
BAYSPEC
2013 Catalog

Contact Information

Worldwide Headquarters
BaySpec, Inc.
1101 McKay Drive
San Jose, CA 95131 USA

Tel. +1(408) 512-5928
Fax. +1(408) 512-5929

info@bayspec.com
sales@bayspec.com
www.bayspec.com

Service Hours:
Monday – Friday
8:00 a.m. to 7:00 p.m.

Ordering Information

Terms:
Net 30 days with credit approval. All shipments delivered EXWORKS, San Jose, California, USA. For all shipments within California, we are required to charge sales tax unless a valid resale certificate is received prior to shipment. Fax resale certificates to Accounting Department: +1(408) 512-5929. Specifications, descriptions, ordering information and item codes described herein are subject to change without notice. Products, software or technology are to be exported from the United States in accordance with the Export Administration Regulations. Diversion contrary to U.S. law is prohibited.

Pricing:
BaySpec has a Universal Pricing Policy to ensure that there is a single product or service price, no matter the location. Extra costs due to currency exchange, custom duties or taxes, or additional shipping charges should not be seen as part of the Universal Pricing Policy, and are the responsibility of the customer. For more information, please contact the Sales Department at +1(408) 512-5928 or sales@bayspec.com.

Shipping:
Shipping charges are the responsibility of the customer. Orders are shipped domestically FEDEX Air 3-Day or overseas FEDEX International Economy, unless otherwise requested. Customers may reverse shipping charges to the carrier of choice.

Standard Warranty:
Products manufactured by BaySpec are warranted for one year. BaySpec utilizes state-of-the-art manufacturing techniques developed during the telecommunications revolution over the last 20 years. Our Design for Engineering/ Design for Manufacturing utilize best practices, such as: extensive thermal cycling over extended wavelength ranges, hermetic sealing, and quality control based on ISO9001:2008, IPC-A-610/J-STD-001, Telcordia GR, MILSPEC-810 and CFR21 Part 11.

Our Vision

Our Products

BaySpec's Innovation

"Can You Make This?"

My name is William Yang, co-founder of BaySpec. When I was working at Thermawave, Jeff MacCubbin, an old friend of mine who worked in optics sales and marketing, gave me a call. He said Bell Labs wanted to make a special type of grating-based WDM device, but such a device didn't yet exist. Would I be interested in designing such a device?

After talking with the people at Bell Labs, it turns out they wanted a multiplexer/demultiplexer (mux/demux) device based on a volume transmission grating. The device required large channel counts and performance under some wide temperature ranges without thermal compensation, which makes for a highly efficient transmission grating ideal for that purpose.

The contract with Bell Labs, and the idea that I could make significant contributions to optical spectrometry, propelled me to launch BaySpec. I brought in Charlie Zhang, a classmate from the University of Waterloo, and BaySpec was born, in a garage, in Silicon Valley. Within two years we held 18 patents.

"Industry Acceptance"

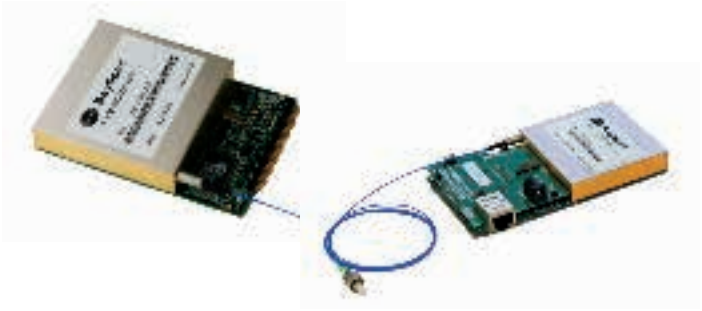
Currently, BaySpec has shipped over 35,000 spectral engines of all types over the last 10 years. In 2011, BaySpec successfully sold its handheld Raman Analyzer line to Rigaku Raman Technologies, which consisted of the Xantus™, FirstGuard™, et al Handheld Raman products.

The development experience and the spirit of continuous innovation allows us to focus our product development activities on new OEM and bench-top products, such as the Agility™ Raman Analyzer - the world's first dual-band Raman Analyzer with a range of new self-aligning sample interface options.

Fully Customizable Solutions

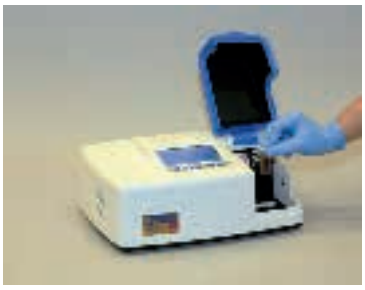
We build our products to exacting specifications using high-end production facilities in San Jose, California. While the current trend is returning manufacturing to the U.S.A., we ironically never left, and will continue to manufacture in the U.S. to ensure the highest product quality and best service and support.

Our products are cost-effective, reliable and stable, built to withstand temperature changes, humidity and prevent damage caused by human handling. Our products are also fully customizable, according to your needs and specifications. With our products available to you, when someone asks you, "can you make this?" you know the answer is "yes, and it will be amazing."



IntelliGuard™ Optical Channel Performance Monitors (OCPM) and *WaveCapture*™ FBG Interrogation Analyzers

SuperGamut™ NIR Spectrometer Prism Award Finalist 2009



Agility™ Raman Instrument

RamSpec™ High Resolution 1064nm Raman Instrument

William Yang, Co-Founder

BaySpec OEM Invitation

Partnership in Product Development, Manufacturing, and Technology Transfer

High Performance Optical Spectroscopy Solutions

BaySpec offers high performance UV, VIS, NIR and Raman spectrometers and Raman Microscope instruments, Soft and Deep-cooled Detectors/ Cameras, Narrow and Broadband Light Sources, and a full variety of fiber optic accessories tailored to the most demanding applications in the world. We specialize in developing leading edge solutions for observing small concentration changes, detection of small amounts of substances or observation of spectra from multiple sources at the same time. All spectrometers are dispersive non-scanning, so that all points along the spectrum are obtained simultaneously. As such, our devices are ideal for field and in-line/at-line process monitoring in the pharmaceutical, biomedical, industrial, agricultural, homeland security and military marketplaces.

OEM Spectral Engines

BaySpec is one of the largest spectral engine manufacturers in the world with over 35,000 systems in the field. Our products are manufactured at our 48,000 sq ft. San Jose, California facility in the fast-paced Silicon Valley. Our devices are manufactured to the highest quality standards, such as Telecordia GR-63, 1209, 1221, and MILSPEC810. During the manufacturing process, we perform extensive thermal cycling, and offer guaranteed performance and factory calibration.

Customizable Multi-wavelength
Nomadic™ Raman Microscope

OEM Areas:

1. Custom Spectrographs and Spectrometers (ranging from 190 - 2500nm)
2. Transportable Raman Spectral Engines for customers with mobile applications
3. OEM NIR Spectral Engines for in-line process monitoring
4. High resolution imaging spectrographs and Raman, OCT and NIR spectrographs
5. Soft-cooled CCD based detectors and InGaAs based arrays
6. Deep-cooled CCD based detectors and InGaAs based arrays
7. Wideband light sources, lasers sources
8. Fiber optic probes, Raman probes
9. OEM components and Integration for Raman Microscopy

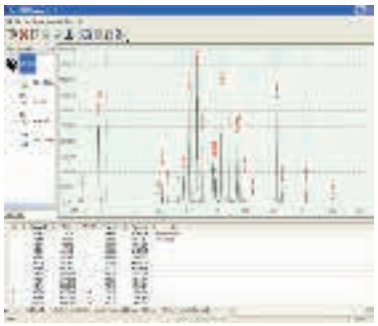
Our ability to design optimally cooled systems allows us to exceed OEM customer performance requirements, while considering trade-offs for power consumption and cost. We have extensive experience with athermal/soft-cooled/deep-cooled detection.

OEM volume discounts available. Our dedicated OEM engineering and software development staff are ready to support your OEM needs from component level selection to fully integrated turn-key products, on-time and under budget.

Do you have a novel product you would like to discuss with us? *Give us a call or email us.*

UV, Visible & NIR Spectrographs & Spectrometers

					
Part Code	UNIR	VNIR	NIRS	SPEC	xSYS RSYS
Description	UV-NIR Spectrometers	Visible-NIR Spectrometers	Near-infrared Spectrometers	Custom Spectrographs for UV, Visible or NIR or Raman systems	Benchtop UV, Visible, NIR or Raman Turn-key Systems, 190-2500nm range
Part Number Series	UNIR-0190-1080	VNIR-0400-1100	NIRS-0900-1700 NIRS-1100-2200 NIRS-1250-2500	SPEC-0532 SPEC-0785 SPEC-1064 SPEC-VIS SPEC-NIR	Contact us for your custom turn-key quote for spectrograph, laser, detector, probe configurations



page 6

SuperGamut™ UV-NIR Spectrometer 190-1080nm

Features:

- High throughput f/3 optics
- Compact Design

Applications

- Biomedical/Biopharmaceuticals
- Trace organics analysis/monitoring
- Thin film measurements
- Colorimetric measurements
- Clinical Analysis
- Trace Pollutant Analysis

page 8

SuperGamut™ Vis-NIR Spectrometer 400-1100nm

Features:

- High throughput f/3 optics
- High efficiency transmission VPG grating
- Best performance/price

Applications

- Pharmaceuticals, Medical diagnostics
- Agriculture, Pulp & Paper, Water Quality
- Semiconductors
- Beverage & Brewery, Food Safety
- Cosmetics, Biomedical Research
- Explosives detection, Homeland Security

page 10

SuperGamut™ NIR Spectrometers
900-1700nm
1100-2200nm
1250-2500nm

Features:

- High throughput f/2 optics
- High efficiency transmission VPG grating
- Best price/performance

Applications

- Blender, Moisture monitoring
- Content uniformity
- Raw material ID
- In-line/ At-line process control

CUSTOM

Custom Spectrographs
Turn-key UV, Visible and NIR Systems:

Features:

- Optimized for performance/price
- Fully customizable

Applications:

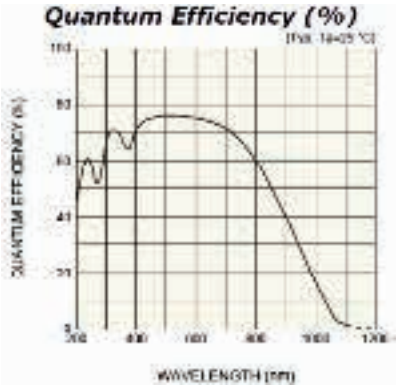
- Beverage, Food, Dairy, Water Safety
- Explosives, WMDs, Homeland Security
- Narcotics, Counterfeit Detection
- Pesticides, Toxic & Common Chemicals
- Cosmetics, White Powders Detection
- In-line/at-line Process Monitoring
- Petrochemical, Oil Exploration, Mining
- Pharmaceuticals, Medical Diagnostics
- Biomedical Research

SuperGamut™ UV-NIR Spectrometer: 190 to 1080 nm

BaySpec's SuperGamut™ series of UV-NIR Spectral Engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience in manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's NIR spectral devices utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The SuperGamut™ Series employs a highly efficient concave grating as the spectral dispersion element and an ultra sensitive CCD array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a fiber optic input or slit optics arrangement based on customer preferences. The signal is spectrally dispersed with the concave grating and the diffracted field is focused onto a CCD array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

SuperGamut™ Stand-Alone



Detector Efficiency Curve

Key Features

- Covers wavelength ranges from 190-1080 nm
- Real-time spectral data acquisition with fast milli-second response time and user settable integration time
- Optimal cooling for low light spectral measurements
- Spec 20/20 SDK supported
- Factory calibrated for reliable operation in harsh environments
- Fast f/3 optics and high throughput holographic VPG®

Key Design Benefits

- Wide spectral range
- Compact size
- No moving parts
- Scientific-grade detector array
- Optimized temperature control
- Solid-state electronics
- Ruggedized packaging

Order Info for Part No. UNIR-

Note: fiber sold separately

Starting Wavelength	Code	Ending Wavelength	Code	Interface Type	Code	Interface Type	Code
190 nm	0190	900 nm	0900	25 µm	025	SMA905	SMA
230 nm	0230	1080 nm	1080	50 µm	050	FC	FC
specify nm	xxxx	specify nm	yyyy	100 µm	100		
				200 µm	200		
code selection:		code selection:		code selection:		code selection:	

order code example: UNIR-0190-1080-050-SMA

Super Gamut™ UNIR-190-1080

PERFORMANCE	
Wavelength Range	190 - 1080 nm or customer specified
Spectral Resolution	1 -20 nm slit dependent
Peak Wavelength (λpk) Nom.	500 nm
Signal / Noise	6000:1
Wavelength Calibration	Factory Calibrated, independent of operating temperature
Integration Time	10 ms to 60 seconds
Dimensions	162 x 105 x 60 mm
OPTICS	
f/ Number	f/3
Grating	Concave Grating
Entrance Aperture (μm)	25, 50, 100, 200, Fiber, or custom design
Stray Light	0.05%
DETECTOR SPECS	
Detector Array	14 μm, 2048x64 pixel CCD
Quantum Efficiency @λpk Min.	80%
Response Non-uniformity	±3% typical, ±10%max
Readout Noise	6 electrons/scan RMS typical
Max Dark Current	50 e-/pixel/sec typical
A/D Converter	16 bit
Power	500 mA@5 V
COMPUTER	
Data Ports	USB or RS-232
Software	Spec 20/20 SDK LabVIEW supported
Operating System	Windows XP or later

Specifications are subject to change without notice

Consider using with:

- *MiniLite*™ Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories

SuperGamut™ OEM Transmission Measurement System Example

Spec 20/20 SDK available for ease of integration.

SuperGamut™ Turn-key Configuration Example

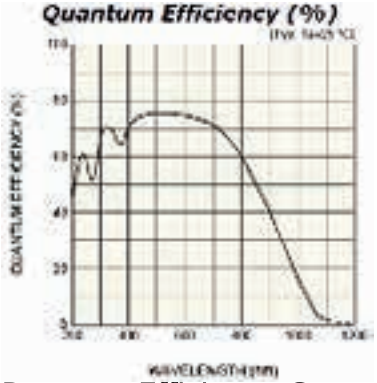
OEM Integration example

SuperGamut™ Visible-NIR Spectrometer: 400 to 1100 nm

BaySpec's SuperGamut™ series of Visible Spectral Engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience in manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's NIR spectral devices utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The SuperGamut™ Series employs a highly efficient Volume Phase Grating (VPG®) as the spectral dispersion element and an ultra sensitive CCD array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a fiber optic input or slit optics arrangement based on customer preferences. The signal is spectrally dispersed with the VPG® and the diffracted field is focused onto a CCD array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

SuperGamut™ Stand-Alone



Detector Efficiency Curve

Key Features

- Covers wavelength ranges from 400-1100 nm
- High throughput Volume Phase Grating (VPG®)
- Real-time spectral data acquisition with fast milli second response time and user settable integration time
- Optimal cooling for low light spectral measurements
- Factory calibrated for reliable operation in harsh environments

Key Design Benefits

- Ultra reliable Volume Phase Grating (VPG®)
- Compact size
- No moving parts
- Scientific-grade detector array
- Optimized temperature control
- Solid-state electronics
- Ruggedized packaging

Order Info for Part No. VNIR-

Note: fiber sold separately

Starting Wavelength	Code	Ending Wavelength	Code	Interface Type	Code	Interface Type	Code
400 nm	0400	900 nm	0900	25 µm	025	SMA905	SMA
650 nm	0650	1100 nm	1100	50 µm	050	FC	FC
specify nm	xxxx	specify nm	yyyy	100 µm	100		
				200 µm	200		
code selection:		code selection:		code selection:		code selection:	

order code example: VNIR-0400-1100-025-SMA

Super Gamut™ VNIR-400-1100

PERFORMANCE	
Wavelength Range	400 - 1100 nm or customer specified
Spectral Resolution	1 -20 nm slit dependent
Peak Wavelength (λpk) Nom.	700 nm
Signal / Noise	6000:1
Wavelength Calibration	Factory Calibrated, independent of operating temperature
Integration Time	10 ms to 300 seconds
Dimensions	162 x 105 x 60 mm
OPTICS	
f/ Number	f/3
Grating	Custom Volume Phase Grating (VPG®)
Entrance Aperture (μm)	25, 50, 100, 200, Fiber, or custom design
Stray Light	0.05%
DETECTOR SPECS	
Detector array	14 μm, 1024x64 pixel CCD
Quantum Efficiency @λpk Min.	80%
Response Non-uniformity	±3% typical, ±10%max
Readout Noise	6 electrons/scan RMS typical
Max Dark Current	50 e-/pixel/sec typical
A/D Converter	16 bit
Power	1 A@12 V
COMPUTER	
Data Ports	USB or RS-232
Software	Spec 20/20 SDK LabVIEW supported
Operating System	Windows XP or later

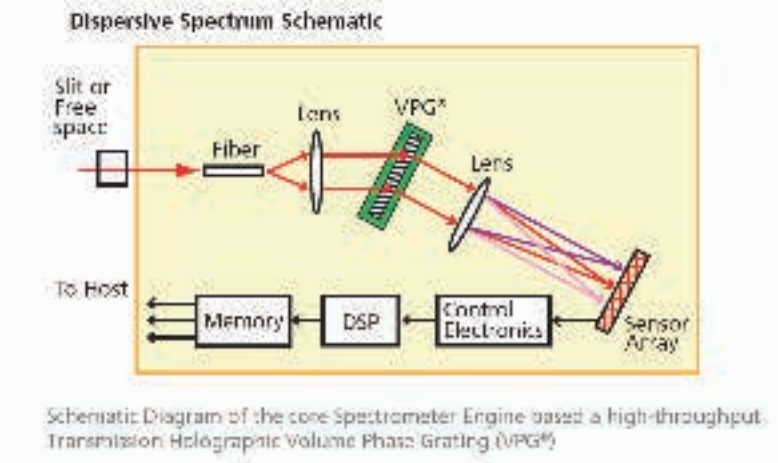
Specifications are subject to change without notice

Consider using with:

- *MiniLite*™ Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories

SuperGamut™ OEM Transmission Measurement System Example

Spec 20/20 SDK available for ease of integration.



Schematic Diagram of the core Spectrometer Engine based a high-throughput Transmission Holographic Volume Phase Grating (VPG®)

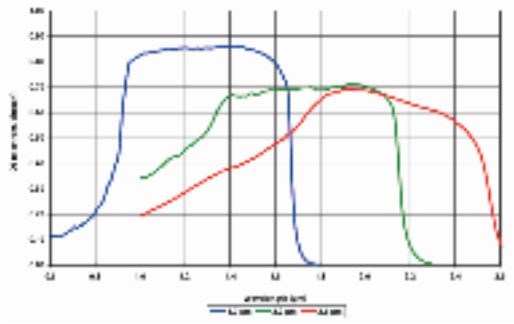
OEM Integration example

SuperGamut™ NIR Spectrometer: 900 to 1700 nm

BaySpec's SuperGamut™ series NIR Spectral Engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's NIR spectral devices utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The SuperGamut™ Series employs a highly efficient Volume Phase Grating (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a fiber optic input or slit optics arrangement based on customer preferences. The signal is spectrally dispersed with the VPG® and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

SuperGamut™ Stand-Alone



Quantum Efficiency Curves

Key Features

- Real-time spectral data acquisition with fast milli second response time
- Optimally cooled for low light spectral sensitivity
- Reliable operation in harsh environments
- Outstanding optical throughput is achieved with VPG® and f/2 design
- Covers wavelength ranges from 900-1700 nm
- Designed for field battery operation

Key Design Benefits

- Ultra reliable Volume Phase Grating (VPG®)
- No moving parts
- Athermal (TEC off) or Temperature controlled
- Solid-state electronics
- Hermetically sealed

Order Info for Part No. NIRS-

Note: fiber sold separately

Type	Code	Starting Wavelength	Code	Ending Wavelength	Code	Interface Type	Code	Interface Type	Code
Standard	SC	900 nm	0900	1700 nm	1700	25 µm	025	SMA905	SMA
Deep Cooled	DC	1100 nm	1100	2200 nm	2200	50 µm	050	FC	FC
		1250 nm	1250	2500 nm	2500	100 µm	100		
		specify nm	xxxx	specify nm	yyyy	200 µm	200		
code selection:		code selection:		code selection:		code selection:		code selection:	

order code example: NIRS-DC-0900-1700-050-SMA

SuperGamut™ NIRS-0900-1700

PERFORMANCE	
Wavelength Range	900-1700 nm or customer specified
Spectral Resolution	5 - 20 nm slit dependent
Peak Wavelength (λpk) Nom.	1.3 µm
Signal / Noise	6000:1
Wavelength Calibration	Factory Calibrated, independent of operating temperature
Integration Time	20 µs to 30 seconds
Dimensions	162 x 105 x 60 mm
Weight	650 g
OPTICS	
f/ number	f/2
Grating	Custom Volume Phase Grating (VPG®)
Entrance Aperture (µm)	25, 50, 100, 200, Fiber, or specify
DETECTOR SPECS	
Detector Array	25 µm x 512 or 50µm x 256 Pixels
Avg. Array Response @ λpk Min.	10.5 nV/photon
Quantum Efficiency @ λpk Min.	70%
Response Non-uniformity, Max.	±10%
Readout Noise	800 electrons/scan typical
Dark Noise	10 counts RMS
Max Dark Current	1.5 pA
Max Dark Voltage Rate	0.15 V/s
Saturation Charge (Typical)	$5x10^6$ electrons
Detector Gain	400 nV/electron typical
Stray Light	0.05%
Detector	TE cooled InGaAs
A/D Converter	16 bit
Power	1 A@12 V
COMPUTER	
Data Rate	Up to 5000 full scan/sec.
Data Ports	USB 2.0 (inquire on others)
Trigger Modes	Software or external TTL Controlled
Software	Spec 20/20 SDK LabVIEW supported
Operating System	Windows XP or later

Consider using with:

- *MiniLite*™ Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories

Spec 20/20 SDK available for ease of integration.

OEM Example

SuperGamut™ NIR Spectrometer: 1100 to 2200 nm

BaySpec's SuperGamut™ series NIR Spectral Engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's NIR spectral devices utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The Super Gamut™ Series employs a highly efficient Volume Phase Grating (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a fiber optic input or slit optics arrangement based on customer preferences. The signal is spectrally dispersed with the VPG® and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

SuperGamut™ Stand-Alone

Key Features

- Real-time spectral data acquisition with fast milli second response time
- Athermal design for ultra-low power consumption and improved reliability
- Reliable operation in harsh environments
- Outstanding optical throughput is achieved with VPG® and f/2 design.
- Covers wavelength ranges from 1100-2200 nm
- Designed for field battery operation

Fiber bundle options

Key Design Benefits:

- Ultra reliable Volume Phase Grating (VPG®)
- Optimized temperature control
- Solid-state electronics
- Hermetically sealed
- No moving parts

Order Info for Part No. NIRS

Note: fiber sold separately

Type	Code	Starting Wavelength	Code	Ending Wavelength	Code	Interface Type	Code	Interface Type	Code
Standard	SC	900 nm	0900	1700 nm	1700	25 µm	025	SMA905	SMA
Deep Cooled	DC	1100 nm	1100	2200 nm	2200	50 µm	050	FC	FC
		1250 nm	1250	2500 nm	2500	100 µm	100		
		specify nm	xxxx	specify nm	yyyy	200 µm	200		
code selection:		code selection:		code selection:		code selection:		code selection:	

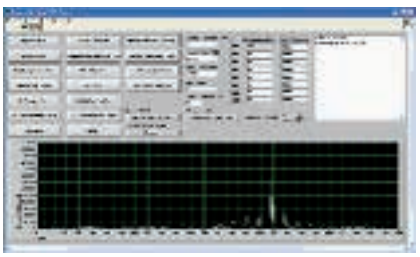
order code ex: NIRS-DC-1100-2200-050-SMA

Super Gamut™ NIRS-1100-2200

PERFORMANCE	
Wavelength Range	1100-2200 nm or customer specified
Spectral Resolution	5 - 20 nm slit and sensor dependent
Peak Wavelength (λpk) Nom.	1.7 µm
Signal / Noise	4000:1
Wavelength Calibration	Factory Calibrated, independent of operating temperature
Integration Time	20 µs to 30 seconds
Dimensions (stand-cooling option)	88 x 122 x 39 mm
Weight	650 g
OPTICS	
f/ number	f/2
Grating	Custom Volume Phase Grating (VPG®)
Entrance Aperture (µm)	25, 50, 100, 200, Fiber, or specify
Stray Light	0.05%
DETECTOR SPECS	
Detector Array	50 µm x 256 Pixel, 25 µm x 512 Pixel
Avg. Array Response @ λpk Min.	>9.0 nV/photon
Quantum Efficiency @ λpk Min.	60%
Response Non-uniformity, Max.	±10%
Readout Noise	800 electrons/scan typical
Max Dark Current	2.75 nA
Max Dark Voltage Rate	275 V/s
Saturation Charge (Typical)	$5x10^6$ electrons
Detector Gain	400 nV/electron typical
Detector	4 Stage TE cooled InGaAs
A/D Converter	16 bit
Power	1 A@12 V
COMPUTER	
Data Rate	Up to 5000 full scan/second
Data Ports	USB 2.0 (inquire on others)
Trigger Modes	Software or External TTL Controlled
Software	Spec 20/20 SDK LabVIEW supported
Operating System	Windows XP or later

Consider using with:

- Deep-cooled version
- *MiniLite*™ Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories



Spec 20/20 SDK available for ease of integration.

SuperGamut™ Turn-key Configuration Example

SuperGamut™ Deep Cooled NIR Spectrometer: 1100 to 2200 nm

BaySpec's SuperGamut™ series NIR Spectral Engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's NIR spectral devices utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The SuperGamut™ Series employs a highly efficient Volume Phase Grating (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a fiber optic input or slit optics arrangement based on customer preferences. The signal is spectrally dispersed with the VPG® and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Deep-cooled option shown

Stand-alone detector

Key Features

- Utilizes a unique deep-cooled InGaAs detector array for 8x sensitivity over conventional systems
- Hermetic sealing ensures reliable operation in harsh environments
- Outstanding optical throughput is achieved with VPG® and f/2 design
- Covers wavelength ranges from 1100-2200 nm
- Real-time spectral data acquisition with fast milli second response time

Key Design Benefits:

- Ultra reliable Volume Phase Grating (VPG®)
- 8-fold improvement in sensitivity
- Solid-state electronics
- Long life vacuum sealed detector
- No moving parts

Order Info for Part No. NIRS

Note: fiber sold separately

Type	Code	Starting Wavelength	Code	Ending Wavelength	Code	Interface Type	Code	Interface Type	Code
Standard	SC	900 nm	0900	1700 nm	1700	25 µm	025	SMA905	SMA
Deep Cooled	DC	1100 nm	1100	2200 nm	2200	50 µm	050	FC	FC
		1250 nm	1250	2500 nm	2500	100 µm	100		
		specify nm	xxxx	specify nm	yyyy	200 µm	200		
code selection:		code selection:		code selection:		code selection:		code selection:	

order code example: NIRS-DC-1100-2200-050-SMA

SuperGamut™ NIRS-DC-1100-2200

PERFORMANCE	
Wavelength Range	1100-2200 nm or customer specified
Spectral Resolution	6 - 20 nm slit and sensor dependent
Peak Wavelength (λpk) Nom.	1.7 µm
Signal / Noise	4000:1
Wavelength Calibration	Factory Calibrated, independent of operating temperature
Integration Time	20 µs to 1500 ms
Dimensions	Spectrograph: 88 x 122 x 39 mm Detector head: 167 x 103 x 84 mm
Weight	1.2 kg
OPTICS	
f/ number	f/2
Grating	Custom Volume Phase Grating (VPG®)
Entrance Aperture (µm)	25, 50, 100, 200, Fiber, or specify
Stray Light	0.05%
DETECTOR SPECS	
Detector Array	50 µm x 256 Pixel, 25 µm x 512 Pixel
Avg. Array Response @ λpk Min.	>9.0 nV/photon
Quantum Efficiency @ λpk Min.	60%
Response Non-uniformity, Max.	±10%
Readout Noise	180 µV rms typical 300 µV rms Max
Dark Noise	16 counts rms
Saturation Charge (Typical)	$5X10^6$ electrons
Detector Gain	400nV/electron typical
Detector	4 stage TE Deep Dooled InGaAs
A/D Converter	16 bit
Power	3.5 A@12 V detector 5.5 A TE cooler max. average 3.5 A
COMPUTER	
Data Rate	Up to 5000 full scans/sec.
Data Ports	USB 2.0 (inquire on others)
Trigger Modes	Software or External Trigger (TTL) Controlled
Software	Spec 20/20 SDK LabVIEW supported
Operating System	Windows XP or later

Consider using with:

- Standard Version
- *MiniLite*™ Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories

Spec 20/20 SDK available for ease of integration.

SuperGamut™ Turn-key Configuration Example

SuperGamut™ Deep Cooled NIR Spectrometer: 1250 to 2500 nm

BaySpec's SuperGamut™ series NIR Spectral Engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's NIR spectral devices utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The SuperGamut™ Series employs a highly efficient Volume Phase Grating (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a fiber optic input or slit optics arrangement based on customer preferences. The signal is spectrally dispersed with the VPG® and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Deep-cooled option shown

Key Features

- Utilizes a unique deep-cooled InGaAs detector array for 8x sensitivity over conventional systems
- Hermetic-sealing ensures reliable operation in harsh environments
- Outstanding optical throughput is achieved with VPG® and f/2 design
- Covers wavelength ranges from 1250-2500 nm
- Real-time spectral data acquisition with fast milli second response time

Stand-alone detector

Key Design Benefits

- Ultra reliable Volume Phase Grating (VPG®)
- 8-fold improvement in sensitivity over uncooled devices
- Solid-state electronics
- Long life
- No moving parts

Order Info for Part No. NIRS

Note: fiber sold separately

Type	Code	Starting Wavelength	Code	Ending Wavelength	Code	Interface Type	Code	Interface Type	Code
Standard	SC	900 nm	0900	1700 nm	1700	25 µm	025	SMA905	SMA
Deep Cooled	DC	1100 nm	1100	2200 nm	2200	50 µm	050	FC	FC
		1250 nm	1250	2500 nm	2500	100 µm	100		
		specify nm	xxxx	specify nm	yyyy	200 µm	200		
code selection:		code selection:		code selection:		code selection:		code selection:	

order code example: NIRS-DC-1250-2500-100-SMA

SuperGamut™ NIRS-DC-1250-2500

PERFORMANCE	
Wavelength Range	1250-2500 nm or customer specified
Spectral Resolution	10 - 20 nm slit dependent
Peak Wavelength (λpk) nom.	2.0 µm
Signal / Noise	500:1
Wavelength Calibration	Factory Calibrated, independent of operating temperature
Integration Time	20 µs to 400ms
Dimensions	Spectrograph: 91 x 122 x 47 mm Detector head: 167 x 103 x 84 mm
Weight	1.2 kg
OPTICS	
f/ number	f/2
Grating	Custom Volume Phase Grating (VPG®)
Entrance Aperture (µm)	25, 50, 100, 200, Fiber, or specify
Stray Light	0.05%
DETECTOR SPECS	
Detector Array	256 x 50 µm
Avg. Array Response @ λpk Min.	>4.0 nV/photon
Quantum Efficiency @ λpk Min.	70%
Response Non-uniformity, Max.	±10%
Readout Noise	180 µV rms typical, 300 µV rms Max
Max Dark Current	200 pA Typ. 800 pA Max.
Dark Noise	60 counts rms
Saturation Charge (Typical)	$187.5X10^6$ electrons
Detector Gain	320 nV/electron typical
Detector	4 stage TE Deep Cooled InGaAs
A/D Converter	16 bit
Power	3.5 A@12 V
COMPUTER	
Data Rate	Up to 5000 full scans/sec.
Data Ports	USB 2.0 (inquire on others)
Trigger Modes	Software or External Trigger (TTL) Controlled
Software	Spec 20/20 SDK LabVIEW supported
Operating System	Windows XP or later

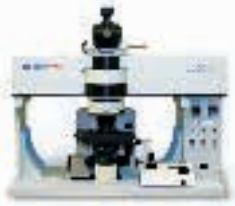
Consider using with:

- Deep-cooled Version
- *MiniLite*™ Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories

SuperGamut™ Turn-key Configuration Example

Spec 20/20 SDK available for ease of integration.

Raman Instrument Portfolio Guide

					
Agility™	*RamSpec*™	*RamSpec*™-HR	*Nomadic*™	*Nomadic*™ 3-in-1	*MovingLab*™
Transportable Benchtop Raman Analyzer	High-performance Benchtop Raman Instrument	High-resolution Benchtop Raman Instrument	Single-wavelength Confocal Raman Microscope	Multi-wavelength confocal Raman Microscope	Portable Raman microscope

See our new multi-wavelength *Nomadic*™ confocal Raman microscopes: high-resolution Raman microscopy integrated with multiple high-performance and cost-effective Raman dispersive spectral engines

page 20

Agility™ Raman Instrument:

Features:

- Single-band or dual-band
- Compact, transportable <16 lbs.
- Flexible quick-change sampling options (liquid, solid, pill/powder adapters)
- Optional fiber probe adapter

Application Examples

- Narcotics, Counterfeit Detection
- Drugs and explosives field detection
- Chemical identifications
- Pharmaceuticals
- Education

page 23

RamSpec™ Benchtop Instruments:

Features:

- Choice of excitation wavelengths: 532, 785, 1064 nm or custom
- Choice of spectral range and resolution
- OEM turn-key solutions
- Deep-cooled detectors
- High-resolution 1064 nm Raman available

Application Examples

- Fluorescence suppression
- Quantitative chemical analysis
- Petrochemical, oil exploration, mining
- Fuels and plant sample analysis

page 26

OEM Raman Engines

Features:

- Choice of excitation wavelength
- Choice of spectral range and resolution
- Choice of fiber Raman probes

Applications

- In-line monitoring
- Use in extreme environmental conditions
- Chemical reactors monitoring
- Fluorescence suppression
- Teaching instrumentation

page 27

Nomadic™ Raman Microscopes:

Features:

- True confocal microscope
- 532, 785 and 1064 nm excitation in one instrument
- High-resolution Raman imaging

Applications

- Chemical mapping
- Material science
- Biomedical research
- Forensic labs
- Fluorescence suppression

page 30

MovingLab™ Raman Microscopes:

Features:

- Portable, battery-powered
- Choice of 532, 785, 1064 nm wavelengths

Applications

- Field tests
- Research
- Thin-films
- Forensic labs
- Fluorescence suppression
- Authentification/ Anti-counterfeiting
- Teaching facilities

Agility™ Transportable Benchtop Raman Instrument

BaySpec's *Agility*™ transportable benchtop Raman instrument delivers high performance with extreme versatility in a ruggedized form factor.

At less than 10 in. x 12.5 in. x 5.5 in. and 16 lbs, *Agility*™ is a high-performance bench-top, yet completely portable Raman Analyzer. It is available in single-wavelength (532, 785, or 1064 nm) or dual-band (any two of 532, 785 and 1064 nm) versions. Its quick-change sampling options accommodate almost all measurements needs without any sample preparation.

Agility™ with sample down option

Key Features

- Transportable, compact system enables chemical detections in a lab or on the field.
- *Agility*™ offers the most versatile sampling options for vastly different sample conditions.
- World's only unique dispersive 1064 nm Raman delivers best signal for samples with fluorescence.
- Single-wavelength or dual-wavelength operational devices. Dual-band configuration expands analytical power significantly.
- Laser output power is continuously adjustable by the software.
- At the heart of every *Agility*™ there are highly transmissive VPG® gratings that deliver unsurpassed optical throughput.
- *Agility*™ has no moving parts and has its sensitive optical engine shock-resistant mounted, resulting in a ruggedized instrument that has withstood the rigors of field testing.
- *Agility*™ is operated by BaySpec's Agile 20/20 software that has an intuitive, streamlined user interface and can output data in .txt, .csv, or .spc format. Baseline correction function is intelligently built in, which greatly facilities reduction in fluorescence interference and accounts for drift in background.

