LED is determined by comparing the LED to a radiant standard -- the LS-1-CAL-INT Calibrated Source, which fits into the sample port of the FOIS-1. SpectraSuite Spectroscopy Operating Software calculates absolute irradiance and spectral features such as dominant, central and centroid wavelength; hue, chroma and saturation, X,Y,Z; L*, a*, b*; xyz; u'v'w'; CCT and more.

Components	Page	Price
1. USB4000 Plug-and-Play Spectrometer	14	$2,199
Grating #2, 350-1000 nm range	16	included
25 µm Slit as entrance aperture	15	$150
L4 Detector Collection Lens	17	$150
DET4-350-1000 Detector with OFLV-350-1000 Order-sorting Filter	17	$150
2. LS-1-CAL-INT Tungsten Halogen Calibrated Light Source	133	$749
3. LED-PS LED Power Supply	104	$499
4. FOIS-1 Integrating Sphere for Emission	105	$499
5. QP400-2-VIS-NIR Premium-grade Patch Cord Assembly	142	$169
6. SpectraSuite Spectroscopy Operating Software	80	$199
7. ASP Annual Service Package	62	$250
	Total:	**$5,014**

QC of LED Curing Lights

High-output LEDs may be a viable alternative to other light sources for curing ceramic materials used in dentistry, according to researchers from the University of Manchester in England.

As researchers Adrian Bennett and David Watts suggested in a 2003 article submitted to the journal *Dental Materials*, LEDs have longer lifetimes, are less prone to degradation and temperature effects, and require less power than tungsten halogen curing units.

To assess LED performance, Bennett and Watts used a radiometrically calibrated USB2000 Spectrometer to measure the absolute spectral output and irradiance of three LED curing units. The spectrometer was radiometrically calibrated using the LS-1-CAL Tungsten Halogen Light Source; a FOIS-1 Integrating Sphere collected the LED output and funneled it to an optical fiber coupled to the spectrometer. The spectral range of the LEDs also was measured.

By most criteria, Bennett and Watts concluded, the LED curing units compared favorably with the tungsten halogen curing units. However, longer curing times may be necessary with LEDs, which have lower irradiance than the tungsten halogen sources.

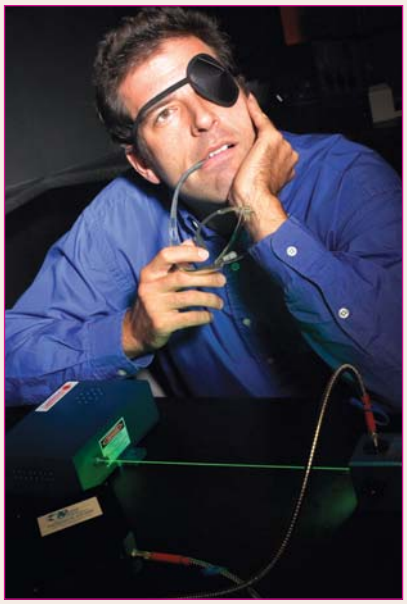
Similar studies also have been performed at the Indiana University School of Dentistry.

Whatever their ultimate application, LEDs can be analyzed for color and absolute spectral intensity very easily and inexpensively with Ocean Optics spectrometers and accessories.

Laser Plume Analysis

Ocean Optics spectrometers and accessories are useful tools for measuring the spectral output and power of lasers, with configurations as simple as the setup shown at right.

But we also provide components for applications involving what happens after the laser fires. Consider laser welding, which is now common to a number of industries. An Ocean Optics customer has used our PC Plug-in Spectrometer and an optical fiber to measure the plume created by a CO_2 laser used in welding metals such as copper and stainless steel alloys. Researchers were particularly interested in the processes related to welding of dissimilar materials.

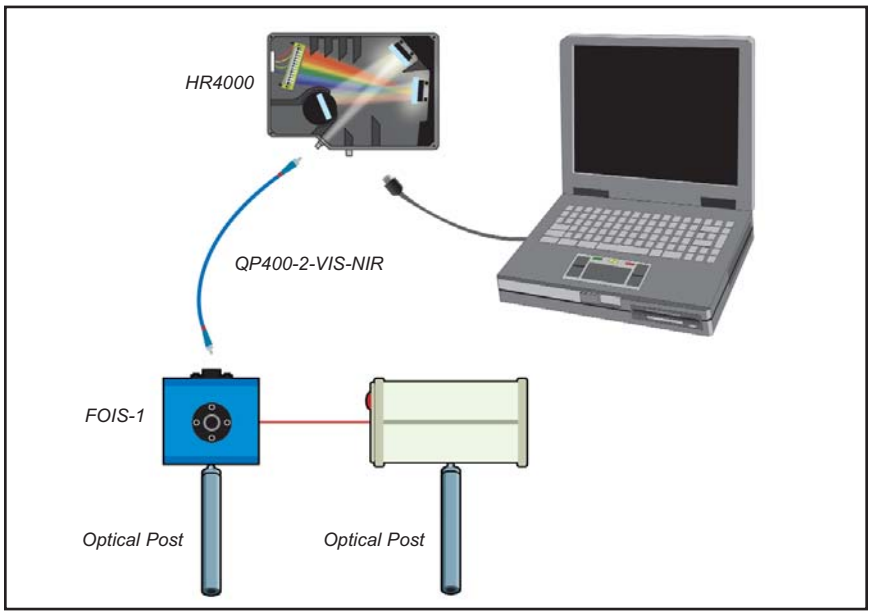


By measuring the concentration of elements within the laser weld plume, as well as the plume temperature, the researchers were able to determine the efficiency of the weld. Species identification is useful in controlling the welding of dissimilar alloys; plume temperature can be correlated to laser power and speed.

The UV-VIS spectrometer used in the study had a wavelength range of 263-523 nm. One leg of a bifurcated optical fiber carried light from a diode laser to the weld site; the other leg sampled the plume emission.

Ultimately, real-time monitoring of the laser weld plume makes it far simpler to correct process problems before large numbers of parts are affected. This increases manufacturing yields and speeds up inspection processes.

Setup: Laser Analysis



Overview

Our HR4000 High-resolution Spectrometer is ideal for measuring the spectral characteristics and intensity of continuous-wave and pulsed lasers. For high-power lasers, an integrating sphere or cosine corrector attenuates the light to avoid saturating the CCD array.

