# Spectral Products Catalog

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## About Spectral Products


Spectral Products is a world leader in optical instrumentation technology and products. Formerly a division of CVI Laser, Spectral Products builds on its rich heritage and extensive technical knowledge to offer a broad range of innovative solutions from components to systems and modules. Spectral Products is an industry leader in the design and manufacture of optical instruments including spectrometers, monochrometers, spectrographs, spectrophotometers, spectrum analyzers, detection systems, light sources, as well as fiber optic cables and couplers.

Spectral Products' focus on quality, value and service has created an innovative approach to manufacturing and design. With employees in Putnam, Connecticut, Albuquerque, New Mexico and Seoul, South Korea, Spectral Products continues the tradition of design innovation, high quality products and exceptional value.

## Spectral Products is Innovation in Instrumentation

In the 1980s advances in micro-controller technology inspired a revolution in optical instrumentation. Spectral Products introduced the first total microprocessor-controlled, direct drive scanning monochromator in 1987.

The award-winning design eliminated the commonly used, but costly and unreliable, sine-bar drive for wavelength control. Today, the Spectral Products Digikrom line of monochromators combines microelectronics with precision optics while featuring computer control, direct digital drive, automatic grating changes and motorized slits. This careful marriage of microcomputers with precision opto-mechanics is an example of why we are now the world leader in low-cost high performance spectroscopic systems.

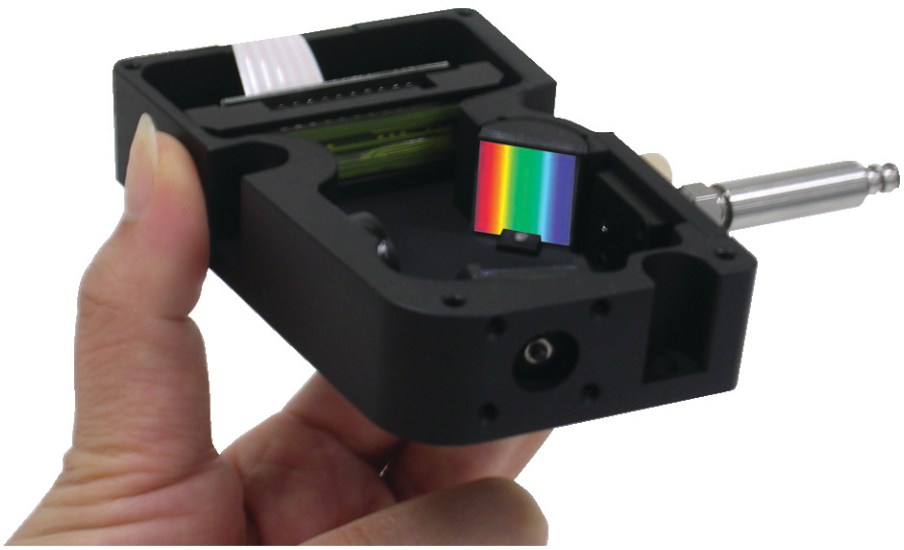
## About Our Products

Monochromators act as tunable bandpass filters for light. They are the critical component for many spectral applications since they can be used to create tunable light sources and also to take high precision spectral measurements. The Digikrom line of monochromators, available in 1/8, 1/4 and 1/2 meter focal lengths, use electronics that are designed-in , rather than appended via accessories or other add-ons after the instrument has been manufactured. The direct digital drive is simple and reliable; a microprocessor-controlled stepper motor, moving in wavelength increments as small as .003nm per step, is linked directly to the grating mount by a worm and worm wheel arrangement. This results in improved accuracy, automatic grating changes and exceptional ruggedness. Because each Digikrom contains its own microprocessor, it is controlled via a standard serial port (RS232), IEEE-488 port (GPIB), or with SP s hand-held controller. This compatibility allows your computer, for example, to make automatic adjustments of bandwidth through motorized slits, to select gratings, choose scan speeds and to store your changes in memory. This versatility is intrinsic to the instrument and available without additional cost.

Spectral Products' SM line of computer-based miniature array spectrometers offer state of the performance yet have compact form factors. Their versatile design and ease use make them a first choice for scientific and industrial applications. SM series optical benches are designed to provide stable operation over a wide range of ambient temperatures. All of Spectral Products instruments take advantage of Spectral Products pioneering research in high quality laser optic manufacturing process control.

The Digikrom and SM products lines together with their accessories (light sources, detectors, filters and fiber optic adaptors) are now used throughout the world in such systems as Raman spectroscopy, emission and excitation fluorescence/ luminescence spectroscopy, arc, spark or plasma spectroscopy, spectrophotometry, spectroradiometry, laser breakdown spectroscopy, picosecond laser analysis, ratiometry, infrared measurements, process control and calibration. Wide applications of our instruments include semiconductor, biomedical, manufacturing, petrochemicals, pulp/paper, clinical labs, QC labs, research & development, pharmaceutical, environmental control, polymers, mining/metals. Whether your need is for high resolution, low stray light, high throughput, or compactness, there is a lowcost Spectral Products system to meet your technical requirements and budget.

## Thank you for considering Spectral Products.



# Contact us

**Spectral Products,**
*EAST OFFICE / HEADQUARTERS*
111 Highland Drive, Putnam, CT 06260, USA
**Tell :** 877-928-5834
860-928-5834
**Fax :** 860-928-2676
**Email :** sales@spectralproducts.com
**Website :** www.spectralproducts.com
www.spectraloptics.com

**Spectral Products,**
*WEST OFFICE*
2659A Pan American Freeway NE,
Albuquerque, NM 87107, USA
**Tel:** 877-208-0245
**Fax:** 505-343-9705
**Email:** sales@spectralproducts.com

**Korea Spectral Products,**
*KOREA BRANCH OFFICE*
407~408 273, Digital-Ro, Guro-Gu,
Seoul, South Korea
**Tel:** 82-2-2109-8871
**Fax:** 82-2-2109-8872
**Email:** sales@ksp.co.kr
**Website :** www.ksp.co.kr

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# Non-dispersive Wavelength Selection

## Filter Based Systems

In many applications source radiation is required to be sorted out into narrow, discrete wavelength bands. Optical filters of absorptive, reflective or interference types are perhaps the simplest apparatus for performing such a task. An absorption filter relies on its unique optical absorption of certain spectrum by use of colored glasses or sandwiched dyed glasses. It is perhaps the least expensive choice for applications where a narrow bandpass is not critical. Figure 1 shows representative transmittance curves of some typical absorption filters.Reflective filters are usually made with dielectric thin films coated onto a glass substrate. These filters can withstand higher radiation power with better thermal stability at increased cost over the absorption filters. Absorptive and reflective filters are useful in the visible and near infrared region for order sorting, band pass, attenuation and other uses. While coupling with multiple filters, an effective bandwidth of tens to hundreds of nanometers can be achieved, Figure2.

Interference filters differ from absorption and reflective filters in that optical interference phenomenon is utilized for the generation of narrow band outputs. Figure 3 illustrates a typical interference filter consisting of a dielectric spacer and metal layers. When wide band radiation occurs at a normal incidence, reflected light from the first and second metallic film interfere with each other resulting in reinforcement or cancellation of various wavelengths of light passing through them.

The reinforced portion thus transmits through while the other wavelength components suffer destructive interference. The wavelength band passing through is determined by the thickness of the dielectric.Interference filters are available throughout UV, visible and infrared regions. Center wavelength, peak transmittance, full width at half maximum (FWHM) are often the specifications characterizing a filter, Figure 4. Peak wavelength, blocking efficiency and transmission profiles are also used to describe a filter performance. A typical interference filter has a band pass on the order of 1 to 2% of the wavelength at peak transmittance. In some wavelength regions this figure can be reduced to almost 0.1%.