Ideal Applications

Chemical identification
Field inspections
Quality Control/Assurance
Surface Enhanced Raman (SERS)

Agility™ Specifications

Model	Agility-532	Agility-785	Agility-1064	Agility-532/1064	Agility-785/1064
	Single-wavelength			Dual-band	
OPTICAL					
Excitation Wavelength	532 nm	785 nm	1064 nm	532 and 1064 nm	785 and 1064 nm
Wavelength Range	100 to 3500 cm^{-1}	100 to 2300 cm^{-1}	100 to 2300 cm^{-1}	100 to 3500 cm^{-1} (532 nm); 100 to 2300 cm^{-1} (785 and 1064 nm)	
Resolution	9 to 12 cm^{-1}	6 to 9 cm^{-1}	12 to 17 cm^{-1}	9 to 12 cm^{-1} (532 nm); 6 to 9 cm^{-1} (785 nm);12 to 17 cm^{-1} (1064 nm)	
Laser Power (adjustable)	0~50 mW	0~450 mW	0~450 mW	0~50 mW (532 nm); 0~450 mW (785 and 1064 nm)	
Spectrograph	f/2; Transmissive VPG®				
Integration Time	5 ms to 600 s	5 ms to 600 s	1 ms to 20 s	5 ms to 600 s (532 and 785 nm); 1ms to 20 s (1064 nm)	
Wavelength Calibration	Automatic				
Detector Array	2048 px CCD	2048 px CCD	256 px InGaAs	2048 px CCD (532 and 785 nm), 256 px InGaAs (1064 nm)	
Cooling	2 stage TE (cooling time < 1 min)				
PHYSICAL					
Dimensions: mm; in	305(d) x 380(w) x 168(h); 10 x 12.5 x 5.5				
Weight	14 lb			16 lb	
Operating Ranges	0 to 45°C; 0 to 95% RH				
ELECTRICAL					
A/D Converter	16 bit				
Power Consumption	< 25 W			< 30 W	
Battery (optional)	Lithium ion, 4 hr battery life			Lithium ion, 3 hr battery life	
SAMPLING OPTIONS					
Fiber Probe	Coaxial, AR coated, filtered				
Liquid Sample Holder	Holds vials, tubes, cuvettes				
Pill Holder	Solid or liquid pills and capsules				
Solid Sample Holder	Upright or inverted options				
COMPUTER					
Operating System	Windows-based (32 or 64 Bit)				
System Control	Onboard touchscreen or external PC				
GUI	Agile 20/20 Windows XP/Vista/7				
Data Ports	USB 2.0				
Security	Tiered password structure (3 levels), event logging and reporting				
Internal Storage	16 GB				
Wireless Connectivity	WiFi (optional)				
Spectral Libraries	BaySpec Factory Library, user-defined, 3rd party options				

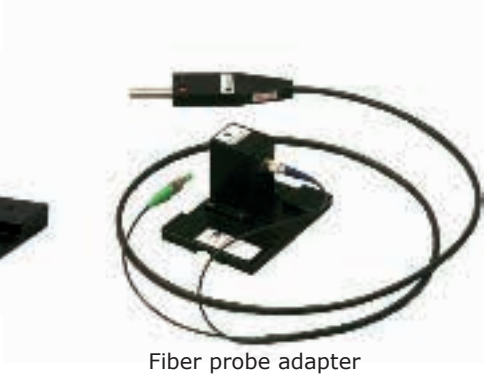
Agility™ Quick-Change Sample Options

Agility™ series offers users the most versatile sampling options available, with a number of magnetically coupling inserts that can be rapidly exchanged within the base system. These inserts maintain the precise optical alignment necessary to ensure high-quality spectral acquisition, and accommodate a number of sample types. These options include vial and cuvette holders for liquids and powders, a fiber adapter for attachment of a remote fiber probe, a solid sample insert with upright or inverted configuration, and a pill holder for capsules and pills.

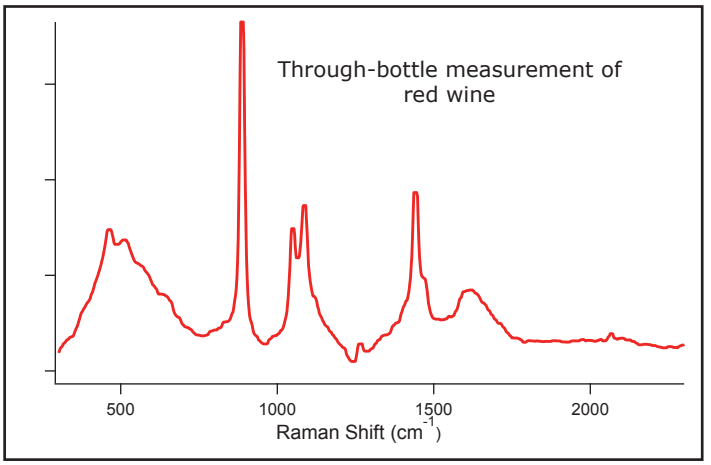
Liquid-vial insert

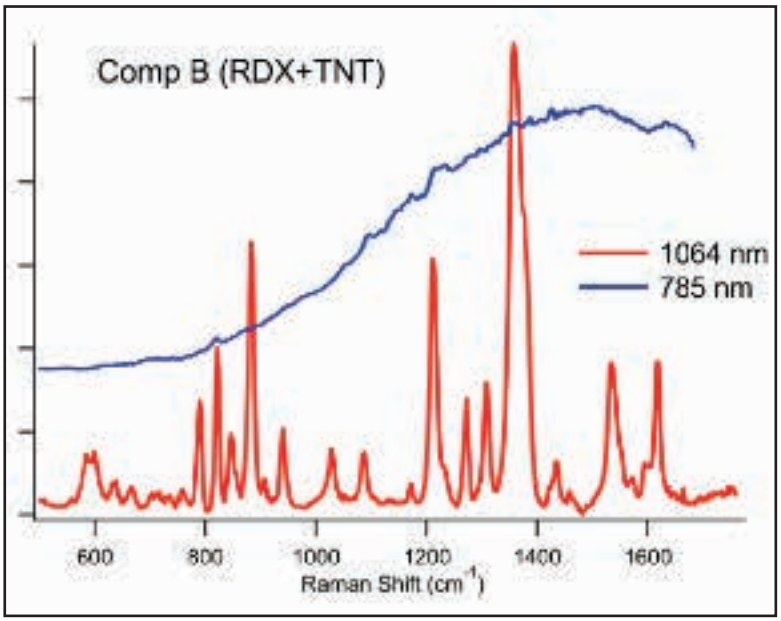
Solid sample insert

Pill holder

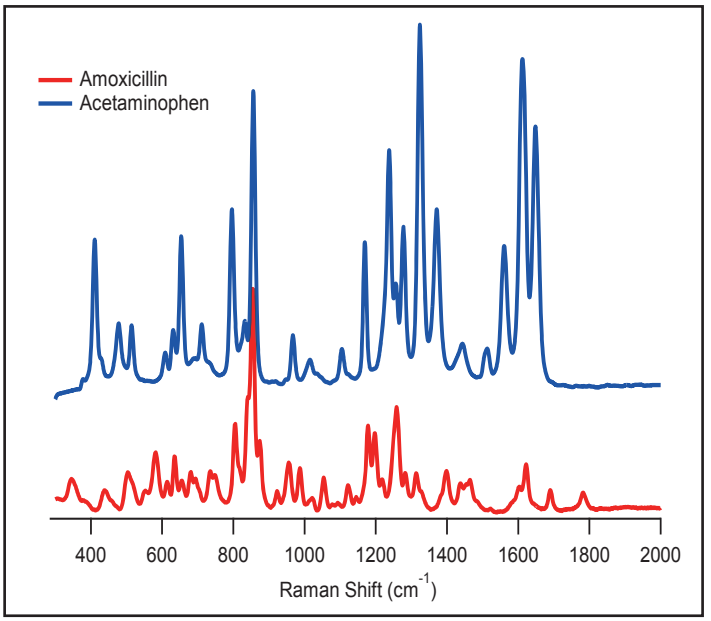


Fiber probe adapter





Explosive measurement. 1064 nm Raman produces the best spectrum due to fluorescence suppression.



Pharmaceuticals measurement using 785 nm wavelength.

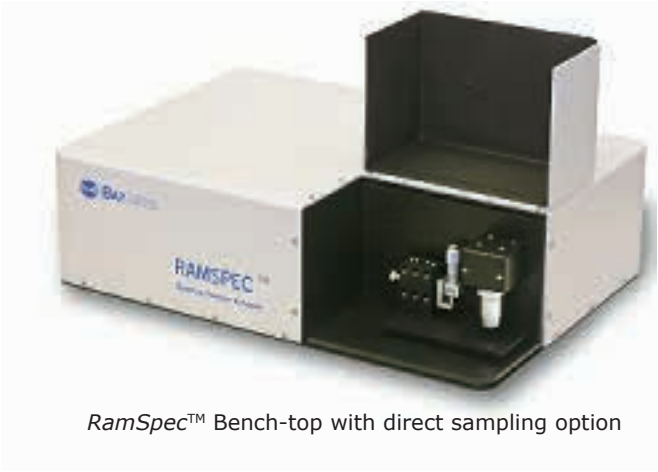
RamSpec™ Bench-top Raman Instruments

BaySpec's *RamSpec*™ Raman Instrument delivers high sensitivity, performance, and repeatability in an affordable, ruggedized form factor.

The *RamSpec*™ Raman Instrument, being the most compact instrument in its class, is equipped with a high- performance Raman spectral engine. Aided by a 2048 element CCD array or 512 InGaAs detector thermo-electrically cooled to less than –55 °C, the *RamSpec*™ delivers full spectral coverage (300 to 3200 cm^{-1}) with up to 4 cm^{-1} resolution. The *RamSpec*™ can be integrated with a 532, 785 or 1064 nm excitation source, offering unprecedented flexibility and versatility in a laboratory setting.

RamSpec™ Bench-top with quick-change sample options

Raman probe (**see page 79 for Raman probes**)



RamSpec™ Bench-top with direct sampling option

Key Features

- Quick-change sample options, including Raman fiber probe and direct sampling options available. Minimal or no sample preparation is required.
- Deep-cooled detectors (-55°C) offer the best signal-to-noise ratio.
- Laser output power can be continuously adjusted from 0 to 500 mW. High-power (up to 2 W) option available.
- Innovative 512-pixel deep-cooled InGaAs array detectors are equipped for 1064 nm systems, which offer spectral coverage and signal-to-noise ratios previously only available from FT-Raman systems.
- *RamSpec*™ has no moving parts and has its sensitive optical engine shock-resistant mounted, resulting in a ruggedized instrument that has withstood the rigors of field testing.
- BaySpec's Micro 20/20 software has an intuitive, streamlined user interface with powerful functionalities such as baseline correction, multiple file format support, continuously background subtraction, automatic data save, peak identification, and integration, overlay of spectra, and arithmetic operations. Optional Raman spectral libraries available.
- High-resolution 1064 nm dispersive Raman system available (*RamSpec*™-HR).

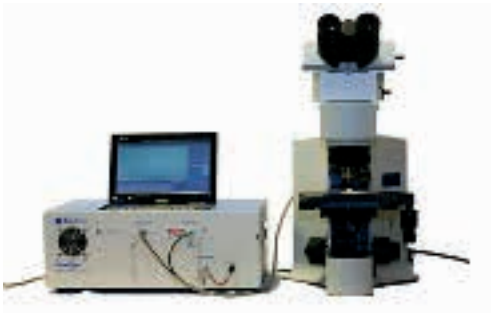
Ideal Applications

Polymorphs classification
Lubricant and fuel analysis
Trace contamination identification
Geochemical applications
Forensic laboratories
Chemical/Biotech research facilities
In-line process monitoring

RamSpec™ Specifications

Model	RamSpec-532	RamSpec-785	RamSpec-1064
SIZE			
Dimensions (mm)	432 (17 in) x 305 (12 in) x 178 (7 in)		
Weight	11 Kg (25 lbs.), 13 Kg (28 lbs.) for direct sampling option		
LASER			
Wavelength	532 nm	785 nm	1064 nm
Power	0-100 mW	0 - 500 mW	0 - 500 mW
SPECTROGRAPH			
Grating Technology	f/2; Transmissive VPG®		
Range*	100-3200 cm^{-1}	100-3200 cm^{-1}	200-1800 cm^{-1} (optional 200-3200 cm^{-1})
Spectral Resolution	4-5 cm^{-1}	4-5 cm^{-1}	6-8 cm^{-1} (10-15 cm^{-1} for 200-3200 cm^{-1} range)
Entrance Slit	25, 50, 100, or 200 µm		
Wavelength Calibration	Automatic		
DETECTOR			
Type	CCD	CCD	InGaAs
Number of Pixels	2048	2048	512
Cooling	TE cooled to -55 °C		
Integration Time	20 ms - 600 sec.	20 ms - 600 sec.	20 ms - 60 sec.
Digitized Output	16 bit		
PROBE			
Design	Coaxial, AR coated, filtering for optimal performance Fiber optic FC/APC or custom		
ELECTRONICS			
Interface	Internal PC or external PC via USB 2.0		
Input Power	110 to 240 V AC		
Power Consumption	< 25 W		
SOFTWARE			
GUI	Micro 20/20 for Windows XP/Vista/7		
SDK	DLL, sample code for VC and LabVIEW		
Spectral libraries	BaySpec Factory Library, user-defined, 3rd party options		

* Contact BaySpec for custom wavelength ranges.



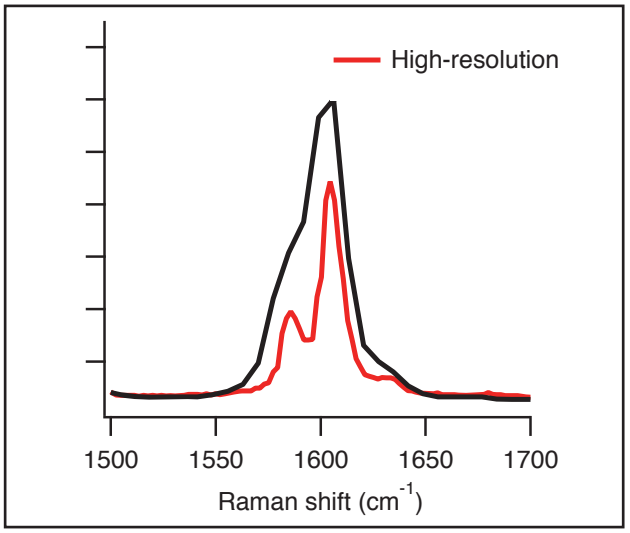
Already have a microscope? -- We can retrofit any commercially available microscope with one of our Raman engines, please contact us.

RamSpec™ High-resolution 1064 Raman Analyzer

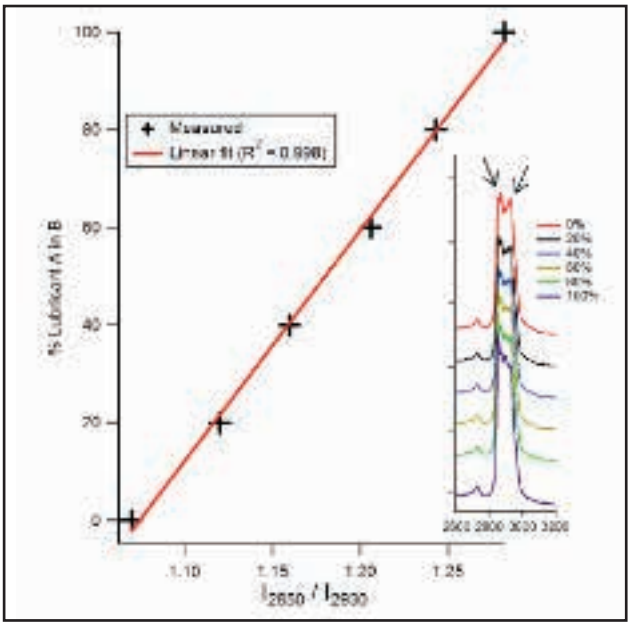
BaySpec's *RamSpec*™-HR high-resolution 1064 Raman analyzer is integrated with three highly efficient VPG® gratings and a deep-cooled InGaAs detector to produce high-resolution (4 cm^{-1}) and high-quality dispersive 1064 Raman spectra. Its sampling stage can accommodate both optical-fiber based Raman probe and direct sampling options. Integrated Spec 20/20 software manages automatic switching of the gratings to provide full-range, high-resolution dispersive 1064 nm Raman spectra simultaneously.

RamSpec™ high-resolution 1064 Raman analyzer is the ultimate solution for high-quality Raman measurements on samples with high photoillumination background. It offers spectral quality parallel to FT-Raman systems but only requires minimal or no sample preparation.

Model	RamSpec-HR-1064
SIZE	
Dimensions (mm)	534 (21 in) x 534 (21 in) x 305 (12 in)
Weight	22 Kg (50 lbs.)
LASER	
Wavelength	1064 nm
Power	0 - 500 mW (high-power option available)
SPECTROGRAPH	
Grating Technology	f/2; Transmissive VPG®
Range	200-3200 cm^{-1}
Spectral Resolution	4 -5 cm^{-1}
Entrance Slit	25, 50, 100, or 200 µm
Wavelength Calibration	Automatic
DETECTOR	
Type	InGaAs
Number of Pixels	512
Cooling	TE cooled to -55 °C
Integration Time	20 ms - 60 sec.
Digitized Output	16 bit
PROBE	
Design	Coaxial, AR coated, filtering for optimal performance Fiber optic FC/APC or custom
ELECTRONICS	
Interface	External PC via USB 2.0
Input Power	110 to 240 V AC
Power Consumption	< 85 W
SOFTWARE	
GUI	Spec 20/20 for Windows XP/Vista/7
SDK	DLL, sample code for VC and LabVIEW
Spectral Libraries	BaySpec Factory Library, user-defined, 3rd party options



High-resolution spectrum provides high specificity in chemical analysis



Quantitative analysis of a mixture of two industry lubricants.

OEM and PAT/In-line Process Raman Engines

BaySpec's OEM Raman engines based on highly-efficient VPG® gratings are featured with high throughput, fast optics and high reliability. For the past decade BaySpec has been a leader in low-cost, high-volume manufacturing in the spectroscopy industry and a reliable OEM partner for some of the Fortune 500 companies in the world. We understand what it takes to initiate and sustain a win-win partnership and thrive in an extremely competitive marketplace.

With a dedicated and experienced team of instrumentation engineers and scientists, BaySpec has delivered over 15,000 spectroscopic devices to leading companies and research institutions around the world. Whether you need a unique laser wavelength or power, or a specific wavelength coverage and spectral resolution, or special mechanical dimensions, please contact us. We have the reputation for providing affordable, high-quality, customized spectroscopic solutions to our customers. Contact us with your OEM opportunities, whether it is a well established product or a brand new application, we are open-minded and thrive to create a long lasting and mutually beneficial relationship with you.

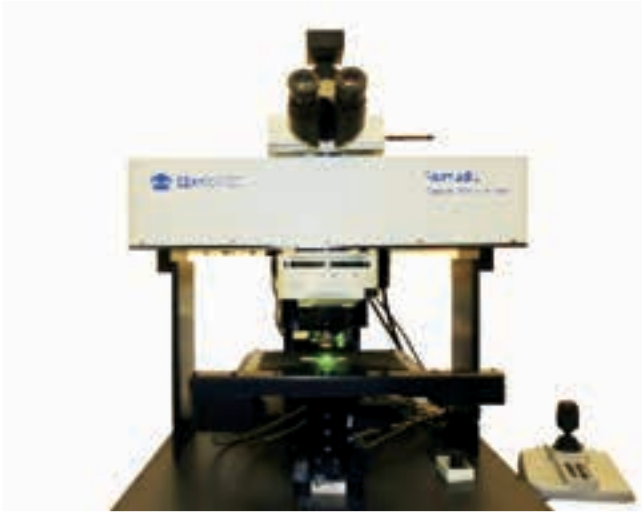
OEM Raman engines

Ask about our NEMA, IP65 ruggedized, waterproof enclosures for GmP ready in-line process monitoring solutions

Nomadic™ Multi-excitation Confocal Raman Microscope

The *Nomadic*™ is the only Raman microscope available today simultaneously equipped with three excitation sources (532, 785, and 1064 nm) covering VIS-NIR.

The newly developed *Nomadic*™ from BaySpec, Inc. is the only available dispersive Raman microscope simultaneously equipped with three laser excitations from the visible to the NIR (532, 785, and 1064 nm, or custom). This research-grade Raman microscope offers unmatched sensitivity and speed via highly efficient, proprietary volume phase grating (VPG®) technology, ultrafast electronics, and high sensitivity, deep cooled CCD and InGaAs detectors for a full spectral range of 400-1700 nm. Each *Nomadic*™ system consists of the dedicated spectrometers for each laser excitation ensuring optimal spectral coverage and resolution with maximum sensitivity and versatility. Coupled to a research grade Olympus® microscope, the modular design of the *Nomadic*™ allows measurements beyond conventional Raman imaging, such as micro-VIS/NIR, dark field Rayleigh scattering, photoluminescence imaging, and AFM-Raman. Along with multivariate image analysis software, Raman imaging has never been easier with fully automated laser switching, laser power attenuation, and confocal parameter adjustment. The novel *Nomadic*™ system is the ultimate tool for the most challenging Raman analyses in biomedical research, material characterization, and forensic science especially when 1064 nm Raman can overcome fluorescence background.



Single-wavelength configuration (model shown here is customized for wafer inspection)

Three wavelength (532, 785 and 1064 nm) configuration (*Nomadic*™ 3-in-1)

Application examples:

- Research labs
- Raman chemical imaging
- Biology and material science research
- Pharmaceuticals
- Wafer inspection
- Forensic Labs

Key features

- Unique multi-wavelength configuration
- Confocal optical design
- Fully automated operation
- Eyepiece interlock and enclosure for maximum laser safety (laser safety level 1 with enclosure)
- Fluorescence suppression by 1064 nm Raman

Nomadic™ Raman Microscope Specifications

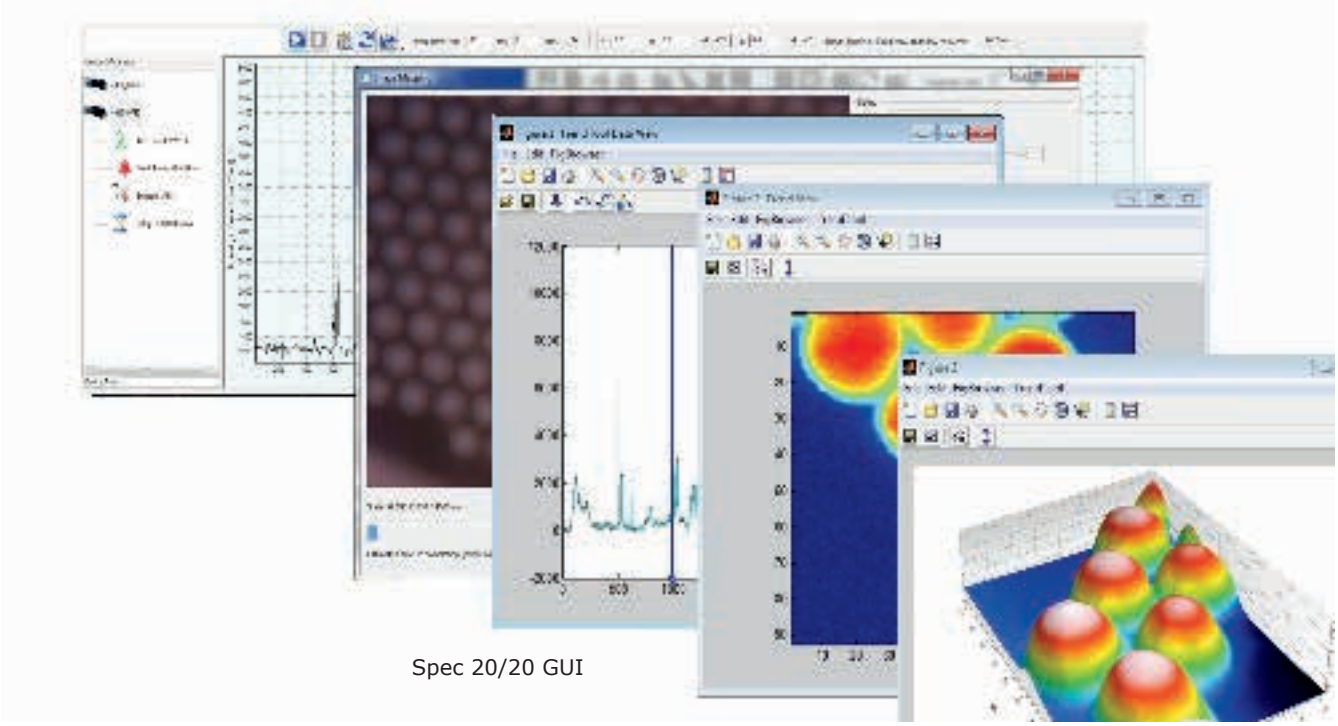
MICROSCOPE			
Base	Upright Olympus BX51, or Nikon Eclipse, or custom		
Objectives	5 position turret with objectives up to 100X		
Confocality	Confocal achieved with slit and binning adjustment		
Camera	1392 X 1040, 4.65 X 4.65 µm sensor, Up to 22 fps		
Stage	Multi-Axis stage fully software-controlled		
Stage Movement	75 mm X 50 mm travel range (long-range optional) with 0.1 µm (20 nm optional) steps		
SIZE	3-in-1	Single-wavelength	
Dimensions (mm)	1920 X 620 X 920 (75 in X 24 in X 36 in)	820 X 620 X 920 (32 in X 24 in X 36 in)	
Weight	68 Kg (150 lbs.)	37 Kg (80 lbs.)	
LASERS			
Wavelength	532 nm	785 nm	1064 nm
Power (max.)	100 mW	100 mW	500 mW
SPECTROGRAPH			
Grating Technology	f/2; Transmission Volume Phase Grating (VPG®)		
Range	100 - 3200 cm^{-1}	100 - 3200 cm^{-1}	200-1800 cm^{-1}
Spectral Resolution	4-5 cm^{-1}	4-5 cm^{-1}	6-8 cm^{-1}
High-Resolution Option	2 cm^{-1}	2 cm^{-1}	4 cm^{-1}
Spatial Resolution	up to 0.5 µm	up to 1 µm	up to 2 µm
DETECTOR			
Type	TE cooled CCD	TE cooled CCD	TE cooled InGaAs
Number of Pixels	2048 × 64	2048 × 64	512
Pixel Size	14 µm	14 µm	25 µm
Cooling	-55 °C		
Integration Time	0 ~ 600 sec.	0 ~ 600 sec.	0 ~ 60 sec.
Digitized Output	16-bit		
ELECTRONICS			
Interface	USB 2.0 for external PC		
Input Power	110 to 220 V AC		
Laser Switch	Push-button switch, software switch, eyepiece interlock		
Power Consumption	< 200 W		
SOFTWARE			
GUI	Spec 20/20 for Windows XP/Vista/7		
SDK	DLL, sample codes for VC and LabVIEW		
Spectral Libraries	User built or 3rd party (optional)		
Chemometrics Tool	Eigenvector Solo+MIA (options available)		

Nomadic™ 3-in-1 with enclosure

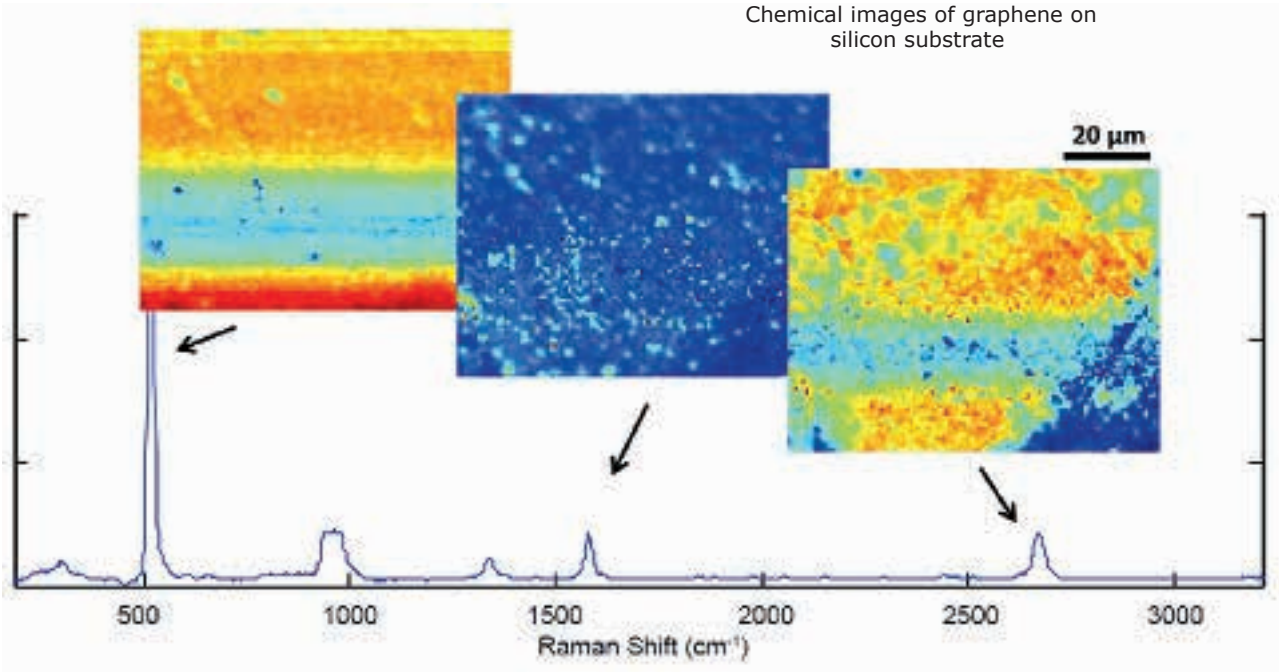
Chemical Imaging at Your Fingertips

Combining the power of optical microscopy and Raman spectroscopy in a confocal geometry, the *Nomadic*™ provides molecular Raman fingerprint information on every point of the sample, with sub-micrometer spatial resolution. It accommodates samples in solid, powder, liquid, or gel forms with minimal preparation. Depending on the nature of the sample, you may choose 532 nm excitation for its high sensitivity or 1064 nm excitation to suppress fluorescence or 785 nm to balance both concerns, with an easy click of a button.

Nomadic™ offers high-resolution, nondestructive chemical imaging. Differences in chemical composition and structure on a sample can be vividly revealed in its chemical image automatically – features that are often completely invisible in optical imaging. Moreover, confocality with powerful 3D chemical mapping capability combined with flagship chemometrics software for analysis such as PCA and MCR, enables both easy measurements and practical data display/manipulation in seconds.



Spec 20/20 GUI



Chemical images of graphene on silicon substrate

MovingLab™ Portable Raman Microscope

***MovingLab*™ is the first Raman microscope on the market offering portable 532, 785, or 1064 nm Raman microscopy for measurements on the go.**

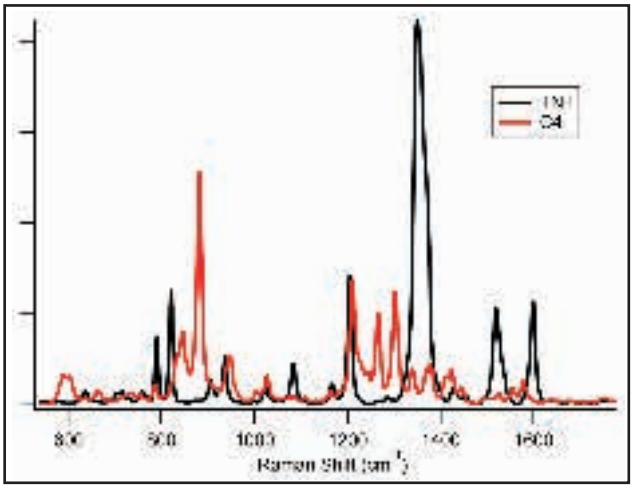
The battery-powered *MovingLab*™ is equipped with a dedicated spectrograph and detector in a compact microscope. All the spectrographs are equipped with highly efficient transmission VPG® gratings that deliver unsurpassed optical throughput. The *MovingLab*™ has no moving parts in its build, and has its sensitive optical engine shock-resistant mounted, resulting in a ruggedized instrument that has withstood the rigors of field testing. The *MovingLab*™ is run by BaySpec's Micro 20/20 software that has an intuitive, streamlined user interface and supports multiple file formats.

Applications:

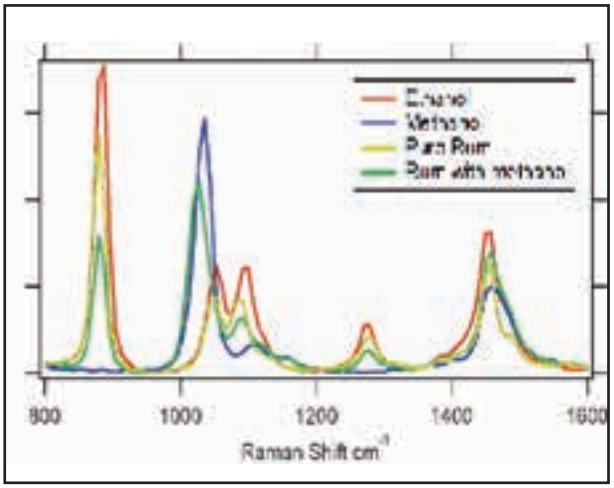
- Field testing
- Forensics
- Thin-film
- Authentification/ Anti-counterfeiting
- Teaching instrumentation
- Remote laboratories

Benefits

- Portable, battery-powered
- Choose a wavelength of 532 nm, 785 nm, 1064 nm or custom
- High throughput Volume Phase Grating (VPG®)
- TE-cooled high-sensitivity detectors
- Optional battery backup
- Fluorescence suppression with 1064 nm wavelength for samples with high fluorescence background



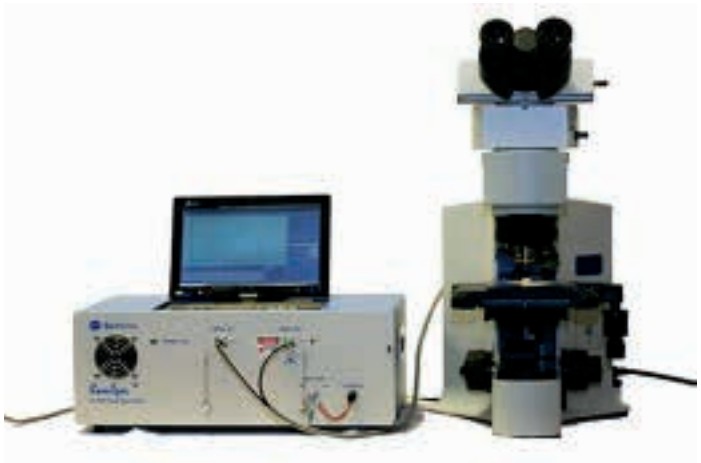
Measurements of explosives using 1064 nm Raman



Counterfeits (Rum) detection using 1064 nm Raman

MovingLab™ Raman Microscope

SIZE			
Dimensions (mm)	305 x 305 x 381 (12 in x 12 in x 15 in)		
Weight	6.8 kg (15 lbs.)		
LASERS			
Wavelength	532 nm	785 nm	1064 nm
Power Output (max)	50 mW	500 mW	400 mW
SPECTROGRAPH			
Grating Technology	f/2; Transmission Volume Phase Grating (VPG®)		
Range (785 nm)	100 - 3200 cm^{-1}	100 - 2300 cm^{-1}	100-2300 cm^{-1}
Spectral Resolution (cm^{-1})	9-12 cm^{-1}	6-9 cm^{-1}	12-17 cm^{-1}
DETECTOR			
Type	TE cooled CCD	TE cooled CCD	TE cooled InGaAs
Number of Pixels	2048	2048	256
Cooling	-20 °C	-20 °C	-20 °C
Integration Time	0 - 600 sec.	0 - 600 sec.	0 - 20 sec.
Readout Speed	250 kHz		
Digitized Output	16-bit		
ELECTRONICS			
Interface	Internal PC, and USB 2.0 for external PC		
Input	110 to 220 V AC		
Battery (optional)	Lithium ion, 3 hr battery life		
SOFTWARE			
GUI	Micro 20/20 for Windows XP/Vista/7		
SDK	DLL, sample code for VC and LabVIEW		
Spectral libraries	User built or 3rd party (optional)		



Already have a microscope? -- We can retrofit any commercially available microscope with one of our Raman engines, please contact us.

Speed, Resolution, Proven

- High efficiency *Volume Phase Gratings*
- Spectral Domain, Fast f/2 Optics
- Ruggedized, No moving parts
- Customizable Wavelength and Bench
- Fully Aligned Camera/Spectrograph
- Ultra fast 41k-140k/lines/sec

BAYSPEC

Gratings | Spectrographs | Cameras | Sources
Integrated Spectral Engines | Custom Engines

Optical Coherence Tomography (OCTS) Portfolio Guide

		
OCTS-800	OCTS-1050 or 1310	OCTS-xxxx
Spectral Domain Optical Coherence Tomography Engine, ~800nm or custom	Spectral Domain Optical Coherence Tomography Engine, ~1050nm or ~1310 or custom	Spectral Domain Optical Coherence Tomography Engine, selectable center and total wave-length range; adaptable to any camera

page 34

DeepView™ OCT NIR ~800nm Engines

Features

- Optimized for ~800nm sources
- Factory aligned for life

Applications

- Fourier or Spectral-Domain Optical Coherence Tomography (SD-OCT)
- High-resolution spectral OCT in retinal diagnostics and measurements in ophthalmology
- Catheter/Endoscopic SD OCT image-guided diagnostics, image-guided surgery, and image-guided therapy
- In vivo and in vitro operation room and surgical procedure Quality Assurance

page 36

DeepView™ OCT SWIR~1050nm/1310nm Engines

Features

- Optimized for ~1050 or 1310nm sources
- Factory aligned for life

Applications

- Long-wavelength Fourier or Spectral-Domain Optical Coherence Tomography (SD-OCT)
- In vivo and in vitro cardiovascular medical diagnostics and imaging
- Non-invasive skin cancer and skin disease diagnostics and detection
- Industrial applications combustion engine analysis

DeepView™ OCT NIR~800nm Spectral Domain OCT Engine

BaySpec's all new *DeepView*™ Fourier or Spectral-Domain (SD) OCT NIR ~800nm Series Spectral Engine incorporates a high speed digital line scan camera with a robust *VPG*®-based spectrograph simultaneously covering multiple wavelengths for precise and rapid optical coherence tomography measurements.