Spectrometer

The HR4000 Spectrometer uses the "HR" Optical Bench, which was designed to yield high optical resolution for resolving fine spectral features. For laser characterization, we recommend a grating with a high groove density, such as the H6 1200 mm-1 grating set to a 750-925 nm wavelength range and with a 5 μm Slit as the entrance aperture. This configuration provides ~0.12 nm resolution (FWHM). For better resolution consider an 1800 mm-1 or 2400 mm-1 grating.

Sampling Optics

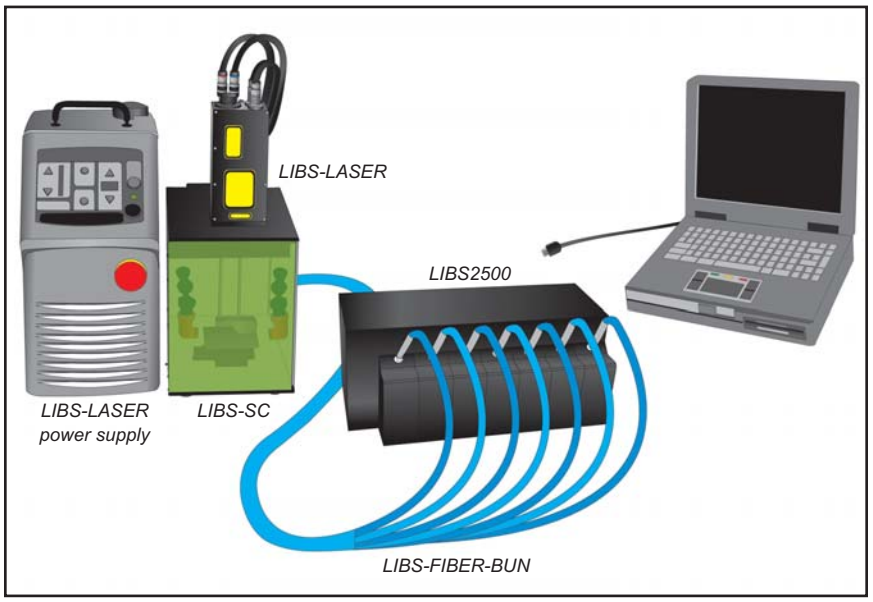
There are several possible sampling setups: a CC-3-UV Cosine Corrector with an optical fiber; FOIS-1 Integrating Sphere with a fiber; or fiber assembly coupled to the laser. Optical posts are used to hold fixtures in place.

Measurements

Our operating software can detect the laser wavelength peak; SpectraSuite Spectroscopy Operating Software obtains peak, centroid and central wavelength values, and full-width half-maximum values.

Components	Page	Price
1. HR4000 High-resolution Spectrometer	21	$3,999
Grating #H6, 750-925 nm range	23	included
5 µm Slit as entrance aperture	22	$150
DET4-VIS Detector	24	Free
2. FOIS-1 Integrating Sphere for Emission	105	$499
3. OPM-3 Three-inch Optical Post (2)	89	$30
4. QP400-2-VIS-NIR Premium-grade Patch Cord Assembly	142	$169
5. SpectraSuite Spectroscopy Operating Software	80	$199
6. ASP Annual Service Package	62	$250
	Total:	**$5,296**

Setup: LIBS



Overview

The LIBS2500 Broadband Spectrometer is a detection system for real-time elemental analysis in solids, solutions and gases. This high-resolution system provides full spectral analysis from 200-980 nm, with optical resolution of ~0.1 nm (FWHM).

Principle of Operation

An Nd:YAG pulsed laser beam is focused on the sample area. The energy of the laser generates a plasma, in which a trace amount of the sample has been ablated. As the plasma decays or cools, the plasma emits light of wavelengths that are distinct to each element. The emission is collected by a 7-fiber bundle and sent to the spectrometers for analysis.

Spectrometers

The LIBS2500-7 uses seven high-resolution spectrometers, which connects to a PC via one USB port. All seven spectrometers acquire data simultaneously; software displays the results. However, you may require a system with less than seven spectrometer channels. See page 48 for options on all LIBS2500 Systems.

Sampling Optics

The LIBS-LASER is a 50 mJ CFR Nd:YAG laser for metal and thin film samples and sells for $14,500. The LIBS-LAS200MJ is a 200 mJ CFR Nd:YAG laser for most all other materials and is priced at $22,500. Both lasers are manufactured by Big Sky Laser. The LIBS-SC Sample Chamber has a manual x-y-z stage and a remote laser safety lock. Signal is collected by a fiber bundle comprising (7) 600 µm UV-VIS patch cords, each with a collimating focusing lens built into the fiber termination.

Measurements

OOILIBS Software allows users to set operating parameters such as the laser Q-switch delay (the time between the firing of the laser and the beginning of spectral acquisition) and signal averaging of laser pulses.

Components	Page	Price
1. LIBS2500-7 7-Channel Laser-induced Breakdown Spectrometer	48	$29,999
2. LIBS-BUN-7 Optical Fiber Bundle	48	$985
3. LIBS-LASER Nd:YAG 50 mJ Laser (from Big Sky Laser)	49	$14,500
4. LIBS-SC Sample Chamber	49	$9,800
5. OOILIBS Software	48	$500
	Total:	**$55,784**

LIBS for Defense

In an earlier LIBS application, closely related spores of the genus *Bacillus* were deposited on silver membrane filters for analysis using broadband Laser-induced Breakdown Spectroscopy (LIBS). The observed spectral differences among the spores -- *Bacillus subtilis*, *Geobacillus stearothermophilus* and *Bacillus pumilus* -- provide evidence of the power of Ocean Optics' Laser-induced Breakdown Spectrometer in resolving complex biological samples.

The presence of the spores' unique spectral lines, as well as different combinations of spectral lines, provide many opportunities for discrimination. While most of the unique peaks occurred in the *G. stearothermophilus* spectrum, spectral differences were observed in the spectra for all the spores. Spore characteristics such as surface profile and coat mineralization may account for these differences.