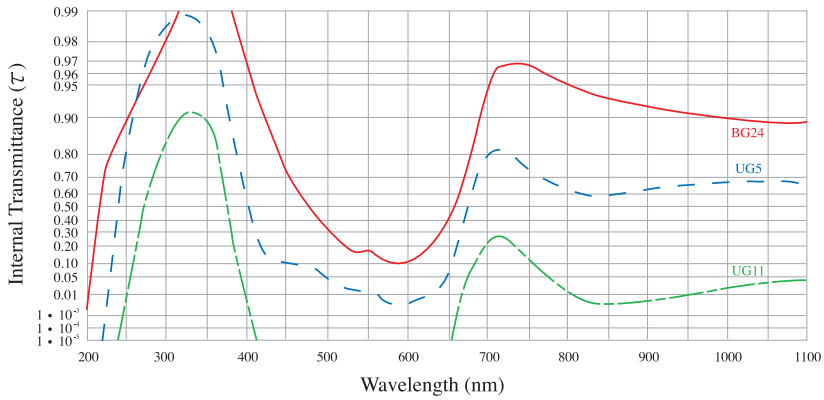



Figure 1. Transmission curves for typical absorption filters.

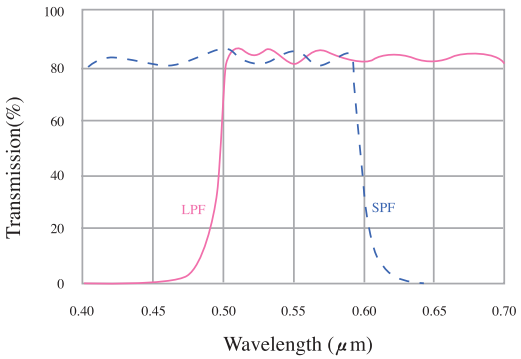



Figure 2. Transmission band by use of multiple filters.

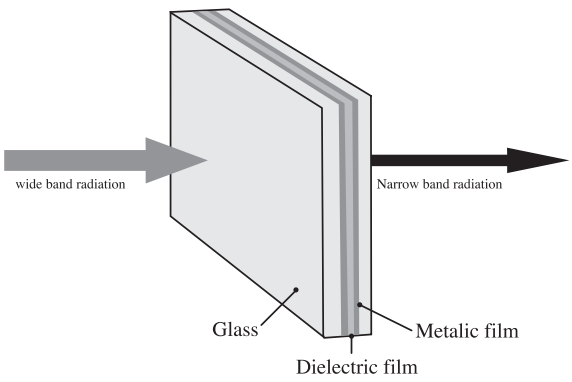



Figure 3. Diagram for a typical interference filter.

## Filter spectrometer

When used in conjunction with appropriate detectors, filters form basic wavelength selective detection systems. A filter spectrometer has the advantages of simplicity, high signal to noise ratio, low cost and high throughput. A rotatable filter wheel allows multiple filters to be mounted and sequentially selected into the light path.

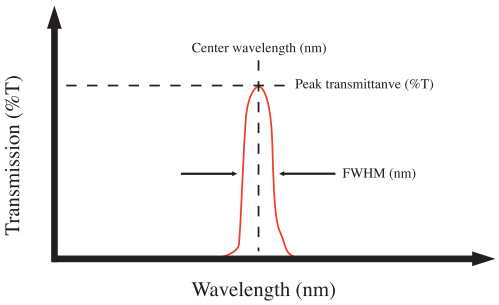



Figure 4. Diagram for fifter characteristics

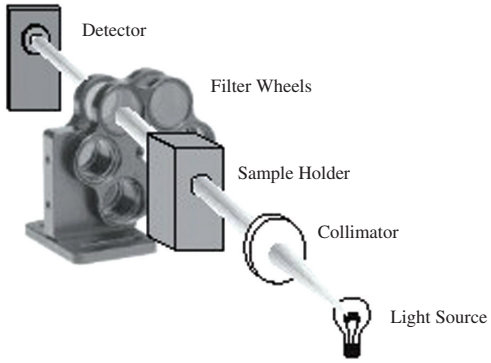



Figure 5. A filter-dased spectrophotometer

Figure 5 depicts a filter transmission spectrophotometer, which uses two wheels in series. The combination of filters in the light path, that have characteristic transmission curves, generates variable pass bands. When equipped with stepping motors and computer interfaces, the filter wheels can be automated to perform programmed sequences. Applications of filter wheels have been found in atomic spectrometry, environmental monitoring, illuminators, laser spectroscopy, and so on.

# Filter Fundamentals

## How to Characterize a Filter

**Center Wavelength:**

The arithmetic mean of the pass band expressed in nanometers. For instance, a HeNe laser filter would have a center wavelength of 632.8nm. By definition, the center wavelength is the arithmetic mean of the half-power wavelength.

**Percent Transmission:**

The amount of power received by the detector compared to the total power available. The traditional formula is %T I/I0 x (100), where I0, is the incident power and I is the transmitted power. Transmission can be specified as power at the center wavelength or peak power that may occur at wavelengths slightly removed from the center wavelength.

**Half Bandwidth:**

The width of the pass band in nanometers at the half-power points of the pass band. It is often expressed as full width at half maximum (FWHM).

**Out-of-Band Rejection (Blocking):**

The amount of energy, outside the filter pass band, reaching the detector. It is often expressed as an absolute level, such as 10-4, meaning there are no transmission peaks outside the pass band exceeding 0.0001 T or 0.01%T. The rejection range in nanometers must accompany this specification. The rejection range is usually chosen to cover the range of the detector in use (PMT, Si, PbS).

**Size:**

Sizes of the filters are specified in inches or millimeters, along with tolerances. Typical sizes are 0.50",1.00" and 2.00" diameters. Typical maximum thickness is 0.25".

**Optical Density:**

Neutral Density Filters vary the intensity of the beam over a wide spectral region by either absorption or a combination of absorption and reflection. Values are specified in units of Optical Density (O.D.).

$$O.D. = \log_{10}\frac{1}{T}$$

Where T transmission. Neutral Density Filters have a range of spectral neutrality that defines the bandwidth over which the O.D. values apply.

**Band Pass Shape:**

Pass band shapes can vary from triangular to nearly square. The number of cavities involved determines the overall shape. In general the morecavities, the more square the band shape.

## How a Filter behaves at off-normal incidence

If a beam incidents a filter at an angle other than normal, certain characteristics will change with incidence angle. Center wavelength, the most important parameter of a filter, varies approximately as a cosine function,shifting towards shorter wavelengths with increasing angle.

Therefore it is a good practice to use a collimated beam in the filter instrumentation, as in Figure 5. The exact amount of the shift is highly dependent on the internal design of the filter. The following equation may be used to determine the wavelength at a certain angle of incidence.

$$\lambda = \lambda_0 \sqrt{1 - \left(\frac{n_0}{n_{eff}}\right)^2 \mathrm{Sin}^2\,\phi}$$

Where:

$\lambda$ Wavelength at Angle of Incidence

$\lambda_0$ Wavelength at Normal Incidence

$\emptyset$ Angle of Incidence

$\mathbf{n_0}$ Refractive Index of External Medium

$\mathbf{n_{eff}}$ Effective Refractive Index of Filter

Figure 6 illustrates a plot showing the relationship between the incident angle and the shifting of the wavelength. $\lambda_0$ is assumed to be at 632nm, $\mathbf{n_0}$ and $\mathbf{n_{eff}}$ are 1.00 and 1.35 respectively.