The ***DeepView***™ spectral engine provides convenience for researchers and OEM users assembling fourier or spectral-domain optical coherence tomography (SD-OCT), white light interferometry (WLI) or VIS-NIR spectroscopy systems. This flat-field spectral analyzer design is based on highly efficient transmission *Volume Phase Grating* (VPG®) and mounts on an ultra fast digital line scan camera. The spectral engine accepts single-mode fiber optic inputs and is customizable via grating inserts to match the spectral bandwidth and center wavelength of the users' light source.

The OCT-NIR 800 Series spectral engine employs a highly efficient *Volume Phase Grating* (VPG®) as the spectral dispersion element and an ultra sensitive pixel CMOS detector array as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. The signal is spectrally dispersed with the VPG®, and the diffracted field is focused onto the CMOS array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Shown with example camera

Key Features

- Ruggedized for long-term reliability and stability
- Highly-efficient, high-resolution *Volume Phase Grating* (VPG®)
- Flexible options for center wavelength and spectral bandwidth, selectable at time of order; contact factory for custom solutions and packaging different camera types.
- Grating and optical bench customizable for your light source and application
- Single-mode fiber coupled input
- Mounted on digital line scan camera of choice

Key design benefits:

- Long-term stability
- Factory calibrated
- High throughput Volume Phase Grating (VPG®)
- Fast optics
- No moving parts

Example spectrograph specifications (customizable)

Optical	Data
Image plane size [1]	26 mm wide
Optical spot size (single mode fiber)	10 µm across detector
Vertical positioning stability	≤5 µm over time
Alignment access [2]	Tip and tilt Camera fine rotation to level spectrum with detector array
Aperture (f number)	f/4
Focal length (nominal)	100 mm
Single fiber input	to read 1 spectra
Mechanical	**Data**
Length x Width x Height	9.1 x 8.3 x 12.0 cm 3.60 x 3.28 x 4.72 in Height includes fiber mount and camera mounting plate
Weight	< 900 g (spectrograph) < 220 g (camera)
Fiber optic interface	Keyed FC/APC (inquire about PM or alternate types)
Camera compatibility	AViiVA SM2 CL spL4096-140k others upon request
Focus adjustment	Available

[1] with single-mode fiber input (core diameter of 5 µm)
[2] Full alignment procedures shipped with spectrograph

Consider using with:

- Fast Digital Line Scan Cameras, we can customize to any available model
- Mini-Wide Light Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories

Ordering Information:

(grating options - ordering suffix [3], other options by request)

	-780-840-900
Center wavelength (nm)	840
Bandwidth (nm) [4]	120
Wavelength range (nm)	780-900
Wavelength dispersion (nm_{avg}/pixel) [5]	0.10
Stray light (% of peak 100 pixels away [6])	0.1%

[3] Spectrometer model number is OCTS-XXX-YYY-ZZZ;
XXX with starting wavelength,
YYY with nominal center wavelength,
ZZZ with ending wavelength
[4] Over 20 mm image plane
[5] With 10 µm pixel pitch
[6] Test laser wavelengths used: 800nm, as appropriate for grating option selected

Camera evaluation software available for application development

Specifications are subject to change without notice.

DeepView™ OCTS SWIR Series Spectral Engine

BaySpec's all new *DeepView*™ Fourier or Spectral-Domain OCT Spectral Engine is an InGaAs line scan camera with an integrated *VPG*®-based Spectrograph simultaneously covering multiple wavelengths for precise and rapid optical coherence tomography measurements.

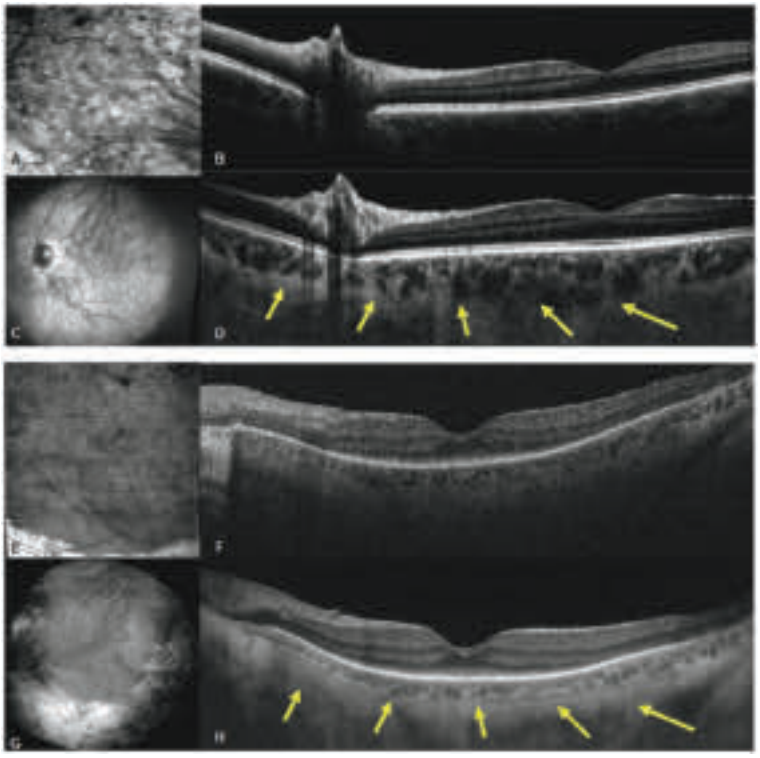
The *DeepView*™ Spectral Engine provides convenience for researchers and OEM users assembling spectral-domain optical coherence tomography (SD-OCT), white light interferometry (WLI) or NIR spectroscopy systems. This flat-field spectral analyzer design is based on highly efficient transmission *Volume Phase Grating* (VPG®) and mounts on a family of digital line scan cameras covering wide wavelength ranges. The spectrometer accepts fiber optic inputs and is customizable via grating inserts to match the spectral bandwidth and center wavelength of the users' light source.

The OCTS NIR Series spectral engine employs a highly efficient *Volume Phase Grating* (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. The signal is spectrally dispersed with the *VPG*®, and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Sensors Unlimited GL2048L-10 camera shown

Key Features

- Rugged and reliable spectrometer featuring no moving parts
- Highly-efficient, high-resolution *Volume Phase Grating* (VPG®)
- Flexible options for center wavelength and spectral bandwidth, selectable at time of order; contact factory for custom solutions and packaging with NIR camera.
- Grating and optical bench customizable for your light source and application
- Single-mode fiber coupled inputs; other input fiber options available



3D Optical Coherence Tomography (OCT) at 800 and 1060nm of (a)–(d) a normal retina and (e)–(h) a patient with retinitis pigmentosa. (a, e) En-face zoomed-in fundus image of the choroid using 1060nm 3D OCT. Arrows indicate enhanced choroidal visualization. (courtesy Cardiff University)

DeepView™ OCTS SWIR Series Spectral Engine

Optical	Data
Image plane size [1]	26 mm wide
Optical spot size (single mode fiber)	25 µm diameter
Aperture (f number)	f/4
Focal length (nominal)	100 mm
Mechanical	**Data**
Length x Width x Height	120 x 80 x x 170 mm Height includes fiber mount and camera mounting plate (size subject to change based on specifications)
Weight	< 800 g (spectrometer only) < 450 g (camera)
Fiber optic interface	Keyed FC/APC (inquire about PM or alternate types)
Camera mount	Optional
Camera compatibility	SU1024LDH2-1.7RT-0500/LC, inquire on other types

[1] with single-mode fiber input (core diameter of 9 µm)

Consider using with:

- Fast Digital Line Scan Cameras
- Mini-Wide Light Sources
- ASE Light Sources
- Fiber-optic Bundles & Accessories

Key design benefits:

- No moving parts
- High throughput Volume Phase Grating (VPG®)
- Temperature Controlled
- Factory calibration

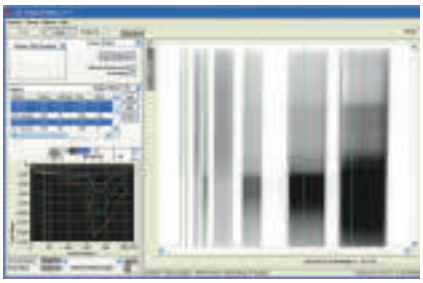


Image Analysis software with each spectral engine purchase

Sensors Unlimited LDH2 camera shown

Ordering Information (customizable):
(grating options - ordering suffix [2], other options by request)

	-1280-1310-1340
Center wavelength (nm)	1310
Bandwidth (nm) [3]	60 or custom
Wavelength range (nm)	1280 (0px) – 1340 (~1024px)
Wavelength dispersion (nm_{avg}/pixel) [4]	0.05
Wavelength dispersion (nm_{avg}/pixel)	1.95
Stray light (% of peak 100 pixels away [6])	0.1%

[2] Spectrometer model number is OCTS-XXX-YYY-ZZZ;
XXX with starting wavelength,
YYY with nominal center wavelength, and
ZZZ with ending wavelength
[3] Over 25.6 mm image plane
[4] With 25 µm pixel pitch
[5] Test laser wavelengths used: 1064nm, 1310nm, or 1550nm as appropriate for grating option selected

Custom OCT Engine


VPG™ Technology
Nunavut™ Raman Series
NIR Raman Spectral Engines
Optimized throughput. Cost effective. Rugged.
BaySpec's Nunavut™ Series Raman Sprectral Engines.
Optimal throughput for the most dynamic spectral conditions.
• High efficiency VPG™ and F/2 optics ensure faster data acquisition
• Accurate and repeatible measurements through temperature compensated design
• Covers 1064-1720 nm (up to 3200 cm-1)
• Compatible with leading cameras
• Ideal for 1064nm Laser Excitation for reduced fluorescence interferences
BAYSPEC

Deep Cooled Cameras & Detectors - Visible Near Infrared (NIR)

		
Part Code	VCAM-S	NCAM
Description	Visible-NIR (CCD) Cameras	Near-Infrared (NIR) Cameras
Part Number Series	VCAM-S-10 VCAM-S-20	NCAM-1.7-02 NCAM-1.7-05 NCAM-1.7-10 NCAM-2.2-02 NCAM-2.2-05 NCAM-2.5-02

page 40

Nunavut™ Visible-NIR CCD 200-1100nm

Applications

- Pharmaceuticals
- Agricultural toxicity studies
- Semiconductors
- Beverage & Brewery
- Cosmetics
- Explosives detection
- Law Enforcement
- Mining & Oil Exploration
- Biomedical Research

Suggested For Use with:

- SuperGamut™ Spectrographs
- Turn-key Solutions

page 42

Nunavut™ InGaAs 900~2500nm

Applications

- Long Wave Raman & NIR Spectroscopy
- Medical Diagnostics
- Water Quality
- Semiconductors
- Beverage & Brewery
- Cosmetics
- Homeland Security
- Petrochemical
- Counterfeit Detection
- Pulp & Paper
- Biomedical Research

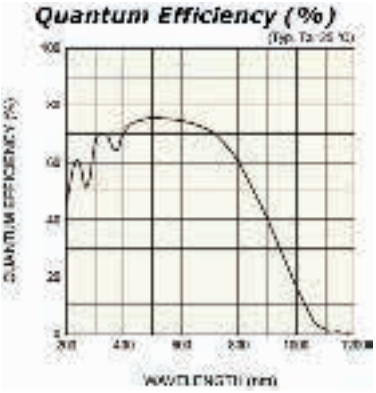
Suggested For Use with:

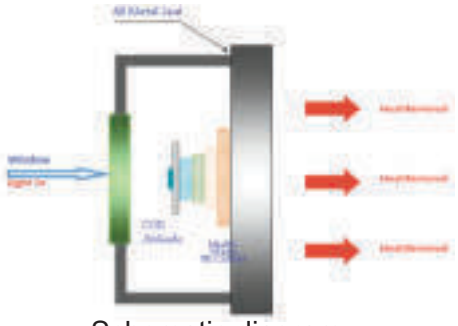
- SuperGamut™ Spectrographs
- Turn-key Solutions

Visible-NIR Nunavut™ Deep Cooled CCD Camera 200 to 1100nm

Nunavut™ series Deep Cooled CCD detectors are designed to meet real-world challenges for best-in-class performance, long term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's CCD cameras utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The Nunavut™ Series employs the latest in opto-electrical components to bring you the very best capability at a very affordable price. When matched to the Nunavut™ Raman spectrograph you have a light weight, very high performance, cost effective instrument. Each camera and spectrograph is calibrated in the factory after extensive thermal cycling. The control electronics read out the compressed digital signal to extract required information. Both the raw data and the processed data are available to the host.





Schematic diagram

Key Features

- Covers wavelength ranges from 200 to 1100nm
- Vacuum-sealing ensures reliable operation in harsh environments
- Deep cooling to -55°C
- Real-time spectral data acquisition
- Design for ultra-low power consumption and improved reliability
- Calibrated for life

Key design benefits:

- Compact size with low power consumption
- Solid-state electronics
- Hermetically sealed
- Life-time vacuum

Applications:

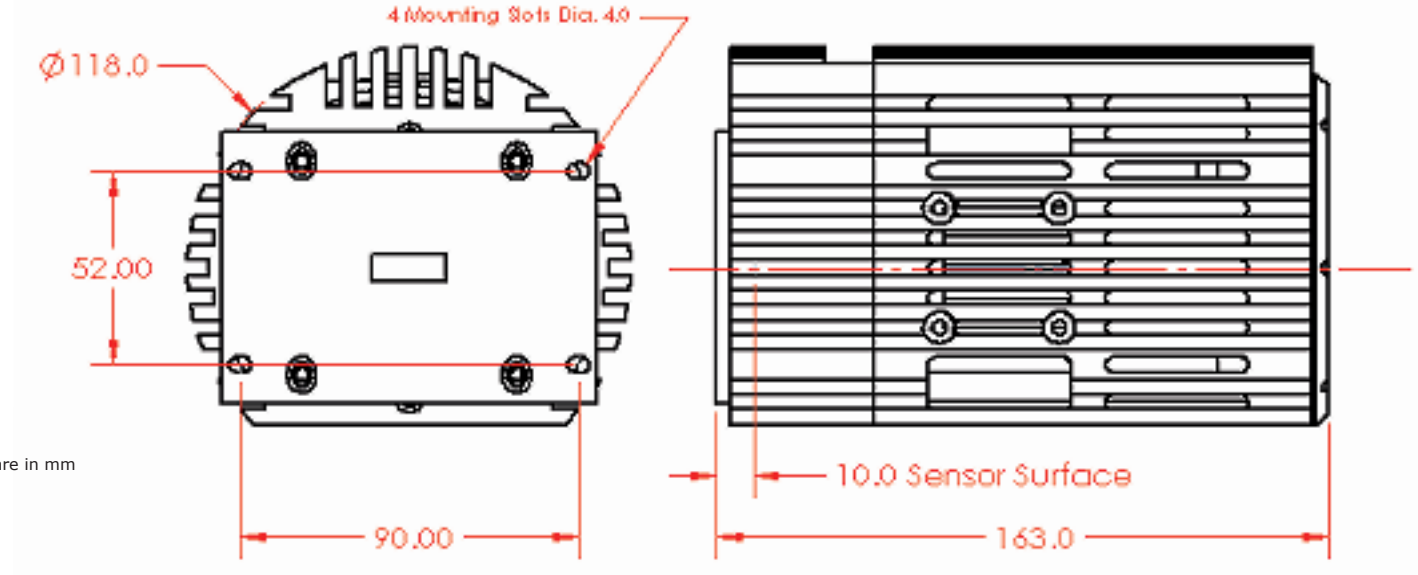
- Raman Spectroscopy
- Fluorescence Spectroscopy
- VIS-NIR Spectroscopy
- Low Light Detection
- Pharmaceuticals
- Medical Diagnostics

Visible-NIR Nunavut™ Deep Cooled CCD Camera 200 to 1100nm

PERFORMANCE	
Wavelength Range	200-1100nm, Customizable
Integration Time	10 ms to 1800 seconds
Dimensions	118 x 118 x 162 mm
OPTICS	
Window	single window design
DETECTOR SPECS	
Detector Array	1028 X 64, 2048 X 64 - 14μ²
CCD Node Sensitivity	6.5μV/e⁻
Quantum Efficiency @λpk Min.	75%
Response Non-uniformity	±3% typical, ±10% Max
Readout Noise	6 e⁻ rms typical, 15 e⁻ rms Max.
Dark Current	50 e⁻/pixel/s @ 25⁰C
Stray Light	0.05%
Cooling	4 stage TEC (water optional)
A/D Converter	16bit
Power	3.5 A@12 V
COMPUTER	
Data Ports	USB 2.0
OPERATION & STORAGE	
Operating Temperature	0 to 40°C
Relative Humidity	75% (non condensing)
Storage Temperature	-25 to 60°C

Consider using with:

- Deep Deplection option
- SuperGamut Spectrographs
- Mini-Wide Light Sources
- Fiber-optic Bundles & Accessories
- Turn-key Solutions



Note: All are in mm

Part number ordering: VCAM-

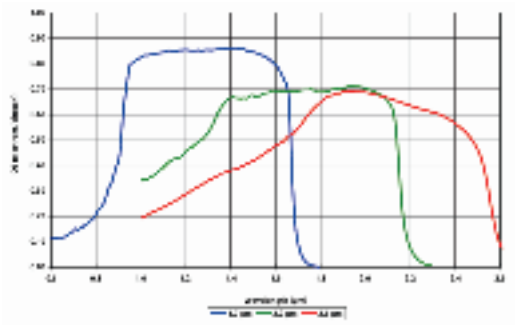
Sensor Type	Code	Starting Wavelength	Code	Ending Wavelength	Code
1024 x 64 Pixel	10	200 nm	0200	1100 nm	1100
2048 x 64 Pixel	20	Specify nm	xxxx	Specify nm	yyyy
code selection:		code selection:		code selection:	

order code example: VCAM-20-0200-1100

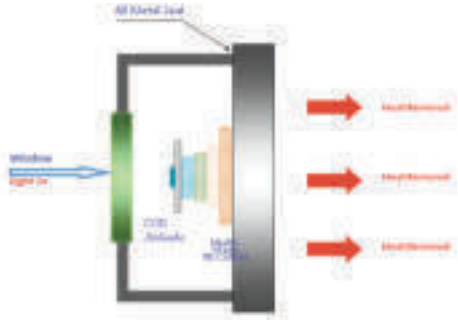
NIR Nunavut™ InGaAs Camera 900-1700nm

Nunavut™ series deep depletion InGaAs detectors are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's InGaAs cameras utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The Nunavut™ Series employs the latest in opto-electrical components to bring you the very best capability at a very affordable price. When matched to the Nunavut™ NIR spectrograph you have a light weight, very high performance, cost effective instrument. Each camera and spectrograph is calibrated in the factory to very high standards.



Quantum Efficiency



Schematic diagram

Applications:

- Raman Spectroscopy
- Fluorescence Spectroscopy
- NIR Spectroscopy
- Low Light Detection
- Pharmaceuticals
- Medical Diagnostics

Key Features

- Real-time spectral data acquisition
- Lifetime vacuum sealing ensures reliable operation
- Deep cooling to -55°C (optional water cooling to -100°C)
- Covers wavelength ranges from 900 to 1700nm
- High sensitive (HS) and High dynamic (HD) modes
- USB2.0 output

Key design benefits:

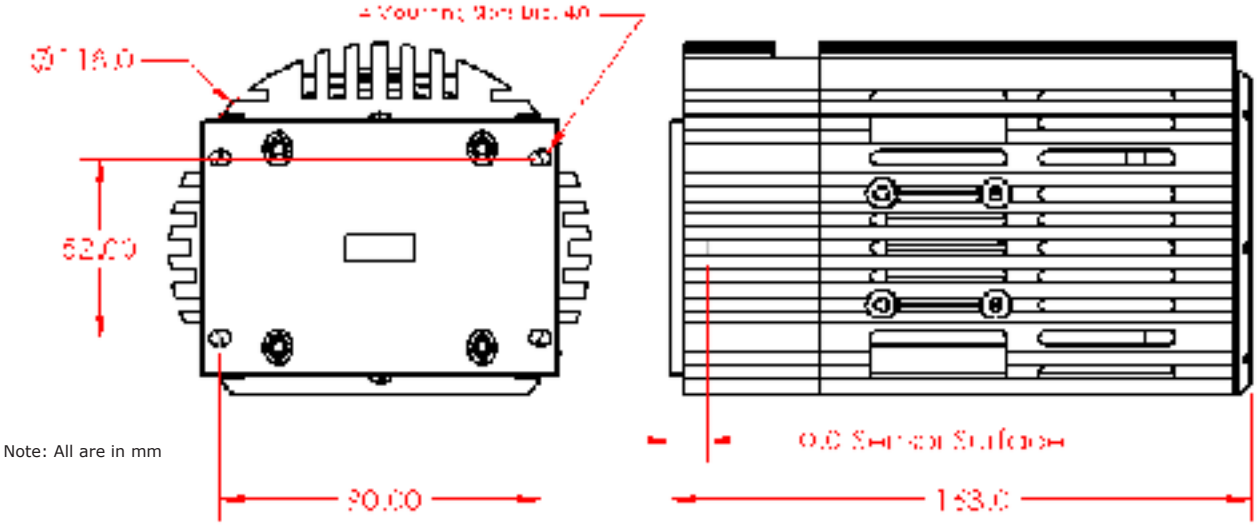
- Solid-state electronics
- Hermetically sealed
- Compact size with lower power consumption
- Life-time vacuum

NIR Nunavut™ InGaAs Camera 900-1700nm

PERFORMANCE	
Wavelength Range	900-1700nm, customizable
Integration Time	20 µs to 75 (HS) or 600 (HD) s
Dimensions	118 x 118 x 162 mm
OPTICS	
Window	single window, AR coated both sides
DETECTOR SPECS	
Detector Array	256 X 50µ, 512 x 25µ or 1024 x 25µ
Quantum Eff. @λpk Typ.	85%
Resp. Non-uniformity, Max	±10%
Dark Noise	16 Counts RMS
Saturation Charge (Typical)	5 (HS) or 130 (HD) X 10^6 electrons
Detector Gain (Typical)	400 (HS) or 15.4 (HD) nV/electron
Detector	InGaAs
Cooling	4 stage TEC (water optional)
A/D Converter	16bit
Power	3.5 A@12 V
COMPUTER	
Data Ports	USB 2.0
OPERATION & STORAGE	
Operating Temperature	0 to 40°C
Relative Humidity	75% (non condensing)
Storage Temperature	-25 to 60°C

Consider using with:

- SuperGamut™ Spectrographs
- Mini-Wide Light Sources
- Fiber-optic Bundles & Accessories
- Turn-key Solutions



Note: All are in mm

Part number ordering: NCAM-

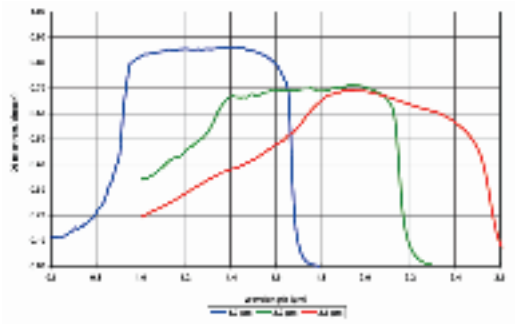
Type	Code	Starting Wavelength	Code	Ending Wavelength	Code
256 pixels	02	900 nm	0900	1700 nm	1700
512 pixels	05	Specify nm	xxxx	Specify nm	yyyy
1024 pixels	10				
code selection:		code selection:		code selection:	

order code example: NCAM-05-0900-1700

NIR Nunavut™ InGaAs Camera 1100-2200nm

Nunavut™ series deep depletion InGaAs detectors are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's InGaAs cameras utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

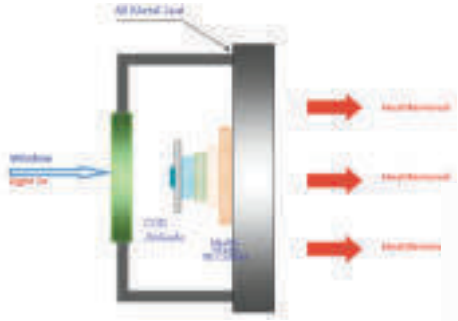
The Nunavut™ Series employs the latest in opto-electrical components to bring you the very best capability at a very affordable price. When matched to the Nunavut™ NIR spectrograph you have a light weight, very high performance, cost effective instrument. Each camera and spectrograph is calibrated in the factory to very high standards.



Quantum Efficiency

Key Features

- Real-time spectral data acquisition
- Vacuum sealing ensures reliable operation
- Deep cooling to -55°C (optional water cooling to -100°C)
- Covers wavelength ranges from 1100 to 2200 nm
- High sensitive (HS) and High dynamic (HD) modes
- USB2.0 output



Schematic diagram

Key design benefits:

- Solid-state electronics
- Hermetically sealed
- Compact size
- Life-time vacuum

Applications:

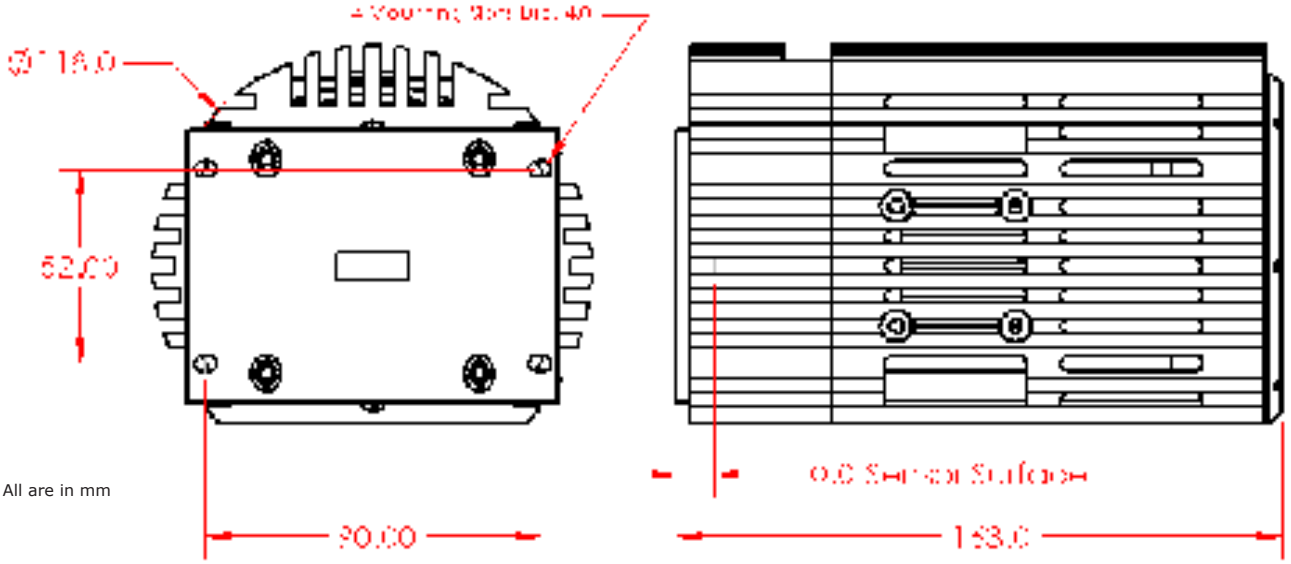
- Raman Spectroscopy
- Fluorescence Spectroscopy
- NIR Spectroscopy
- Low Light Detection
- Pharmaceuticals
- Medical Diagnostics

NIR Nunavut™ InGaAs Camera 1100-2200nm

PERFORMANCE	Data
Wavelength range	1100-2200nm, customizable
Integration time	20 µs to 50 (HS) or 1500 (HD) ms
Dimensions	118 x 118 x 162 mm
OPTICS	Data
Window	single window, AR coated both sides
DETECTOR SPECS	Data
Detector array	256 X 50µ, 512 x 25µ
Quantum Eff. @λpk Typ.	70%
Resp. Non-uniformity, Max	±10%
Dark Noise	16 Counts RMS
Saturation Charge (Typical)	5 (HS) or 130 (HD) X 10^6 electrons
Detector Gain (Typical)	400 (HS) or 15.4 (HD) nV/electron
Detector	InGaAs
Cooling	4 stage TEC (water optional)
A/D converter	16bit
Power	3.5 A@12 V
COMPUTER	Data
Data Ports	USB 2.0
OPERATION & STORAGE	Data
Operating Temperature	0 to 40°C
Relative Humidity	75% (non condensing)
Storage Temperature	-25 to 60°C

Consider using with:

- SuperGamut™ Spectrographs
- Mini-Wide Light Sources
- Fiber-optic Bundles & Accessories
- Turn-key Solutions



Note: All are in mm

Part number ordering: NCAM-

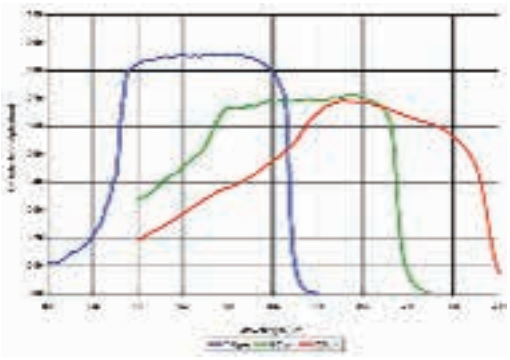
Type	Code	Starting Wavelength	Code	Ending Wavelength	Code
256 pixels	02	1100 nm	1100	2200 nm	2200
512 pixels	05	Specify nm	xxxx	Specify nm	yyyy
code selection:		code selection:		code selection:	

order code example: NCAM-05-1100-2200

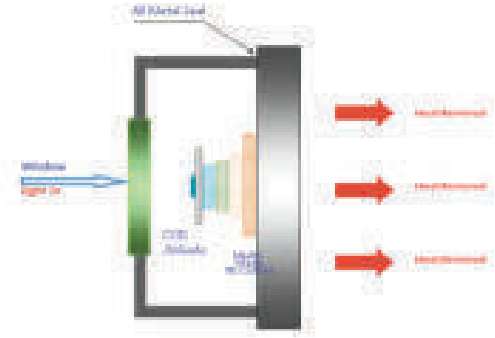
NIR Nunavut™ InGaAs Camera 1250-2500nm

Nunavut™ series deep depletion InGaAs detectors are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and ultra-low power consumption. Benefiting from experience manufacturing high-volume optical channel performance monitoring devices for the telecommunications industry, BaySpec's InGaAs cameras utilize low-cost field proven components. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is a reality.

The Nunavut™ Series employs the latest in opto-electrical components to bring you the very best capability at a very affordable price. When matched to the Nunavut™ NIR spectrograph you have a light weight, very high performance, cost effective instrument. Each camera and spectrograph is calibrated in the factory to very high standards.



Quantum Efficiency



Schematic diagram

Key Features

- Real-time spectral data acquisition
- Vacuum sealing ensures reliable operation
- Hermetic-sealing ensures reliable operation in harsh environments
- Deep cooling to -55°C (optional water cooling to -100°C)
- Covers wavelength ranges from 1250 to 2500 nm

Key design benefits:

- Solid-state electronics
- Hermetically sealed
- Compact size with lower power consumption
- Life-time vacuum

Applications:

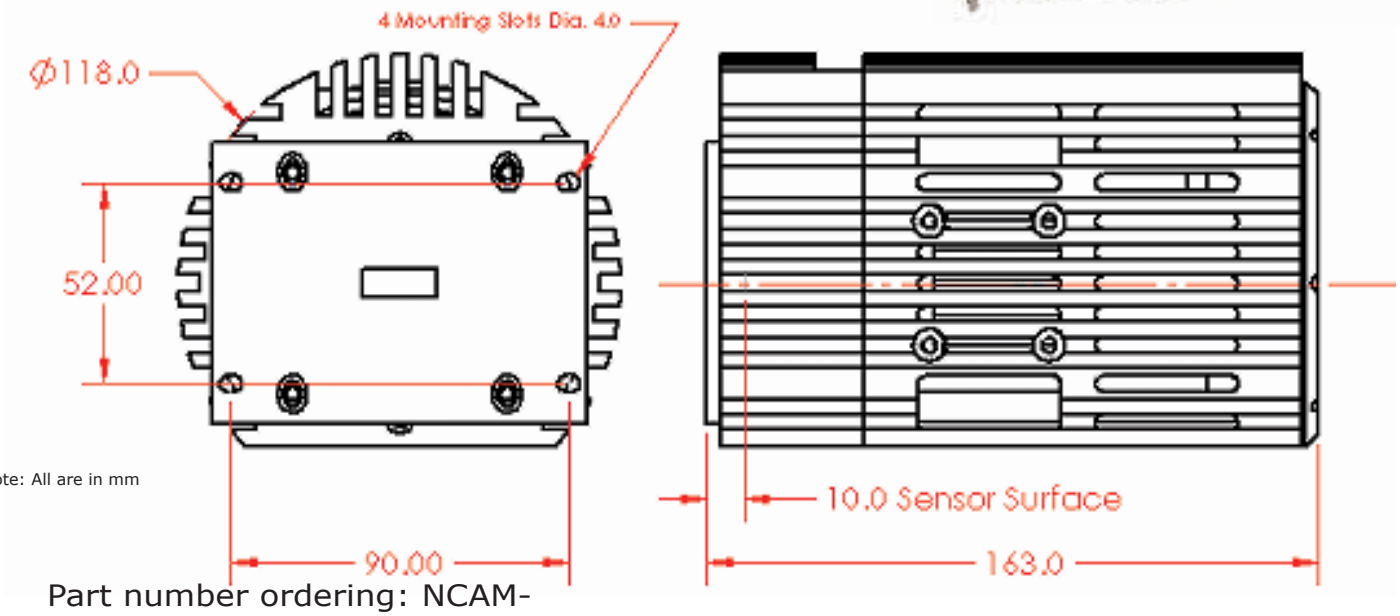
- Raman Spectroscopy
- Fluorescence Spectroscopy
- NIR-MIR Spectroscopy
- Low Light Detection
- Pharmaceuticals
- Medical Diagnostics

NIR Nunavut™ InGaAs Camera 1250-2500nm

PERFORMANCE	
Wavelength range	1250-2500nm, customizable
Integration time	20 µs to 400 ms
Dimensions	118 x 118 x 162 mm
OPTICS	
Window	single window, AR coated both sides
DETECTOR SPECS	
Detector array	256 X 50µ
Quantum Eff. @λpk Typ.	70%
Resp. Non-uniformity, Max	±5%
Dark Noise	60 Counts RMS
Saturation Charge (Typical)	187.5 X 10^6 electrons
Detector Gain (Typical)	16 nV/electron
Detector	InGaAs
Cooling	4 stage TEC (water optional)
A/D converter	16bit
Power	3.5 A@12 V
COMPUTER	
Data Ports	USB 2.0
OPERATION & STORAGE	
Operating Temperature	0 to 40°C
Relative Humidity	75% (non condensing)
Storage Temperature	-25 to 60°C

Consider using:

- SuperGamut™ Spectrographs
- Mini-Wide Light Sources
- Fiber-optic Bundles & Accessories
- Turn-key Solutions



Note: All are in mm

Part number ordering: NCAM-

Type	Code	Starting Wavelength	Code	Ending Wavelength	Code
256 pixels	02	1250 nm	1250	2500 nm	2500
		specify nm	xxxx	Specify nm	yyyy
code selection:		code selection:		code selection:	

order code example: NCAM-02-1250-2500

Optical Channel Performance Monitors & FBG Interrogators

		  	
Part Code	OCPM	FBGA, FBGA-IRS, SYS-FBG	
Description	Optical Channel Performance Monitors	Fiber Bragg Grating Interrogation Analyzers	
Part Number Examples	OCPM-050 OCPM-100 OCPM-CWDM OCPM-WBND OCPM-Thin Custom OSA	FBGA-S-1525-1565 FBGA-S-1510-1590 FBGA-S-IRS-1525-1565 FBGA-S-IRS-1510-1590 FBGA-E-1525-1565 FBGA-E-1510-1590	FBGA-F-1525-1565 FBGA-F-1510-1590 FBGA-F-IRS-1525-1565 FBGA-F-IRS-1510-1590 SYS-FBG-S-1525-1565-1 SYS-FBG-F-1510-1590-4 SYS-FBG-E-1510-1590-8 SYS-FBG-E-1510-1590-16

Ask us about new ultra-fast Ethernet connectivity options as well as integrating 1xN fiber optic switches for high sensor count configurations

page 50

WaveCapture™ FBGA and FBGA-IRS

Applications

- Real time fault detection and isolation in fiber optic sensing systems
- High speed temperature & stress measurements
- OEM module for portable handheld field test equipment
- Academic research

Compliance

- Telcordia GR-63/1209/1221
- MILSPEC STD 810

page 54

WaveCapture™ FBG Systems

Applications

- Long-term imbedded monitoring of smart structures
- Biomedical endoscopic measurements of stress & temperature
- Real time fault detection and isolation in fiber optic sensing systems

Compliance

- Telcordia GR-63/1209/1221 qualified
- MILSPEC STD 810

page 56

IntelliGuard™ OCPM Series

Applications

- EDFA gain balancing
- Reconfigurable ptical add/drop monitoring
- Physical layer monitoring for provisioning and commissioning optical networks
- Real time fault detection and isolation in DWDM systems
- Channel power, wavelength, and OSNR measurement
- OEM module for field test equipment

Compliance

- Telcordia GR-63/1209/1221
- MILSPEC STD 810

page 58

IntelliGuard™ OCPM Thin Series

Applications

- Ultra-compact portable OSA engine
- Reconfigurable optical add/drop monitoring
- Physical layer monitoring for provisioning and commissioning optical networks
- Real time fault detection and isolation in DWDM systems
- Channel power, wavelength measurement

Compliance

- Telcordia GR-63/1209/1221
- MILSPEC STD 810

page 60

IntelliGuard™ OCPM Wideband Series

Applications

- Military/Defense applications non-ITU grid
- Physical layer monitoring for provisioning and commissioning optical networks
- Real time fault detection and isolation in DWDM systems
- EDFA gain balancing
- Wideband channel power
- Wavelength upgradeable
- OEM module for field test equipment

Compliance

- Telcordia GR-63/1209/1221 qualified
- MILSPEC STD 810

page 62

IntelliGuard™ OCPM CWDM

Applications

- OEM module for portable handheld field test equipment
- Physical layer monitoring for provisioning and commissioning optical networks
- Real time fault detection and isolation in CWDM systems
- Channel power, wavelength, and OSNR measurement
- CWDM component R&D test equipment

Compliance

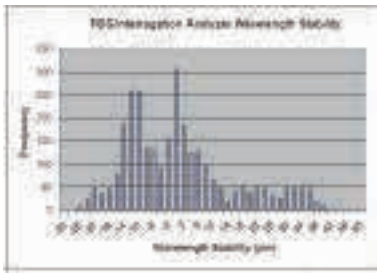
- Telcordia GR-63/1209/1221
- MILSPEC STD 810

WaveCapture™ High Speed FBGA Series

BaySpec's *WaveCapture*™ FBGA Interrogation Analyzer is an integrated spectral engine simultaneously covering multiple wavelengths for precise and Rapid Fiber Bragg Grating (FBG) sensor system measurements.