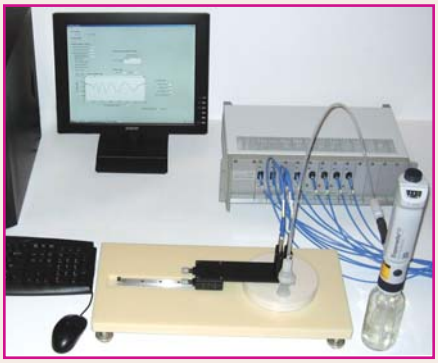
The results reported for the Bacillus spores, along with others obtained for biological molecules including nucleic acids and proteins, provide exciting evidence of the discriminating capability of our LIBS system. In fact, we are now collaborating with others to develop a man-portable LIBS system for field detection of chemical and biological warfare agents. The system will be able to make a complete analysis every one to two seconds, be small enough to carry in a backpack, and require very little power to operate.

Thin Film Thickness

Product developer Thickness Detection Systems (TDS) of Salt Point, N.Y., has integrated an Ocean Optics multichannel spectrometer into a broadband dissolution rate monitor (DRM) for analyzing very thin resist films used in the semiconductor and optics industries.

DRMs help to determine the thickness of thin film layers and the rate at which the film resist material dissolves -- important parameters in controlling thin film production processes. In its initial testing, Thickness Detection Solutions focused on applications involving films of <300 nm thickness, where existing monochromatic and polychromatic interferometric testing methods have had limited effectiveness.

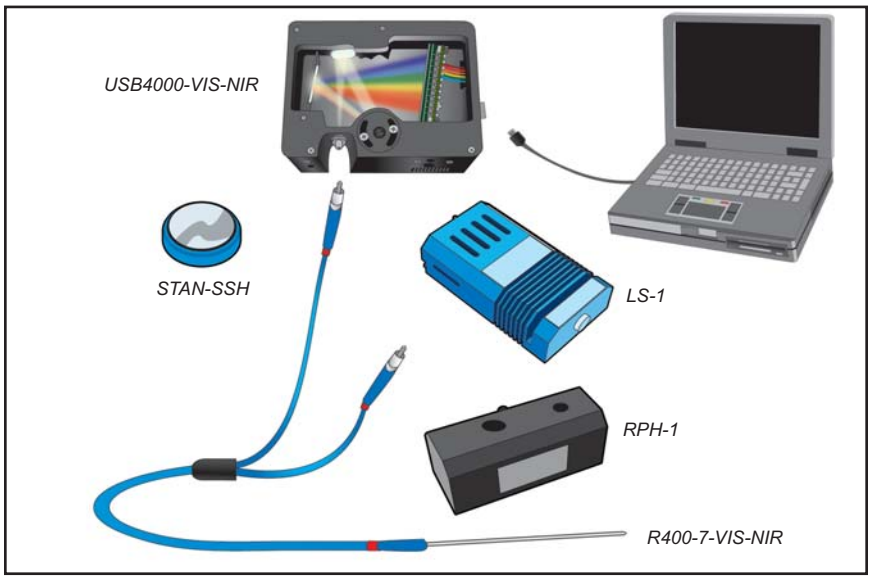
In testing, TDS used an SD2000 Dual-channel Spectrometer. Reflection measurements were performed with an R-series Reflection Probe. As TDS reports on its website, results indicated that multi-wavelength DRMs would be able to determine film thicknesses at discrete time intervals, to monitor photoresist phenomena that are difficult to separate with traditional DRMs, and to provide additional value to the researcher "by eliminating the need for discrete, static optical thickness measurement tools."



Today, TDS offers 1-, 2-, 4- and 8-channel configurations. TDS just recently announced the commercial release of its L-Series DRM product line for photoresist R&D, formulation studies, photoresist manufacturing QC, and polymer resin manufacturing QC.

The L-series line includes multiwavelength and multilayer analysis algorithms, which enable discrete thickness measurements to zero film thickness and provide accurate data of non-linear dissolution rate phenomena. For more details, visit www.thicknessdetection.com.

Setup: Metrology



Overview

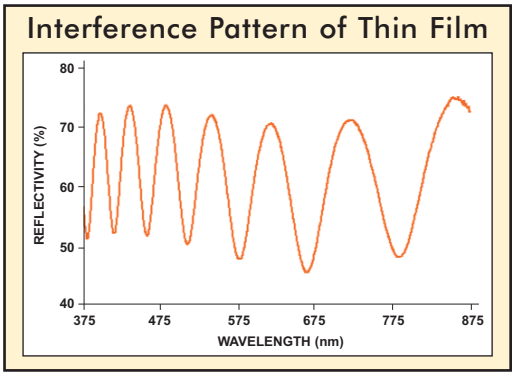
A thin film on a substrate can act as an etalon, creating an interference pattern superimposed on the surface reflectivity when viewed in reflection. The spacing of the pattern's sinusoidal peaks, when combined with the refraction index of the material, can be used to calculate the thickness of the material.

Spectrometer

The USB4000-VIS-NIR (350-1000 nm) is ideal for reflectometry of thin films. The spectrometer is preconfigured with Grating #3, which is blazed at 500 nm; an OFLV-350-1000 Filter to eliminate second- and third-order effects; and a 25 μm slit for optical resolution of ~1.5 nm (FWHM).

Sampling Optics

The R400-7-VIS/NIR Reflection Probe positioned at 90° measures specular reflectance from surfaces such as thin films. An LS-1 Tungsten Halogen Lamp and a STAN-SSH High-reflectivity Specular Reflectance Standard complete the sampling setup.