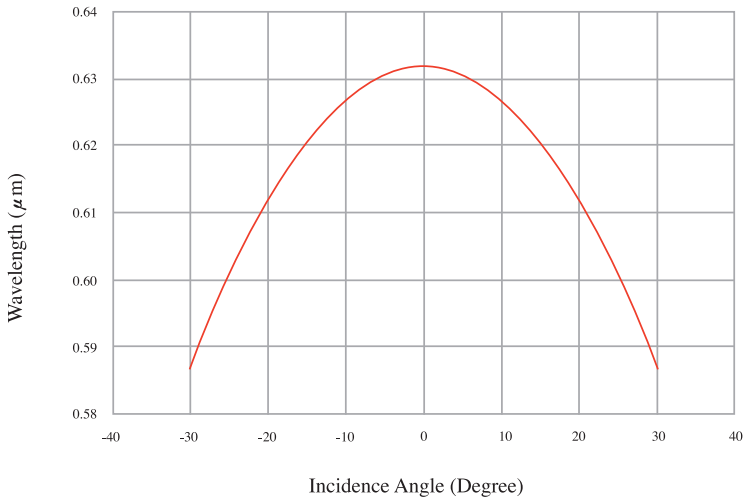



Figure 6. Filter wavelength shift as a function of incident angle

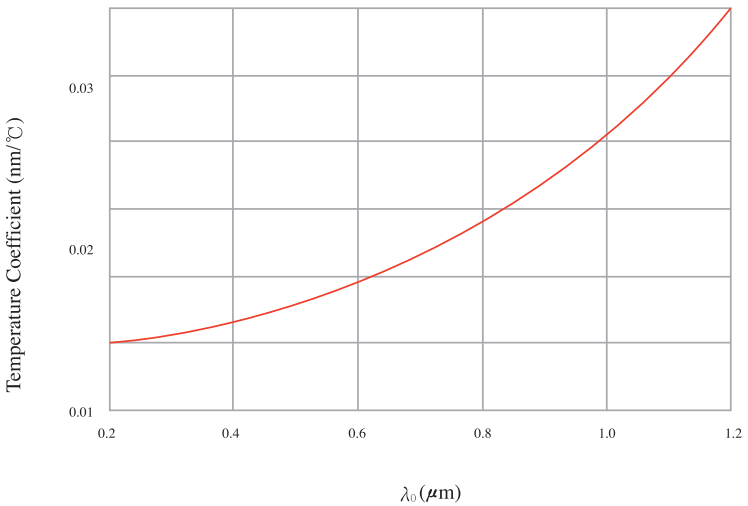



Figure 7. Filter wavelength shift as a function of incident angle

## How does a filter respond to Environmental Condition Changes?

Filters are sensitive to changes in environment, with temperature and humidity being the most critical factors. Temperature change causes the center wavelength to shift approximately 0.02nm per degree Celsius. Meanwhile optical cements used in the filters may be broken down when the temperature exceeds a certain limit. It is recommended that wherever possible the filters should be placed away from heat sources such as quartz tungsten halogen lamps. Figure 7 shows the approximate behavior of the Temperature Coefficient. Long-term exposure to extreme humidity may cause filter deterioration, although there is no precise correlation between humidity and filter life. Temperature/humidity cycling tests indicate filters that survive the most cycles last longer under normal operating conditions.

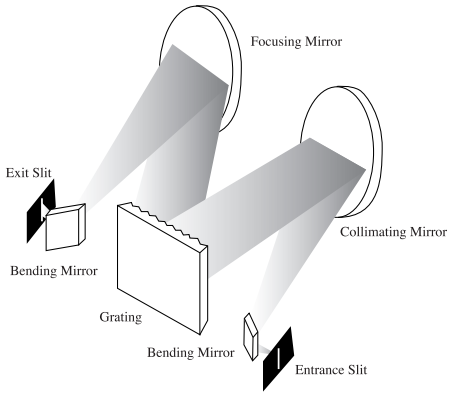



Figure 8. Diagram of a grating monochromator

## Dispersive Instruments: Grating Monochromators and Polychromators

In many spectroscopic applications, a scanning wavelength selection device is essential, which can be tuned to isolate a narrow spectral radiation continuously over a wide spectral range. This can be accomplished by employing a dispersive element such as a grating together with a scanning mechanism, Figure 8. Diffraction gratings are widely used as the wavelengthdispersing element today

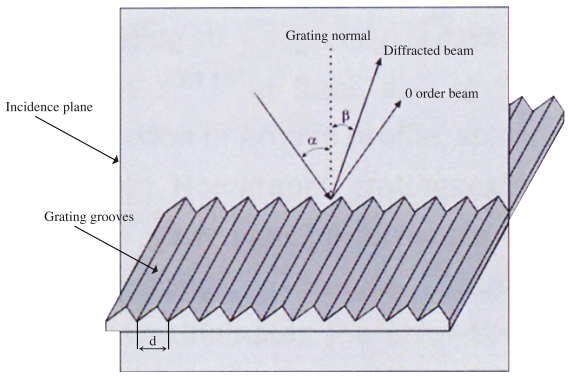



Figure 9. A reflective diffraction grating

## Grating Fundamentals

### How Does a Grating Work?

Gratings demonstrate a unique dispersion phenomenon by which a spectrum of light is separated in space by wavelength. A reflective diffraction grating has microscopic periodic structures, grooves, corrugated on a substrate material, Figure 9. The series of parallel grooves are spaced at about the wavelength of light. The grating surface is usually coated with a metal for high reflectivity.

Interaction of light with a grating possessing grooves the same size as the wavelength of the radiation exhibits diffraction. Light reflected from the grating surface is diffracted by the grooves. A monochromatic light incident on a reflective grating is diffracted first and then undergoes a destructive interference in most directions resulting in a cancellation at these angles. It is only along certain finite number of direction that rays from grooves survive as a result of constructive interference. These directions are termed as diffraction orders. In Figure 9, the grooves of the grating are shown perpendicular to the plane of incidence. The light strikes the grating at an incident angle $\alpha$, to the grating normal, is then diffracted at an angle $\beta$. When defining integer m as the diffraction order and d as groove spacing, maximum constructive interference is found to occur under the condition:

$$m\lambda = d(\sin\alpha + \sin\beta)$$

Several important characteristics are revealed by the above grating equation:

1. For a given diffraction angle $\beta$ several values of $\lambda$ may satisfy the equation with corresponding order m.First order radiation (m 1) of 900nm shares the same diffraction angle with that from a second order 450nm and from a third order 300nm radiation lines.
2. The diffraction order m may carry a sign of either positive or negative to reflect the fact that the incident light may be diffracted on either side of the grating normal.
3. If parallel rays carrying multiple wavelength components fall on the grating, each wavelength within the same order will have a distinctive value of $\beta$, determined by the grating equation. Consequently, a polychromatic light is spatially dispersed.

## GratingPerformance Characteristics

Gratings are primarily characterized by their groove density, blaze (peak efficiency) wavelength and manufacturing method. For example a 1200 x 300 ghost-free ruled grating would have a groove density of 1200 grooves per millimeter, a peak efficiency at 300 nanometers, and would have been manufactured by an interferometrically controlled process that eliminated spectral ghosts.

### Groove Density

Groove density, groove frequency or pitch of a grating, G, is defined as the reciprocal of groove spacing, 1/d. If the groove spacing is in a unit of millimeters, G is commonly referred to as grooves per millimeter.

### Grating Type

Commercially available gratings are manufactured by processes including ruling, replication, holographic methods, etcetera. Ruled gratings are mechanically ruled with a diamond-ruling engine on a surface coated with thin metal. Replicated gratings are produced by the replication of a master diffraction grating. Ruled and replicated gratings typically have grooves in a triangle format. The production of holographic gratings involves the photographic recording of laser generated interference patterns. Holographic gratings usually contain sinusoidal shaped grooves.

### Reflective Coatings

Aluminum is primarily used as the reflective material for gratings throughout ultra-violet (UV), visible and near infrared regions. Protected aluminum coating is more resistant to oxidation, thus is more suitable for UV use. For near infrared and infrared applications, gold overcoating demonstrates superior reflectance performance over aluminum.

### Blaze Wavelength

Shaping individual grooves can alter the distribution of light into different orders. The optimization of groove profile to maximize grating efficiency in a certain spectral region is often referred to as blazing. The maximum grating efficiency occurs at the blaze wavelength. See Figure 10.

### Grating Efficiency

Grating efficiency is expressed as the ratio between monochromatic light diffracted into a given order and the incident monochromatic radiation. As the incident wavelength differs from the blaze wavelength, the two polarizations will exhibit different diffraction efficiency. Figure 10 shows a typical grating efficiency curve. The dashed line represents the “P” polarized radiation while the thin solid line is for“S” polarization and the bold solid line is the average.