The device covers wide wavelength ranges and provides simultaneous measurements at very fast response rates and excellent wavelength resolution. High reliability (MIL STD 810 shock and vibration) is achieved through a rugged mechanical design with no moving parts. Periodic calibration is not required. High speed Input/Output (I/O) is achieved through the use of USB2.0 communications (serial communications also supported at lower speeds).

The *WaveCapture*™ FBGA Series employs a highly efficient *Volume Phase Grating* (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a tapped signal from the main data transmission link through a single mode fiber, then collimating it with a micro lens. The signal is spectrally dispersed with the VPG®, and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.



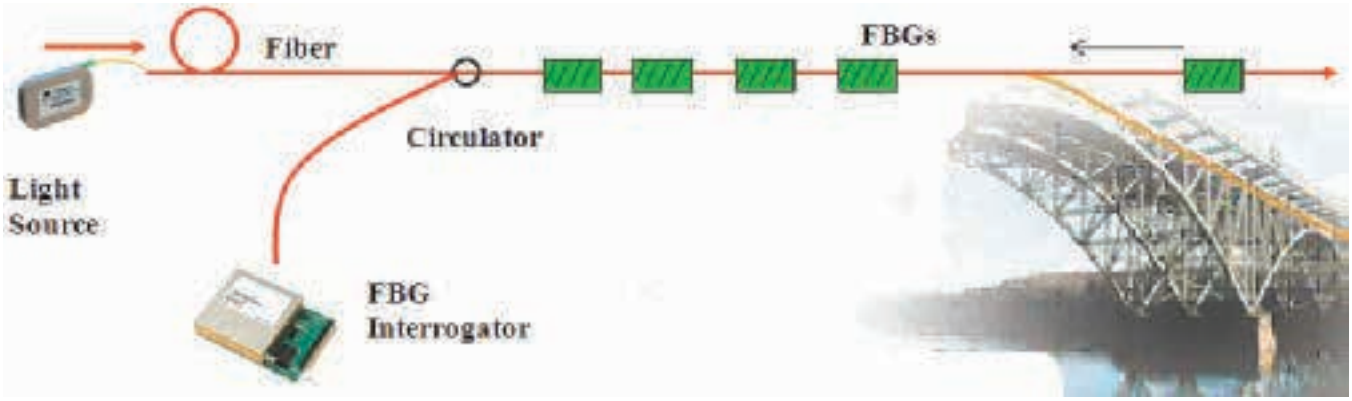
Key Features

- Wide wavelength range
- Ultra fast response time (up to 5kHz)
- Excellent wavelength repeatibililty and resolution
- Athermal design enabling battery-operated portable operation
- High reliability for use in harsh environment
- Compact, card-mountable design

Key design benefits:

- No moving parts
- High throughput *Volume Phase Grating* (VPG®)
- Athermal (no TEC)
- Solid-state electronics
- Hermetically sealed

Functional Schematic

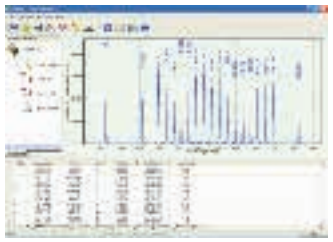


WaveCapture™ High Speed FBGA Series

Parameter	Data	Unit
Wavelength Range Standard Extended	 1525 - 1565 1510 - 1590	nm
Wavelength repeatibility	± 5 pm	pm
Wavelength Readout Resolution	1	pm
Frequency Response Time (typ.) Standard Fast	 ~5 Hz (RS232/USB1.1) ~5 kHz (USB2.0/Ethernet)	
Channel Input Power Range	-60 to -20 or specify	dBm
Min. Detectable Wavelength Change	0.1	dB
Size (for standard)	68 x 96 x 15.8	mm
Interface	RS-232, USB, DPRAM (Fast board USB, Ethernet)	
Operating Temperature	-5 to 70⁰ C	
Software	GUI evaluation software included, DLL for development	

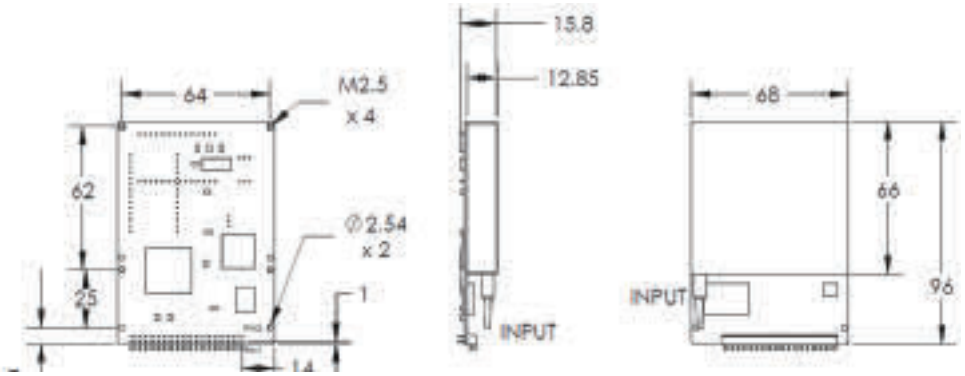
Consider using with:

- Mini-Lite Wideband Light Sources
- Fiber-optic Accessories



BaySpec *Sense2020* software and full SDK/dll available for ease of integration

Mechanicals (for standard):



Order Info for Part No. FBGA-

Note: Standard fiber length is 1.0m

Frequency Response	Code	Starting Wavelength	Code	Ending Wavelength	Code	Connector Type	Code
Standard (~5Hz)	S	1525 nm	1525	1565 nm	1565	No Connector	NC
Fast USB(~5kHz)	F	1510 nm	1510	1590 nm	1590	FC/APC	FA
Ethernet (~5kHz)	E	specify nm	xxxx	specify nm	yyyy	FC/PC	FP
						SC/APC	SA
						SC/PC	SP
						LC/APC	LA
						LC/PC	LP
code selection:		code selection:		code selection:		code selection:	

example: FBGA-S-1525-1565-FA

WaveCapture™ High Accuracy FBGA-IRS Series

BaySpec's *WaveCapture*™ FBGA-IRS is a spectral engine with an internal reference source that interrogates multiple wavelengths for precise fiber bragg grating (FBG) sensor system measurements requiring high end of life (EOL) wavelength accuracy at high frequency response time.

The device covers wide wavelength range and provides simultaneous measurements at very fast response rates and excellent wavelength resolution. High reliability (MIL STD 810 shock and vibration) is achieved through a rugged mechanical design with no moving parts. Periodic calibration is not required. High speed Input/Output (I/O) is achieved through the use of USB2.0 or Ethernet interface (serial communications also supported at lower speeds).

The *WaveCapture*™ FBGA-IRS Series employs a highly efficient *Volume Phase Grating* (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a tapped signal from the main data transmission link through a single mode fiber, then collimates it with a micro lens. The signal is spectrally dispersed with the VPG®, and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Standard package

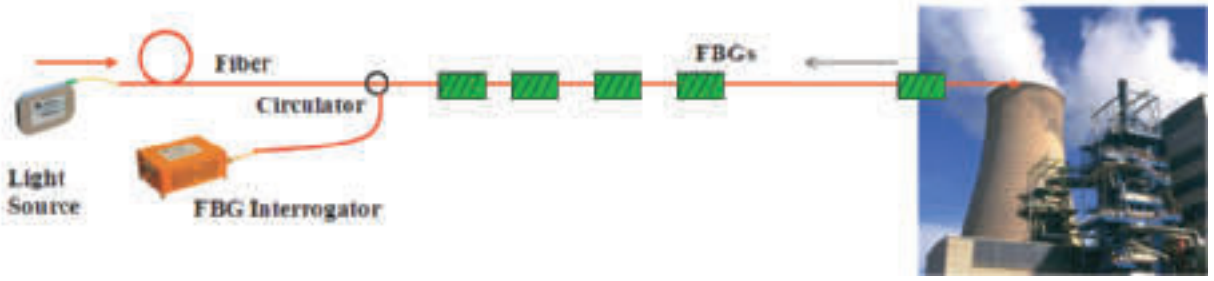
Thin package

Key Features

- Selectable wavelength range
- Ultra fast response time (up to 5 kHz)
- Excellent wavelength repeatibililty and resolution
- Athermal design enabling battery-operated portable operation
- High reliability for use in harsh environment

Key design benefits:

- No moving parts
- High throughput Volume Phase Grating® (VPG®)
- Athermal (no TEC)
- Solid-state electronics
- Hermetically sealed

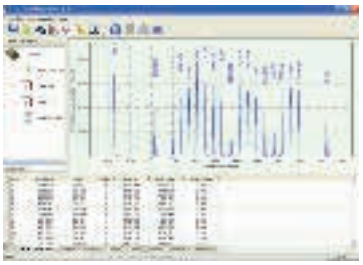


WaveCapture™ High Accuracy FBGA-IRS Series

Parameter	Data	Unit
Wavelength Range Standard Extended	 1525 - 1565 1510 - 1590	nm
Wavelength Repeatibility	± 2	pm
Wavelength Readout Resolution	1	pm
Minimum Detectable Wavelength Change	± 1	pm
Frequency Response Time Standard Fast	 ~ 5 Hz (RS232/USB1.1) ~ 5 kHz (USB2.0/Ethernet)	
IRS - Internal Reference Source	Integrated	Yes
Channel Input Power Range	-60 to -20 or specify	dBm
Min. Detectable Wavelength Change	0.1	dB
Size	Standard: 113.5 x 84 x 47.5 Thin: 148 x 142 x 29.1	mm
Interface	Standard: RS-232, USB, DPRAM Fast board: USB2.0, Ethernet	
Operating Temperature	-5 to 70	^{0}C

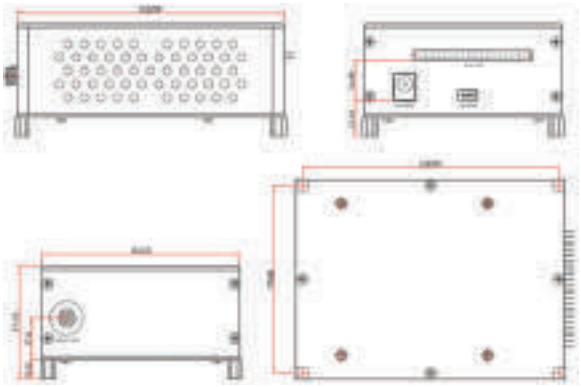
Consider using with:

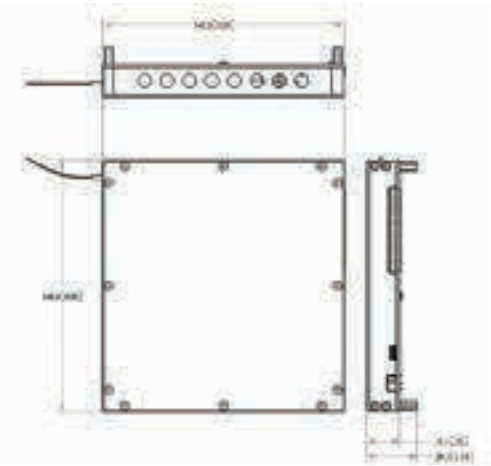
- Mini-Lite Wideband Light Sources
- Fiber-optic Accessories



BaySpec *Sense2020* software and full SDK/dll available for ease of integration

Mechanicals:





Order Info for Part No. FBGA-IRS-

Note: Standard fiber length is 1.0m

Frequency Response	Code	Starting Wavelength	Code	Ending Wavelength	Code	Connector Type	Code
Standard (~5Hz)	S	1525	1525	1565	1565	No Connector	NC
Fast (~5kHz)	F	1510	1510	1590	1590	FC/APC	FA
Ethernet (~5kHz)	E	specify nm	xxxx	specify nm	yyyy	FC/PC	FP
						SC/APC	SA
						SC/PC	SP
						LC/APC	LA
						LC/PC	LP
						TBD	XY
code selection:		code selection:		code selection:		code selection:	

order code example: FBGA-IRS-F-1510-1590-FP

WaveCapture™ FBG Interrogation Systems

BaySpec's *WaveCapture*™ FBG Interrogation Systems are turn-key solutions for interrogating multiple wavelengths for precise fiber bragg grating (FBG) sensor system measurements requiring high end of life (EOL) wavelength accuracy at high frequency response time.

The system covers wide wavelength range and provides simultaneous measurements at very fast response rates and excellent wavelength resolution. High reliability (MIL STD 810 shock and vibration) is achieved through a rugged mechanical design with no moving parts. Periodic calibration is not required. High speed Input/Output (I/O) is achieved through the use of USB2.0 or Ethernet interface (serial communications also supported at lower speeds).

The *WaveCapture*™ FBG Systems employsa highly efficient *Volume Phase Grating* (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a tapped signal from the main data transmission link through a single mode fiber, then collimates it with a micro lens. The signal is spectrally dispersed with the VPG®, and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Bench-top System
(4-channels shown)

Portable System

Key Features

- Selectable wavelength range
- Ultra fast response time (up to 5 kHz)
- Excellent wavelength repeatibililty and resolution
- Low power consumption for battery-operated operation
- High reliability for use in harsh environment

Key design benefits:

- No moving parts
- High throughput *Volume Phase Grating* (VPG®)
- Long battery life
- Solid-state electronics
- Hermetically sealed optics

Structural Health Monitoring of buildings, bridges, dams, power plants, etc.

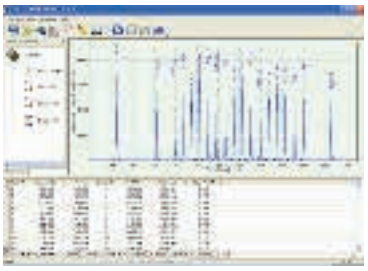
Fiber optic sensing in biomedical diagnostics

WaveCapture™ FBGA Systems

Parameter	Data	Unit
Wavelength Range Standard Extended	 1525 - 1565 1510 - 1590	nm
Wavelength Repeatibility	± 5	pm
Wavelength Readout Resolution	1	pm
Minimum Detectable Wave-length Change	± 1	pm
Frequency Response Time Standard Fast	 ~ 5 Hz (RS232/USB1.1) ~ 5 kHz (USB2.0/Ethernet)	
IRS - Internal Reference Source	Integrated	Yes
Channel Input Power Range	-60 to -20 or specify	dBm
Size	Standard: 325 x 271 x 105 or 19" rack mount, 1U height	mm
Interface	RS-232, USB, Ethernet	
Operating Temperature	-5 to 70	^{0}C
Software	GUI evaluation software in-cluded, DLL for development	

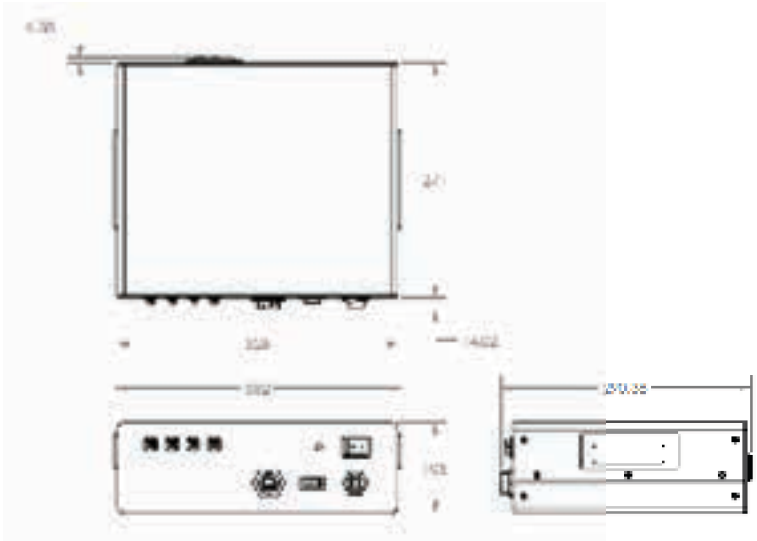
Consider using with:

- Mini-Lite Wideband Light Sources
- Fiber-optic Accessories



BaySpec *Sense2020* software and full SDK/dll available for ease of integration

Mechanicals:



Order Info for Part No. SYS-FBG-

Note: add-IRS for Internal Reference Source

Frequency Response	Code	Starting Wavelength	Code	Ending Wavelength	Code	# of Channels	Code
Standard (~5Hz)	S	1525	1525	1565	1565	1	1
Fast (~5kHz)	F	1510	1510	1590	1590	2	2
Ethernet (~5kHz)	E	specify nm	xxxx	specify nm	yyyy	4	4
						8	8
						16	16
						32	32
code selection:		code selection:		code selection:		code selection:	

order code example: SYS-FBG-E-1510-1590-4

IntelliGuard™ OCPM Series

BaySpec's *IntelliGuard*™ OCPM Series is an embedded, integrated spectrum analyzer delivering precise measurement and powerful processing capabilities for dense wavelength division multiplexing (DWDM) applications.

The device covers C and/or L band wavelength ranges and provides simultaneous measurements of up to 160 channels spaced 50 GHz apart. High reliability (GR-63/1209/1221 qualified) is achieved through a rugged mechanical design with no moving parts. Periodic calibration is not required. Input/Output (I/O) is provided through a dual port RAM interface accessed through ADD/DAT bus direct connection or serial (RS232 or USB) communications.

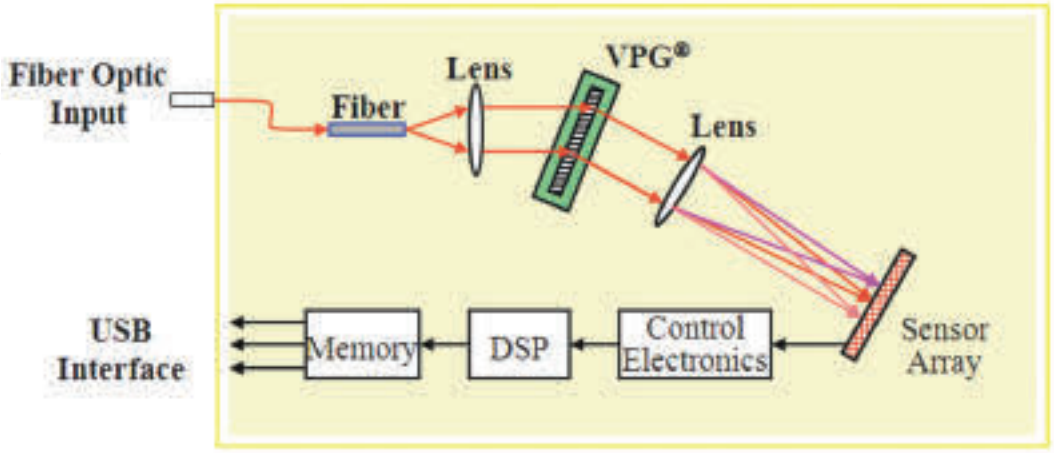
The *IntelliGuard*™ OCPM Series employs a highly efficient *Volume Phase Grating* (VPG©) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a tapped signal from the main data transmission link through a single mode fiber, then collimates it with a micro lens. The signal is spectrally dispersed with the VPG© and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host through the chosen interface.

Key Features

- Real-time <1 ms response time for raw data
- Remote gain equalization of DWDM networks based on optical power or OSNR
- High dynamic range - 50 dB
- High reliability - no moving parts and Telcordia GR-63/1209/1221 qualified
- Athermal design for ultra-low power consumption
- Compact for new system space constrained environments at 68 x 96 x 15.8 mm^3; legacy designs available upon request
- Supports different modulation schemes for 10/40/100 /400 GHz transmission

Key benefits of BaySpec's design :

- No moving parts
- Ultra reliable *Volume Phase Grating* (VPG®)
- Athermal (no TEC)
- Solid-state electronics
- Hermetically sealed



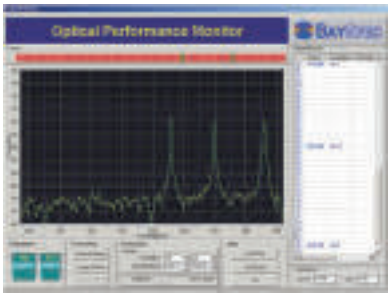
IntelliGuard™ OCPM Series

Parameter	Data	Unit
Wavelength Range	C- and/or L-band	
Number of Channels	40, 80, 96, or specify	
Channel Spacing	100, 50, or specify	GHz
Absolute Wavelength Accuracy	±50	pm
Relative Wavelength Accuracy	30	pm
Channel Input Power Range	-65 to -15, or specify	dBm
Channel Power Accuracy	±0.5	dB
Power Resolution	0.1	dB
PDL	0.3	dB
Response Time	<50	ms
OSNR	25	dB
OSNR Accuracy	±2	dB
Size	68 x 96 x 15.8*	mm
Interface	USB, RS-232 or Dual-port RAM	
Weight	<260*	g
Operating Temperature	-5 to 70	^{0}C
Power Consumption	<2 W max.*	W

*subject to change, depending on specifications

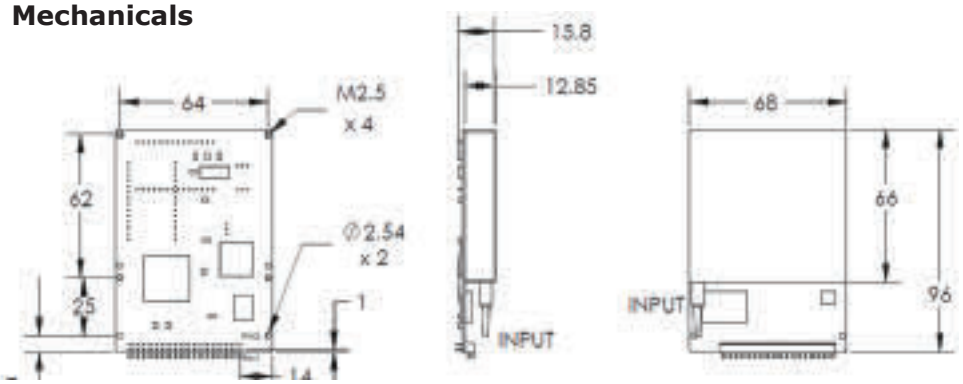
Consider using with:

- Erbium-doped Fiber Amplifiers
- ASE Light Sources
- Fiber-optic Accessories



BaySpec SEDP software available for ease of integration.

Mechanicals



Order Info for Part No. OCPM-

Note: Standard fiber length is 1.0m

Channel Spacing	Code	Channel Number	Code	Starting Wavelength	Code	Connector Type	Code
100 GHz	100	40	040	1529.55 nm	2955	No Connector	NC
50 GHz	050	80	080	Specify	zzzz	FC/APC	FA
Specify	xxx	96	096			FC/PC	FP
		Specify	yyy			SA/APC	SA
						SA/PC	SP
						LC/APC	LA
						LC/PC	LP
code selection:		code selection:		code selection:		code selection:	

Note: OSNR reporting optional

order code example: OCPM-100-040-2955-FA

IntelliGuard™ OCPM-T Series (Ultra-thin)

BaySpec's *IntelliGuard*™ OCPM Series is an embedded, integrated spectrum analyzer delivering precise measurement and powerful processing capabilities for dense wavelength division multiplexing (DWDM) applications.

The device covers C or L band wavelength ranges and provides simultaneous measurements of up to 160 channels spaced 50 GHz apart. High reliability (GR-63/1209/1221 qualified) is achieved through a rugged mechanical design with no moving parts. Periodic calibration is not required. Input/Output (I/O) is provided through a dual port RAM interface accessed through ADD/DAT bus direct connection or serial (RS232 or USB) communications.

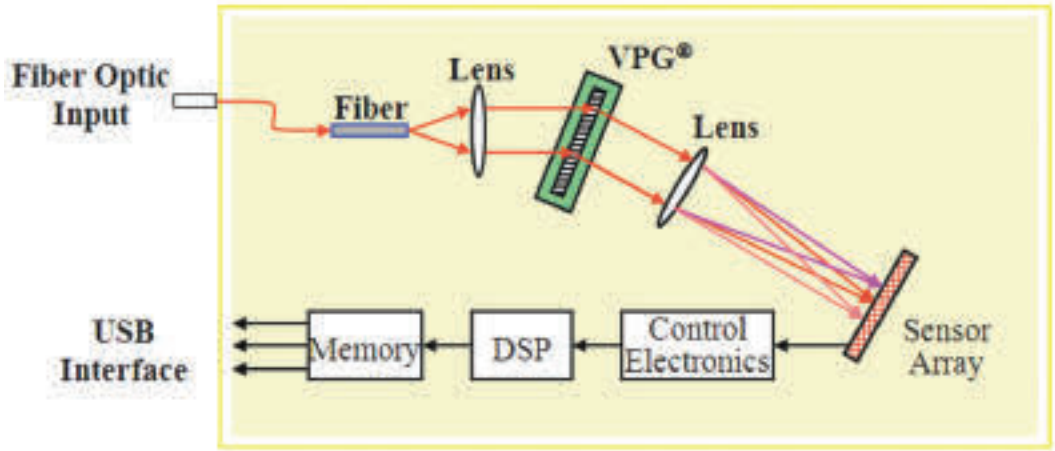
The *IntelliGuard*™ OCPM-T Series employs a highly efficient *Volume Phase Grating* (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a tapped signal from the main data transmission link through a single mode fiber, then collimates it with a micro lens. The signal is spectrally dispersed with the VPG®, and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host through the chosen interface.

Key Features

- Real-time <50 ms response time
- Remote gain equalization of DWDM networks based on optical power
- High dynamic range: 50 dB
- High reliability: no moving parts and GR-1209/1221 qualified
- Athermal design for ultra-low power consumption
- Compact for new system space constrained environments 68 x 96 x 9.8 mm
- Compatible with different 10/40/100/400 GHz modulation schemes

Key benefits of BaySpec's design :

- No moving parts
- Ultra reliable *Volume Phase Grating* (VPG®)
- Athermal (no TEC)
- Solid-state electronics
- Hermetically sealed

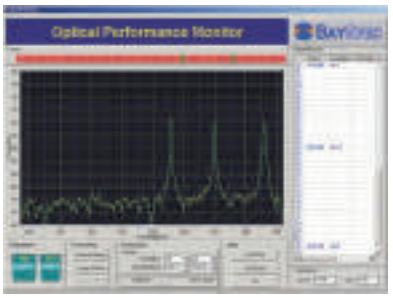


IntelliGuard™ OCPM-T Series (Ultra-thin)

Parameter	Data	Unit
Wavelength Range	C- and/or L- band	
Number of Channels	40, 80, 96 or specify	
Channel Spacing	100, 50 or specify	GHz
Absolute Wavelength Accuracy	±50	pm
Relative Wavelength Accuracy	30	pm
Channel Input Power Range	-60 to -15 or specify	dBm
Channel Power Accuracy	±0.5	dB
Power Resolution	0.1	dB
PDL	0.3	dB
Response Time	<50	ms
Size	68 x 96 x 9.8	mm
Interface	USB, RS-232 or Dual-port RAM	
Operating Temperature	-5 to 70	^{0}C
Weight	<190	g
Power Consumption	<2 W max.	W

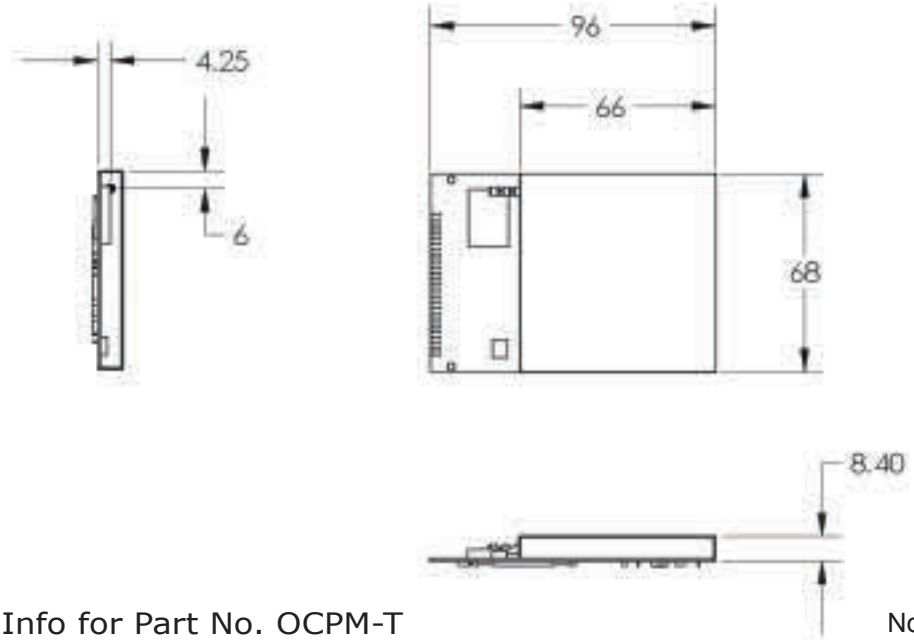
Consider using with:

- Erbium-doped Fiber Amplifiers
- ASE Light Sources
- Fiber-optic Bundles & Accessories



BaySpec SEDP Software available for ease of integration

Mechanicals



Order Info for Part No. OCPM-T

Note: Standard fiber length is 1.0m

Channel Spacing	Code	Channel Number	Code	Starting Wavelength	Code	Connector Type	Code
100 GHz	100	40	040	1529.55 nm	2955	No Connector	NC
50 GHz	050	80	080	specify nm	zzzz	FC/APC	FA
specify spacing	xxx	96	096			FC/PC	FP
		specify number	yyy			SA/APC	SA
						SA/PC	SP
						LC/APC	LA
						LC/PC	LP
code selection:		code selection:		code selection:		code selection:	

order code example: OCPM-T-100-040-2955-FA

IntelliGuard™ OCPM Wideband Series

BaySpec's OCPM-W Series optical wideband power monitor is an embedded, integrated power analyzer delivering precise measurements and powerful processing capabilities over a wide wavelength range (1230-1670nm).

The device covers S, C and L band wavelength ranges and provides simultaneous measurements at coarse WDM and dense WDM wavelength power levels. High reliability (GR-63/1209/1221 qualified) and fully compliant to MIL STD 810 achieved through a rugged mechanical design with no moving parts. Periodic calibration is not required. Input/Output (I/O) is provided through a dual port RAM interface accessed through ADD/DAT bus direct connection or serial (RS232 or USB) communications.

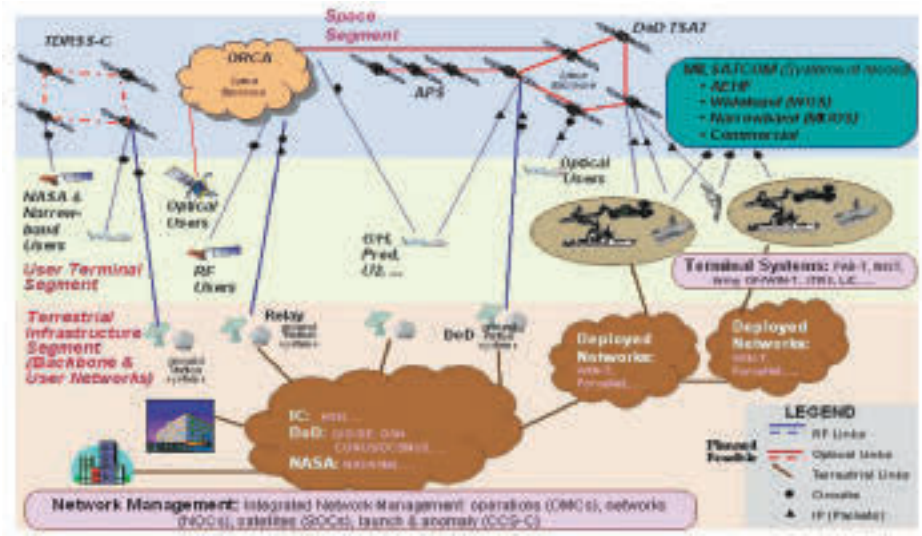
The OCPM-W Series employs a highly efficient *Volume Phase Grating* (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a tapped signal from the main data transmission link through a single mode fiber, then collimating it with a micro lens. The signal is spectrally dispersed with the VPG®, and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Key Features

- Real-time optical power monitoring over a wide wavelength range
- High dynamic range: 50 dB
- High reliability: no moving parts and GR-63/1209/1221 qualified and compliant with MIL STD 810
- Athermal design for ultra-low power consumption
- Compact, card-mountable design
- Deep cooling for ultra low noise floor available upon request

Key design benefits:

- No moving parts
- Ultra reliable Volume Phase Grating (VPG®)
- Optional TEC-cooling
- Solid-state electronics
- Hermetically sealed



Advanced Transformational Communication Network

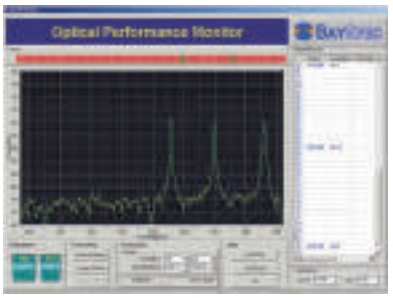
IntelliGuard™ OCPM Wideband Series

Parameter	Data	Unit
Wavelength Range Coarse Fine	 1230 - 1670 1460 - 1625	 nm nm
Channel Input Power Range	-60 to -15	dBm
Power Resolution	0.1	dB
PDL	0.3	dB
Response Time	<50	ms
Size	160 x 150 x 20	mm
Interface	USB, RS-232	
Weight	<900	g
Operating Temperature	-5 to 70	^{0}C
Power Consumption Off State Idle State Reconfiguring	 0 <50 mW <10 W	max.