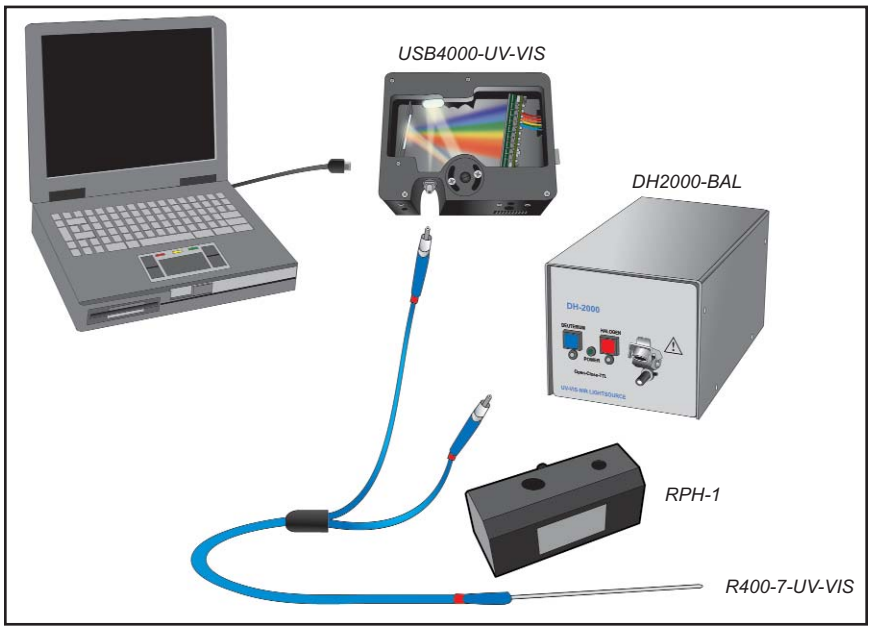


Measurements

Spectra observed in our operating software (see above) reveal oscillations caused by optical interference within the layers of the thin film substrate. Analysis of the wavelength position of the minima or maxima can determine either the thin film's thickness (with the known refractive index of the film) or its refractive index (with the known film thickness). Keep in mind that the thickness of samples may not be uniform; we recommend measuring several locations on the film.

Components	Page	Price
1. USB4000-VIS-NIR General-purpose Spectrometer	34	$2,499
Grating #3, 600 lines per mm, blazed at 500 nm	16	included
25 µm Slit as entrance aperture	15	included
DET4-350-1000 Detector with OFLV-350-1000 Order-sorting Filter	17	included
2. LS-1 Tungsten Halogen Light Source	128	$499
3. R400-7-VIS-NIR Reflection/Backscattering Probe	148	$499
4. RPH-1 Reflection Probe Holder	157	$75
5. STAN-SSH High-reflectivity Specular Reflectance Standard	108	$499
	Total:	**$4,071**

Setup: UV-VIS Reflection



Overview

Diffuse reflection measurements can be used to determine information about the chemical content or color (see page 177) of a sample.

Spectrometer

The USB4000-UV-VIS (200-850 nm) is ideal for most UV-VIS reflectometry. The spectrometer is preconfigured with Grating #1, which is efficient in the deep UV; an OFLV-200-850 Order-sorting Filter to eliminate second- and third-order effects; and a 25 µm slit for optical resolution of ~1.5 nm (FWHM).

Sampling Optics

The R400-7-UV-VIS Reflection Probe measures diffuse or specular reflectance from surfaces, or backscattering from translucent materials and fluids. The RPH-1 Probe Holder positions the R400-7 at either 45° for diffuse reflection or 90° for specular reflection. (For reflection measurements with an integrating sphere, see page 106.) For illumination, we recommend the DH2000-BAL Deuterium Tungsten Halogen Light Source. If your application requires portability, use the smaller DT-MINI-2 Deuterium Tungsten Halogen Light Source. (Because the DT-MINI-2 is a low-power source, configure your spectrometer with a 50 µm Slit and an L4 Detector Collection Lens.)

Measurements

Reflectance standards include the WS-1 Diffuse Reflectance Standard (page 107) for diffuse measurements and the STAN-SSH Specular Reflectance Standard (page 108) for specular measurements. Use our software to correct data for deviations from 100% reflectivity of standards, field tiles or NIST-traceable materials.

Components	Page	Price
1. USB4000-UV-VIS General Lab Spectrometer	34	$2,649
Grating #1, 200-850 nm range	16	included
25 µm Slit as entrance aperture	15	included
DET4-200-850 Detector with OFLV-200-850 Order-sorting Filter	17	included
2. DH2000-BAL Deuterium Tungsten Halogen Light Source	122	$3,588
3. R400-7-UV-VIS Reflection Probe	148	$499
4. RPH-1 Reflection Probe Holder	157	$75
5. SpectraSuite Spectroscopy Operating Software	80	$199
6. ASP Annual Service Package	62	$250
	Total:	**$7,260**

Plants and Reflectance

Spectral reflectance measurements of fruits, vegetables and other plants have long been performed using Ocean Optics spectrometers, light sources and fiber optic probes, with applications in the lab and in the field.

For example, researchers at the University of Arkansas at Little Rock have measured spectral reflectance of rice seedlings (pictured) in relation to soil salinity and to the chlorophyll content of individual rice leaves -- two factors related to rice yield. The experiment setup included an S2000 Spectrometer, LS-1 Tungsten Halogen Light Source and R-series Fiber Optic Reflection Probe.

One of our favorite plant applications is a high school science fair-winning project covering similar territory. Then-student Naomi Levine used one of our old S1000 Spectrometers, a tungsten halogen source, and a fiber optic probe to measure the reflection at 90° of philodendron plant leaves. Naomi believed that correlating reflectance to fertilization levels could be useful in detecting over-fertilization in crops.

What Naomi discovered was that plant reflectance at wavelengths >700 nm was insensitive to the stress of over-fertilization (samples were fertilized at 4x the recommended amount), while the peak within the 530-630 nm range was noticeably sensitive to stress (manifest as increased leaf reflection). She concluded that the latter related to a decrease in chlorophyll and to the effects of osmosis. Osmosis caused water to collect between the cell membrane and cell wall and exposed more of the leaf surface, thus increasing reflectance.

As for Naomi, she graduated from Princeton University in 2003.

Nice Asp!