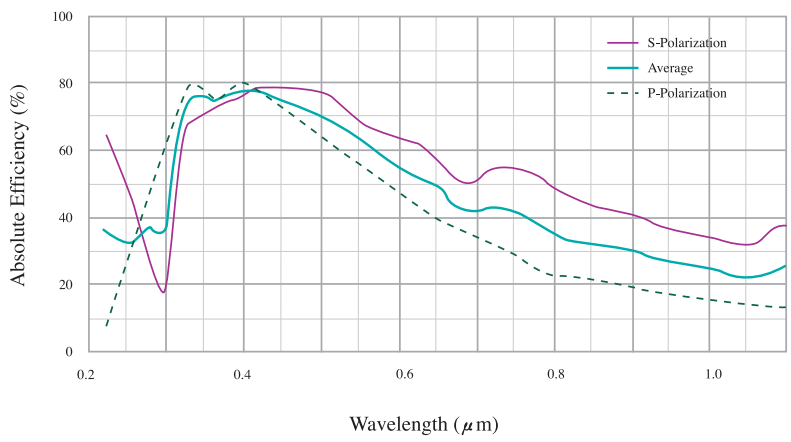



Figure 10. Typical grating efficiency curves

## Resolving Power

The resolving power of a grating, R, is the measure of its ability to separate two close wavelength lines. It can be expressed as the product of the diffraction order m and N, the number of grooves being illuminated by the incident radiation.

R mN

## Stray Light

Grating stray light is the unwanted spurious spectral lines arising from imperfection in groove profile, spacing and depth. Holographic gratings exhibit superior stray light performance over ruled gratings. The use of optical recording eliminates the error source originating from the ruling processes and minimizes the manufacturing inconsistency.

## Practical Grating Instruments

Many spectrometers, including monochromators, and spectrographs employ gratings as the dispersing elements. A grating monochromator, for example,consists of the following key elements:

1. An entrance slit
2. Collimating/focusing optics
3. A grating dispersing element
4. An exit slit
5. Driving mechanisms

Both monochromators and spectrographs share the same optical recipe; they are usually one-to-one imaging systems in which one image of the entrance slit appears at the exit for each wavelength passed through the instrument. If the incident radiation is a continuous source, an infinite series of overlapping monochromatic images of the entrance slit are found at the exit-slit focal plane. Figure 8 shows a diagram of a typical monochromator. The incident radiation consisting of three wavelength components enters through an entrance slit, forms a narrow optical image, and is then directed to a collimating mirror by a folding mirror. The collimating mirror produces a parallel beam and projects it onto the grating. The grating disperses the radiation into its component wavelengths at different angles in the plane of incidence. The focusing mirror then reforms the image (of the slit) and focuses it on a focal plane. The exit slit isolates the desired spectral band by spatially discriminating against the unwanted bands as shown. Mechanical rotation of the grating about its vertical axis scans the images through the exit slit.

A spectrograph differs from the device shown by removing the exit slit, thus allowing a multi-channel array detector to be mounted along the focal plane as shown in Figure 11. In this case the array detector elements see a signal that is proportional to the amount of the entrance-slit image that falls on the element. The wavelength ”scanning” is accomplished by electric read-out means

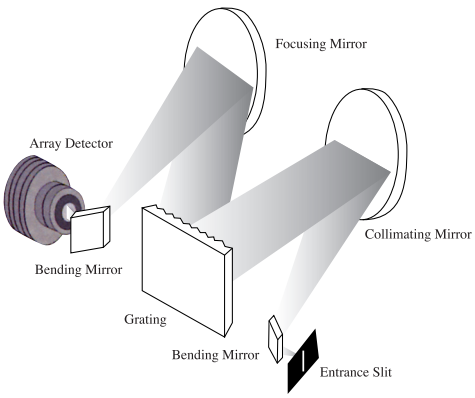



Figure 11. Diagram of a typical array spectrometer

of the multi-channel detector.

Figure 12 shows a low-pressuremercury lamp emission spectrum recorded by an array spectrometer consisting of 512 sensing elements. The detector pixel numbers can be

linked to wavelengths via a process called calibration, in which known wavelength peaks are used to establish a relationship. An array spectrometer demonstrates high readout speed and stable wavelength calibration when using fixed grating

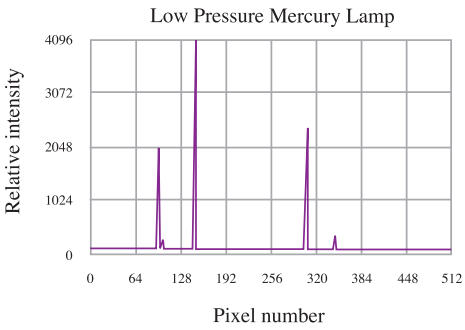



Figure 12. A typical spectrum recorded with a 512-pixel CCD spectrometer

position.

# Grating Spectrometer Fundamentals

## Grating Instrument Performance Characteristics

Important spectrometer performance characteristics include wavelength resolution, stray light rejection ratio, throughput and many others.

## Dispersion

Dispersion of a grating spectrometer determines its ability to separate wavelengths. The reciprocal linear dispersion of a spectrometer can be found by calculating the change in wavelength $\lambda$ with respect to change in distance x along its focal plane.

That is: $$\frac{\Delta\lambda}{\Delta x} = \frac{d\cos\beta}{nF}$$

d, $\beta$ and F are the grating groove spacing, diffraction angle, and effective system focal length, respectively. Reciprocal linear dispersion is not a constant; it varies with wavelength as the equation shows. The variation can exceed a factor of two over the useful spectral range. A mid-value of the dispersion for a 1200g/mm grating, typically at 514.5nm, is used throughout this catalog.

## Resolution

The resolution R of a grating monochromator is a measure of its ability to separate two close together spectral lines. By use of Raleigh criteria
it is: $R = \frac{\lambda}{\Delta\lambda}$

One practical definition for resolution of a spectrometer is the fullwidth- at-half-maximum (FWHM) measured for a single monochromatic spectral line. In practice, the resolution depends upon the resolving power of the grating, effective system focal length, slit width setting, system optical aberration characteristics and other parameters.

Because of the dependence of resolution on the measurement parameters, specific measurement methods are used for most of our discussion in this catalog. Typically, resolution is defined as the FWHM derived from the fewest amount of squares fit into a spectral scan assuming a gaussian profile. Illumination is at 514.5nm and is uniform on a 1200g/mm grating. Entrance and exit slits are .010mm apertures. Obviously, the resolution number resulting from this measurement is a guide to performance only.

## Bandpass

Bandpass is the wavelength band exiting the spectrometer at a given wavelength under conditions where optical aberrations, diffraction, scanning method, detector pixel width, slit height, uniformity of illumination and the like are neglected. (It is then the reciprocal dispersion times the slit width). For example, a monochromator configured with 0.25 millimeter slits and a grating displaying a reciprocal dispersion of 8nm/mm has a bandpass
of 8 * 0.25  2nm.

## Wavelength Precision, Reproducibility and Accuracy

Wavelength precision is the gradation on the scale that the spectrometer uses in determining wavelength. Nanometers, angstroms and tenths of angstroms are typical units of precision. Frequently, precision is a function of wavelength and will vary by a factor of three over the useful spectral range. SP quotes a worst-case precision for each of its instruments.

Wavelength reproducibility is the ability of a spectrometer, which has been set to a given wavelength, to change settings then return to the original wavelength. This is a measure of the mechanics of the wavelength drive and the over-all stability of the instrument. SP's spectrometers have excellent wavelength drives and mechanical stability; their reproducibility always exceeds their precision.

Wavelength accuracy is the difference between the spectrometer's set wavelength and the true wavelength. It is not meaningful to apply a wavelength accuracy specification to spectrographs because a wide band of wavelengths exit onto the detector array in a spectrograph. In checking wavelength accuracy in monochromators, the accuracy must be checked against known spectral line wavelengths. SP typically checks its monochromators at 10 to 20 wavelengths across the spectral region.

## Etendue and Transmission efficiency

The percentage of light that can be sent from a light source through a spectrometer would be a desirable measure of its throughput. Unfortunately, the properties of sources vary so much that this measure would not provide a useful standard. Instead, two separate specifications are useful; **etendue** - a measure of the degree of coupling that can be achieved, and **transmission efficiency** - a measure of how much of the input light exits the monochromator.

The etendue of an instrument is the product of an instrument's physical aperture [cm2] and its angular aperture [steradians]. For a source of a given brightness [watts/(cm2*steradian)], the maximum power [watts] that can be coupled into an instrument is the product of the brightness and the etendue. This is true because the brightness of a source cannot be changed; changing the apparent emission angle changes the apparent size in inverse proportion. The brightness (a Lagrange Invariant) is unchanged. For a monochromator, the etendue is:

E  $S_w * S_h * W_g^2 / F^2$

Where $S_w$ Slit Width
$S_h$ Slit Height
$W_g$ Grating Width
F Instrumental Focal Length

In a chain of optics or optical instruments, the component with the smallest etendue will determine the etendue of the system.