Note: specifications subject to change without notice

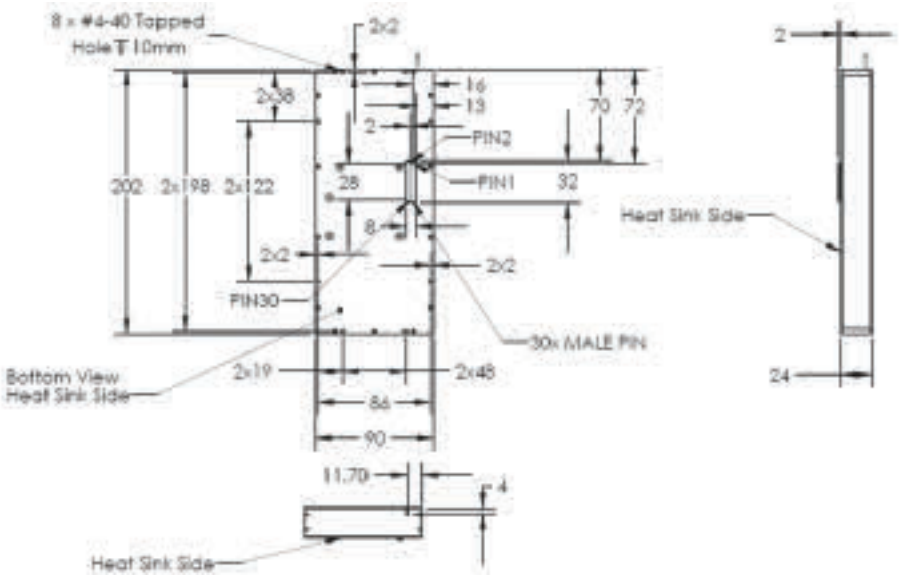
Consider using with:

- Erbium-doped Fiber Amplifiers
- ASE Light Sources
- Fiber-optic Accessories



BaySpec SEDP Software available for ease of integration

Mechanicals



Order Info for Part No. OCPM

Note: Standard fiber length is 1.0m

Starting Wavelength	Code	Ending Wavelength	Code	Connector Type	Code
1230 nm	1230	1670 nm	1670	No Connector	NC
specify nm	xxxx	specify nm	zzzz	FC/APC	FA
				FC/PC	FP
				SA/APC	SA
				SA/PC	SP
				LC/APC	LA
				LC/PC	LP
code selection:		code selection:		code selection:	

order code example: OCPM-1230-1670-NC

IntelliGuard™ OCPM CWDM Series

BaySpec's CWDM Series Optical Channel Performance Monitor is an embedded, integrated spectrum analyzer delivering precise measurements and powerful processing capabilities to coarse wavelength division multiplexing (CWDM) applications compliant with the ITU-T G.695 standard.

Coarse Wave Division Multiplexing (CWDM) combines up to 18 wavelengths onto a single fiber. CWDM technology uses ITU standard 20nm spacing between the wavelengths from 1260nm to 1640nm. High reliability (GR-63/1209/1221 qualified) is achieved through a rugged mechanical design with no moving parts. Periodic calibration is not required. Input/Output (I/O) is provided through a dual port RAM interface accessed through ADD/DAT bus direct connection or serial (RS232 or USB) communications.

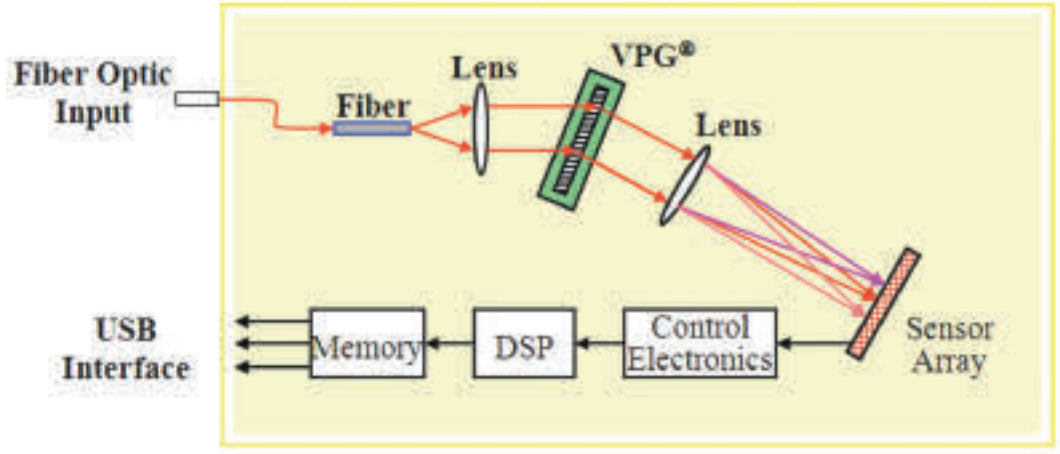
The *IntelliGuard*™ OCPM CWDM employs a highly efficient Volume Phase Grating (VPG®) as the spectral dispersion element and an ultra sensitive InGaAs array detector as the detection element, thereby providing high-speed parallel processing and continuous spectrum measurements. As an input, the device uses a tapped signal from the main data transmission link through a single mode fiber, then collimating it with a micro lens. The signal is spectrally dispersed with the VPG® and the diffracted field is focused onto an InGaAs array detector. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host through the supported interfaces.

Key Features

- Wide wavelength range 1260-1640nm
- Ultra fast real-time response time in <50 ms
- Athermal design enabling battery operated hand-held operation
- High reliability - No moving parts, GR-63/1209/1221 qualified
- Compact, card-mountable design - 68 x 96 x 15.8 mm

Key design benefits:

- No moving parts
- Ultra reliable Volume Phase Grating® (VPG®)
- Athermal (no TEC)
- Solid-state electronics
- Hermetically sealed

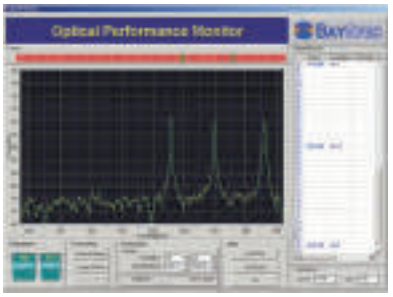


IntelliGuard™ OCPM CWDM Series

Parameter	Data	Unit
Wavelength Range	1260 - 1640	nm
Number of Channels	86+	
Channel Spacing	4.5	nm
Absolute Wavelength Accuracy	±1	nm
Relative Wavelength Accuracy	±0.5	nm
Channel Input Power Range	-65 to -15 or specify	dBm
Spectral Resolution	<5	nm
Dynamic Range	50	dB
Power Resolution	0.1	dB
PDL	0.3	dB
Response Time	<50	ms
Size	68 x 96 x 15.8	mm
Interface	USB, RS-232 or Dual-port RAM	
Operating Temperature	-5 to 70	°C
Weight	<260	g
Power Consumption (in Power-Down Mode)	<2.0 (<10 mW)	W

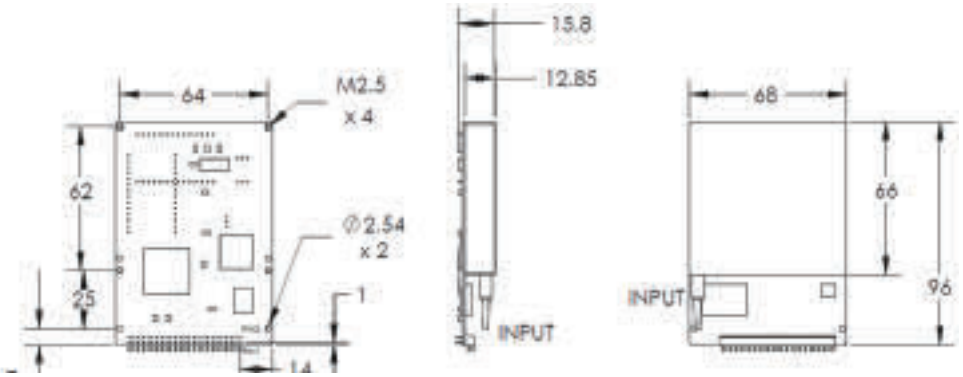
Consider using with:

- Erbium-doped Fiber Amplifiers
- ASE Light Sources
- Fiber-optic Accessories



BaySpec SEDP Software available for ease of integration.

Mechanicals



Order Info for Part No. CWDM

Note: Standard fiber length is 1.0m

Channel Number	Code	Starting Wavelength	Code	Connector Type	Code
86	086	1260 nm	1260	No Connector	NC
Specify	xxx	custom nm	zzzz	FC/APC	FA
				FC/PC	FP
				SA/APC	SA
				SA/PC	SP
				LC/APC	LA
				LC/PC	LP
code selection:		code selection:		code selection:	

order code example: CWDM-086-1260-FA

Optical Light Sources: Lasers, Amplifiers, EDFA, ASE

				
Part Code	MNLS-O MWLS-O	MNLS-C MWLS-C	EDFA	MNLS-B MWLS-B ASE
Description	*MiniLite*™ OEM Narrow line-width Lasers or Wideband Light Sources	*MiniLite*™ Card-mounted Narrow linewidth Lasers or Wide-band Light Sources	*IntelliGain*™ C- and L-band Erbium-doped Fiber Amplifier Series	*MiniLite*™ Bench-top Narrow Linewidth Lasers and Wide-band Light Sources with adjustable power control

BaySpec was founded by laser spectroscopists in 1999 and our technologists have an average of 30 years experience in light source selection and integration.

If you have a need for a standard or novel light source, give us a call and we will work with you to find an optimal solution for your lighting needs.

p 66

MiniLite™ Narrow Linewidth Lasers

Wavelengths:

- 532nm
- 785nm
- 1064nm
- 1309nm

Applications

- Raman Spectrograph
- Turn-key Raman Instruments
- Fiber-optic Bundles & Accessories
- Medical Diagnostics
- Academic Research

p 72

MiniLite™ 650 ~ 1690nm Wideband

Suggested For Use With:

- WaveCapture™ FBG Interrogators
- DeepView™ OCT Spectral Engines
- Fiber-optic Bundles & Accessories

Applications

- Medical Diagnostics
- Structural Health Monitoring
- Oil/Gas Down-hole Drilling
- Fiber Optic Gyroscopes
- Optical Coherence Tomography

NOTE

Applications

- Raman Spectroscopy
- Confocal Raman Microscopy
- Medical Diagnostics
- Fiber Optic Sensing
- T&M Source
- Laboratory Source
- OEM Integration

p 74

IntensiGain™ C- and L- Band Amplifiers
IntelliGain™ Metro AE EDFA
IntelliGain™ ASE Light Sources

Suggested For Use With:

- IntelliGuard™ Optical Channel Performance Monitors
- Reconfigurable Optical Add/Drops
- WDM Optical Networks
- Fiber Optic Gyroscope Sources
- Fiber-optic Bundles & Accessories

Fiber-Coupled *MiniLite*™ Laser 532nm *Multi-mode* Series

BaySpec's *MiniLite*™ 532nm Multi-mode lasers are designed to enhance Analytical Raman Spectroscopy and Test & Measurement capabilities in the 532nm wavelength region. Devices benefit from low-cost field proven components.

OEM option

Card-mount option

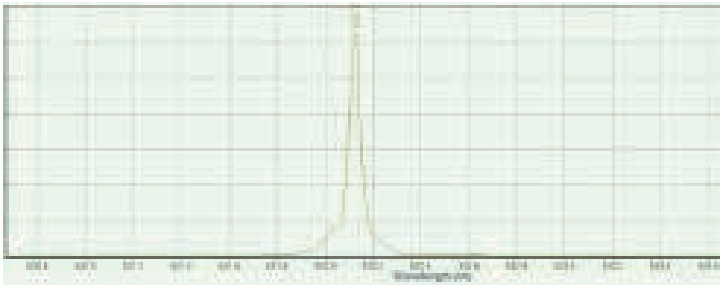
Bench-top option

Part Number:

- MNLS-O-MM-0532 (OEM type)
- MNLS-C-MM-0532 (Card-mount type)
- MNLS-B-MM-0532 (Bench-top type)

Key Features

- Fiber optic coupled, narrow spectral linewidth
- Compact size, ready for OEM integration
- Solid state light source, reliable operation in harsh environments
- Operates over wide -5 to +55^0 C temperature range
- Operates in high +85% relative humidity environments
- Center wavelength 532nm



Parameter	Unit	Min.	Typical	Max.
Operating Current	mA			1.2
Fiber Coupled Output Power	mW		80	
Center Wavelength	nm	531	532	533
Spectral Width (FWHM)	nm		0.3	
Wavelength stability (+/-)	pm		50	
Fiber Type	105 µm core Multi-mode Fiber			
Power Supply	100~220V AC for Bench-top 5V DC for Card-mount and OEM			
Size:	OEM option: 70 x 50 x 11 mm^3 Card-mounted: 120 x 95 x 26 mm^3 Benchtop: 212 x 88 x 203 mm^3			

Specifications are subject to change without notice.

Fiber-Coupled *MiniLite*™ Laser 785nm *Single-Mode* Series

BaySpec's *MiniLite*™ 785nm Single-mode fiber lasers are designed to enhance Analytical Raman Spectroscopy and Test & Measurement capabilities in the 785nm wavelength region. Devices benefit from low-cost field proven telecommunication components.

Bench-top option

Card-mounted option

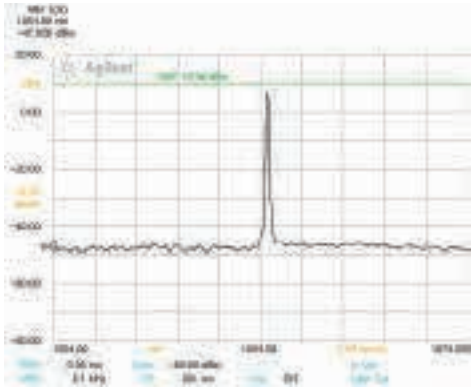
OEM option

Part Number:

- MNLS-O-SM-0785 (OEM type)
- MNLS-C-SM-0785 (Card-mount type)
- MNLS-B-SM-0785 (Bench-top type)

Key Features

- Fiber optic coupled, narrow spectral linewidth
- Compact size, ready for OEM integration
- Solid state light source, reliable operation in harsh environments
- Operates over wide -5 to +55^0 C temperature range
- Operates in high +85% relative humidity environments



Parameter	Unit	Min.	Typical	Max.
Operating Current	mA			110
Fiber Coupled Output Power	mW		40	
Center Wavelength	nm	784	785	786
Spectral Width (FWHM)	nm		0.06	
Wavelength stability (+/-)	pm	5	10	30
Side Mode Suppression Ratio	dB		40	
Fiber Type	900/125/5.5 µm Single-mode Fiber or PM Fiber			
Power Supply	100~220V AC for Bench-top 5V DC for Card-mount and OEM			
Size:	OEM option: 70 x 50 x 11 mm^3 Card-mounted: 120 x 95 x 26 mm^3 Bench-top: 212 x 88 x 203 mm^3			

Specifications are subject to change without notice.

Fiber-Coupled *MiniLite*™ 785nm *Multi-mode* Laser Series

BaySpec's *MiniLite*™ 785nm Multi-mode fiber lasers are designed to enhance Analytical Raman Spectroscopy and Test & Measurement capabilities in the 785nm wavelength region. Devices benefit from low-cost field proven telecom components.

OEM option

Card-mounted option

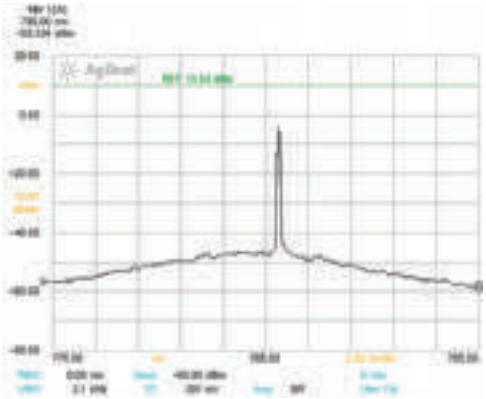
Bench-top option

Part Number:

- MNLS-O-MM-0785 (OEM type)
- MNLS-C-MM-0785 (Card-mount type)
- MNLS-B-MM-0785 (Bench-top type)

Key Features

- Fiber optic coupled, narrow spectral linewidth
- Compact size, ready for OEM integration
- Solid state light source, reliable operation in harsh environments
- Operates over wide -5 to +55^0 C temperature range
- Operates in high +85% relative humidity environments
- Center wavelength 785nm



Parameter	Unit	Min.	Typical	Max.
Operating Current	mA			2000
Fiber Coupled Output Power	mW		700	800
Center Wavelength	nm	784	785	786
Spectral Width (FWHM)	nm	0.05	0.08	0.18
Wavelength stability (+/-)	pm	5	10	50
Side Mode Suppression Ratio	dB		40	
Fiber Type	105um core Multi-mode Fiber			
Power Supply	100~220V AC for Bench-top 5V DC for Card-mount and OEM			
Size:	OEM option: 70 x 50 x 11 mm^3 Card-mounted: 120 x 95 x 26 mm^3 Benchtop: 212 x 88 x 203 mm^3			

Specifications are subject to change without notice.

Fiber-Coupled *MiniLite*™ 1064nm *Single-mode* Laser Series

BaySpec's *MiniLite*™ 1064nm *Single-mode* lasers are designed to enhance Analytical Raman Spectroscopy and Test & Measurement capabilities in the 1064nm wavelength region. Devices benefit from low-cost field proven telecommunication components.

Bench-top option

Card-mounted option

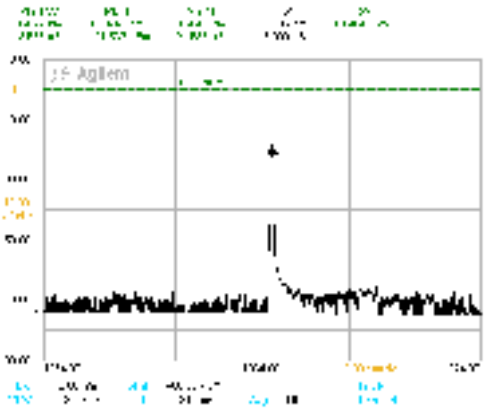
OEM option

Part Number:

- MNLS-O-SM-1064 (OEM type)
- MNLS-C-SM-1064 (Card-mount type)
- MNLS-B-SM-1064 (Bench-top type)

Key Features

- Fiber optic coupled, narrow spectral linewidth
- Compact size, ready for OEM integration
- Solid state light source, reliable operation in harsh environments
- Operates over wide -5 to +55^0 C temperature range
- Operates in high +85% relative humidity environments
- Center wavelength 1064nm



Parameter	Unit	Min.	Typical	Max.
Operating Current	mA			1000
Fiber Coupled Output Power	mW			490
Center Wavelength	nm	1063	1064	1065
Spectral Width (FWHM)	nm	0.05	0.08	0.18
Wavelength stability (+/-)	pm	5	10	50
Side Mode Suppression Ratio	dB		40	
Fiber Type	1060 Single-mode Fiber or PM Fiber			
Power Supply	100~220V AC for Bench-top 5V DC for Card-mount and OEM			
Size:	OEM option: 70 x 50 x 11 mm^3 Card-mounted: 120 x 95 x 26 mm^3 Benchtop: 212 x 88 x 203 mm^3			

Specifications are subject to change without notice.

Fiber-Coupled *MiniLite*™ 1064nm *Multi-mode* Laser Series

BaySpec's *MiniLite*™ 1064nm *Multi-mode* lasers are designed to enhance Analytical Raman Spectroscopy and Test & Measurement capabilities in the 1064nm wavelength region. Devices benefit from low-cost field proven telecommunication components.

Bench-top option

Card-mounted option

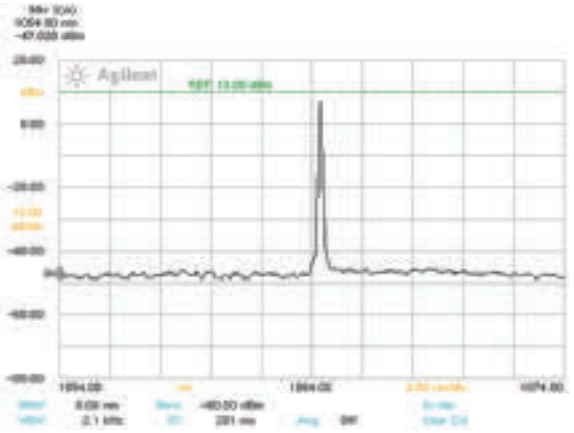
OEM option

Part Number:

- MNLS-O-MM-1064 (OEM type)
- MNLS-C-MM-1064 (Card-mount type)
- MNLS-B-MM-1064 (Bench-top type)

Key Features

- Fiber optic coupled, narrow spectral linewidth
- Compact size, ready for OEM integration
- Solid state light source, reliable operation in harsh environments



Parameter	Unit	Min.	Typical	Max.
Operating Current	mA			1200
Fiber Coupled Output Power	mW			700
Center Wavelength	nm	1063	1064	1065
Spectral Width (FWHM)	nm	0.05	0.08	0.18
Wavelength stability (+/-)	pm	5	10	50
Side Mode Suppression Ratio	dB		40	
Fiber Type	105 μm core Multi-mode Fiber			
Power Supply	100~220V AC for Bench-top 5V DC for Card-mount and OEM			
Size:	OEM option: 70 x 50 x 11 mm^3 Card-mounted: 120 x 95 x 26 mm^3 Benchtop: 212 x 88 x 203 mm^3			

Specifications are subject to change without notice.

Fiber-Coupled *MiniLite*™ 1309nm *Single-mode* Laser Series

BaySpec's *MiniLite*™ 1309nm Single-mode lasers are designed to enhance Test & Measurement capabilities in the 1309nm wavelength region. Devices benefit from low-cost field proven components.

Card-mounted option

Bench-top option

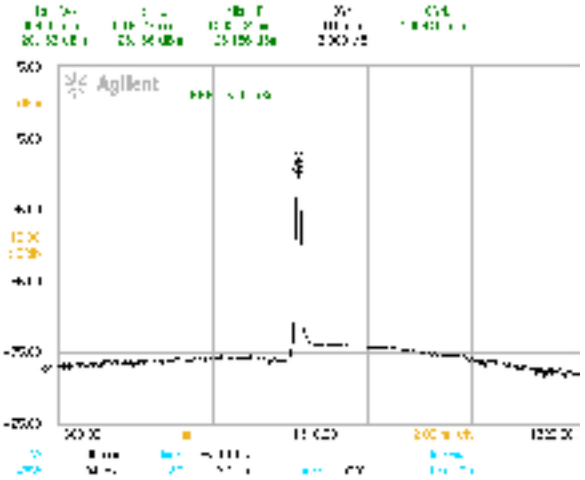
OEM option

Part Number:

- MNLS-O-SM-1309 (OEM type)
- MNLS-C-SM-1309 (Card-mount type)
- MNLS-B-SM-1309 (Bench-top type)

Key Features

- Fiber optic coupled, narrow spectral linewidth
- Compact size, ready for OEM integration
- Solid state light source, reliable operation in harsh environments



Parameter	Unit	Min.	Typical	Max.
Operating Current	mA		1100	1300
Fiber Coupled Output Power	mW	250		
Center Wavelength	nm	1307	1309	1311
Spectral Width (FWHM)	nm	0.1		0.2
Wavelength stability (+/-)	pm	5	10	30
Side Mode Suppression Ratio	dB		40	
Fiber type	Single-mode Fiber or PM Fiber			
Power Supply	100~220V AC for Bench-top 5V DC for Card-mount and OEM			
Size:	OEM option: 70 x 50 x 11 mm^3 Card-mounted: 120 x 95 x 26 mm^3 Benchtop: 212 x 88 x 203 mm^3			

Specifications are subject to change without notice.

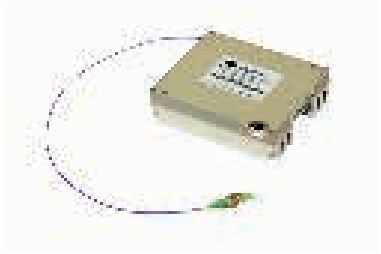
Fiber-Coupled *MiniLite*™ 650 ~ 1690nm Wideband Light Sources

BaySpec's *MiniLite*™ Broadband Light Sources are designed for use in Optical Coherence Tomography Systems, fiber sensing systems, test & measurement applications. Devices benefit from low-cost field proven telecommunication components.

Applications

- OCT Medical Diagnostics
- Fiber Optic Sensing
- T&M Source
- Laboratory Source

OEM option



Card-mount option

Bench-top option

Key Features:

- Covers wavelength ranges from 650nm~1690nm
- Fiber optic coupled, wide spectral coverage
- Integrated driver electronics
- Compact size, ready for OEM integration
- Solid state light source, reliable operation in harsh environments
- Operates over wide 0 to +70◦C temperature range
- Operates in high +85% relative humidity environments

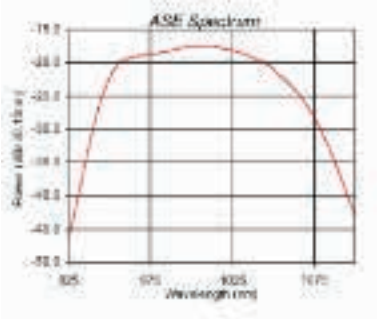
Standard Products:

Wavelength (nm)	Bandwidth (nm)	Power (mW)	Current (mA)
650	6	3	120
750	20	5	150
790	25	5	120
825	65	2	250
825	55	5	200
825	45	10	350
830	20	10	140
840	50	5	150
850	55	5	160
870	65	5	200
880	60	7	200
1030	35	3	300
1050	60	20	400
1050	70	10	200
1060	70	20	350
1070	90	10	250
1270	30	25	450
1275	75	7	400
1275	40	18	350
1300	120	5	450
1300	45	15	350
1300	60	1.5	200
1310	50	5	250
1310	75	8	400
1310	30	10	250
1310	30	15	300
1310	83	15	600
1310	40	15	250
1310	100	10	500
1310	30	20	350

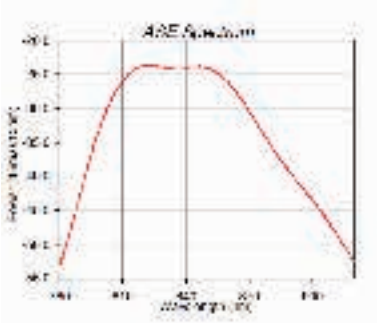
Fiber-Coupled *MiniLite*™ 650 ~ 1690nm Wideband Light Sources

Standard Products cont'd:

Wavelength (nm)	Bandwidth (nm)	Power (mW)	Current (mA)
1310	56	20	500
1310	58	30	700
1310	43	40	700
1310	38	50	700
1320	65	30	650
1340	80	0.4	180
1350	55	20	350
1380	40	8	250
1400	35	15	350
1430	45	15	350
1450	45	15	350
1470	40	15	450
1480	50	15	350
1480	60	2	300
1510	100	0.2	180
1520	60	8	250
1530	90	8	600
1550	60	5	250
1550	60	10	250
1550	45	15	300
1550	60	20	500
1560	40	30	500
1570	65	10	250
1580	58	5	200
1580	60	20	500
1600	90	1	200
1600	55	5	200
1600	60	8	300
1620	60	8	300
1650	85	2	300
1650	50	10	350
1690	50	10	400



Typical Gaussian Spectrum



Typical Flat-top Spectrum

Order Info for Part No. MWLS-

Enclosure Type	Code	Center Wave-length	Code	FWHM	Code	Fiber Type	Code	Connector Type	Code
OEM type	O	850 nm	0850	55 nm	055	Single mode	SM	No Connector	NC
Card-mount	C	1310 nm	1310	80 nm	080	Multi-mode	MM	FC/APC	FA
Bench-top	B	1550 nm	1550	specify nm	yyy	Custom	zz	FC/PC	FP
		specify nm	xxxx					SC/APC	SA
								SC/PC	SP
								LC/APC	LA
								LC/PC	LP
code selection:		code selection:		code selection:		code selection:		code selection:	

order code example: MWLS-C-0850-055-SM-NC

Light Sources *IntelliGain*™ Metro_AD EDFA Series

Parameter	Unit	Metro-I_AD EDFA	Metro-II_AD EDFA	Metro-III_AD EDFA	Notes
Operating Temperature	^{0}C	-5 to 70	-5 to 70	-5 to 70	Bellcore Qualified
Wavelength Range	nm	1530 - 1562	1530 - 1562	1530 - 1562	-5 to 70^{0}C
Saturated Output Power	dBm	=+5	=+10	=+15	Pin = -3 dBm
Small Signal Gain	dB	=15	=20	=25	Pin = -20 dBm
Noise Figure	dB	=5.5	=5.5	=5.5	Pin = -10 dBm
Polarization Sensitivity	dB	<0.5	<0.5	<0.5	
Return Loss (Input & Output)	dB	>35	>35	>35	Pin = -10 dBm @ Pump off
Pump Wavelength	nm	980	980	980	
Pump Current	mA	=80	=150	=300	
Pump Forward Voltage	V	<1.5	<1.8	<2.0	
Operating Current	A	<0.8	<1.0	<1.3	
Operating Voltage	V DC	+5	+5	+5	
Total Power Consumption	W	=4.0	=5.0	=6.5	
Package Dimension	mm	100 x 71 x 13	100 x 71 x 13	100 x 71 x 13	

Notes

- All electronics for Metro-I and Metro-II are packed into the Metro-I box.
- All electronics for the Metro-III are packed into the Metro-II box.
- A power supply of 5 V DC with maximum 0.1 A current output is required to operate the Metro-I or Metro-II units.
- Total power consumption depends upon environment operating temperature.
- Mechanical drawings of layout and electronics pin out are provided upon request.
- Custom design available.

Light Sources *IntensiGain*™ C- & L-Band Amplifiers

Parameter	Unit	C-Band In-Line Amplifier	C-Band Power Amplifier	L-Band In-Line Amplifier	L-Band Pre-Amplifier	L-Band Power Amplifier
Operating Temperature	^{0}C	-5 to 70	-5 to 70	-5 to 70	-5 to 70	-5 to 70
Wavelength Range	nm	1530-1562	1530-1562	1570-1605	1570-1605	1570-1605
Saturated Output Power	dBm	=15	=20	=14	=10	=17
Small Signal Gain	dB	=25	=30	=24	=20	=27
Noise Figure	dB	=5.5	=6.0	=5.5	=5.5	=6.0
Polarization Sensitivity	dB	<0.5	<0.5	<0.5	<0.5	<0.5
Gain Flatness (peak-to-peak)	dB	<1.0	<1.0	<1.0	<1.0	<1.0
Return Loss	dB	>35	>35	>35	>35	>35
Case Dimension	mm	120x 80x 13	120x 95x 13	120x 95x 13	120x 80 x 13	120x 95x 13

Notes

- Custom design and OEM are available.
- Mechanical drawings of layout and electronics pin out are provided upon request.
- See IntensiGain™ C-band series Power, Pre- and In-Line Amplifiers.

IntelliGain™ Broadband (EDFA) ASE Light Sources

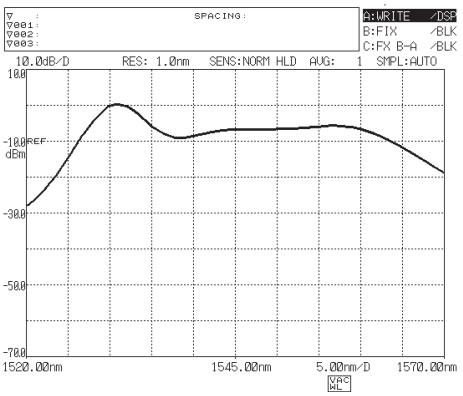
BaySpec's *IntelliGain*™ Broadband ASE Light Sources are based on amplified spontaneous emission in erbium-doped fibers and are developed using our proprietary EDFA technology. These light sources provide superior optical output to the conventional LED sources over a broad spectral range (1525 - 1605 nm). Different power levels and multi-output options are available and suitable for a variety of different applications, providing cost effective solutions to the market.

Key Features

- High output power
- Adjustable power control
- High spectral stability
- Non-polarized light output
- Low power consumption
- Compact size

Applications

- Optical component spectral tests
- DWDM system and component tests
- Optical measurement systems
- Optical sensing



Parameter	Unit	C-Band Normal	C-Band Flat-Top	C+L Band Normal	Note
Wavelength Range	nm	1525 - 1565	1525 - 1565	1525 - 1605	
Maximum Output Power	dBm	> 16	> 11	> 16	
Spectral Density	dBm/nm	> -10	> -10	> -17	
Power Stability	dB	< 0.03	< 0.03	< 0.03	After 1 hour warming up
Power Supply	V	100 - 240	100 - 240	100 - 240	
Power Consumption	W	< 10	< 10	< 12	
Operating Temperature	^{0}C	0 to 40	0 to 40	0 to 40	
Storage Temperature	^{0}C	-40 to 80	-40 to 80	-40 to 80	
Optical Fiber	-	SMF-28	SMF-28	SMF-28	
Optical Connector	-	FC/PC	FC/PC	FC/PC	Customer-specified
Dimension	mm	212 x 88 x 203			OEM

Notes:

Fiber Optic Probe & Custom Assemblies

			
Part Code	PROB	SMA	TP
Description	Raman Probes	Bundles Jumpers	Dip Probes, Tips
Part Number Series	PROB-0532 PROB-0785 PROB-1064 Immersion/Reaction Custom	SMA-XX	TP-C-X

p. 79-81

Peak-Finder™ Fiber Optic Raman Probes

- 532nm
- 785nm
- 1064nm
- Immersion/Reaction
- Custom

Applications:

- Raman Spectroscopy
- Cancer Research
- Oil/Gas/Biofuel Analysis
- Raw Material ID
- Process Monitoring

p. 82-93

Spec-Connect™ Series:

- Component Options
- Jumpers
- Bundles
- Furcated Bundles
- Dip Probes
- Dip Probes Removable Tips
- Optical Adapters
- Flanges

The *Peak-Finder*™ Probe Series

BaySpec's Peak-Finder™ fiber optic probe series feature optical filtering of 6 OD for efficient attenuation of the Rayleigh line for background-free spectra. The probe is lightweight and compact, and has a manual safety shutter to shield the user from the laser light. The Peak-Finder™can be used with a compact sample holder for routine measurement of liquids and solids. The unit utilizes a polymer-encased fiber optic cable, 105µm excitation fiber with FC/PC or FC/APC connector, 200µm collection fiber with FC/PC or SMA905 connector for easy coupling to most laser/spectrograph combinations. Custom configurations available.

Applications:

- Biomedical Research
- Law Enforcement/Forensics
- Counterfeit Detection
- Biofuels Processing
- Pharmaceuticals

Features:

- Optimized for Raman Instrumentation
- N/A=0.33 Optics
- Durable, ruggedized packaging

Parameter	Specification
Part number	PROB-0532 (532nm); PROB-0785 (785nm); PROB-1064 (1064nm)
Sampling Head	Anodized aluminum probe, 4.2" x 1.5" x 0.5" (107 x 38 x 12.7 mm), with 1" long (25.4mm) stainless-steel probe tip
Spectral Range	200-3400 cm^{-1} (Stokes)
Excitation Wavelength	532nm; 785nm; 1064nm
Spot Size	120µm (532 & 785nm); 10µm (1064nm)
Working Distance	12.5mm (inquire on others)
Fiber Configuration	Permanently-aligned combination of two single fibers (105µm excitation fiber, 200µm collection fiber standard) with filtering and steering micro-optics, N.A. 0.22, in a rugged polyurethane jacket
Filter Efficiency	Patented design for complete filtering of the laser line and quartz spectral contributions from both input and ouput fibers (O.D.>6 at laser wavelength)
Fiber Type	Polymer-encased fiber optic cable, 105µm excitation/ 200µm collection fiber
Cable Length	1.5 meters
Coupling System	Available with multi-mode FC (standard) or SMA905 connectors

The *Peak-Finder*™ Immersion/Reaction Process Probe Series

BaySpec's Peak-Finder™ immersion/reaction fiber optic probe series features the same optical performance as the standard Peak-Finder™ with a stainless-steel extension head for liquids and harsh environments. The probe is lightweight and compact, and has a manual safety shutter (with built-in calibration standard) to shield the user from the laser light. The Peak-Finder™ can be used with a compact sample holder for routine measurement of liquids and solids. The unit utilizes a polymer-encased fiber optic cable, 105µm excitation fiber with FC/PC or FC/APC connector, 200µm collection fiber with FC/PC or SMA905 connector for easy coupling to most laser/spectrograph combinations. Custom configurations available.