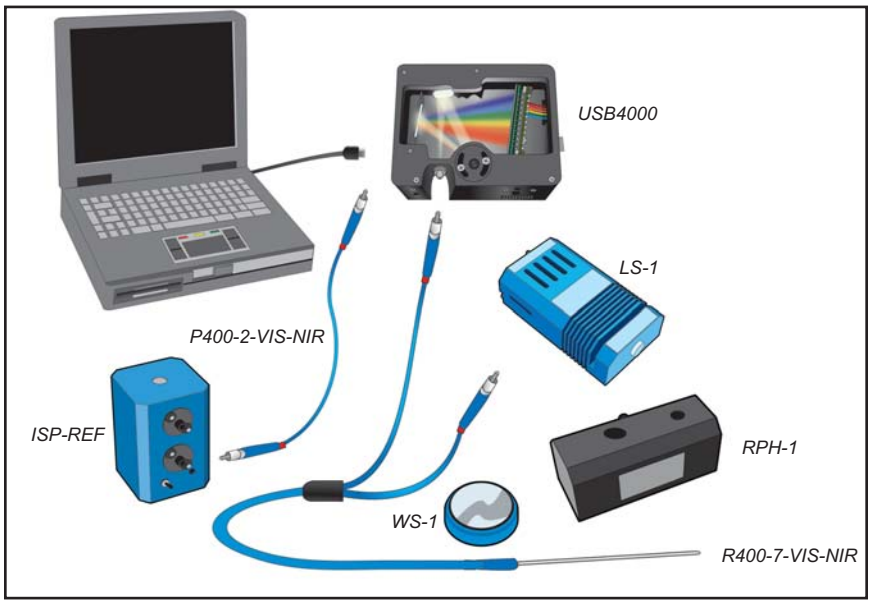
No, it's not an asp, but we couldn't resist. Dr. Ted Rohr -- a wildlife biologist and lecturer at RMIT University in Melbourne, Australia -- is actually holding an Australian Copperhead, which is one of the most venomous snakes in the world.

The Australian Copperhead is a front-fanged snake restricted to the cooler parts of Southeastern Australia. It preys on frogs, lizards, snakes and small mammals.

Rohr is studying the capacity of these snakes to undergo rapid color change -- from several shades of brown or green to black -- on the dorsal surface. Using a USB2000 Spectrometer and a fiber optic probe with a custom shield on its end (the shield helps to maintain a fixed distance to the sample point of interest), Rohr measured the reflectance of individual snake scales, both in the field and in the laboratory.

According to Rohr, the snake's ability to change body color makes sense in a cool-temperate environment, where thermal conditions can change many times during the season and even throughout the day. Changing colors is a perfect mechanism for adapting to fluctuations in temperature. However, body coloration is also important for camouflage. Being black may be great in order to absorb solar radiation, but it makes the snake more obvious to birds of prey -- and wary researchers!

Setup: Reflected Color



Overview

Color measurement involves determining the reflection spectrum of a sample and applying it to a standard illuminant. The amount of light energy the sample reflects is manipulated and reduced to tristimulus values X, Y and Z. These values correspond to the physiological response of the three types of color receptors in the human eye. X, Y and Z values are combined into uniform colorspace values such as L*, a* and b*.

Spectrometer

A USB4000 with a 25 μm Slit and Grating #2 (350-1000 nm) works well for color analysis. For those using an integrating sphere as the sampling optic, we recommend an L4 Detector Collection Lens to improve sensitivity.

Sampling Optics

When taking reflective-color measurements, your data depends on sampling geometry. The R400-7-VIS-NIR Reflection Probe provides illumination and detection from the same direction. If you use the probe at a 45°, it measures diffuse reflection. If you use the probe at a 90°, it measures specular reflection. The distance from the probe to the surface determines the sample size. An alternative is the ISP-REF Integrating Sphere, which provides 180° illumination and detection from flat surfaces for measuring specular and diffuse reflection.

Measurements

Reflectivity is measured against a reference standard such as the WS-1 Diffuse Reflectance Standard. SpectraSuite Spectroscopy Operating Software calculates a variety of colorspace values from the reflection spectra.

Components for Color Measurements	Page	Price
1. USB4000 Plug-and-Play Spectrometer	14	$2,199
Grating #2, 350-1000 nm range	16	included
25 µm Slit as entrance aperture	15	$150
L4 Detector Collection Lens	17	$150
DET-4-350-1000 detector with OFLV Order-sorting Filter	17	$150
2. WS-1 Diffuse Reflectance Standard	107	$299
3. SpectraSuite Spectroscopy Operating Software	80	$199
4. LS-1 Tungsten Halogen Light Source	128	$499
5. R400-7-VIS-NIR Reflection Probe	149	$499
6. RPH-1 Reflection Probe Holder	157	$75
7. ASP Annual Service Package	62	$250
	Total:	**$4,470**

Spectral Identity

It's not uncommon for our customers to be unfamiliar with the absorbing or emitting wavelength or wavelength range of their analytes. In the next few pages, we've provided absorbance and emission data for many analytes. Our Applications Scientists are another good resource for this information -- after all, we've configured nearly than 85,000 spectrometers -- as are Internet searches and commercial ventures specializing in spectral data.

Absorption Wavelength Bands for Chromophores

Chromophore	System	Max. Absorption in nm	Absorb. Intensity
Acetylide	—C≡C—	175-180	6 000
Aldehyde	—CHO	210	strong
		280-300	11-18
Amine	—NH_2	195	2 800
Azido	>C=N—	190	5 000
Azo	—N=N—	285-400	3-25
Bromide	—Br	208	300
Carbonyl	>C=O	195	1 000
		270-285	18-30
Carboxyl	—COOH	200-210	50-70
Disulfide	—S—S—	194	5 500
		255	400
Ester	—COOR	205	50
Ether	—O—	185	1 000
Ethylene	—C=C—	190	8 000
Iodine	—I	260	400
Nitrate	—ONO_2	270 (shoulder)	12
Nitrile	—C≡N	160	—
Nitrite	—ONO	220-230	1 000-2 000
		300-400	10
Nitro	—NO_2	210	strong
Nitroso	—NO	302	100
Oxime	—NOH	190	5 000
Sulfone	—SO_2—	180	—
Sulfoxide	>S=O	210	1 500
Thiocarbonyl	>C=S	205	strong
Thioether	—S—	194	4 600
		215	1 600
Thiol	—SH	195	1 400
	—$(C=C)_2$— (acrylic)	210-230	21 000
	—$(C=C)_3$—	260	35 000
	—$(C=C)_4$—	300	52 000
	—$(C=C)_5$—	330	118 000
	—$(C=C)_2$— (alicyclic)	230-260	3 000-8 000
	C=C—C≡ C	219	6 500
	C=C—C=N	220	23 000
	C=C—C=O	210-250	10 000-20 000
		300-350	weak
	C=C—NO_2	229	9 500
Benzene		184	46 700
		204	6 900
		255	170
Diphenyl		246	20 000
Naphthalene		222	112 000
		275	5 600
		312	175
Anthracene		252	199 000
		375	7 900

Beer's Law

Beer-Lambert Law, more commonly known as Beer's Law, states that the optical absorbance of a chromophore in a transparent solvent varies linearly with both the sample cell pathlength and the chromophore concentration. Beer's Law is the simple solution to the more general description of Maxwell's far field equations describing the interaction of light with matter. In practice Beer's Law is accurate enough for a range of chromophores, solvents and concentrations, and is a widely used relationship in quantitative spectroscopy.