For spectrometers it is useful to find the spectral energy density [watts/nanometer] that can be coupled. This can be found by dividing the etendue by the spectral bandwidth:

D  $E / (S_w / (F * A))$

D  $(S_h / F) * W_g^2 * A$

A is the angular dispersion of the grating. The ratio of usable slit height to focal length is approximately constant across all monochromators; it is limited by the aberrations. Therefore, the spectral energy density depends primarily on the grating width, and secondarily on the dispersion. To get the maximum throughput, use the widest highest dispersion grating available.

Etendue defines the coupling between a light source and a spectrometer. Transmission efficiency describes the light loss within the spectrometer. The transmission efficiency becomes:

$T \quad (R_m)^N * R_g$

Where $R_m$ is the reflectance of a single mirror, N is the number of mirrors and $R_g$ is the diffraction efficiency of the grating.

Mirror reflectance is typically 0.92 for a protected aluminum mirror. (See the SP optics catalog for a spectral profile of the reflectance). In a 4-mirror system, about 70% is transmitted by the mirrors. In a 2-mirror system this is about 85%. SP offers custom broadband high reflectance coatings that can boost this efficiency to almost 95% in a 4-mirror system over about a wavelength octave.

Grating diffraction is quite complicated; it is both wavelength and polarization dependent. Grating diffraction efficiency for a ruled grating typically reaches 90% at the blaze wavelength, falling off to 20% at 0.6 $l_B$ and 1.5$l_B$. Holographic gratings typically have a flatter 30% efficiency. More information on grating efficiency is presented in the Selection Guide Section. Due to the strong wavelength dependence of diffraction efficiency, SP stocks a wide variety of diffraction gratings. This allows good transmission efficiency at any wavelength.

## Throughput

We can get a measure of total spectrometer throughput per nanometer by multiplying the spectral energy density by the transmission efficiency. The result is:

$H \quad (S_h/F) * W_g^2 * A * (R_m)^N * R_g$

## The f/#

The f/# is defined as the ratio of diameter to focal length of an optic. It is a measure of the acceptance angle of an optical instrument. f/# is a useful concept in judging optimum coupling between spectrometers and sources or detectors. When f/#s are matched, the full aperture of the spectrometer will be utilized. Unfortunately, there is no agreement in how f/# should be defined for the rectangular optics that appear in most monochromators. The most conservative method defines the f/# to be the ratio of width to focal length. Some companies define the ratio as being the diagonal measurement divided by focal length. SP uses the ratio of the equivalent diameter to focal length where the equivalent diameter of the rectangular optics is the diameter of the circle that has the same area. These are illustrated in the Figure 13. SP uses this definition because this is the point at which the maximum coupling occurs between a Lambertian source and a spectrometer.

## Spectral Purity, Stray Light, and their Antecedents: Rediffracted Light, Secondary Sources,Higher-Order Diffraction, Ghosts and Scatter.

Spectral purity can be defined as the ratio of the in-band light passed by the spectrometer to that light transmitted which falls outside of the selected spectral band. Stray light is all spurious radiation transmitted by a spectrometer. The stray radiation sources include rediffracted light, secondary sources, higher order diffraction, ghosts, scatters and imperfection in gratings.

Two methods for stray light measurement are generally used. The first involves a laser source at a spectrometer entrance and the measurement of the exiting radiation at the peak of the line as well as at five band-passes from the peak. The stray light is then expressed as the inverse ratio of the two values. This method measures the contribution of stray light originating near the bandpass region when using a line source. Due to the simplicity, reliability,and comparability of this measurement method, SP uses this method as its stray light measurement.

The second method uses an incandescent lamp together with calibrated long and short pass blocking filters. This is useful for measuring the contribution of stray light originating far from the bandpass region when using a continuum source.

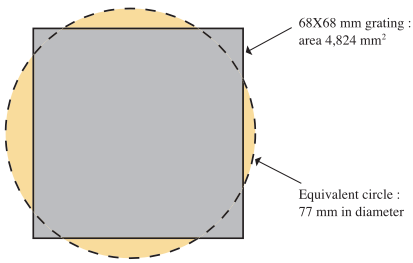



Figure 13. The f/# definition used by SP for rectangular optics

## Understanding the Slit Function

As discussed in the previous sections, the width of slits in a spectrometer plays a significant role in determining the instrument' s bandpass and resolution. Figure 14 shows a "slit function" plot that depicts the spectrometer bandpass characteristics. In most cases entrance and exit slits are set at the same width. Under the assumption that the magnification of the optics is one, the image of the entrance slit is formed at the exit focal plane at same size as the exit. Now let us introduce monochromatic light at a wavelength of $\lambda_0$ through the entrance and start rotating the grating for a wavelength scan. The image of the entrance slit will sweep across the exit slit as is shown in Figure 15.

The light intensity passing through is a function of the overlap of the entrance slit image with the exit slit. At the grating setting where the image of the entrance does not enter into the exit slit, essentially zero light intensity is exiting. When the image of the entrance slit is filling up the exit as in Figure 15B, a maximum light intensity passing through is seen. The light intensity will drop to half when the overlap is only 50% as the cases in Figure 15A and C. The energy distribution curve passing through the exit slit can thus be constructed as a triangle, Figure 14. This is also referred to as slit function. The bandpass of a spectrometer is conventionally defined as the full width (of wavelength band) measured at half maximum $\triangle\lambda$, or FWHM as illustrated in Figure 14. In the situation where the incident radiation is a continuous source, a series of overlapping images of the entrance slit for each wavelength present are found at the exit focal plane. The triangular intensity distribution applies in a way that it determines the range of the wavelength passing through.