Features:

- Optimized for 532, 785, or 1064nm Raman Instrumentation
- N/A=0.33 Optics
- Durable, ruggedized packaging

Applications:

- Petrochemical
- Oil Exploration
- Beverage & Brewery
- Water quality
- Pulp & Paper
- Mining

Parameter	Specification
Part number	PROB-P-532, PROB-P-785, PROB-P-1064
Sampling Head	Standard stainless-steel tube with extension head 3/8" (9.5mm) diameter x 9" (228 mm) length. (Inquire on custom options)
Spectral Range	200-3400 cm^{-1} (Stokes)
Excitation Wavelength	532, 785, 1064nm, others available upon request
Spot Size	120µm (532 & 785nm); 10µm (1064nm)
Working Distance	Spherical "ball" lens for general solution measurements (std.), flat window with fixed working distance optional.
Fiber Configuration	Permanently-aligned combination of two single fibers (105 µm excitation fiber, 200 µm collection fiber) with filtering and steering micro-optics, N.A. 0.22, in stainless-steel jacket Option: fiber sizes ranging from 50 µm to 500 µm
Filter Efficiency	Complete filtering of the laser line and quartz spectral contributions from both input and output fibers (O.D. > 6 at laser line)
Fiber Type	Polymer-encased fiber optic cable, 105µm excitation/ 200µm collection fiber
Chemical resistance	316 Stainless-steel sleeve, sapphire window (flat or lensed) and gold seal are resistant to corrosive chemical environments
Cable Length	4m steel-jacketed cable (std.), up to 300m on request. PVC coating over steel cable optional.
Coupling System	Available with multi-mode FC (standard) or SMA905 connectors

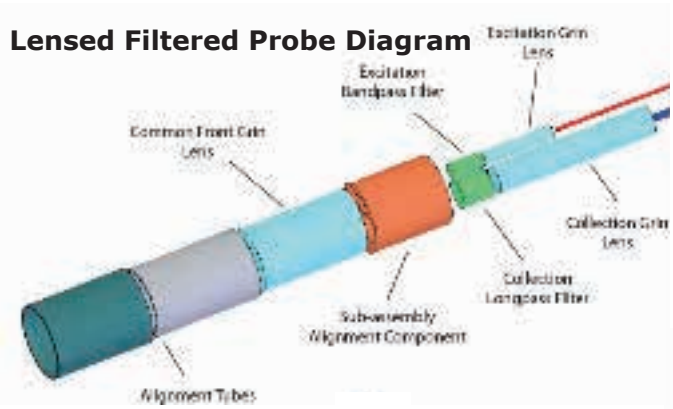
Miniature Lensed and Bundle Fiber-Optic Raman Probes

BaySpec Lensed Filtered Probe is the first fiber optic probe to deliver the performance of a larger lensed probe in an extremely small diameter. BaySpec's probe designs will allow measurements and applications previously not possible. The optical elements in this design are permanently fixed in alignment, with no possibility of movement due to impact or vibrations. The tip is scratch resistant and easy to clean.

The probe designs have been optimized for either direct contact or stand-off measurements. The working distance from the face of the probe can be designed to achieve distances from 0 to 2.5mm. Another unique aspect of the BaySpec Lensed Filtered Probe is that the probe design can allow different spectroscopic techniques to be performed from one probe. For example, Raman and near-infrared measurements can be taken through the same probe, ensuring those readings come from the same location.

Several options are available for coupling the Lensed Filtered Probe to your spectrographic instrument. From standard connectors to custom ferrules, an option is available for your needs. When contact measurements are required, the BaySpec Bundle Contact Probe has been optimized to significantly outperform a general purpose fiber bundle probe while maintaining its small form factor.

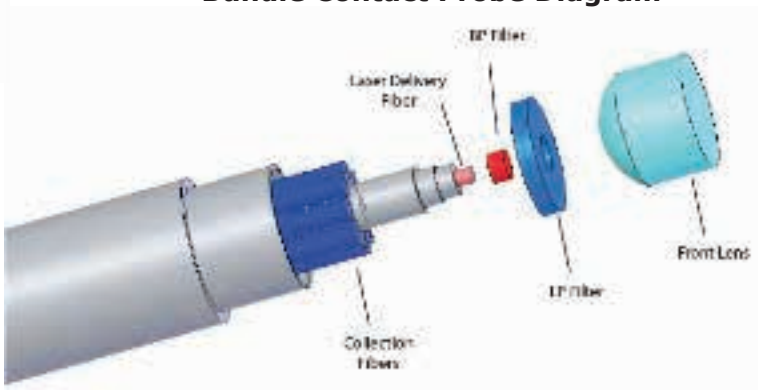
Lensed Filtered Probe Diagram



Applications:

- Raman spectroscopy
- Biomedical research
- Process monitoring

Bundle Contact Probe Diagram



Parameter	Miniature Lensed Probe	Miniature Contact Probe
Probe Dimensions (rigid 304 SS tip)	0.2" (5.2mm) diameter 4" (10cm) length	0.083" (2.1 mm) diameter 4" (10cm) length
Spectral Range	300-3900 cm (Stokes)	300-3900 cm (Stokes)
Excitation Wavelength	532, 785, 1064nm, others available upon request	532, 785, 1064nm, others available upon request
Working Distance	2.2mm standard	0-400µm (sample dependent)
Fiber Configuration	Collection: (1) 400µm core Excitation: (1) 105µm core	Collection: (7) 300µm core Excitation: (1) 200µm core
Filter Specifications	OD > 6 at laser line	OD > 6 at laser line
Cable Length	4.6' (1.4m) standard	4.6' (1.4m) standard
Coupling System	Available with FC/PC or SMA905 connectors	Available with FC/PC or SMA905 connectors

The *SPEC-CONNECT*™ Series

BaySpec's SPEC-CONNECT™ Series Custom Fiber & Probe Assemblies include everything needed to easily connect or manipulate fibers for experiments or OEM applications.

Example: 1x4 Fiber Bundle with *SuperGamut*™ NIR Spectrometer

Product Types:

- Jumpers
- Bundles
- Furcated Bundles
- Probes
- Optical Adapters
- Hardware Adapters

Jumpers

Commonly called jumpers or patchcords, these basic fiber assemblies range from more generic datacom jumpers to the single fiber, large core cable designs utilizing more robust and customized components.

Optical coatings to lower the reflection (AR coating) or to create a cutoff wavelength can be added to the fiber, as well as any multi-fiber assembly.

We also offer high power SMA's using SS or copper ferrules which have an air pocket surrounding the front of the SMA ferrule, as well as an aluminum or copper heatsink to pull the thermal energy away from the fiber.

Bundles

A fiber bundle assembly is used for transporting light from extended sources using more than one fiber, up to thousands of fibers.

The style of termination on each end may be any of our standard types of terminations.

However, many products are OEM based and therefore require a specific design that can be manufactured by one of our top quality suppliers to our exacting standards.

The fibers can be arranged into round, ring, a single line or a multi-segment line or arc, or packed into 2D shapes and arrays.

V-grooves in the base material are commonly used for interfacing to diode lasers and can be AR coated to maximize light throughput.

Bifurcated Bundles

These assemblies are the same as bundles, but either one side or both sides of the assembly can be separated into a multiple number of standard or custom-designed terminations and fiber configurations to match the physical and optical characteristics required at the terminations.

These assemblies can be used to split or combine optical power and are available with various fiber distribution designs from one end to the other.

Bundle assemblies, commonly called harnesses, that use SM, 50, or 62.5µm core fibers are generally made for datacom applications. They use standard datacom connectors such as FC, ST, LC, SC, MTP, MT-RJ, etc. for short assemblies.

Probes

These assemblies can be immersed into a liquid solution in order to obtain spectra of its constituents and are commonly referred to as a Dip Probe or a Transmission Probe. The basic design consists of two fibers with a lens that collimates the light from one fiber through an open section through which the liquid can pass.

The light is reflected off of a mirror to pass through the liquid and lens a second time and is refocused onto the second fiber for transmission to the analyzing instrument. For the standard probe design, the liquid absorption path length is double the physical opening of the threaded, replaceable tip.

Other designs may call for larger probes or more robust probes designed to meet harsher conditions, or specialized single pass designs.

Optical Adapters

Optical adapters are designed to fit onto a connector or custom termination, or can be designed to mount onto a piece of equipment.

Their purpose is to image or collimate the light from the fiber(s), or to focus light onto the fiber(s) from a light source.

Generally they consist of a machined part with the optical element mounted in place, with or without a focusing adjustment.

These adapters also consist of vacuum feed-throughs where optical testing is performed through a chamber wall.

This can be accomplished using a variety of modified vacuum flange designs, such as the standard conflat flanges which are available.

The fiber assembly is sealed using Varian Torr Seal and may include a lens to collimate or capture the signal.

Key Design Benefits:

- Premium-grade components
- Proven reliability
- Flexible options
- Customizable

Hardware Adapters

These generally contain no optical components, but can be used for mounting fiber assemblies to a piece of equipment, to another fiber assembly, or for enclosing optical components or assemblies.

Standard adapters include those which mate SMA, FC, ST or any other standard connector to another connector.

Other custom adapters are generally made specifically for OEM clients and their applications.

Applications:

- Pharmaceuticals
- Medical diagnostics
- Agriculture
- Semiconductors
- Beverage & Brewery
- Cosmetics
- Explosives detection
- Counterfeit detection
- Water quality
- Food safety
- Petrochemical
- Law Enforcement
- Pulp & Paper
- Homeland security

The *SPEC-CONNECT*™ Series

Component Options

There are many options available to build a fiber optic assembly. These options will be restricted by your specific environmental requirements including: temperature, pressure, chemical media and bundle size, among other criteria. Please detail any requirements that may be present, or if a desired option is not found below.

Fiber Optics

Parameter	Specification
SM and Graded Index	50, 50µm-10Gig and 62.5µm
Step-index Fibers from	<50µm to >2000µm
Wavelength ranges UV (180-1100nm) NIR (<400-2400nm) Broadband (<275-2100nm) Solarization Resistant UV Other specialty fiber ranges include IR grades	 Standard Grade UV/Vis Standard Grade UV/Vis Wide range, higher attenuation at select peaks For high-power UV sources <280nm ranging from <2µm to >15µm wavelength
Silica/Silica Core/Clad ratio Options Numerical Aperture Options	 1.10 (standard) 1.05 to 1.40 0.22 +/- 0.02 (standard) 0.10 to 0.53
Hard/Plastic Clad Silica Core/Clad ratio Numerical Aperture Options	 core + 30µm (typical) 0.37/0.39 0.22 to >0.50
Plastic optical fiber Core Diameter (mm) Numerical Aperture	 typically .010, .020, .030, .040 & .060 >0.50
Fiber Buffers Operating Ranges Acrylate Nylon Tefzel (intermittent up to 200°C) Silicone Polyimide (intermittent up to 400°C) Aluminum Gold	 -40°C to 85°C -40°C to 100°C -40°C to 150°C -40°C to 150°C -65°C to 300°C -269°C to 400°C -269°C to 700°C
Bending Radii: <100x intermittently, to 400x long term. Values depend on factors including the type of fiber, temperature, fiber proof test level, number of fibers and dynamic motion of the installed fiber.	

Connectors / Terminations

Parameter	Specification
Telecom connectors:	LC, SC, ST, FC, MU, E2000, MT-RJ, MTP
Large core terminations: SMA-905 ST/FC w/metal ferrule Ceramic ferrules Ø1/4" x 2" or 3" Long SS 303/4 Ø10mm x 50mm SS 303/4 Custom ferrules and materials for your application	options include counterbored copper versions for high power laser applications

Cabling

Parameter	Specification
2.0, 2.8, 3.0 & 3.8mm Fiberoptic Tubing	various colors PVC rated for 0°C to 70°C* Polyurethane for -40°C to 85°C* (more flexible/abrasion-resistant than PVC)
Stainless Steel Monocoil with Black PVC Jacket	Rated for -40°C to 100°C
SS Monocoil with Fiberglass Braid, Grey Silicon Rubber	Rated for -40°C to 200°C
Polymide Tubing	
Various plastic, rubber and blended varieties of tubing	
* Cabling may be used outside of these temperature ranges, but brittleness, flexibility and softening should be considered when operating near the stated minimum and maximum temperature ranges.	

Coatings

Parameter	Specification
Anti-reflection optical, AR coatings are optional	These can be a single or dual wavelength V coating, broadband or of a customed design
Coatings and material treatment for terminations can also be provided	

The *SPEC-CONNECT*™ Series

Jumpers: Cable Designs

These basic fiber assemblies are single fiber, large core cable designs made with the standard cable options.

They can also use more robust cable designs to meet specific environmental concerns, such as high power using standard or copper ferrules.

Jumpers: Tubing

Round nut/boot and 3.0mm furcation tubing is standard in green PVC jacket for all fiber sizes 500µm and less.

Hex nut/boot and 3.8mm furcation tubing is standard in green Polyurethane jacket for fibers >500µm.

Substitutions allowed upon request.

Part Number Configurator

J-AA-B-C-D-E-F-G-xxxH, where xxx is the length in meters or cm's and "J" is for Jumper

Example: J06U554UG007M: 600µm UV, 0.22 NA S/S, SMA-905 to SMA-905 jumper
Ø3.8mm Green Polyurethane Furcation Tubing, 7 meters

Fiber Size µm		Fiber Type		Connectors		Jacket Type (1)		Jacket Material		Color		Length	
AA		B		C & D		E		F		G		xxxH	
1	100	P	PMMA	1	10mm OD 303/4 SS x 50mm	1	900µm	V	PVC	B	Blue	M	M's
2	200	U	0.22 UV S/S	2	.250" OD 303/4 SS x 2"	2	2mm Furcation	F	PVDF	O	Orange	C	CM's
3	300	L	0.22 UV S/S Low Solarization	3	.250" OD 303/4 SS X 3"	3	3mm Furcation	T	TEFLON	G	Green		
4	400	N	0.22 NIR S/S	4	SMA-905 with Round Nut	4	3.8mm Furcation	U	POLYURE-THANE	N	Brown		
5	500	1	0.37 UV HCS	5	SMA-905 with Hex Nut	5	4.5mm PVC Monocoil	R	RISER	S	Slate		
6	600	2	0.37 NIR HCS	6	SMA-906	6	5.6mm PVC Monocoil	R	PLENUM	W	White		
8	800	3	0.48 UV HCS	7	SMA-905, Copper Ferrule	7	5.1mm OD SS	P	LSZH/ RISER	R	Red		
10	1000	4	0.48 NIR HCS							K	Black		
15	1500									Y	Yellow		
20	2000									V	Violet		
										P	Rose		
										A	Aqua		

Jumpers: Optical Coatings

Optical coatings can be added to enhance the fiber's properties for reflection or cutoff wavelengths.

Jumpers: Standard SMA-905 to SMA 905, 0.22NA, UV grade jumpers

- Substitute the "U" with an "N" for NIR grade. "xxx" is for Meters or CM's.

Fiber Core µm	Part Number
100	J01U443VGxxxM
200	J02U443VGxxxM
300	J03U443VGxxxM
400	J04U443VGxxxM
500	J05U443UGxxxM
600	J06U554UGxxxM
800	J08U554UGxxxM
1000	J10U554UGxxxM

Fiber Core µm	Part Number
UV Low Solarization	
200	J02L443VGxxxM
600	J06L554UGxxxM
UV 0.37NA	
Substitute the 4th digit "1" with "2" for NIR	
200	J021443VGxxxM
400um	J041443UGxxxM

Available with Aluminum or Copper Heatsink

High Power SMA with Copper Ferrule

The *SPEC-CONNECT*™ Series

Bundles

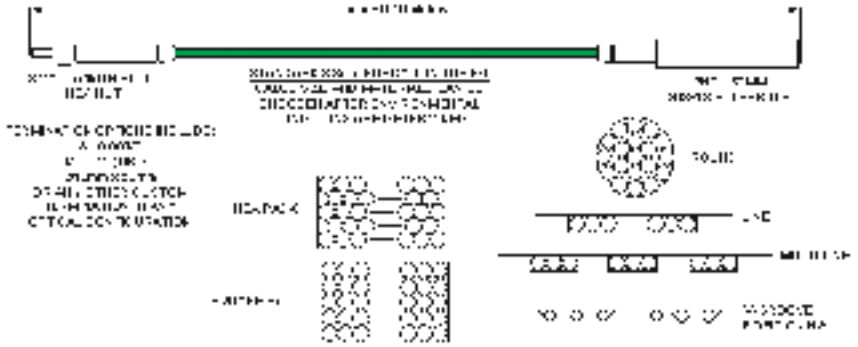
A bundle can be thought of as a jumper assembly, but with many more fibers, and a virtually unlimited number of options available for fiber types, cable materials and construction as well as end terminations.

Many of these bundles can have one of our standard types of terminations.

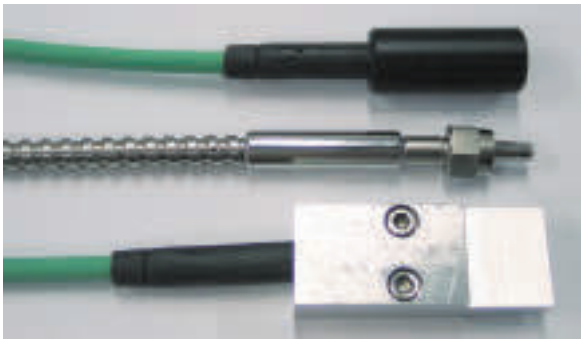
However, many products are OEM based and therefore require a specific design that can be manufactured by one of our top quality hardware suppliers.

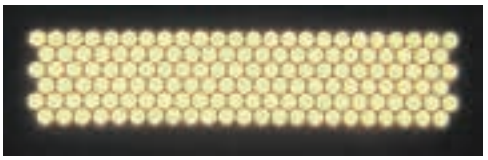
The fibers can be arraigned into a round, ring, continuous or multi-segment line or arc, or packed into 2D shapes or arrays.

V-grooves in the base material or silicon are commonly used for coupling to Diode-Pumped Solid-State Lasers (DPSSL) which are often optically coated to minimize de-stabilizing reflection of energy from the polished fiber surfaces back to the diodes or interface hardware.



Due to the unlimited variety of configurations possible, customer specific part numbers will be generated upon the RFQ. Options for high and low temperature applications as well as coatings required for high power applications are available upon request.





The *SPEC-CONNECT*™ Series

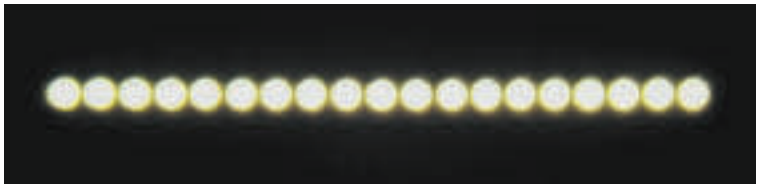
Bundles

Some basic assemblies are listed below using 3.8mm green Polyurethane furcation tubing. For all other designs, please e-mail or call us.

All SMA's use a Hex Nut

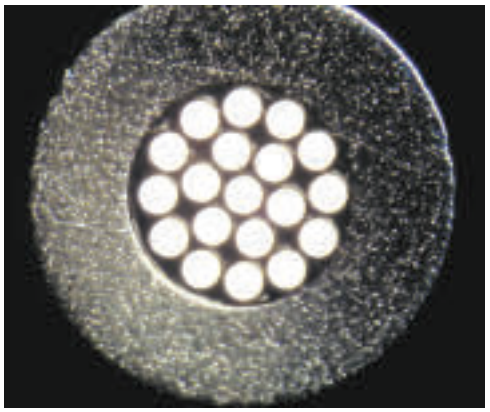
Bundle Type	# of Fibers Fiber Size (µm)	Part Number 0.22NA, UV	Part Number 0.22NA, NIR
Round to Round SMA-905 to SMA-905	7 - 100	BU0001-001M	BU0011-001M
	19 - 100	BU0002-001M	BU0012-001M
	7 - 200	BU0003-001M	BU0013-001M
	19 - 200	BU0004-001M	BU0014-001M
Round to Line SMA-905 to 1/4 x 2" Ferrule	7 - 100	BU0005-001M	BU0015-001M
	19 - 100	BU0006-001M	BU0016-001M
	7 - 200	BU0007-001M	BU0017-001M
	19 - 200	BU0008-001M	BU0018-001M

Ø10mm OD x 2" 303/4 SS Ferrule



Close up of 19 x 200µm

19 Fibers, 200µm SMA-905 to 10mm OD Ferrule



Close up of SMA-905

The *SPEC-CONNECT*™ Series

Furcated Bundles

A furcated bundle is the same as a bundle, except that one or both ends can be split into two or more terminated legs.

The number of options available for fiber types, cable materials and construction as well as end terminations is unlimited.

They may use some of our standard types of terminations, or can be OEM based and therefore require a specific design that can be manufactured to exacting specifications.

7 Fibers, 200µmSMA-905 to
1 & 6 Fiber SMA-905

Fiber Optic Bundles

Some basic assemblies are listed below using 3.8mm green Polyurethane furcation tubing.

All SMA's use a Hex Nut

Bundle Type	# of Fibers Fiber Size (µm)	Part Number 0.22NA, UV	Part Number 0.22NA, NIR
Ø1/4" x 3" Round to (2) SMA-905's 1 & 6 fiber	7 - 100	BF0001-001M	BF0021-001M
	19 - 100	BF0002-001M	BF0022-001M
	7 - 200	BF0003-001M	BF0023-001M
	19 - 200	BF0004-001M	BF0024-001M
Ø1/4" x 3" Round to (1) SMA-905 & (1) Ø1/4" x 3" Fiber Line	7 - 100	BF0005-001M	BF0025-001M
	19 - 100	BF0006-001M	BF0026-001M
	7 - 200	BF0007-001M	BF0027-001M
	19 - 200	BF0008-001M	BF0028-001M

Legs are 0.5 meters in length

Options for high and low temperature applications, as well as AR coatings are available upon request. Specific fibers can be routed from the common end termination to specific locations within the leg terminations as required.

For all other designs, please e-mail or call.

The *SPEC-CONNECT*™ Series

Bifurcated Bundles

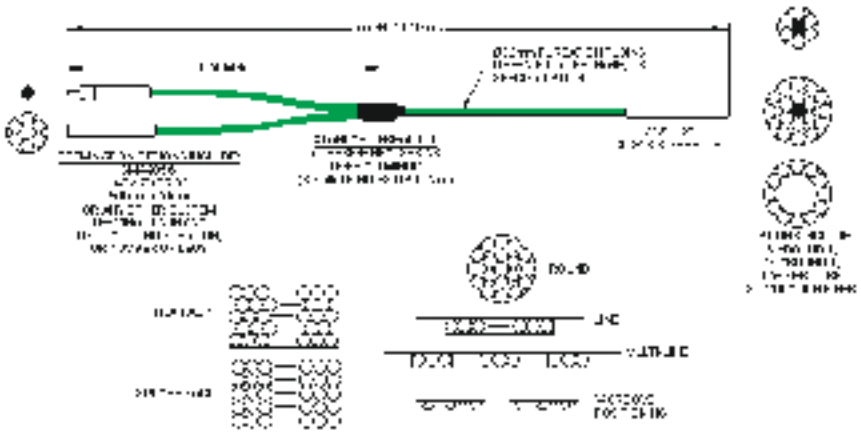
Bifurcated assemblies that are used to measure fluorescence, backscattering or reflection from various surfaces may contain anywhere from 2 to >100 fibers.

They function by using a single or multitude of fibers as the excitation/illumination source and the remaining fibers as the collection/ detection fibers.

The fibers can be arranged into a round, ring, continuous or multi-segment line or arc, or packed into 2D shapes or arrays.

V-grooves in the base material or silicon are commonly used for interfacing to multi-channel spectrometers or to Diode-Pumped Solid-State Lasers (DPSSL). Images for DPSSL are generally coated to minimize de-stabilizing reflection of energy from the polished fiber surfaces back to the diodes or interface hardware.

Standard Heatshrink Breakout (Bottom)
Optional SS Breakout



1 to 3, SS Armored Cable

The *SPEC-CONNECT*™ Series

Dip Probes

Commonly referred to as a Dip Probe or Transmission Probe and used for liquids spectroscopy.

These assemblies contain two fibers using a lens to collimate the light from one fiber through an open section, through which a liquid can pass.

The light is then reflected off of the mirror, passing through the liquid and lens a second time, and is refocused onto the second fiber for transmission to the analyzing instrument, typically a spectrometer.

The optical pathlength in this design is double the physical opening of the replaceable tip.

Other designs can be manufactured for specific applications including dissolution and harsh environments.

All SMA's use a Hex Nut

Fiber Size (µm)	Part Number
200	PD200UF-1.5M
300	PD300UF-1.5M
400	PD400UF-1.5M
600	PD600UF-1.5M
Low Solarization Fiber	
300	PD300LF-1.5M
600	PD600LF-1.5M

For NIR grade 0.22 NA fibers, substitute the "U" with an "N" for the probe and tip part numbers.

For Monocoil, substitute the "F" with an "M".

Monocoil 1/4" OD Probe

Fiber Optic 1/4" OD Probe

Dip Probe Removable Tips

Parameter	Specification
Fiber Type	0.22 NA
Fiber Size	200 to 600µm
Wavelengths	UV, NIR & Low Solarization
Terminations	SMA-905's
Cable Designs	Polyurethane Tubing with PVC Monocoil (all PVC Monocoil with SS breakout optional)
Probe Body Length	127mm (5.0")
Probe / Tip Material	Passivated 316L SS
Max Temperature	100^{0}C (due to Monocoil)

The *SPEC-CONNECT*™ Series

Optical Adapters

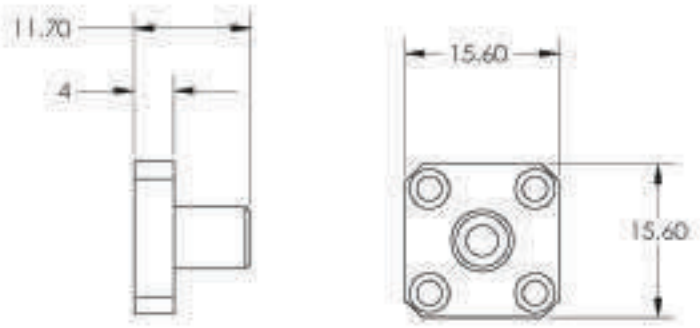
Optical adapters are used for focusing or collimating light to/from fiber optics.

These can be made to fit ferrules or connectors such as an SMA-905 or FC.

Modified Conflat Flanges using a sealed fiber can be mounted into vacuum chambers. They can be used with a fiber within the chamber or with a screw on collimator.

An AR coating can be applied to the optics for less reflection, but will limit the useful wavelength range.

Please contact us with any inquiries.



Flanges

All standard sized conflat flanges are available and can be modified to fit multiple fiber or optical feedthroughs. Choose from rotatable, non-rotatable, threaded or non-threaded mounting holes, type of bolts/nuts, seal and flange material.

The standard combination is non-rotatable, non-threaded hex bolt & hex nut in 304L SS.

Technical Resources

Application Notes

Dispersive NIR Spectrometers for Moisture/Blending Analysis
Quantifying Blending of Gasoline Components by Raman Analysis
1064nm Raman for Petroleum Products
1064nm Raman: Algae Biofuels Measurement
Tissue Raman at 1064nm

Academic Grant Program

Academic Grant Program Description

White Papers in Brief

Volume Phase Grating®
Near-Infrared Spectroscopy
Dispersive Raman Instrumentation in the Longer Near-Infrared, 1064nm and Beyond
Deep-Cooled Detectors/Cameras
Optical Channel Performance Monitors
Fiber Bragg Grating Interrogation Analyzer

Industry Terms and Definitions

Spectroscopy
Telecom/ Fiber Sensing

NOTE:

Full Application Notes and White Paper texts located at: **www.BaySpec.com**

To request additional information, please email: **info@bayspec.com**

Application Note

Dispersive NIR Spectrometers: Pharmaceuticals / Neutraceuticals / Food / Paper / Beverage/ Ag

Assuring Water Content during Blending and Mixing Results by Near Infrared Spectrometer

Confirming the water content of pharmaceuticals and food during processing is critical for GmP results. The ability to measure water content until recently has been a difficult challenge. As a result of developments in the telecom industry, near infrared spectrometers offer highly repeatable, cost effective solutions.

It has been well-documented that NIR spectroscopy is an excellent method to measure water in powder mixtures. However, absorption curves are different for each given process and are developed for a given manufacturer's process. Once completed, the understanding and control of the blending process has significant benefits and typically pays for the metrology in time savings, waste reduction, faster time to market, reduced maintenance on machinery, and faster process certification.

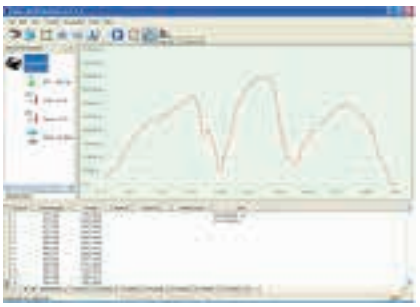
Better process control and process understanding has intangible benefits as well. With subtle problems, sometimes knowing where not to look can have great value.

Blend Uniformity Measurement

The same instrument that can measure your water during process has the ability to assure blend uniformity. In 2004 the FDA published a guidance document for PAT. The real intent of the document is to get manufacturers to fully understand their product completely during the production cycle. This has many benefits, not the least of which is if the FDA has confidence that the manufacturer understands his processes thoroughly, they are more willing to allow changes to the production process. The manufacturer knowing his product better knows where economies can be improved without adversely effecting product.

SuperGamut™ NIR Spectral Engine

Figure 1: Pharmaceutical blending operation.



Benefits of real time in-situ NIR Spectroscopy are:

- Greater control of the process
- Reduced waste
- Improved yield
- Shorter time to market
- Optimized process times
- Better process understanding
- Real-time feedback
- Reduced maintenance
- Minimal operator involvement
- Optimizes equipment utilization
- Improved process documentation
- Reduced manufacturing costs
- Better lot–to-lot uniformity

Quantifying Blending Components in Gasoline by a Raman Spectrometer

Portable Raman spectrometers have gained wide acceptance in recent years for identifying unknowns in field applications. They have been successfully deployed in mission-critical situations such as hazardous materials identification. They have proven to be especially effective in raw materials inspection for chemical, pharmaceutical, and electronic industries. As impressive as these applications may be, however, they are qualitative in nature. In this short note we present an example of using BaySpec's Raman spectrometer for quantitation work, namely, measuring methanol component in blended gasoline.

In the last couple of years the world has witnessed a most spectacular roller-coaster ride in crude oil prices, which impacts national economies and ordinary citizens alike. To mitigate the high price of transportation fuels and reduce green house gas emissions at the same time, blending less expensive oxygenates into gasoline has become a common, acceptable practice. In the US ethanol is the main blending stock, with E85 widely available in certain parts of the country. However, it is not a viable option for a developing and populous country like China, due to competition with food crops and diminishing or negative price differential with gasoline. On the other hand, methanol is an industrial commodity chemical and readily produced from coal or natural gas. Worldwide over-capacity of methanol production has driven its price to a third of that of gasoline. Therefore methanol instead of ethanol becomes the preferred blending stock in some parts of the world.

Gasoline blended with methanol is a cleaner burning fuel. However, methanol is corrosive to metal parts at high temperatures and swells many elastomers, especially at high blending proportions. Car engines must be modified to operate safely with methanol containing fuel. Methanol also has a tendency to phase separate from gasoline at low temperatures if lacking proper co-solvents. Thus unregulated production and distribution of gasoline blended with methanol could cause serious property damage to unsuspecting motorists.

Raman spectroscopy is a non-invasive, nondestructive analytical technique. Unlike the more popular and closely related technique FTIR, it requires no sample preparation and is insensitive to interference from water or moisture. As demonstrated by the BaySpec Raman Spectrometer, homogeneous samples with constant sampling volume and stable laser output (power and wavelength) can achieve excellent quantitation results produced.

Typical Raman spectra are shown in the graph below.

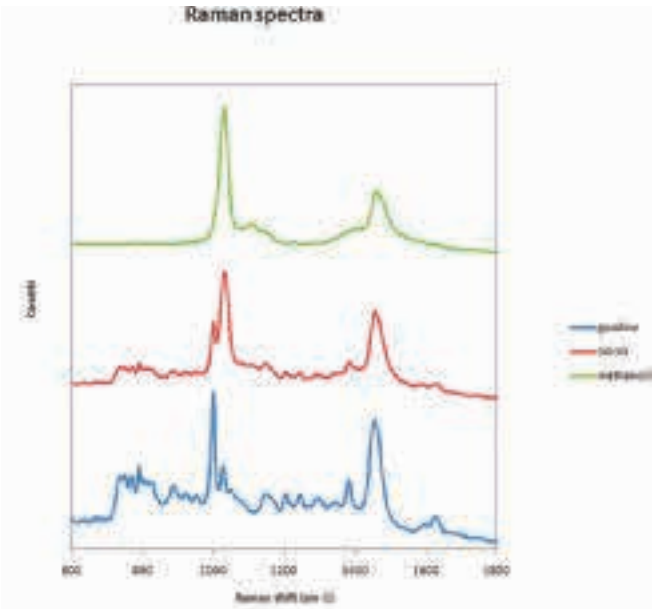


Figure 1 Typical Raman spectra taken with BaySpec's Raman Analyzer. Integration time: 4 seconds.

Figure 2 shows quantitation results covering the whole blending range: from neat gasoline to pure methanol. By observing and choosing spectral features carefully, simple linear correlation can be found between methanol percentage and the spectral quantity. With the established equation, the percentage of methanol of known samples is predicted to be within ± 2% of their actual values; for example, 8.3% was predicted for a 10% sample and 51% was predicted for a 50% sample from experiments.

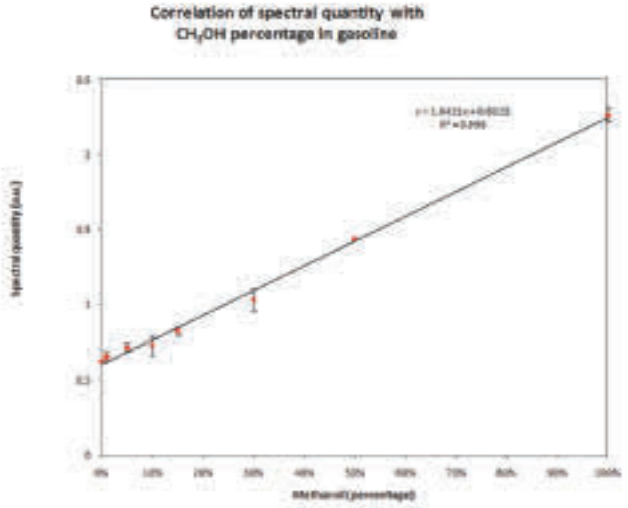


Figure 3 Correlation of a spectral quantity with the methanol percentage in blended gasoline. Data were fit with linear regression. Error bars represent ± 3σ.

In conclusion, we have demonstrated that a portable Raman spectrometer can be reliably used to measure quantitatively the methanol content in pre-blended gasoline samples.

1064 nm Dispersive Raman Systems for Analysis of Petroleum Products

Raman now works on lubricants and petroleum -based samples

Raman spectroscopy is an in situ, non-invasive, and sensitive technology to probe and analyze chemical compositions and structures with high specificity, in a near real-time manner. As a non-contacting optical method, it essentially does not require sample preparation. However, in the past it has not found much usefulness on petroleum and petroleum-based products such as lubricants, due to the high level of photoluminescence (e.g., fluorescence and phosphorescence) intrinsically existed in those samples. Their fluorescent background, thousands of times stronger than Raman emission, can easily overwhelm any Raman signals when excited by visible wavelengths.

This issue is now relieved by BaySpec, Inc.'s 1064 nm excitation dispersive Raman systems that offer maximum reduction in fluorescence interference. By moving to a much longer excitation wavelength, far away from most pigments and fluorophores' absorption range, it fundamentally eliminates, or minimizes the excitation of the fluorescence.

For example, most lubricants are based on heavier petroleum fractions in a yellow or brownish color. They play critical roles in almost all machines with moving parts to reduce friction, transfer heat or keep the parts clean by moving away debris and contaminates. Lubricants degrade with time. Understanding them in a quantitative manner is crucial in the design and use of machineries. Traditionally, they have to be sent to a laboratory for analysis using wet chemistry techniques such as GC or HPLC, which are costly and time-consuming. High-throughput and real-time Raman spectroscopy would be ideal. But traditional Raman instruments based on visible and NIR (e.g., 785 or 830 nm) lasers induce strong fluorescent background from these samples thus render the method useless.

BaySpec's 1064 nm Raman systems offer the means to minimize interference from fluorescence and unmask Raman spectra for those highly fluorescent samples. Here we demonstrate methods using 1064 nm dispersive Raman to characterize a common type of engine oil, and quantitatively analyze a mixture of two common machine lubricants. The spectra were taken by BaySpec's benchtop ***RamSpec***™ systems. All spectral acquisition times were less than 10 seconds.

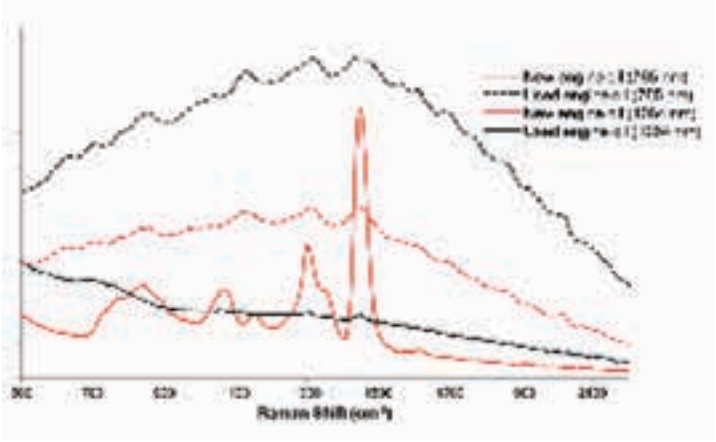


Figure 1. New (red lines) and used engine oil (black lines) characterized by 785 (dotted lines) and 1064 nm (solid lines) Raman spectroscopy. 785 nm laser excites high fluorescence from the samples which masks their Raman markers. Only 1064 nm produces high-quality Raman markers that clearly characterize the difference between new and used engine oils.