Absorbance is measured in a spectrophotometer by passing a collimated beam of light at wavelength λ through a plane parallel slab of material that is normal to the beam. For liquids, the sample is held in an optically flat, transparent container called a cuvette. Absorbance (A_λ) is calculated from the ratio of light energy incident passing through the sample (I_0) to the energy that is incident on the sample (I):

$$A_\lambda = -\log (I/I_0)$$

Beer's Law follows:

$$A_\lambda = \varepsilon_\lambda bc$$

- ε_λ = molar absorptivity or extinction coefficient of the chromophore at wavelength λ (the optical density of a 1-cm thick sample of a 1 M solution). ε_λ is a property of the material and the solvent.
- b = sample pathlength in centimeters
- c = concentration of the compound in the sample, in molarity (mol L^{-1})

In an absorbance experiment, light is attenuated not only by the chromophore, but also by reflections from the interface between air and the sample, the sample and the cuvette, and absorbance by the solvent. These factors can be quantified separately, but are often removed by defining I_0 as the light passing through a sample "blank" or "baseline" or reference sample (for example, a cuvette filled with solvent but zero concentration of the chromophore is used as the blank).

Many factors can affect the validity of Beer's Law. It is usual to check for the linearity of Beer's Law for a chromophore by measuring the absorbance of a series of standards. This "calibration" can also remove errors in the experiment, the equipment and the batch of reagents (such as cuvettes of unknown pathlength).

Spectral Identity

Determining Optical Resolution

The optical resolution, measured as Full Width Half Maximum (FWHM), of our spectrometers depends on the groove density of the grating and the width of the entrance aperture (slit width or fiber diameter).

In selecting these components, consider two trade-offs. First, the optical resolution improves as the groove density of the grating increases, but at the expense of spectral range and signal strength. Second, the resolution improves as the slit width or diameter of the fiber decreases, but at the expense of signal strength. The formula for calculating the optical resolution follows:

Step 1
Choose a Grating from the Grating Selection Chart. See the table below to locate the page for the grating choices for your spectrometer. Note the value in the Spectral Range column in the chart. Check the number of pixel elements in the spectrometer's detector. Divide the Grating's Spectral Range by the total number of Detector Elements in the detector. This is your Dispersion.

Step 2
Choose a Slit. See the table below to find the page on slit choices for your spectrometer. Note the value in the Pixel Resolution column in the slit chart. Multiply the Dispersion (nm/pixel value from Step 1) x Pixel Resolution of your entrance aperture. This is your Optical Resolution (in nm).

Example
Here is an example of how to calculate optical resolution of a USB4000 Spectrometer using Grating #3 and a 10- μm slit. With this data, you can obtain the approximate optical resolution.

Step 1 650 nm ÷ 3648 = 0.178
Step 2 0.178 x 5.7 = 1.015 nm
FWHM = ~1.02 nm

Finding Your Values

Spectrometer	Grating Spectral Range	Entrance Aperture Pixel Resolution
USB2000:	website	website
USB4000:	page 16	page 15
HR2000:	website	website
HR2000+:	page 23	page 22
HR4000:	page 23	page 22
QE65000:	page 28	page 27
NIR-512:	pages 32	page 32
NIR256-2.1:	pages 32	page 32
NIR256-2.5:	pages 32	page 32

Absorption Wavelength Bands for Chromophores

Chromophore	Max. Absorption in nm	Absorb. Intensity
Phenanthrene	251	66 000
	292	14 000
Naphthacene	272	180 000
	473	12 500
Pentacene	310	300 000
	585	12 000
Pyridine	174	80 000
	195	6 000
	257	1 700
Quinoline	227	37 000
	270	3 600
	314	2 750
Isoquinoline	218	80 000
	266	4 000
	317	3 500

Absorption Wavelength Cutoffs for Solvents*

Solvent	Wavelength
Acetic Acid	260
Acetone	330
Acetonitrile	190
Benzene	280
1-Butanol	210
2-Butanol	260
Butyl acetate	254
Carbon disulfide	380
Carbon tetrachloride	265
1-Chlorobutane	220
Chloroform (stabilized with ethanol)	245
Cyclohexane	210
1,2-Dichloroethane	226
Diethyl ether	218
1,2-Dimethoxyethane	240
N,N-Dimethylacetamide	268
N,N-Dimethylformamide	270
Dimethylsulfoxide	265
1,4-Dioxane	215
Ethanol	210
2-Ethoxyethanol	210
Ethyl acetate	255
Ethylene chloride	228
Glycerol	207
Heptane	197

Solvent	Wavelength
Hexadecane	200
Hexane	210
Isobutyl alcohol	230
Methanol	210
2-Methoxyethanol	210
Methylcyclohexane	210
Methylene chloride	235
Methyl ethyl ketone	330
Methyl isobutyl ketone	335
2-Methyl-1-propanol	230
N-Methylpyrrolidone	285
Nitromethane	380
Pentane	210
Pentyl acetate	212
1-Propanol	210
2-Propanol	210
Pyridine	330
Tetrachloroethylene (stabilized with thymol)	290
Tetrahydrofuran	220
Toluene	286
1,1,2-Trichloro-1,2,2-trifluoroethane	231
2,2,4-Trimethylpentane	215
o-Xylene	290
Water	191