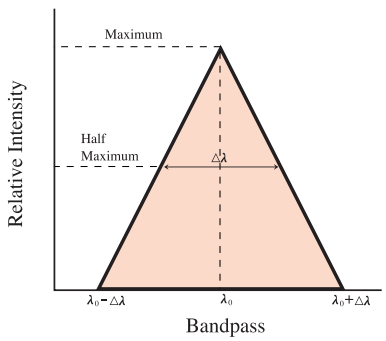



Figure 14. Illustration of a slit function

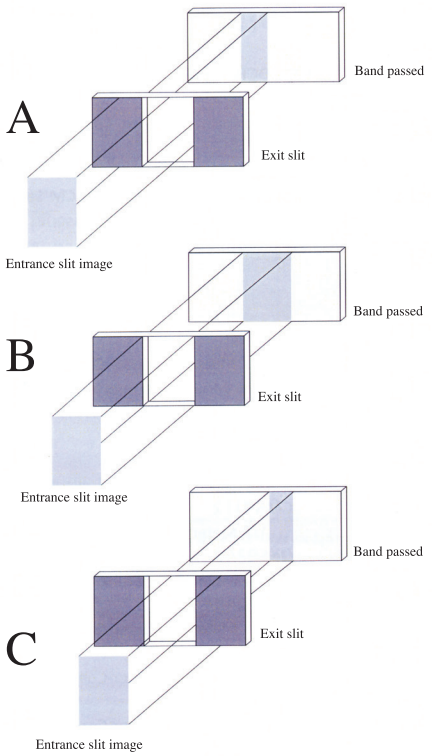
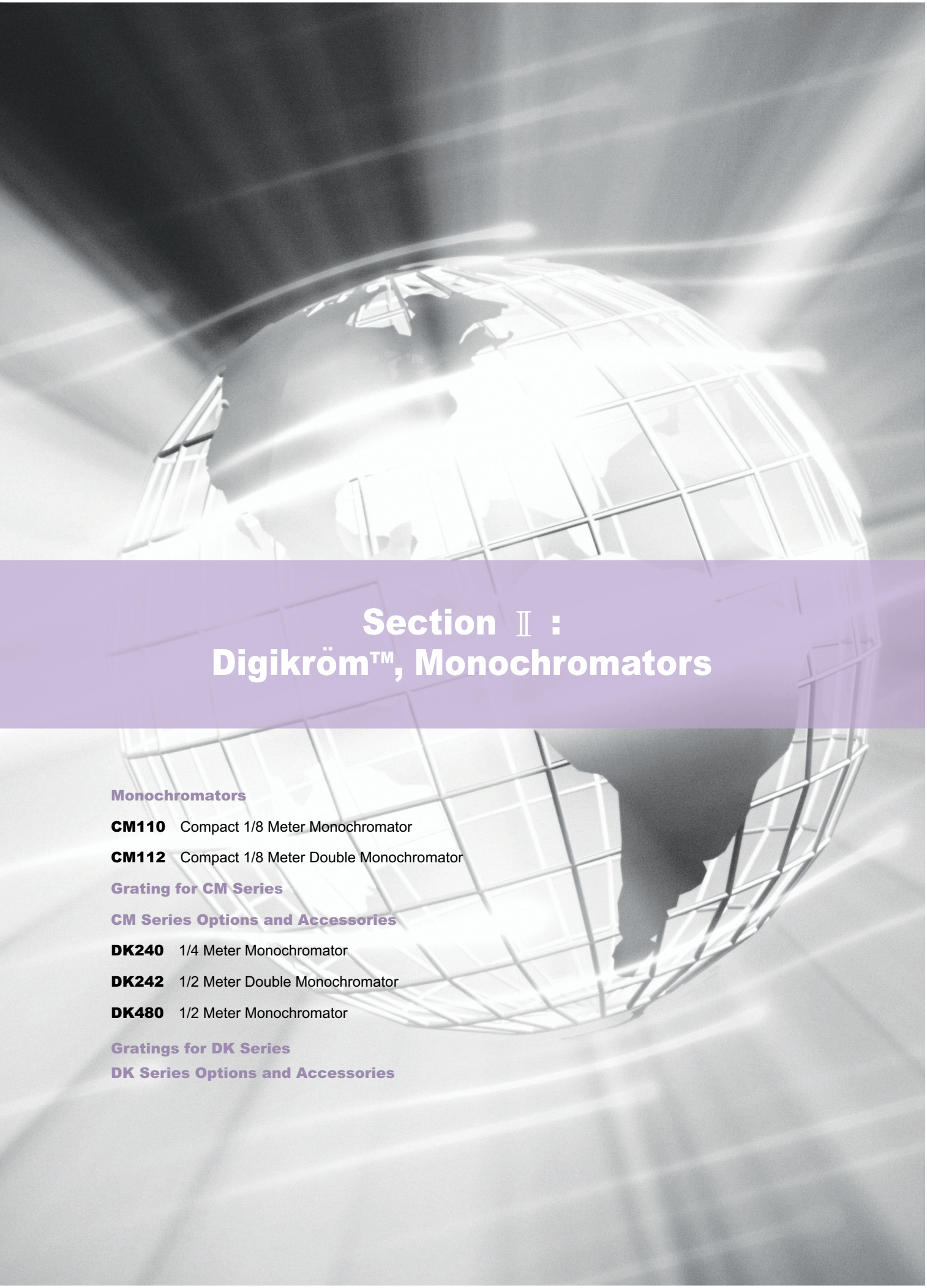


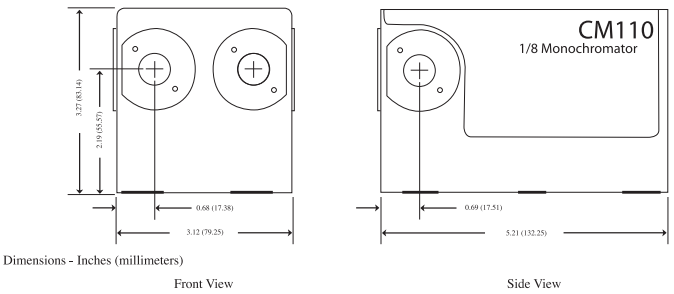

Figure 15.Bandpass versus grating settings



# Section Ⅱ :
# Digikröm™, Monochromators

# CM110 Compact 1/8 Meter Monochromator

- ompact size - Only 5-1/4"x3-1/4"x3-1/4"
- Connects to any computer via standard RS232 interface.
- Double grating turret allows for a broad spectral range coverage.
- May be factory configured as a monochromator or a spectrograph.
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV.
- Change slits on the fly.
- Monochromator may be factory configured for right angle or straight through beam path.
- Suitable for fluorescence, radiometry, process control, colorimetry, tunable filtering, Raman spectroscopy, among others.


Dimensions - Inches (millimeters)

Front View Side View

## The Leader: Price, Performance, Versatility

Single piece base construction, direct grating drive, and anti-backlash gearing ensure this unit is rugged and stable enough for demanding applications. Loaded with SP Optics and able to hold two high quality gratings, the CM110 is ideal for spectrometry in the UV to IR spectra. Each instrument is calibrated and certified prior to delivery and comes with easy-to-use software.

## Specifications :

| Feature | Value | Feature | Value |
|---|---|---|---|
| Design | Czerny Turner, dual grating turrets | Max Resolution | <1nm w/1200G/mm grating and standard slits |
| Focal Length | 110mm | Gratings | One to two gratings. (30 x 30mm) must be purchased.<br>See CM grating options page |
| f/# | 3.9 | | |
| Beam Path | Straight through standard, right angle provided on request. | Software | Demonstration control program<br>and LabView driver included. |
| Wavelength Drive | Worm and wheel with microprocessor control and anti backlash gearing.<br>Bi directional. Usable in positive or negative grating orders. | Power | UL listed 110/220V power pack |
| | | Interface | RS232 standard |
| Wavelength Precision | 0.2nm | Warranty | One year |
| Wavelength Accuracy | ±0.6nm | Options | ▸Hand held control module with function keys and display for local control<br>▸IEEE 488 interface<br>▸Interface cables<br>▸Gold optics<br>See options and accessories |
| Slewing Speed | >100nm/second | | |
| Stray Light | $<10^{5}$ | | |
| Slits | Standard Set includes; 0.125mm, 0.15mm, 0.30mm,<br>0.6mm, 1.2mm and 2.4mm x 4.0mm. For other sizes, consult SP. | | |

**Ordering Information :** Please indicate product number plus description when ordering.
**CM110** Compact 1/8meter Monochromator

# CM112 Compact 1/8 Meter Double Monochromator

- Compact size - Only 5-1/4"x6-1/4"x3-1/4"
- Connects to any computer via RS232.
- Scans in both directions. Programmable in angstroms, nanometers, microns, wavenumbers, or eV.
- Dual double-grating turrets with automatic grating change allows for broad spectral range coverage.
- Subtractive dispersion mode minimizes image distortion and pulse spread, with sub-picosecond residual broadening versus nanosecond pulse broadening of regular monochromators.
- Additive mode gives increased dispersion and low stray light for Raman and fluorescence studies.
- May be configured as a monochromator or a spectrograph.
- Monochromator may be factory configured for right angle or straight through beam path.

## The Digikrom CM112 : Much More than a Monochromator

The CM112 is two single monochromators in series. The exit slit of the first monochromator is the entrance slit of the second. The two monochromators act as a double filter with the rejection of stray light being almost the square of the single monochromator value.
The CM112 may be factory configured as an additive or subtractive dispersion double monochromator. As an additive instrument, the first grating spreads the spectrum over an angular range; the second grating then doubles this dispersion. The result is twice the resolution of a single 1/8 meter monochromator. As a subtractive instrument, the first monochromator selects a bandpass, the second monochromator then removes the temporal and angular aberrations introduced by the angular spectral dispersion in the first monochromator. The CM112 offers a solution to practical problems in monochromatic imaging. Selecting a monochromatic image with an ordinary monochromator fails because multiple wavelengths in the bandpass create multiple, overlapping images. In the CM112, the second subtractive monochromator recombines these multiple images, creating a clear image. Finally, the CM112 is a unique solution to practical problems in the spectroscopy of pulsed sources. An ordinary monochromator has a spread in the internal optical path lengths that will introduce a 25 to 100 picosecond broadening in light pulses that are passed through the monochromator. In the subtractive dispersion CM112, the second monochromator equalizes the optical path lengths so that broadening is reduced to a minimum.