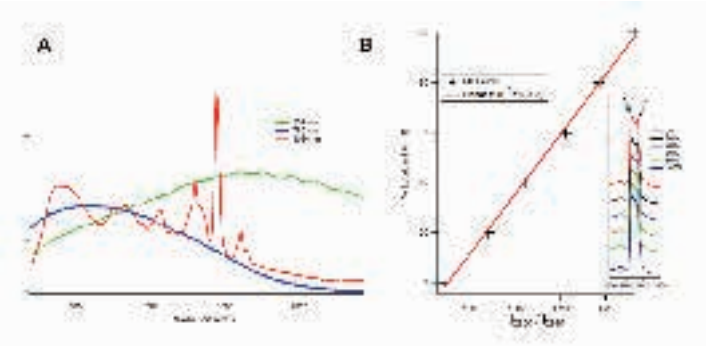


Figure 2. (A) Comparison of Raman spectroscopy of a machine lubricant using 532 (green line), 785 (blue line), and 1064 nm (red line) excitations. Only 1064 nm excitation produces high-quality Raman markers. (B) The intensity ratios of two Raman markers around 2850 cm^{-1} and 2930 cm^{-1} measured by *RamSpec*™-1064 are used to quantify the mixing percentage of two types of lubricants. The Raman ratio is linearly correlated to the percentage of the mixtures.

Based on these experiments, highly fluorescent samples such as lubricants and petroleum derivatives in their native states can now be characterized by 1064 nm dispersive Raman spectroscopy in a real-time, quantitative manner.

1064 nm Dispersive Raman Systems in Biofuel and Plant Research

Raman now works on highly fluorescent plant-based samples without sample preparation.

Raman spectroscopy is a non-invasive, highly sensitive technology to quantitatively probe and analyze chemical compositions and structures. It requires essentially no sample preparation. However, in the past it did not find much usefulness on plant-based samples, due to the high level of photosynthetic pigments in those samples. Their fluorescent background can easily overwhelm any Raman signals in all visible wavelengths. This issue is now resolved by BaySpec, Inc.'s complete line of 1064 nm excitation dispersive Raman systems that offer maximum reduction in fluorescence interference.

For example, as we strive for reducing greenhouse gas emissions and energy security, biofuels (both cellulosic and algal based) are becoming a current focus of government funding, research efforts, and many industries. Intensive R&D effort is the key to make the new-generation of biofuels economical and widely available. Traditionally, these efforts are largely based on wet chemistry methods which are not efficient because they are very slow and they need spend large amounts of samples. Some fluorescence based optical methods allow in-situ analysis but only work on very limited samples. Raman spectroscopy would be ideal for high-throughput and real-time analysis. But traditional Raman instruments based on visible and NIR (e.g., 785 or 810 nm) lasers induce strong fluorescent background from plant-based samples and render the method useless.

Only now, BaySpec's 1064 nm Raman systems offer the means to minimize interference from fluorescence and unmask Raman spectra for those highly fluorescent samples. We use microalgae as an example. Microalgae can efficiently produce high level of lipids which then can be converted into biodiesel. Due to their abundance of pigments, only 1064 nm Raman systems can produces their Raman spectra. In Figure 1, grown microalgae cultures have been analyzed using the benchtop *RamSpec*™ 1064 nm system, which reveals important Raman peaks related to microalgae's composition and physiology changes.

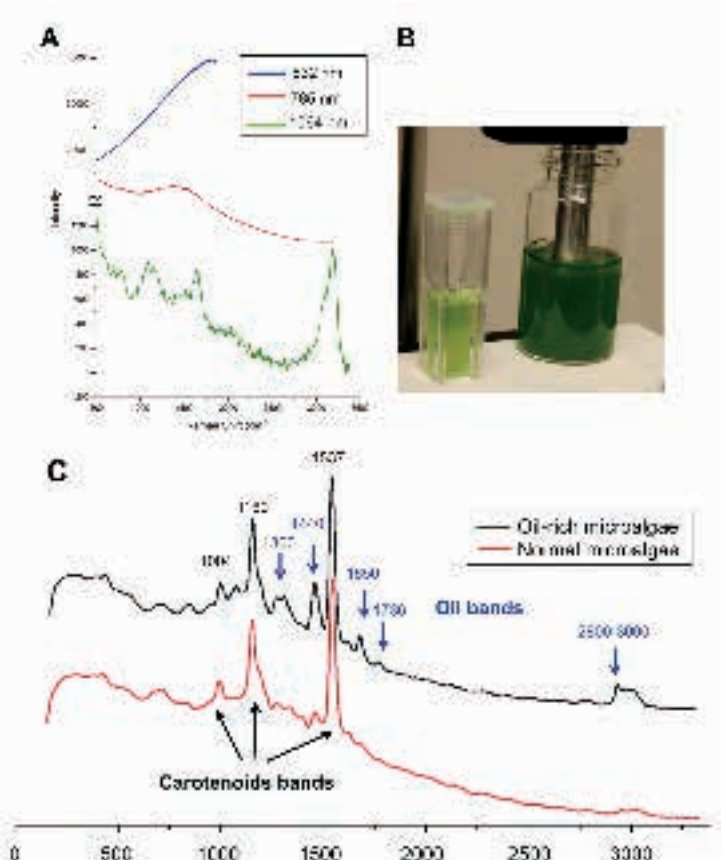


Figure 1. (A) Only 1064 nm laser can produce microalgae's Raman spectra. Visible lasers excite high fluorescence which overwhelms Raman signals. (B) Native microalgae cultures can be tested without any preparation. A dip probe is currently under development. (C) Raman spectra of microalgae cultures grown in different conditions, measured by *RamSpec*™ 1064, reveal their compositional difference.

Based on these experiments, 1064 nm dispersive Raman is a viable new option for users who are studying highly fluorescent samples such as plants and biofuels. Samples in native state can be simultaneous measured. Future studies will certainly evidence further advantages of this approach, as compared to shorter wavelength (e.g., 785 nm) Raman or FT-Raman system

Tissue Raman Measurement at 1064nm

Biological tissues and other materials often autofluoresce at near-infrared wavelengths, prohibiting Raman acquisition. New, dispersive Raman systems at 1064nm allow fluorescence-free measurement in similar integration times.

Introduction

Fluorescence is much more likely and intense at short wavelengths where energies are more apt to cause an electronic transition. Yet even at near-IR wavelengths like 785 or 830nm, many substances still fluoresce, sometimes prohibiting Raman spectral acquisition. For those users who require longer wavelengths such as 1064nm, the only available option has been FT-Raman, which is typically noisier and slower than dispersive Raman systems. But now, BaySpec's new dispersive 1064nm Raman spectrometer family of instruments offers a turn-key solution that combines the speed, sensitivity, and rugged design of traditional dispersive Raman instruments with the fluorescence avoidance of traditional FT-Raman instruments.

Experimental Conditions

A variety of animal tissues obtained from a local market were interrogated using two BaySpec benchtop systems: the RamSpec™ 785 and the RamSpec™ 1064. Both systems utilized filtered fiber probes designed for each respective wavelength. Acquisition times were 30 seconds for both systems. Power was set at 50mW for the 785nm measurements, and 150mW for the 1064nm measurements.

Results

Pigmented and porphyrin-rich tissues such as kidney, are often too fluorescent to be measured, even at 785nm; see Figure 1. But using 1064nm, a clear Raman spectrum relatively devoid of fluorescence background is generated using the same integration time. Additionally, because of the extended quantum efficiency of the InGaAs detector, high wavenumber features (C–H, O–H, and N–H stretching modes) are also simultaneously captured with the same laser.

In addition to allowing users the ability to measure Raman spectra from highly fluorescent samples, the dispersive 1064nm Raman systems also reduce the stringent sampling conditions necessary at shorter wavelengths. For example, 785nm Raman measurement through vials, cuvettes, or under cover slips often requires that these materials be made of fused silica, quartz, or calcium fluoride for their reduced fluorescence, all of which cost considerably more than bulk glass materials. However, as seen in Figure 3, even inexpensive glass sample vials can be used for 1064nm measurement of weak Raman scatterers such as chicken breast tissue.

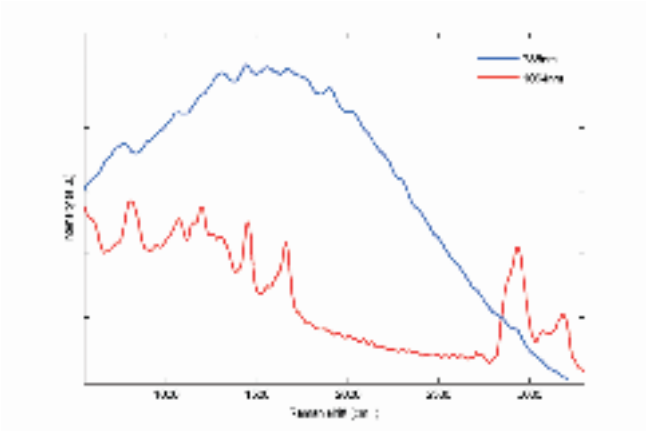


Figure 1: Kidney (porcine) is highly fluorescent at 785nm, preventing extraction of a usable Raman signal. At 1064nm, however, this fluorescence interference is largely avoided and clear Raman bands are evident.

Dispersive Raman measurement at 1064nm offers a number of advantages over shorter wavelength options like 785nm. One of the lingering concerns about the use of 1064nm Raman is the reduced Raman scattering cross-section. As compared to 785nm Raman, this cross-section, indeed, reduces approximately 3.4×. However, according to permissible standards for human tissue (skin) exposure, the Maximum power level that can be tolerated at 1064nm is approximately 3.4× higher than the power permissible at 785nm (1). So, even in photosensitive samples such as biological tissue, the physical reduction in Raman efficiency can be totally compensated by increased laser power.

Conclusions

Based on these experiments, 1064nm dispersive Raman will provide a viable new option for those users who are studying highly fluorescent tissues, desire to measure multiple samples in simple glass containers, or those users who are interested in simultaneous fingerprint and high wavenumber spectral acquisition. Future studies will certainly evidence further advantages over this approach, as compared to shorter wavelength (785 or 830nm) Raman approaches or FT-Raman systems.

References

1) National Institute of Standards and Technology, Z136.1, 76-77, (2007).

Academic Grant Program

BaySpec's Academic Grant Program offers resources to public and private teaching institutions. The program strives to promote the use of laser spectroscopy as a general, pervasive measurement tool, while providing access to state-of-the-art instrumentation and technology in science and engineering curricula.

Grants are available to any non-profit educational institution in the United States or overseas. Applications must be signed by the submitting instructor (or principal investigator) and an authorized official of the institution. The submitting instructor should be a full-time (>50%) employee of the institution.

Areas of academic interest are unrestricted and institutions are encouraged to explore cutting edge applications that provide a benefit to industry and humanity at whole.

For an application or more information, please contact:

BaySpec, Inc.
Academic Grant Program
1101 McKay Drive
San Jose, CA 95131 USA
info@bayspec.com
Fax: +1(408)512-5929

Volume Phase Gratings (VPG®) White Paper in Brief

Volume Phase Gratings (VPG®) work much like conventional surface relief reflection gratings, except in transmission. They are periodic phase structures, whose fundamental purpose is to diffract different wavelengths of light from a common input path into different angular output paths.

A VPG® is formed in a layer of transmissive material, usually dichromatic gelatin, which is sealed between two layers of clear glass or fused silica. The phase of incident light is modulated as it passes through the optically thick film that has a periodic differential hardness or refractive index. Hence the term "Volume Phase". This is in contrast to a conventional grating, in which the depth of a surface relief pattern modulates the phase of the incident light.

Transmission diffraction gratings

A diffraction grating is a conventional optical device used to spatially separate the different wavelengths or colors contained in a beam of light. The device consists of a collection of diffracting elements (narrow parallel slits or grooves) separated by a distance comparable to the wavelength of light under study. These diffracting elements can be either reflective or transmitting, forming reflection grating or transmission grating. An electromagnetic wave containing a plurality of wavelengths incident on a grating will, upon diffraction, have its electric field amplitude, or phase, or both, modified and, as a result, a diffracting pattern is formed in space. Diffraction gratings can also be classified into two types of gratings: amplitude and phase according to the physical nature of diffracting elements. The former, amplitude grating, is commonly encountered in the textbooks, which is produced through mechanically ruling a thin metallic layer deposited on a glass substrate or photography (lithography) whereas the latter, phase grating, consists of a periodic variation of the refractive index of the grating material. The gratings are known as free-space because the phase difference among diffracted beams is generated in the free space, rather than in dispersion media like waveguides.

Volume Phase Gratings®

VPG®, short for volume phase gratings, is also called thick phase grating according to the well-known *Q*-parameter.

BaySpec's volume phase grating is a thick transmission phase grating, which is designed and manufactured to provide the highest diffraction efficiency (up to 99%) and largest angular dispersion for DWDM devices. The volume phase grating is made from a diffractive element sandwiched between two substrates, each of which is formed from low scattering glass whose external surface is coated with an anti-reflection coating to enhance the passage of radiation. The diffractive element is a volume hologram comprising a photosensitive medium with thickness ranging from a few to tens of micrometers, such as a layer of proprietary photo-polymer materials. Through exposing an interference pattern coming from two mutually coherent laser beams to the photosensitive medium layer, a periodic modulation to the refractive index of the medium is formed, which typically has a sinusoidal profile. This is the volume phase grating. The fabrication of holographic elements for different purposes has been described in several references. The manufacturing cost of forming holographic elements is low because the work is basically a photographic process.

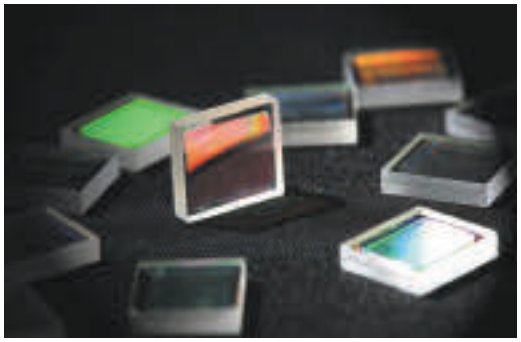
Diffraction by volume phase gratings

The high diffraction efficiency and large angular dispersion capability of a volume phase grating provides a proven technology to demultiplex equally spaced DWDM signals. For a thick grating, the diffraction must simultaneously satisfy the well-known grating equation and Bragg condition.

BaySpec's VPG® Technology

BaySpec's patented VPG technologies are widely used in most demanding applications in the world. These include Optical Channel Performance Monitors, Mux/Demux Modules, and as a stabilization mechanism for Transmission Lasers in Telecommunications networks, FBG Interrogation Analyzers for fiber sensing networks, Spectrographs for Spectral Domain Optical Coherence Tomography, and general purpose UV-VIS-NIR-Raman Spectroscopy.

For the complete white paper with formulas, graphs, and references, visit www.BaySpec.com.



Volume Phase Gratings®

Near-Infrared Spectroscopy in Brief

Instrumentation professionals have long recognized great potential for NIR spectroscopic analyzers in many application areas ranging from lab analysis to portable field monitors. Until now, however, NIR process analytical instrumentation were too big, too expensive, too fragile, and so sophisticated they required highly trained operators for "real-world" application use. Recent advances in high volume telecom device manufacturing presents a disruptive new picture today.

Before we discuss device manufacturing however, we should first revisit the essential importance for spectral information in the NIR.

Near-infrared (NIR) spectroscopy is a rapid, reagentless and nondestructive analytical technique, employed widely for quantitative application in chemistry, pharmaceutics and food industry, and for the optical analysis of biological tissue.

The NIR spectral region, i.e., 800 to 2500nm, is the Overtone and Combination region of the Mid IR region (see Chart 1 below). NIR spectra contain absorbance bands mainly due to three chemical bonds, i.e., C-H (fats, oil, hydrocarbons), O-H (water, alcohol) and N-H (protein). Other chemical bonds may exhibit overtone bands in the NIR region; however, they are generally too weak to be considered for use in analysis of complex mixtures such as foods, agricultural product, pharmaceuticals, toiletries, cosmetics, textiles etc. NIR is ideal for the detection of C-H, N-H and O-H (i.e. for the quantitative determination of oils, protein and moisture). In addition, high scatter coefficients allow for excellent diffuse reflectance spectra of solids.

The sensitivity and directivity of any spectroscopic measurements depends on band intensities. Short wavelengths, such as the visible region (400-800nm) are what spectroscopists call "3rd overtones", which have considerably weaker band intensities (10x less) when compared to the 2nd overtone region (800-1100 nm). This is even further weaker (another 10x) compared to the 1st overtone region (1500-1800nm). Furthermore, overtones in the short wavelength region of 400-1100nm of various molecular stretches diminish the spectral finger print effects, which render no spectral discrimination, making it harder to identify molecular information. Therefore, it is advantageous to use near infrared instead of using visible. NIR spectra do not have the resolution of the Mid IR spectra, but NIR spectra can generally be collected off or through materials without sample preparation as well as being suitable for measuring high and low water content materials. Whereas Mid IR is mainly a qualitative technique, NIR is mainly a quantitative technique. NIR provides a very rapid means of measuring multiple components in foods, agricultural products, pharmaceuticals, cosmetics, toiletries, textiles and virtually any organic material or compound.

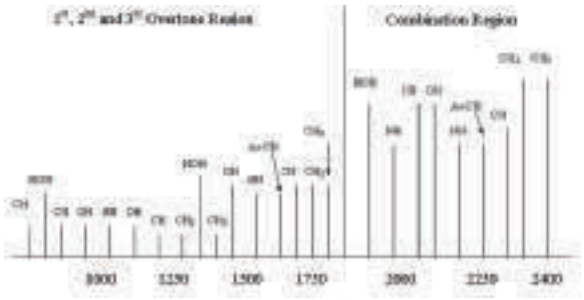


Chart 1: Overtone and Combination Spectral Regions

Components & Instrumentation Advantages

The NIR offers other practical considerations when compared to other wavelength ranges, including:

- Sampling cells can be made from glass, compared to Mid-IR which requires sodium chloride or potassium bromide (expensive preparation devices and rigorous sample preparations)
- Relatively little sample preparation
- Pathlengths up to 10-20mm may be used, because of low molar absorptivity and high-energy throughput in this region
- Commercial availability of light sources
- Compatibility with fiber optic cables for portable QC analyses

Spectral Information

An understanding of NIR spectral information serves two purposes: allowing the prediction of where a particular chemical species should absorb, while providing an assessment of the ability of NIR to perform an application.

The NIR region can be broken out into three sections:

1) Transflectance: 800 to 1100nm. This section is most suited to transflectance through a thick sample, such as seeds, slurries, liquids, and pastes. The absorption bands are due to 3rd overtones of the fundamental stretch bonds in the Mid IR region.

2) Transmission: 1100 to 1800nm. This section can be used for transmission through liquids and films, as well as diffuse reflectance measurements off samples with high water contents. The absorption bands are due to the 1st and 2nd overtones of the fundamental stretch bonds in the Mid IR region.

3) Reflectance: 1800 to 2500nm. This section is predominantly used for making diffuse reflectance measurements off ground or solid materials. The absorption bands are due to combination bands, i.e., C-H stretch and bend combination bands.

The Transflectance region is of particular interest in the analysis of foods, as it is suitable for measuring high moisture and high fat content products including meat, dairy products, jams and conserves, dough and batters. Longer pathlength sample cells can be used to collect the NIR spectra. Typically a 10-20mm pathlengths can be used. This makes sampling easier and allows viscous and non-homogeneous samples to be scanned without further sample processing.

A major advantage of measuring in Transflectance as compared with Reflectance is that the spectra represent the variation in components throughout the entire sample, not just the surface. In reflectance, the first 1mm contributes as much as 99% of the spectrum. Uneven distribution of components (in the sample, egg, drying at the surface, or separation of a water or oil layer at a glass window) results in reflectance spectra that do not represent the entire sample.

The advantages of utilizing Transmission Spectroscopy however, are evident in that the intensity of near infrared bands are approximately an order of magnitude higher than the Transflectance region allowing for relatively long pathlengths. Furthermore, the Reflectance region provides an additional 10x improvement over the Transmission region.

The performance of NIR technology greatly depends on the abilities to control and acquire data from the particular instrument and to calibrate and analyze data. Optical pathlength is a key parameter of the NIR instrument, which has been thoroughly discussed in univariate quantitative analysis in the presence of photometric errors. Although multiple wavelengths can provide more chemical information, it is difficult to determine a single pathlength that is suitable for each wavelength region. Therefore, availability of full NIR wavelength ranges is necessary.

Portable NIR Instruments

The state-of-the-art NIR spectrometer today borrows largely from the massive investments made in telecom grade components over the last ten years. These include: transmission holographic volume phase gratings, linear array image sensors, miniature lasers and light sources, and solid-state computer chips. Collectively, these are now assembled into ultra-compact, no moving parts, low power consumption, hermetically-sealed, reliability-tested spectral engines that can run on batteries in a handheld form factor. NIR spectra can generally be collected off or through materials without sample preparation as well as being suitable for measuring high and low water content materials, whereas Mid IR is mainly a qualitative technique.

There are four general parameters that describe the capability of a spectrometer: 1) spectral range, 2) spectral bandwidth, 3) spectral sampling, and 4) signal-to-noise ratio (S/N). Spectral range is important to cover enough diagnostic spectral absorption to solve a desired problem. A spectrometer must measure the spectrum with enough precision to record details in the spectrum. The signal-to-noise ratio (S/N) required to solve a particular problem will depend on the strength of the spectral features under study. The S/N is dependent on the detector sensitivity, the spectral bandwidth, and intensity of the light reflected or emitted from the surface being measured. A few spectral features are quite strong and a S/N of only about 10 will be adequate to identify them, while others are weak, and a S/N of several hundred (and higher) are often needed. In addition, device-device repeatability is now effective with manufacturing lot-lot consistencies learned from higher volumes.

Today's spectral engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size, and ultra-low power consumption at affordable prices. NIR spectrometers utilize telecom reliability-tested components and feature no moving parts for long term reliability and life-time calibration in the field. For the first time in instrumentation history an affordable, accurate and ruggedized spectral device is helping to fulfill the promise of NIR spectroscopy.

White Paper

Dispersive Raman Instrumentation in the Longer Near-Infrared, 1064nm and Beyond White Paper in Brief

Biomedical and analytical instrumentation professionals have long recognized great potential for longer wavelength excitation Raman spectroscopic analyzers in many application areas, ranging from lab analysis, to hospital bedside or portable field monitors. Until now, however, the longer wavelengths, i.e., excitation wavelengths beyond the typical 785nm or 810nm Raman instruments based on dispersive technology were virtually non-existed. This was due to the unavailability of practical components and technologies. Raman analytical instrumentation was too big, too expensive, too fragile, and so sophisticated they required highly trained operators for "real-world" applications use. Recent advances in high volume optical telecom device manufacturing; however, presents a disruptive new picture today.

Why dispersive Raman in the longer wavelength?

As it is well known to analytical chemists and vibrational spectroscopists that, although Raman spectroscopy is truly "color-blind" in terms of excitation laser wavelengths vs. Raman shifts, special attention must be given when choosing an excitation laser. The laser wavelength (and power) must be selected in reference to the target sample. It is also well known to analytical chemists and vibrational spectroscopy professionals that trade-offs must be considered, such as: 1) laser availability, 2) Raman detection sensitivity, 3) sample damage, and last but not least, 4) avoiding sample fluorescence, which will impede and interfere with weak Raman signals.

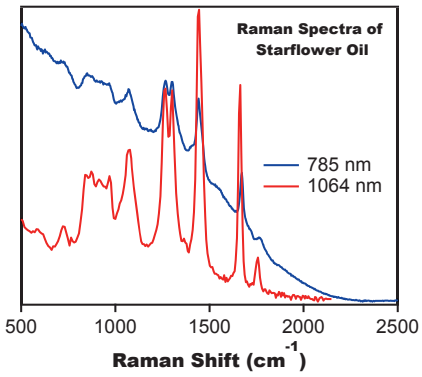


Figure 1: 785nm vs. 1064nm

Longer excitation wavelength in the near infrared, such as 1064 nm, offers many known advantages in Raman measurements of highly florescent samples, especially biological samples, such as tissue or skin samples. Using both in-vivo and in-vitro methods, this offers tremendous advantages in reducing or eliminating fluorescence interferences.

Until recently longer wavelength Raman has been largely fulfilled with unpredictable Fourier Transform Raman (FT-Raman) instruments, which have moving parts, are large in size, and cumbersome to operate. Often this involves cryogenic cooling of photo detectors. Essentially, FT technology is based on a Michaelson interferometer, which suffers from vibration or shock, especially when the reference mirror is moving. FT instruments typically have a relatively tight specification for both base motion and acoustical vibration. Intrinsically, FT is unstable compared to a dispersive spectrometer with no moving parts.

A dispersive Raman spectrograph based on a transmissive Volume Phase Grating® (VPG®), in conjunction with a deep thermo-electrically (TE) cooled InGaAs detector arrays, solves issues related to FT technology and enable practical longer wavelength excitation measurements. It took the telecom boom-and-bust to bring us many of these technologies.

Telecom brings reliable, low-cost components

In the time span of the last decade, the boom of optical telecommunication business in the wavelength division and multiplexing arena enabled significant advances in optical technology, especially components technologies in the wavelength range of 1000-1700 nm, covering light sources to detection devices, with better reliability and lower cost.

In summary, the following four areas of multi-disciplinary technologies advancement make the miniaturization of longer waves Raman spectral sensors possible today:

- Mini lasers & compact narrow and broadband light sources
- Holographic optical elements
- Low cost, sensitive solid state optoelectronics
- Cheaper, faster computer chips
- Portable Long-wave NIR Raman Instruments

The state-of-the-art longer wave dispersive spectrometer today borrows largely from the massive investments made in telecom grade components over the last ten years. These include: transmission holographic volume phase gratings, linear array InGaAs image sensors, miniature lasers at 1064nm, and solid-state computer chips to control, contain and compute data. The instrument working range is 1000-1700 nm, covering up to 3200 cm^{-1} wave numbers (which can be extended to 850 nm to 2000 nm). Collectively, telecom grade components are now assembled into ultra-compact, no moving parts, reliability-tested, spectral engines that can be battery-operated in a handheld form factor.

White Paper

There are four general parameters that describe the capability of a spectrometer: 1) spectral range, 2) spectral bandwidth, 3) spectral sampling, and 4) signal-to-noise ratio (S/N). Spectral range is important to cover enough diagnostic spectral absorption to solve a desired problem. A spectrometer must measure the spectrum with enough precision to record details in the spectrum. The signal-to-noise ratio (S/N) required to solve a particular problem will depend on the strength of the spectral features under study. The S/N is dependant on the detector sensitivity, the spectral bandwidth, and intensity of the light reflected or emitted from the surface being measured. A few spectral features are quite strong and a signal to noise of only about 10 will be adequate to identify them, while others are weak, and a S/N of several hundred (and higher) are often needed. In addition, device-device repeatability is now effective with manufacturing lot-lot consistencies learned from higher volumes.

Today's BaySpec's spectral engines are designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size, ultra-low power consumption at affordable prices. Spectral engines utilize telecom reliability-tested components and feature no moving parts for long term reliability and life-time calibration in the field. Devices are factory calibrated and perform to specifications at +10 to +50°C temperature range without the need of user calibration or adjustment.

Solving real-world problems: Melamine in the food supply

Recent surfacing of Melamine in the food supply presents particular challenges for health officials. The potential sources grow geometrically further down the food chain with the most important detection point at the level just before human consumption to prevent poisoning. This requires a technique that is fast, accurate and cost effective while ensuring consistency and repeatability.

Utilizing BaySpec's Nunavut Raman System, results show Melamine reported in concentration levels down to 3ppm. It can be done in the field and takes less than 10 seconds to provide accurate repeatable results as to the presence of Melamine or not.

For the first time in instrumentation history an affordable, accurate and ruggedized spectral device in longer wavelength excitation is helping to fulfill the promise of portable Raman spectroscopy.

For more information, visit www.BaySpec.com.

TEC Cooled CCD and InGaAs Detectors for Ultra Sensitive and High Dynamic Range Spectroscopic Applications

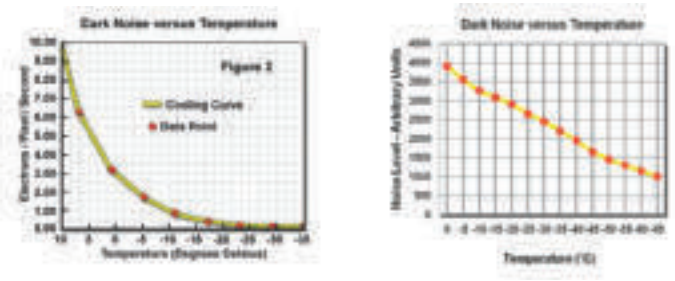
Instrumentation professionals have long recognized great potential for NIR/Raman spectroscopic analyzers in many application areas ranging from lab analysis to portable field monitors. Until now, however, NIR and Raman process analytical instrumentation were too big, too expensive, too fragile, and so sophisticated they required highly trained operators for "real-world" application use. One of the main drawbacks preventing the full potential realization of these spectroscopic applications owes itself to the photo detectors requiring deep cooling to achieve high sensitivity and high dynamic range. A key component for the resolving many of the practical problems associated with measurement and diagnostics is related to the availability of ruggedized, sensitive, high dynamic range, yet low cost photo detectors that can operate at various environmental conditions and without the use of liquid nitrogen (LN2) cooling.

High volume optical telecom device manufacturing has driven recent advances in the hermetic sealing process, thus, presenting a disruptive new picture today.

The Deep Cooling Choice

In research labs, detector cooling used to be achieved by liquid nitrogen (LN2). The use of LN2 as the coolant is understandably cumbersome and almost impossible for applications in remote areas or out of lab environments. Advancements in semiconductor technology over the last 30 years has increased the availability of thermal electrical cooler chips, created improvements in hermetic sealing and long life vacuum generating processes, and allowed for the development and use of TE cooled detectors.

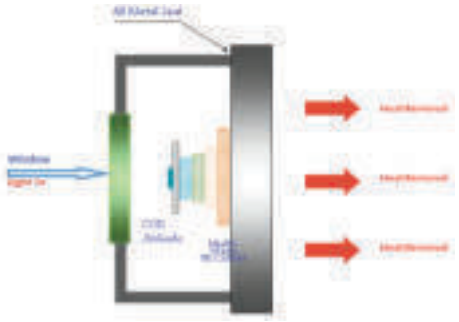
Photodetector cooling reduces the dark noise of the detector. The dark noise arises from statistical variation in the number of electrons thermally generated within the semiconductor structures, such as silicon in the case of CCDs (200nm to 1100nm) and InGaAs (900 to 2500 nm). The dark noise is directly dependent on the semiconductor temperature. The generation rate of thermal electrons at a given CCD temperature is referred to as dark current. Cooling the CCD reduces the dark current dramatically. The dark noise typically drops by half when the temperature of the CCD detector chip drops 10°C, as seen in the figure below.



The dark noise for InGaAs arrays are also reduced by half for every 7~8°C reduction in sensor temperature, as seen in the figure above. In practice, high-performance detectors and cameras are usually cooled to a temperature at which dark current is negligible over a typical exposure time.

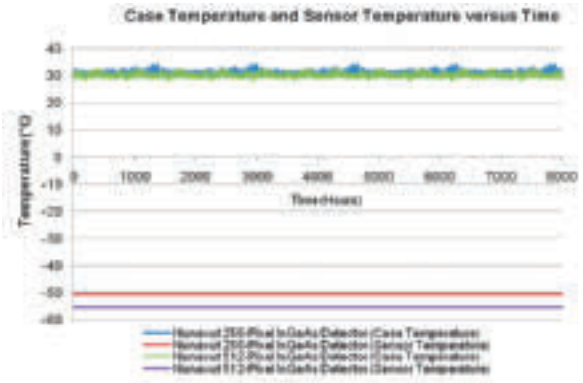
Description of the BaySpec Cooling Technology

In order to keep the photodetector temperature low and stable, the detector must be thermally isolated from the surrounding environment, leaving only one pathway for heat dissipation. This is accomplished via pumping the heat outside the Dewar through multi-stage TE coolers, as indicated by the schematic below.



The most optimal way to achieve this insulation of heat transfer is by vacuum. This is obtained by some evacuating and sealing processes that are carefully designed and meticulously carried out. BaySpec's proprietary evacuating methods and its hermetic sealing process involves metal to metal as well as metal to glass seals. Our manufacturing process ensures vacuum integrity and stability for five plus years of vacuum life time allowing continuous adequate cooling of the photo detector at -60°C Min.

The figure below presents 8000 hours of continuous sensor temperature testing for the Nunavut™ 256- or 512-pixel detectors to show the three-stage TEC working stability and vacuum integrity, as well as its stability. Operating in a sealed vacuum environment, the Nunavut™ series cameras use significantly less power to cool and maintain detector temperature. Utilization of the optimized cooling allows for extremely low dark current levels resulting in longer exposure times and significantly enhanced sensitivity.



Profile and Key Optoelectronic Attributes

The Nunavut™ Series detectors employ the latest in opto-electrical components to bring you the very best capability at a very affordable price. Each Detector/ Camera is designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and low power consumption. When matched to the Nunavut™ Raman spectrograph or photoluminescence spectrograph you will have a high performance, light weight, cost effective instrument. Each camera is calibrated in the factory after extensive thermal cycling. The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host.

Key Features:

- Real-time spectral data acquisition
- Small footprint profile
- Design for ultra-low power consumption and improved reliability
- Hermetic sealing ensures reliable operation in harsh environments
- Air Deep-Cooling to -60°C min
- Water cooling optional to -90°C
- CCD Detector wavelength ranges from 200-1100nm
- CCD-Deep Depletion Detector wavelength ranges from 400-1100nm
- InGaAs wavelength ranges: 850-1700, 1100-2200, or 1250-2500nm

For traditional spectroscopy applications, integration times can range from a few seconds to hundreds of seconds. During these experiments, adjustment in scan rates may be utilized to optimize system noise and detection limit since readout times are less significant compared to the sensitivity resulting from increased exposure times. BaySpec's Nunavut™ cameras offer a range of scan rates designed to meet the needs of both low light level and high brightness applications. For time resolution applications with moderate to high brightness levels, it is possible to obtain up to 1000 continuous scans per second.

Conclusion:

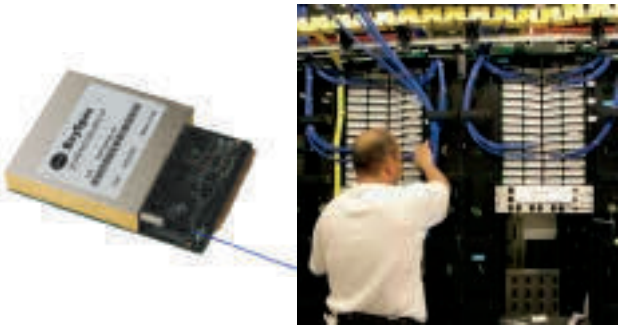
BaySpec's innovative engineering approach to designing new instrumentation around recent advancements in telecom and semi-conductor technology has led to low cost, reliable systems that meet the needs of most any application. These detectors incorporate the most recent advances in vaccum sealing technology which provide ultra low dark current levels and enable low light level applications. Utilizing the latest in opto-electronic components, Nunavut™ detectors offer excellent quantum efficiency, high dynamic range, very low readout noise, and integration times designed to work for both high brightness and low light level applications.

For the complete White Paper, visit:
www.bayspec.com.

Optical Channel Performance Monitors (OCPM) White Paper in Brief

Introduction

The explosive expansion of telecommunications and computer communications, especially in the area of the Internet, has created a dramatic increase in the volume of worldwide data traffic that has placed an increasing demand for communication networks providing increased bandwidth. To meet this demand, fiber optic networks and dense wavelength-division-multiplexing (DWDM) communications systems have been developed to provide high-capacity transmission of multi-carrier signals over a single optical fiber. In accordance with DWDM technology, a plurality of superimposed concurrent signals is transmitted on a single fiber, each signal having a different wavelength. In WDM networks, optical transmitters and receivers are tuned to transmit and receive on a specific wavelength.



IntelliGuard® Optical Channel Performance Monitor (OCPM)

With the widespread deployment of DWDM optical networks, knowing what is happening at the optical layer of the network is quickly becoming a real-time issue for network management. Stable and protected DWDM links cannot be realized without real-time optical monitoring at each channel. For example, as the number of channels deployed in a WDM optical network increases, say 40, 80 or 160, wavelength drifts and power variations are more likely to cause data errors or transmission failures. It is therefore becoming important for engineers to dynamically monitor the performance of the communications channels. Conventional optical network performance monitoring devices typically contain a detection element that is responsive to the combined amplitudes of all signal channels carried by the main signal stream, and operative to generate a data signal indicating the collective power level provided by all channels. Such a data signal is unable to provide detailed information of channel performance and hence is less useful. For instance, if the power level of one channel is decreased while the power level of another channel is increased, the total power level measured by such a device may remain unchanged, thereby providing an inaccurate indication of the performance of the network. Even worse, some network monitoring is still conducted in the electronic domain. Thus, in order to monitor the health of the individual wavelengths in a DWDM network, the performance monitoring must be carried out in the optical layer.