** Solvents are transparent at wavelengths greater than the stated cutoff.*

Spectral Identity

Absorption/Emission for Fluorophores

Fluorophore	Absorption in nm	Emission in nm
1,5 IAEDANS	336	490
4-Methylumbelliferone	385	502
5-Carboxynapthofluorescein (pH 10)	512/598	563/668
5-Carboxytetramethylrhodamine (5-TAMRA)	542	568
6-Carboxyrhodamine 6G	518	543
6-CR 6G	518	543
6-JOE	520	548
7-Amino-4-Methylcoumarin	351	430
7-Aminoactinomycin D (7-AAD)	546	647
7-Hydroxy-4-methylcoumarin	360	449,455
Acridine Orange +DNA	502	526
Alexa Fluor 350™	346 342	442 441
Alexa Fluor 430™	431	540
Alexa Fluor 488™	495,492	519,520
Alexa Fluor 532™	531,532	553,554
Alexa Fluor 546™	556,557	572,573
Alexa Fluor 568™	577,578	603
Alexa Fluor 594™	590,594	617,618
Alexa Fluor 633™	632	650
Alexa Fluor 647™	647	666
Alexa Fluor 660™	668	698
Alexa Fluor 680™	679	702
Allophycocyanin (APC)	630,645	655,660
AMCA (Aminomethylcoumarin)	345 347	425 444
AMCA-X	353	442
ATTO-TAG™ FQ	486	591
BCECF (high pH)	492,503	520,528
BCECF (low pH)	482	520
Bodipy 505/515	502	510
Bodipy 558/568	558	569
Bodipy 564/570	564	570
Bodipy 576/589	579	590
Bodipy 581/591	584	592
Bodipy 630/650-X	625	642
Bodipy 650/665-X	647	665
Bodipy 665/676	605	676
Bodipy FI	504,505	511,513
Bodipy TMR	542	574
Bodipy TR	589	617
Calcein	494	517
Calcein Blue	373	440
Calcium Crimson™	588,589	611,615
Calcium Green	501,506	531
Calcium Green-1 Ca2+ Dye	506	531
Calcium Orange	549	575
Calcofluor White	385,395,405	437,440,445
Cascade Blue™	377 398 399	420 423
CFP - Cyan Fluorescent Protein	430,433,436,(453)	474,475,476,(501)

Non-linearity & CCDs

All CCD detectors exhibit a non-linearity in their response to light; i.e., doubling the number of photons received during the sample interval results in slightly less than a doubling of the voltage output. The effects of non-linearity, if left uncorrected, will be slight but detectable errors in the calculation of normalized values (absorbance, transmission or irradiance).

The non-linearity is a consequence of the R-C circuit used to read out the electrons that are left on the CCD capacitor (the charge well). The effect is independent of light level, integration time and optics. It depends only on the charge in the charge well.

The pattern of non-linearity is different for the various detector models used in our spectrometers. The magnitude of the linearity varies from detector to detector, but fortunately it is the same for all pixels in the detector. This makes it possible to 1) measure the linearity, and 2) correct for the errors in software.

For example, the ILX511 has a maximum response at 2000 counts (half well capacity). It drops to ~94% at 4000 counts and near zero counts. We can establish this curve precisely using an automated program that varies the integration time to precisely control the amount of light being sampled. This program (OOINLCorrect) is available for free download at our website at OceanOptics.com/Technical/Software Downloads.asp.

The linearity is captured from the experiments as a plot of normalized counts/sec versus counts for a constant light source observed at a series of integration times. The data is fit to a 7th order polynomial. The inverse of this function is stored in the software and/or on the EEPROM. When the linearity correction feature is turned on, all spectra are multiplied by the stored coefficients. Uncorrected spectra are linear to ~92%. Corrected spectra are linear to >99.8%.

Collimating Lenses

The 74-UV and 74-VIS Collimating Lenses screw onto the end of SMA 905-terminated fibers and other sampling optics to convert divergent beams of radiation (light) into a parallel beam. The optical fibers we sell have a field of view (FOV) of ~25° -- an acceptance angle that may not be appropriate for some experiments. Collimating lenses are adjustable, providing FOV angles from collimation (near 0°) to ~45°. Without the collimating lenses, the light would disperse more than is required for efficient transmission and collection of the signal.

Focus the Lamp's Collimating Lens

In order to obtain accurate data, the light entering and exiting a sample by means of a fiber/collimating lens assembly must be well collimated. Here are instructions for adjusting the focus of the collimators in a typical spectrometer setup.

1. Connect to the light source the fiber that you're going to use as the illumination fiber in your setup. The female SMA 905 Connector of the fiber must be screwed all the way into the male connector of the lamp.
2. Turn on the lamp and inspect the beam emitted from the other end of the fiber by pointing the fiber at a white piece of paper. The distance is not too critical but should be at least 3 inches from the surface.
3. Loosen the setscrew on the fiber barrel of the light source with an Allen wrench.
4. Slide the inner barrel of the collimating lens until you see an even intensity across the beam spot. The spot should be uniform in intensity and color.
5. Once the inner barrel is positioned so that a well-focused, uniform spot is obtained, tighten the setscrew. Don't put down the fiber and then tighten the setscrew as you may lose the focus.

Focus the Next Collimating Lens

6. The illumination fiber is still connected to the lamp and the lamp is on. Take the second collimating lens in your setup (removed from a cuvette holder, for example) and screw it securely onto the other end of the fiber. Point this end of the fiber at least 2 meters from a wall.
7. Repeat Steps 3, 4 and 5. Then remove the lens from the end of the fiber and install it back into your setup (back into a cuvette holder, for example).
8. Continue to adjust the focus of the other collimating lenses in your setup.