## Specifications :

| Feature | Value | Feature | Value |
|---|---|---|---|
| Design | Double cascaded Czerny Turner, double grating turrets standard in each section | Slits | Standard Set includes; 0.125mm, 0.15mm, 0.30mm, 0.6mm, 1.2mm and 2.4mm x 4.0mm. For other sizes, consult SP. |
| Focal Length | 110mm each section | Gratings: | Two or four gratings (30 x 30mm) must be purchased. See CM grating options page |
| f/# | 3.9 overall | | |
| Beam Path | Straight through standard, right angle provided on request. | Software: | Demonstration control program and LabView driver included. |
| Wavelength Drive | Dual worm and wheel with electronic synchronization and computer control. Programable in additive or subtractive dispersion with positive or negative grating orders. | Power: | UL listed 110/220V power pack |
| | | Interface: | RS232 standard |
| Wavelength Precision | 0.1nm (additive) 0.2nm (subtractive) | Warranty: | One year |
| Wavelength Accuracy | ±0.3nm (additive) ±0.6nm (subtractive) | Options: | ▸Hand held control module with function keys and display for local control<br>▸IEEE 488 interface<br>▸vInterface cables<br>▸Gold optics<br>See options and accessories |
| Max Resolution | <0.5nm (additive) <1nm (subtractive) | | |
| Band Pass | 0.25nm (additive) 0.50nm (subtractive), w/standard slits | | |
| Slewing Speed | >100nm/second | | |
| Stray Light | $<10^{9}$ | | |

**Ordering Information :** Please indicate product number plus description when ordering.
**CM112** Compact 1/8meter Double Monochromator

# Standard Ruled Gratings

## for installation in Digikrom™, CM110/CM112 Monochromators

### CM Standard Ruled Gratings Size = 30 x 30 mm

| SP Part # | Ruling (g/mm) | Peak (nm) | Range(nm) @ > 30%T | Peak %T |
|---|---|---|---|---|
| AG2400 00240 303 | 2400 | 240 | 180 680 | 70 |
| AG1200 00200 303 | 1200 | 200 | 180 450 | 65 |
| AG1200 00300 303 | 1200 | 300 | 200 750 | 72 |
| AG1200 00500 303 | 1200 | 500 | 330 1000 | 83 |
| AG1200 00600 303 | 1200 | 600 | 400 1500 | 80 |
| AG1200 00750 303 | 1200 | 750 | 480 1500 | 85 |
| AG0600 00500 303 | 600 | 500 | 350 1300 | 80 |
| AG0600 01200 303 | 600 | 1200 | 800 3000 | 85 |
| AG0300 00500 303 | 300 | 500 | 310 1100 | 80 |
| AG0300 02500 303 | 300 | 2500 | 1500 6000 | 88 |
| AG0150 00500 303 | 150 | 500 | 320 980 | 72 |
| AG0150 04000 303 | 150 | 4000 | 2500 9000 | 93 |
| AG0075 01700 303 | 75 | 1700 | 1100 2800 | 85 |
| AG0075 08000 303 | 75 | 8000 | 5000 15000 | 82 |
| AG0045 01750 303 | 45 | 1750 | 1100 3000 | 78 |

See Appendix A for grating efficiency curves

NOTE: Ruled gratings blazed at different wavelengths and Holographic gratings are available on request - call for prices and availability. Response curves also available upon request.

### AG-303-KIT

Backplate mounting kit, required for user installation of CM gratings.

# CM series Options and Accessories

## DK1201

Hand-held control module, 2 line x 20 character LCD display. Allows local operation of CM110/112 monochromators and CMSP110/112 spectrographs.

## CMGPIB

IEEE-488/GPIB option for parallel interface operation of CM110/112 monochromators and AB300 Series automatic filter wheels.

## CMGPIB- 220V (220Vac input)

IEEE-488/GPIB option for parallel interface operation of CM110/112 monochromators and AB300 Series automatic filter wheels.

## CMSP-TO-CM

Attachment to allow CMSP Spectrograph to operate as a monochrometor.

## AB200

Single filter carrier that mounts directly between CM unit and accessories

## IR110

For use with CM110. Infrared(gold) coatings on CM110 mirrors. Enhances transmission by up to 40% between 600 and 1100 nm. Not suitable for work below 600nm

## IR110SP

Same as above, for use with CMSP110.

## IR112

For use with CM112. Infrared(gold) coatings on CM112 mirrors. Enhances transmission by up to 80% between 600 and 1100 nm.

## IR112SP

Same as above, for use with CMSP112.

## DK12AT

RS232 Cable for AT style computer

## DK12PS

RS232 Cable for PS2 style computer

## DK12MA

RS232 Cable for PS2 style computer

## Special Slit Sizes

| | |
|---|---|
| DKFS010 | Pair, 10$\mu$m slits |
| DKFS020 | Pair, 20$\mu$m slits |
| DKFS025 | Pair, 25$\mu$m slits |
| DKFS050 | Pair, 50$\mu$m slits |

DK1201 controller

# DK240 1/4 Meter Monochromator

- Connects to any computer via RS232 or IEEE-488.
- Motorized slits.
- Triple-grating turret allows high efficiency scanning across a broad spectral range.
- May be factory configured as a monochromator or spectrograph.
- Scans in both directions and with Constant Spectral Resolution (CSR).
- Integrates with SP filter wheel for automatic filter switching.
- Suitable for fluorescence and absorption studies, detector characterization, thin film measurements, etc.


## The Workhorse : Direct Digital Drive/Constant Spectral Resolution

The Digikrom DK240 is a complete computer integrated solution. Easy to use commands control the triple grating turret, motorized slits, and optional motorized filter wheel for quick and easy sorting. Instrument mode can be set for constant spectral resolution (CSR), where the slit width is automatically modified to compensate in the change in dispersion with wavelength to maintain constant spectral bandpass.

Rugged cast construction, A-Thermal design, and SP direct grating drive make this unit the most repeatable and reliable in its class. Each instrument is calibrated and certified prior to delivery.



## Specifications :

| Feature | Value | Feature | Value |
|---|---|---|---|
| Design | Czerny Turner, triple grating turrets standard. | Gratings | One to three gratings (68 x 68mm standard, 68 x 84mm optional) must be purchased. See DK Gratings. |
| Focal Length | 240mm | | |
| f/# | 3.9 | Software | Demonstration control program and LabView driver included. |
| Reciprocal Dispersion | 3.2nm/mm (with 1200 g/mm grating) | Power | 100 240V, 50/60Hz, 60W<br>220/230/240V, 50/60Hz @ 0.5A optional. |
| Wavelength Drive | Worm and wheel with microprocessor control and anti backlash gearing.<br>Bi directional. Usable in positive or negative grating orders. | Interface | RS232 standard |
| | | Weight | 35lbs |
| Wavelength Precision and reproducibility | 0.007nm (with 1200g/mm grating) | Warranty | One year |
| Wavelength Accuracy | ±0.30nm standard (with 1200g/mm grating) | Options | ▸IDKBS Bi lateral slits<br>▸IDKGPIB IEEE 488 communication interface (internal)<br>▸IDK2400 and Hand held controllers for local control<br>▸IIR240 Gold optics<br>▸IDK2PORT Bifurcated fiber bundle for attaching 2 devices to 1 port.<br>▸IAB300 Automated 6 position filter wheel<br>See options and accessories |
| Scan Speed | 1 to 1200nm/minute (with 1200g.mm grating) | | |
| Stray Light | < 0.01% at 220nm (Nal) | | |
| Slits | Unilateral, computer controlled, curved entrance and straight exit standard.<br>Width 10㎛ to 3000㎛<br>Height 2mm to 20mm | | |
| Max Resolution | 0.06nm (with 1200 g/mm grating) | | |

**Ordering Information :** Please indicate product number plus description when ordering.
**DK240** 1/4meter Monochromator

# DK242 1/4 Meter Double Monochromator

- Internal controller connects to any computer via RS232 or IEEE-488. Hands-off control of three slit assemblies and two grating turrets.
- Scans in both directions and with Constant Spectral Resolution (CSR).
- Triple-grating turrets allows high efficiency scanning across a broad spectral range.
- Additive dispersion increases resolution and reduces stray light for Raman and fluorescence studies, subtractive dispersion minimizes broadening of pulse sources.
- Integrates with SP filter wheel for automatic filter switching.
- May be factory configured as a monochromator or spectrograph.