What we need is an integrated spectrometer device at a module level operating in the optical layer, which is capable of simultaneously monitoring the performance of all individual channels, and of providing rapid channel identification, and non-invasive wavelength, power and optical signal-to-noise ratio (OSNR) measurements. This is what the optical channel performance monitor is about.

Optical Channel Performance Monitors (OCPM)

As seen, the network-monitoring device is a crucial optical element for modern optical network systems with DWDM technology. It is the surveillance device in optical layer by providing information about the optical power level, channel wavelength, and optical signal-to-noise ratio (OSNR) of each individual channel. It also serves as a feedback device for controlling certain functions of the optical networks, such OADM, DGE, etc.

What is an OCPM?

OCPM is certainly a new class of devices in fiber-optic products. It is difficult to give it a general definition. Structurally, an OCPM consists of a spectral element, a detection unit, and an electronic processing unit. The spectral element separates the wavelength components of the multiplexed signal containing a plurality of wavelengths. The detection unit is usually a detector array and is used to convert the optical signal to electric signal for further processing by the electronics circuit. Functionally, an OCPM should be capable of providing real-time measurements of the wavelengths, powers, and OSNR of all DWDM channels. From these measurements, we will know: 1) channel central wavelengths, 2) central wavelength shifts with respect to the ITU grid, 3) channel powers, 4) channel power distribution, 5) presence of channels, and 6) OSNR of each channel.

Several types of the OCPM devices are available in the market, each of which addresses different functions and different purposes. Optical Channel Monitor (OCM) and Optical Performance Monitor (OPM) are representative. The former measures power, or power and OSNR while the latter usually looks at power, wavelength, and OSNR. The OCM emphasizes the information (power) at given channels, rather than monitoring wavelength and its variation. OCMs commonly use Demux-type components as its spectral elements. Since a Demux-type component,

such as AWG, gives a set of fixed discrete channels with a pre-defined frequency interval (channel spacing), such OCMs can only provide power measurements at the wavelength positions corresponding to the DWDM channels. It is obvious that the measurements will be biased when there is thermal-wavelength drift of the spectral element. It seems that OPM can provide more network information than OCM since an OPM not only measures power and OSNR, but also monitors wavelength and its variation. However, as more and more such network monitoring devices are employed, the difference between OCM and OPM is evolving to be ambiguous. And some customers prefer to use the name of OCMs while the others would like to use the term of OPMs.

In order to avoid the confusion in using network-monitoring devices, we suggest a more general name for this class of products: Optical Channel Performance Monitor (OCPM). It is an integrated spectrometer module that embraces the full functions of optical channel monitor and optical performance monitor. In response to the increasing demands for network performance monitoring, BaySpec has developed IntelliGuard™ series optical channel performance monitors for DWDM networks. (continued in detail in the full white paper)

OCPM Applications

In this section, a survey of OCPM applications is listed to help you to understand who need the OCPMs and where the OCPMs are employed. In the modern communications networks, OCPM has nearly become a standard part and appears at many key physical positions. In general, the OCPM acts as a window on the DWDM networks by giving the management and control systems a true picture of the health of the optical signal. Specifically,

- Real-time optical performance monitoring of DWDM networks
- Tracking channel power, wavelength, and OSNR
- Monitoring channel inventory in DWDM networks
- Channel presence and detection for optical protection systems
- Fault detection and isolation in DWDM systems
- Optical add/drop monitoring and diagnostics
- Remote gain equalization of DWDM systems based on optical power or OSNR
- Transmission laser wavelength locking
- Real-time system error warning and alarming
- EDFA gain balancing
- Optical cross connect channel quality monitoring

BaySpec's IntelliGuardTM Optical Channel Performance Monitors adopt its proprietary high-resolution volume phase gratings (VPG®) as the spectral dispersion elements, which we call a spectral engine, and high-sensitive InGaAs array detector as detection unit so as to provide both high-speed parallel processing and continuous measurements. The OCPM configuration is schematically illustrated in Figure 2. From the main data transmission link, a small fraction of power signal is taken with a tap coupler. The tapped signal is quite weak, typically ~2% in magnitude, depending on the applications. The weak light is inputted to the one-port OCPM through a single-mode fiber and is collimated by a bulk lens. The signal is spectrally dispersed by a high-efficient volume phase grating and the diffracted field is focused onto an 256-element InGaAs array detector. The control electronics reads out the signal that is then processed by DSP to extract the information. Both the raw data and the processed data are available in memory for the host through either serial communications or parallel port.

BaySpec has used its patented VPG® technologies and patented OCPM design, in which the VPG® technologies have been developed and extensively tested for DWDM Mux/Demux components as well as high-performance OCPMs. They include 1) high diffraction efficiency, 2) low insertion loss, 3) low polarization sensitivity, 4) high thermal stability, and 5) athermalized packaging. These technologies are fairly matured. Figure 3 exemplifies a photograph of the IntelliGuard™ optical channel performance monitors. The miniature optical unit measures 60 × 68 × 15 mm, which fits on an electronics board as small as a credit card. For the OEM design, the electronics boards are scalable.

Conclusion

At present, optical channel performance monitors have nearly become a standard device in high-performance DWDM networks. Most recently, the OCPMs have also been extended in CWDM applications. Both the DWDM networking and OCPM technologies are evolving. High-degree performance measurements are required and small-size monitoring device is desired. In addition, key performance for selecting an OCPM is identified according to wide dynamic range, high OSNR, high power and wavelength accuracy, and excellent thermal stability. In view of these considerations along with cost aspect, the BaySpec's IntelliGuard™ optical channel performance monitors provide you with the best network monitoring devices.

For the complete white paper with formulas, graphs, and references, visit www.BaySpec.com.

White Paper

FBG Interrogation Analyzer White Paper in Brief

The invention of optical fiber and semiconductor lasers in the 1960s opened up a cornucopia of applications, notably as a medium of carrying light signals for communications and sensing applications. Optical fibers provide a fundamental improvement over traditional methods offering lower loss, higher bandwidth, immunity to electromagnetic interference (EMI), lighter weight, lower cost, and lower maintenance. By applying a UV laser to "burn" or write a diffraction grating (A Fiber Bragg Grating-FBG) in the fiber, it became possible to reflect certain wavelengths of light, when used together with an interrogation analyzer (spectral analyzer), precise sensing measurements could be taken. The recent developments of optoelectronics components in the optical telecommunications field have dramatically enhanced the capabilities of many components, such as: light sources, fibers, detectors, optical amplifiers, mux/demuxes, switches, etc. As a result, numerous applications are now available for monitoring strain, stress and pressure in harsh environments.

WaveCapture™ Interrogation Analyzer

What is an FBG Interrogation Analyzer (FBGA)?

Structurally, an FBGA consists of a spectral analyzer element, a detection unit, and an electronic processing unit. The spectral element separates the wavelength components of the multiplexed signal containing a plurality of wavelengths. The detection unit is a single element or arrayed detector, which is used to convert the optical signal to electric signal for further processing by the electronics circuit. Functionally, an FBGA should be capable of providing fast measurements of the wavelength and power levels. From these measurements, the following information is collected: 1) peak central wavelengths, 2) central wavelength shifts with respect to reference wavelengths, 3) peak powers, 4) peak power distribution, and 5) presence of peaks.

FBG Interrogation Analyzer Types

The following information is helpful in selecting an optimal FBGA. The critical optical performance of an FBGA depends on its spectral element and detection unit.

Let us look at what types of spectral elements and detection units can be used.

The spectral elements can be classified into categories:

1) Scanning filters, such as tunable Fabry-Perot filters

2) Continuous dispersion spectral elements, such as volume holographic phase gratings.

The combination of one specific spectral element with one of the two detection manners determines the operating fashion of an FBGA.

It is well known that the FBGA using scanning filters, whether combined with single or arrayed detectors, operates in a serial manner. This approach does not provide fast measurements due to its serial wavelength scanning and processing. Furthermore, such devices may contain moving mechanical parts compromising reliability and accuracy.

It is highly desirable to have a spectral element that can avoid moving parts and provide continuous spectrum measurement in order to overcome discrete wavelength measurements. Free-space diffraction gratings would do the job. In considering efficiency, reliability, and other related issues, transmission volume phase gratings (VPG) have emerged as the best spectral elements for FBGAs. FBGAs based on highly-efficient VPG as its spectral element in combination with high-sensitivity detector array provides the best solution and ideal choice. These spectral engines feature high speed parallel processing, continuous spectrum monitoring, superior performance, and the smallest dimension of this kind in the world.

BaySpec's WaveCapture™ FBG Interrogation Analyzer utilizes a proprietary high-resolution volume phase grating (VPG®) spectral dispersion element and a high-sensitivity InGaAs array detector as a detection unit to provide both high-speed parallel processing and continuous measurements.

WaveCapture™ Interrogation Analyzer
with Internal Reference Source (IRS)

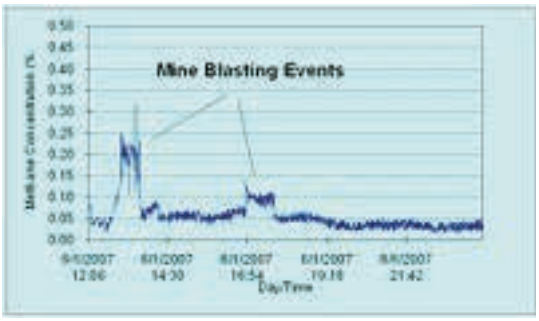
White Paper

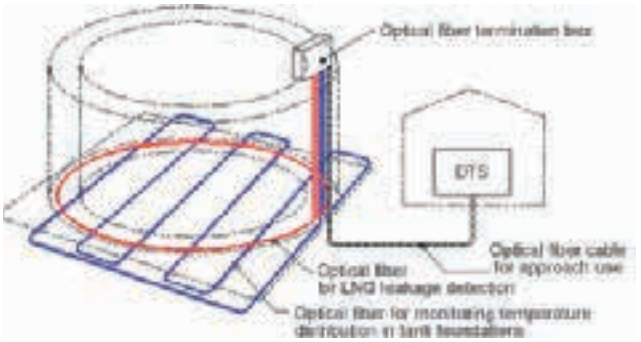
The WaveCapture™ configuration is illustrated. The weak light is input to the one-port FBGA through a single-mode fiber and is collimated by a micro lens. The signal is spectrally dispersed by a highly-efficient VPG and the diffracted field is focused onto a multi-element InGaAs array detector. The control electronics reads out the signal that is then processed by a DSP to extract the information. Both the raw data and the processed data are available in memory for the host through either serial communications or parallel port. BaySpec's patented (issued) VPG® technology and patent (pending) FBGA design, have been developed and extensively tested for high-volume DWDM telecom monitoring. The miniature optical unit measures 60 × 68 × 15 mm, which fits on an electronics board as small as a credit card. OEM designs are available for custom mounting with existing electronics boards.

It is worth emphasizing that the WaveCapture™ FBGA response is to a continuous spectral band, rather than to a series of discrete wavelengths. This is a differential advantage over tunable filter approaches. More importantly, as the ambient temperature changes, the center wavelengths of the carrier signal in a DWDM network will offset from the wavelength references. Thus, with the use of WaveCapture™ FBGAs, the whole spectral regime is measured independently of the absolute locations of wavelengths providing robust and unbiased measurements.

At present, FBG Interrogation Analyzers based on VPGs and detector arrays technology have the largest installed base in high-performance DWDM, such as ROADM networks. Both the DWDM networking and FBGA technologies are evolving. High-degree performance measurements are required and small-size monitoring device are desired. In addition, key performance for selecting an FBGA is identified according to wide dynamic range, high power and wavelength accuracy, and excellent thermal stability. In view of these considerations along with low-cost requirements, BaySpec's WaveCapture™ Interrogation Analyzer provides the industry's best price-performance solution for FBG sensing applications.

For the complete white paper with formulas, graphs, and references, visit www.BaySpec.com.





Spectroscopy Industry Terms & Definitions

Aberration: Geometric deviation of an image formed by an imaging grating from the ideal point image.

Absorbance: A.-The logarithm to the base 10 of the reciprocal of the transmittance, (T).

$A = \log10 (1/T) = - \log10 T$

Absorption Band: A region of the absorption spectrum in which the absorbance passes through a maximum.

Analytical Wavelength: Any wavelength at which an absorbance measurement is made for the purpose of the determination of a constituent of a sample.

Baseline: Any line drawn on an absorbtion spectrum to establish a reference point representing a function of the radiant power incident on a sample on a given wavelength.

Background: Apparent absorbtion caused by anything other than the substance for which the analysis is being made.

Beer's Law: The absorbance of a homogeneous sample containing an absorbing substance is a directly proportional to the concentration of the absorbing substance.

Blaze grating: The facet or inclination angle of the longer profile edge (called glance angle or blaze angle) is usually determined by the wavelength for which the diffraction efficiency of the first order should be a maximum in case the groove number G is given. Specially it is true sin = 0.5 G.

Blaze wavelength: Wavelength at which an echelette grating has maximally efficiency.

CIE: The abbreviation for the French title of the International Commission on Illumination, Commission Internationale de l'Eclairage.

Color (of an Object): The aspect of the appearance of an object dependent upon the spectral composition of the incident light, the spectral reflectance or transmittance of the object, and the spectral response of an observer.

Concentration: The quantity of a substance contained in a unit quantity of sample.

Derivative Absorption: A plot of rate of change of absorbance or of any function of absorbance with respect to wavelength or any function of wavelength, against wavelength or any function of wavelength.

Diffraction efficiency: Fraction of the light diffracted in a certain order at a certain wavelength relative to the reflection of a comparison mirror or absolute to the incident light.

Diffraction order: In accordance with the grating equation $\lambda = g/m (\sin \alpha + \sin \beta)$, where g is the grating constant, α is the angle of incidence; β is the diffraction angle and m is the order of the diffraction, the wavelengths $m^* \lambda$

(m = 0; +/-1; +/-2) fall in the same direction β.

Efficiency anomaly: Minimum of the wavelength-dependent efficiency curve of a grating diffracting in several directions simultaneously but the light of one order doesn't expand in the clearance but along the grating surface. Because of that it is missing in the energy balance.

Focal curves: Plot of the focal distance of an imaging grating against the wavelength in case of an ideal point imaging in the direction of dispersion

Grating equation: $\sin \alpha + \sin \beta = m \lambda G$

α light incidence angle, β light diffraction angle, m diffraction order, λ light wavelength, G groove number.

Groove number: Number G of lines of a grating with the dimension mm^{-1}, reciprocal to the grating constant

Groove profile: Cross section of the grating groove shape. It can be found a symmetric profile (sine, triangle, rectangle) or an asymmetric triangular one.

Holographic exposure: In a photoresist layer deposited on a plane or curved substrate an interference figure is recorded formed by two point laser light sources. Plane gratings are exposed in case plane waves interfere, imaging ones in case plane or spherical/aspherical waves interfere. If the interfering bundles originate in the same hemisphere the groove profile is sinusoidal, if they originate in different hemispheres the profile is sawtooth-shaped with something rounded edges. After the exposure the photoresist have to be developed.

Holographic grating: The grooves of the master grating were generated by recording of an interference figure in a photoresist layer

Imaging grating: The diffracting structure is placed on a substrate's convex surface (convex grating with positive radius) or concave surface (concave grating with negative radius)

Imaging properties: Point resp. slit imaging by an imaging grating in amounting resulting in a minimum of astigmatism and coma.

Infrared Spectrum: Pertaining to the region of the electromagnetic spectrum from approximately 0.78 to 300μ.

Ion etching: A method to increase the blaze angle of holographic photoresist gratings by transfer of the grooves into the substrate material taking advantage of the different etching rates of resist and substrate. Because of that the spectral distribution of the grating efficiency is shifted to greater wavelengths. Ion etching is also a method to transform a sine profile in a rectangular one.

Laminar grating: The grating groove profile is rectangular.

Linear Dispersion: The derivative, $dx/d\lambda$, where x is the distance along the spectrum, in the plane of the exit slit, and λ is the wavelength.

Mechanically ruled grating: The grooves of the master grating were cutted or pressed in a ductile material by a ruling diamond.

Monochromator: A device or instrument that with an appropriate energy source may be used to provide a continuous calibrated series of electromagnetic energy bands of determinable wavelength or frequency range.

Opacity: The degree of obstruction to the transmission of visible light. (D 16)a.

Photometer: A device so designed that it furnishes the ratio, or a function of the ratio, of the radiant power of two electromagnetic beams. These two beams may be separated in time, space, or both.

Photometric Linearity: The ability of a photometric system to yield a linear relationship between the radiant power incident on ist detector and some measurable quantity provided by the system.

Plane grating: The grating has a plane substrate and straight and equidistant grooves.

Reflection grating: The grating is used in reflection which the incident light is getting a directional reversal. Aluminum and gold are preferred reflective coatings.

Refelectance: The ratio of reflected to incident radiation. (A practical definition requires that basic term be modified by adjectives to indicate the spectral and geometric weighting of the incident and reflected radiation).

Replication: Profile-true multiplication method to mass-produce diffraction gratings. The grating structure is replicated in epoxy or uv cured adhesive. Usually the replicated gratings are duplicates of a higher generation (copies of copies) but their efficiency comes closest to that of the master gratings

Resolution capability: Minimum spacing of 2 wavelengths separable by resolving power a grating, proportional to the grating area and inversely proportional to the wavelength

Resolution, Spectral: a). Display Spectral Resolution: decimal points in the displayed wavelength value. We have 3 decimals in nanometer, which is 1 picometer resolution for displayed wavelength value.

(b). Readout Spectral Resolution: This is the minimum value of the wavelength variation which can be detected and reported by this device. For example, If you input a tunable laser signal to the FBGA and tune the laser wavelength by 1pm step, you will see the FBGA reported wavelength value following the tunable laser with each 1pm step.

(c). Physical Wavelength Resolution: This is the minimum wavelength spacing between two signal peaks which can still be distinguished as two peaks.

Sinusoidal grating: The grating groove profile is sinusoidal.

Spectrograph: Is an optical instrument that transforms an incoming light signal into a sequence of spectra. There are several kinds of spectrographs. A spectrograph is an instrument without a photo detector, but typically have all the front optics, diffractive elements and focusing/imaging optics, but no photo detector or any data acquisition electronics and software attached or associated to it.

Spectrometer: An instrument with an entrance slit and one or more exit slits, with which measurements are made either by scanning the spectral range point by point or by simultaneous measurements at several spectral positions.

Spectrophotometer: A spectrometer with associated equipment so designed that it furnishes the ratio or a function of the ratio of the radiant power of two beams as a function of spectral position.

Spectral Bandwidth: The wavelength or frequency interval of the radiation leaving the exit slit of a mono-chromator between limits set at a radiant power level half way between the continuous background and the peak of an emission line or an absorption band of negligible intrinsic width.

Transmission grating: The grating is used in transmission mode.

Transmittance: The ratio of radiant power transmitted by the sample to the radiant power incident on the sample.

Ultraviolet: Pertaining to the region of the electromagnetic spectrum from approximately 10 to 380 nm. The term ultraviolet without further qualification usually refers to the region from 200 to 380 nm.

Visible: Pertaining to radiant energy in the electromagnetic spectral range visible to the normal human eye (approximately 380 to 780 nm).

Wavelength: The distance measured along the line of propagation between two points that are in phase on adjacent waves.

Wave number: The number of Waves per unit length.

Telecom & Fiber Sensing Industry Terms & Definitions

Core Concepts:

I. OCPM stands for Optical Channel Performance Monitor, a combination of OCM, OPM, optical power metering, and optical wavelength metering for use in monitoring OSNR by measuring continuous spectra rather than discrete channels.

II. EDFA stands for Erbium-Doped Fiber Amplifier and BaySpec's EDFA products are mainly for use with metro applications.

III. DWDM stands for Dense Wavelength Division Multiplexing for when multiple wavelengths of light signals are involved.

OCPM stands for Optical Channel Performance Monitor used for monitoring the health of DWDM networks in the optical layer. It embraces the essential functions of optical channel monitor (OCM), optical performance monitor (OPM), optical power meter, and optical wavelength meter, and more importantly measures OSNR. BaySpec's OCPM measures continuous spectra, rather than monitoring discrete channels.

Absolute Wavelength Accuracy (pm) is the maximally allowed wavelength errors ±Dm centered at 0 error. For an OCPM, the measurement wavelength errors must be within the limits of [-Dm, +Dm], i.e.,

$$\text{Max}(|Dl|) = \text{Max}(|lOCPM - lc|) <= Dm \text{ or } -Dm <= Dl <= +Dm$$

where Dl = lOCPM - lc is the wavelength error of an arbitrary channel, lOCPM is the peak wavelength reported by an OCPM and lc is the wavelength measured by a calibrated wavelength meter (e.g., OSA or wavemeter). Max(|Dl|) is the absolute value of the maximum wavelength error among all channels.

Channel Input Power Range (dB) specifies the operating power range of an OCPM. The detection sensitivity determines its lower limit. Beyond its upper limit, the device becomes saturated.

Channel Input Power Range = Upper limit of channel input power - Lower limit of channel input power

Note: "Channel input power range" is different from "Dynamic range"

Channel Power Accuracy (dB) is the maximally allowed power errors centered at 0 error. It is a measurement tolerance of power obtained with respect to the actual power value against all wavelengths. It is calibrated based on power meter.

Channel Power Repeatability (dB) measures the channel power accuracy over a given time period. BaySpec's channel power repeatability is defined as the power fluctuation over 24 hours of continuous measurement.

power P(noise), measured in units of dB, i.e.,

$$OSNR = 10 \times \log10[\ P(\text{signal})/\ P(\text{noise})]$$

Dynamic Range (dB) is the optical power range where an OCPM is operated. It is approximately expressed as

Dynamic Range = Upper Limit of Channel Input Power - Noise Floor

Note that OSNR is a relative measure. For example,

Upper Limit of Channel Input Power = -20 dBm and Noise Floor = -80 dBm, yields the Dynamic Range = 60 dB.

Noise Floor (dBm) is the lowest power level detectable by the OCPM, which is limited by the electronic system. An optical noise level lower than the noise floor would not be recognized and, as a result, OCPM will give the noise floor value instead.

Operating Temperature (°C) is the temperature range over which the device can be operated and maintain its specifications.

OSNR (dB) of a channel is defined as an absolute ratio of the clean optical signal power P(signal) to noise power P(noise), measured in units of dB, i.e.,

$$OSNR = 10 \times \log10[\ P(\text{signal})/\ P(\text{noise})]$$

In practice, we approximate ***P***(signal) = ***P***(mixed) - ***P***(noise) since the clean optical signal is not obtainable, where ***P***(mixed) is the total power measured at the corresponding channel wavelength.

Relative Wavelength Accuracy: There are two different definitions that have been used.

Definition 1: Relative Wavelength Accuracy (pm) is the maximally allowed wavelength error span (dm) over all channels. For an OCPM, the maximum wavelength error span is:

$$dlm = DlMax - DlMin <= dm$$

where DlMax and DlMin are the maximum and minimum wavelength errors reported by the OCPM.

Definition 2: Relative Wavelength Accuracy (pm) is defined as ±dm/2, where dm is the maximally allowed wavelength error span. It may not be centered at 0 error.

The two different definitions for relative wavelength accuracy describe the same phenomenon.

The absolute wavelength accuracy determines the maximally allowed wavelength errors whereas the relative wavelength accuracy determines the uniformity of wavelength errors over all channels.

Response Time (ms) is the aggregate time span of that OCPM needs to give a complete measurement. It includes intensity response time, calculation time and display time. In total, it is less than 20 ms for BaySpec's OCPMs.

Storage Temperature (°C) is the temperature range over which the device can be stored without damage and can be operated over operating temperature according to its specifications.

Wavelength Range (nm) is the spectral region over which the spectral engine and detectors are operated. BaySpec's technology ensures to work in the C-band & L-band.

Wavelength Resolution (Spectral Resolution) (pm) is the full-width-half-maximum (FWHM) resolution. It is the spectral width at the half power level that the OCPM can resolve with high confidence level. In the other words, the wavelength resolution is the minimum resolvable wavelength separation between two nearby power spectra.

Note: Some customers define "resolution" as "readout resolution", i.e., the number of significant digits returned from the measurement through the communications interface. This applies to "Wavelength" and "Power".

EDFA stands for Erbium-Doped Fiber Amplifier. The BaySpec's EDFA series products are mainly for metro applications.

Amplified Spontaneous Emission (ASE) is the amplified optical power resulting from the spontaneous (i.e., not stimulated by any signal photons) release of photons within the gain spectrum of an EDFA operation due to the random decay of erbium ions from the metastable state to the ground state.

Backward ASE Power is the amount of ASE power emitted from the EDFA input port.

Backward Remnant Pump Power is the amount of pump power that is not absorbed by the rare earth ions and is accessible at the input port of the amplifier.

Dynamic Gain Equalizer is a dynamic spectral device that flattens the output spectrum of an erbium-doped fiber amplifier. The output spectrum of an erbium-doped fiber amplifier may change in time so that it requires real-time adjustment of spectrum over various wavelength ranges.

Forward ASE Power is the amount of ASE power emitted from the EDFA output port.

Forward Remnant Pump Power is the amount of pump power that is accessible at the output port of the EDFA.

Gain (dB): An optical amplifier is nothing but a laser, except that no feedback exists in amplifier configuration. The external pump, either optically or electrically, generates population inversion in amplification media, through which an incident light signal is optically amplified. An important measure for the amplification ability of an optical amplifier is gain. In optical amplifiers, Gain is defined as the ratio of output to input optical power and is usually expressed in dB through

Gain (dB) = 10 × log10[*P*out/*P*in]

Gain Flatness (dB) indicates the degree of the gain variation over its range of operating wavelengths. A flat gain profile is highly desired. This can be achieved by using the gain flattening filters.

Gain Flattening Filter is a static spectral device that flattens the output spectrum of an erbium-doped fiber amplifier.

Gain Flattening is a process by which an uneven gain profile is adjusted by counteracting the gain spectrum of an erbium-doped fiber amplifier.

Gain Saturation: When the optical power is too high, the gain coefficient starts to decrease, thus reducing the power of the signal undergoing amplification. This effect is called gain saturation. More precisely, when the optical power P exceeds the saturation optical power Psat, the gain becomes saturated. Gain saturation is an important characteristic of an EDFA, especially in a booster application and largely determines the maximum output power (saturated output power, see below).

Gain Tilt (dB) is the non-flatness of the gain of an EDFA. Gain tilt contributes to the cumulative degradation of an optical signal as it passes through multiple amplification stages. Specifically, the effect is a distortion of the gain spectrum in an erbium-doped fiber amplifier caused by an unexpected change in the power of the input signals entering the amplifier.

Noise Figure (dB) quantifies the noise performance of an optical amplifier and is defined as the signal-to-noise ratios of the input and output signals:

$$nf = [SNR]in/[SNR]out$$

It is usually expressed in units of dB, given by

$$nf = 10 \times \log10\{[SNR]in/[SNR]out\}$$

nf is often referred to as a figure of merit when one is evaluating the noise performance of an optical amplifier.

Telecom & Fiber Sensing Industry Terms & Definitions

Operating Current and Operating Voltage (A & V) are electrical parameters applied to pump semiconductor lasers.

Operating Temperature (°C) is the temperature range over which the device can be operated and maintain its specifications.

Polarization Sensitivity (dB): The maximum change in an optical amplifier gain due to changes in the state of polarization (SOP) of the amplifier input signal.

Pump Current (mA) is the current externally supplied to the pumping diode lasers.

Pump Forward Voltage (V) is the voltage produced by the flow of current through the pump laser diode when it is biased for a specified output power.

Pump Wavelength (nm) is the operating wavelength of external pumping lasers. For EDFAs, it is either 980 nm or 1480 nm, or both.

Return Loss (Input or Output) (dB) is the ratio of input optical power Pin to the reflected optical power Pref, in units of dB. It is usually a positive number.

Return Loss = 10 × log10[*P*in / *P*ref]

S-, C-, and L-Band: S-Band (short band) is not well defined. Usually it is the spectral window from about 1450 nm to 1530 nm. C-band (conventional band) is the spectral window from about 1525 nm to 1565 nm corresponding to the strong amplifying range of the erbium-doped fiber amplifiers. L-band (long band) is the spectral window from about 1568 nm to 1610 nm.

Saturated Output Power (dBm) is the maximum output power Pout from an optical amplifier when the optical power within the amplification medium reaches the saturation optical power Psat. Note that the saturated output power Pout is usually less than the saturationoptical power Psat because the latter is the sum of the input pump power and output power. For EDFAs, the pump wavelengths are 980 nm or 1480 nm and the amplification wavelengths are across 1528-1562 nm.

Small Signal Gain (dB) is the amplifier gain, when operated in the linear region, where it is essentially independent of the input signal power at a specific signal wavelength and operating conditions (e.g., pump power, temperature, et al).

Storage Temperature (°C) is the temperature range over which the device can be stored without damage and can be operated over operating temperature according to its specifications.

Total Power Consumption (W) is the total energy supply in the unit time, including external pumping to the semiconductor lasers and power loss in the thermoelectric coolers.

Wavelength Range (nm) is the spectral region over which the EDFAs are operated and provide effective light amplification for signal channels.

DWDM stands for Dense Wavelength Division Multiplexing, which is applied to the WDM process when multiple wavelengths of light signals are involved.

0-dB Reference Level is defined as the straight-through intensity level when the devices to be tested are removed.

Athermal is a term used to specify the thermal stability of the devices. If the performance parameters are well below some defined critical values over the operating temperature, the device is said to be athermal. Historically, the grating-based MUX/DEMUX required temperature control in order to maintain its optical performance. Now, the BaySpec's MUX/DEMUX uses an athermalized design and advanced packaging technology, which make the devices fully passive - the thermal wavelength drift is less than 0.5 pm/°C and the temperature-dependent insertion loss is reduced below 0.01 dB/°C over the operating temperature range of 0-70°C.

Center Wavelength Offset (pm) is a relative drift of the actual central wavelength of a particular channel with respect to the standard ITU Grid. The wavelength drift may result from inappropriate alignment and the design of the optical system.

Channel Center Wavelength (nm) is the wavelength at which a particular signal channel is centered. The International Telecommunications Union (ITU) has defined the standard optical frequency grid (channel center-frequency) with 100 GHz spacing based on the reference frequency of 193.10 THz (1552.52 nm), the so-called ITU Grid. Channel center wavelengths are chosen at the wavelengths corresponding to the ITU Grid.

Channel Isolation (dB) is also called far-end crosstalk at a given wavelength that is the ratio of the light intensity at the undesired port to the light intensity at the desired port. So it is a measure of how well different wavelengths are separated at the output of a dense wavelength division demultiplexer.

Channel Pass Bandwidth (nm) is defined as a maximum wavelength (or frequency) range around the corresponding center wavelength (or frequency) at a given power level. Now, the industry well accepts the definition at 0.5 dB down power level. Note that due to the cen-

ter wavelength offset of a channel the operating channel pass bandwidth may be smaller than that when the center wavelength is accurately at the ITU Grid.

Channel Spacing (GHz) is the frequency difference between two neighboring channel center frequencies in DWDM components or modules. DWDM MUX/DEMUX devices in BaySpec have their channel spacing of 50, 100 and 200 GHz.

Channel Uniformity (dB) is the maximum difference of insertion loss over all signal channels. Channel uniformity is a measure of how evenly power is distributed between the output ports of the devices.

Channel: A single signal channel consists of a frequency band that has a finite pass bandwidth and is centered at a given frequency such as one specified by the ITU Grid. In DWDM, each channel corresponds to one particular wavelength and carries an individual data stream. For example, BaySpec produces 40 Channel 100 GHz DWDM MUX/DEMUX. Each channel has its pass bandwidth of 0.2 nm at 0.5 dB down.

Dense Wavelength Division Demultiplexer (DWDM DEMUX) is a device that separates the received composite signal into multiple light signals of a plurality of wavelengths, which are directed to several fibers for output.

Dense Wavelength Division Multiplexer (DWDM MUX) is a device that combines input multiple light signals of a plurality of wavelengths into one composite signal for transmission. It is also called DWDM by convention, more precisely DWDM device.

Directivity (dB) is also called near-end crosstalk that is the ratio of the optical power launched into an input port to the optical power returning to any other input port. In DWDM, directivity is applied to MUX devices only.

Flat-Top Pass Band (nm) specifies a class of DWDM MUX/DEMUX devices whose spectrum profiles within the pass band are relatively flat by comparison with the Gaussian profile. A flat-top spectrum profile may be super-Gaussian or ideally box-like. The BaySpec's MUX/DEMUX devices feature both Gaussian and flat-top pass bands according to customers' requirements.

Gaussian Pass Band (nm) specifies a class of DWDM MUX/DEMUX devices whose spectrum profiles within the pass band are essentially Gaussian.

Insertion Loss (dB) is the relative power level transmitted to the output end referenced to the 0-dB reference level when a device is inserted.

Non-adjacent Channel Isolation (Non-adjacent Channel Crosstalk) (dB) is the relative amount of unwanted power that occurs in a particular channel pass band from the non-adjacent channels. Commonly, only the two first non-adjacent channels (left- and right-hand sides) are accounted for.

Operating Temperature (°C) is the temperature range over which the device can be operated and maintain its specifications.

Polarization Dependent Loss (PDL) (dB) is defined as insertion loss difference between two orthogonal polarization states.

Polarization Mode Dispersion (PMD) (ps) occurs when different planes of light inside a fiber travel at slightly different speeds, leading to spread of optical pulses. In a DWDM device, PMD measures the average time difference of two orthogonal polarization states elapsed when the two corresponding pulses pass through the device.

Return Loss (dB) is the relative power level reflected back to the input fiber in the backward direction referenced to the 0-dB reference level when a device is inserted.

Ripple (dB) is the insertion loss variation within the pass band of a signal channel. It is often used for the thin-film-based devices. In the grating-based MUX/DEMUX, the spectrum profile is bell-like; no ripples are specified.

S-, C-, and L-Band: S-Band (short band) is not well defined. Usually it is the spectral window from about 1450 nm to 1530 nm. C-band (conventional band) is the spectral window from about 1525 nm to 1565 nm corresponding to the strong amplifying range of the erbium-doped fiber amplifiers. L-band (long band) is the spectral window from about 1568 nm to 1610 nm.

Storage Temperature (°C) is the temperature range over which the device can be stored without damage and can be operated over operating temperature according to its specifications.

Thermal Wavelength Stability (pm/°C) specifies the maximum wavelength drift of the spectral center of a particular channel due to temperature variation with respect to the central wavelength value at the room temperature (23° C).

Wavelength Division Multiplexing (WDM) is the process by which a few wavelengths of individual light signals, each of which carries a separate data stream, are assembled on a single optical fiber at the transmitting end, and then the multiplexed signal is separated into their respective channels at the receiving end.

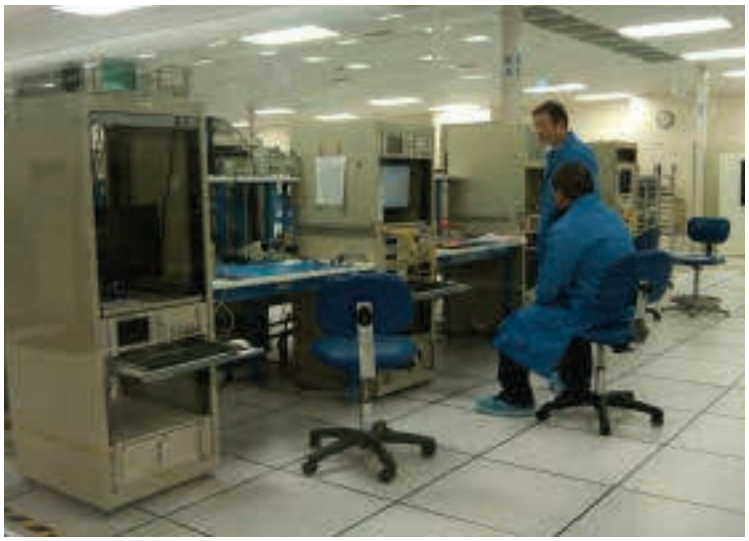
Wavelength Range (nm) is the spectral region over which the device is operated.

Notes:

Notes:

Index

NOTE: Most products are customizeable: you deliver the specs, we deliver the quality product you need for your specific OEM applications. If you see something in this catalog but it is not exactly what you are looking for, give us a call discuss your custom requirements.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www.bayspec.com | +1.408.512.5928 | info@bayspec.com

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Pervasive Spectral Sensing

1101 McKay Drive
San Jose, California 95131 USA
Phone: +1(408)512-5928
Fax: +1(408)512-5929
www.bayspec.com