Absorption/Emission for Fluorophores (continued)

Fluorophore	Absorption in nm	Emission in nm
CL-NERF (Ratio Dye, pH)	504/514	540
Cy2™	489	506
Cy3.5™	581	598
Cy3™	514	566
Cy5.5™	675	695
Cy5™	649	666
Cy7™	710,743	767,805
Dabcyl	453	
Dansyl Cadaverine	335	518
DAPI	359	461
Di-4-ANEPPS	496	705
Di-8-ANEPPS (non-ratio)	488	605
	498	713
DiA (4-Di-16-ASP)	456	591
DIDS	341	415
DiI (DiIC18(3))	549,551	565
Dinitrolphenol	349	
DiO (DiOC18(3))	484,487	501,502
DM-NERF (Ratio Dye, high pH)	497/510	540
ELF 97	345	530
Eosin	524	545
Erythrosin	529,532	554,555
Ethidium Bromide	510,523	595,605
Ethidium homodimer -1 (EthD-1)	528	617
Europium (III) chloride	337	613
Fast Blue	360	440
Fluo-3	480-506,506	520,527
Fluo-4	494	516
Fluorescein (FITC)	490,494	520,525
Fluoro-Gold (Hydroxystilbamidine)	361	536
FluorX	494	520
FM 1-43™	479	598
Fura Red™ (high pH)	572	657
Fura-2, high calcium (Excitation ratio dye)	335	505
Fura-2, low calcium (Excitation ratio dye)	363	512
GFP (S65T)	498	516
Hoechst 33258	345	487
Hoechst 33342	347	483
JC-1	514	529
JO-JO-1	530	545
JO-PRO-1	532	544
Lucifer Yellow	425,428	528,536,540
Lyso Tracker Green	504,534	511,551
Mag-Fura-2 (Ratio Dye, Ca2+)	369/329	508
Mag-Fura-2 (Ratio Dye Mg2+)	369/330	511/491
Mag-Fura-5 (Ratio Dye, Ca2+)	369/330	505/500
Mag-Fura-5 (Ratio Dye, Mg2+)	369/332	505/482
Magnesium Green	506,507	531
Marina Blue	362	459
Mitotracker Green FM	490	516

Spectral Identity

Absorption/Emission for Fluorophores (continued)

Fluorophore	Absorption in nm	Emission in nm
Mitotracker Orange	551	576
NBD	466	539
Nile Red	515-555,559	590,640
Oregon Green™	503	522
Oregon Green™ 488	490,493	514,520
Oregon Green™ 500	497	517
Oregon Green™ 514	506	526
PKH26 (Sigma)	551	567
POPO-3	533	574
PO-PRO-3	539	567
Propidium Iodid (PI)	(305), 536,538	617
Pyrene	360	387
QSY 7	560	591
Rhod-2	552	576
Rhodamine 110	496,497	520
Rhodamine 123	507	529
Rhodamine 6G	525	555
Rhodamine B	540	625
Rhodamine Green	502	527
Rhodamine Phalloidine	542	565
Rhodamine Red	570	590
R-phycoerythrin (PE)	565	578
SITS (Ion Channels)	336	436
SNAFL-1 (Ratio Dye, pH)	508/540	543/623
SNARF1 Excitation and emission ratio dye	576/548	635/587
Sodium Green Na+, K+	506,507	532
SpectrumGreen (Vysis)	497/30, 509/31	538/44,524/56
SpectrumOrange (Vysis)	559/38,560	588/48
SPQ (6-methoxy-N-(3-sulfopropyl)	344	443
SYTO 11Dye for DNA, RNA	508,510	527,530
SYTO 13Dye for DNA, RNA	488,491	509,514
SYTOX Green (Nucleic Acid Stain	504	523
SYTOX Orange (Nucleic Acid Stain	547	570
Tetramethylrhodamine (TRITC)	555	576
Texas Red™	595	620
TO-PRO-1	515	531
TOTO-1	514	531,533
YFP (Yellow Fluorescent Protein)	513,520	527,532
YO-PRO-1	491	506
YOYO-1	491	508,509

Phosphorescence & Fluorescence

Phosphorescence and fluorescence are closely related subcategories of luminescence. The difference between the two is in the nature of a material's ground and excited states.

In a singlet excited state, the higher-energy orbital electron spins opposite the lower-energy orbital. The two electrons are considered "paired." In a triplet state, the electrons are "unpaired," and spin in the same direction. A return to the ground state from a singlet excited state does not require one of the electrons to change its spin orientation; a return from a triplet state to the ground state does require an electron's spin orientation to change.

Fluorescence is the photonic emission that occurs when the higher-energy electron in a singlet state returns to the lower-orbit electron. The laws of quantum mechanics permit this rapid transition at a rate near 10^{-8} second.

The fluorescence lifetime is the average period of time that a fluorophore remains in the excited singlet state. By comparison, phosphorescence emission occurs as the electronically excited condition of a material in the triplet state returns to the singlet ground state. Again, the laws of quantum mechanics prevail, and the probability of this transition is lower. The lifetime of an excited triplet state is much longer than that of an excited singlet state, producing phosphorescence lifetimes that range from milliseconds to seconds.

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Standard & Extended Warranty Coverage

All products manufactured by Ocean Optics are warranted for one year. Ocean Optics also offers an Annual Service Package (ASP) that extends by one year the standard warranty on our spectrometers. The holder of the ASP is entitled to several benefits during the one-year period commencing with the spectrometer invoice date:

- Additional year of warranty protection and certification
- Factory calibration and certification of your spectrometer, including optical alignment, wavelength calibration, linearity calibration, stray light measurement and signal-to-noise analysis, optical resolution evaluation and baseline uniformity evaluation
- Waiver of $250 labor charge for upgrades to your spectrometer configuration, such as changing a slit or grating
- A spiffy new Maxwell's Equations T-shirt – be the envy of all your friends, like our Ocean Optics models!

Also available is a two-year extended warranty renewal option for most of our spectrometers. Enjoy all the great ASP benefits with the additional year of coverage at a steep discount.

The purchase of an ASP comes with the latest Maxwell's Equations T-shirt, modeled by (left to right) Fernando Quinones, Accounting Specialist; Jada Mains, Customer Support Coordinator; Nick Sebastian, Global Distribution Sales Manager; and Ricardo Nobara De La Torre, Electrical Engineer.

Item	Description	For These Spectrometer Series	Price
ASP	Extends the standard warranty from 1 year to 2 years. Price is per spectrometer channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000, USB4000	$250
ASP-ES	A 1-year warranty package available to customers whose original warranty has expired. Price is per spectrometer channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000, USB4000	$300
ASP-R	1-year renewal option for holders of expiring ASPs; price is per channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000, USB4000	$250
ASP-R-E	2-year renewal option for holders of expiring ASPs; price is per channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000, USB4000	$350
ASP-NIR	Extends the standard warranty on NIR Spectrometers from 1 year to 2 years.	NIR256-2.1, NIR256-2.5, NIR512	$1,000
ASP-QE	Extends the standard warranty on QE Spectrometers from 1 year to 2 years.	QE65000	$750

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