## The Pioneer : Better Resolution, Stray Light Control

The DK242 is two cascaded monochromators, with the exit slit of the first monochromator functioning as the entrance slit of the second. This instrument may be factory configured to operate as either an additive or subtractive dispersion double monochromator. In both modes, the two monochromators act as a double filter with the rejection of stray light being nearly the square of the single monochromator value. In the additive dispersion mode, the DK242 is the equivalent of a half-meter monochromator, but permits greater reduction of stray light. The first grating spreads the spectrum over an angular range; the second grating then doubles this dispersion. The result is twice the resolution of a single 1/4-meter monochromator. In subtractive dispersion mode the first monochromator selects a bandpass. The second monochromator then removes the temporal and angular aberrations introduced by the angular spectral dispersion in the first monochromator. The DK242 offers a unique solution to practical problems in the spectroscopy of pulsed sources. For example, an ordinary monochromator will introduce up to 250 pico second broadening in light pulses that are passed through the monochromator. Operated in the subtractive dispersion mode, the DK242 reduces this broadening to almost zero because the second monochromator equalizes the optical path length of the first. The DK242 is also a unique solution to the practical problems of Raman spectroscopy because the high stray light rejection of the two monochromators allows observation close to the laser line. SP's unique CSR scanning technology also improves efficiency in the red and near IR while maintaining resolution. (In the CSR mode, the monochromator's change in dispersion with wavelength is compensated by a change in slit widths while bandpass remains constant. Intensity improvement up to 4x can occur). Equipped with SP's Direct Digital Drive, the DK242 is a complete computer-controlled instrument. The control electronics are internal, calibration is automatic. Any computer can control the DK242 through its RS232 interface with simple commands (shown in all capital letters) to direct the monochromator to GO TO a wavelength, to SCAN between wavelengths at a preset SPEED, to SELECT gratings, or to report its STATUS.

## Specifications :

| Feature | Value | Feature | Value |
|---|---|---|---|
| Design | Double cascaded Czerny Turner.<br>Triple grating turrets standard in each section. | Gratings | <0.04nm (additive) 0.06nm (subtractive) |
| Focal Length | 240mm each section | Software | Two to six gratings (68 x 68mm standard, 68 x 84mm optional) must be purchased. See DK Gratings. |
| f/# | 3.9 overall | Power | Demonstration control program and LabView driver included. |
| Reciprocal Dispersion | 1.60nm/mm (additive) (with 1200 g/mm grating) | Interface | 110 / 120V, 50/60Hz @ 1A standard. 220/230/240V, 50/60Hz @ 0.5A optional. |
| Wavelength Drive | Dual worm and wheel with electronic synchronization and computer control.<br>Programmable in additive or subtractive dispersion<br>Programmable in additive or subtractive dispersion | Weight | RS232 standard |
| | | Warranty | One year |
| Wavelength Precision | 0.01nm (additive) 0.01nm (subtractive) | Options | ▸DKBS Bi lateral slits<br>▸DKGPIB IEEE 488 communication interface (internal)<br>▸DK2400 and Hand held controllers for local control<br>▸IR240 Gold optics<br>▸DK2PORT Bifurcated fiber bundle for attaching 2 devices to 1 port.<br>▸AB300 Automated 6 position filter wheel<br>See options and accessories |
| Wavelength Accuracy | ±0.30nm standard (with 1200 g/mm grating) | | |
| Scan Speed | >1 to 1200nm/minute (with 1200g.mm grating) | | |
| Stray Light | $< 10^{9}$ | | |
| Slits | Unilateral, computer controlled, curved entrance and straight exit standard.<br>Width 10μm to 3000μm<br>Height 2mm to 20mm | | |
| Pulse Broadening | 200 ps max (additive) 10 fs max (subtractive) | | |

**Ordering Information :** Please indicate product number plus description when ordering.
**DK242** 1/4meter Double Monochromator

# DK480 1/2 Meter Monochromator

- Connects to any computer via RS232 or IEEE-488.
- Motorized slits.
- Triple-grating turret allows high efficiency scanning across a broad spectral range.
- May be factory configured as a monochromator or spectrograph.
- Scans in both directions and with Constant Spectral Resolution (CSR)
- Integrates with AB300 for automatic filter switching. AB300 is controlled by monochromator
- Suitable for fluorescence and absorption studies, detector characterization, thin film measurements, etc.




## Wavelength Selection is No Longer Expensive

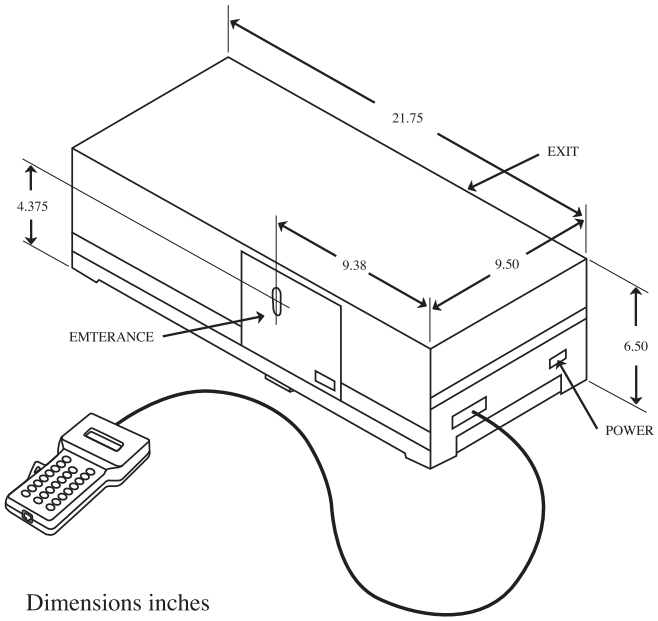
The Digikrom DK480 is a complete computer integrated solution. Easy to use commands control the tripple grating turret, motorized slits, and optional motorized filter wheel for quick and easy sorting. Instrument mode can be set for constant spectral resolution (CSR), where the slit width is automatically modified to compensate in the change in dispersion with wavelength to maintain constant spectral bandpass.

Rugged cast construction, a thermal design, and SP direct grating drive make this unit the most repaetable and reliable in its class. Each instrument is calibrated and certified prior to delivery.

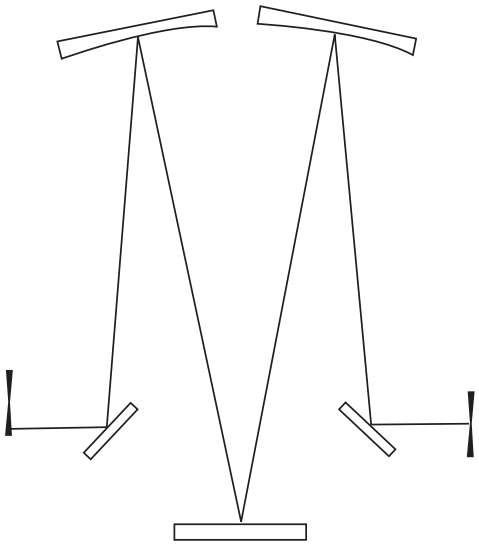
For DK480 models, for a ful list of gratins see Appendix A

| Grating groove/mm | wavelength (nm) | Dispersion nm/mm | Resolution* (nm)/slit 0.01mm | 0.125mm |
|---|---|---|---|---|
| 1200 | 200 | 3.5 | 0.05 | 0.2 |
| | 800 | 3.3 | 0.05 | 0.2 |
| | 1500 | 1.9 | <0.05 | 0.1 |
| 600 | 200 | 6.9 | 0.1 | 0.5 |
| | 1500 | 6.6 | 0.1 | 0.4 |
| | 3000 | 3.8 | 0.05 | 0.2 |
| 150 | 200 | 27.5 | 0.4 | 2 |
| | 5000 | 27.1 | 0.3 | 2 |
| | 10000 | 21.2 | 0.3 | 1 |

※ approximately equivalent to bandpass




Dimensions inches



Optical Path

## Specifications :

| Feature | Value | Feature | Value |
|---|---|---|---|
| Design | Czerny Turner, triple grating turrets standard. | Software | Demonstration control program and LabView driver included. |
| Focal Length | 480mm | Power | 100 240V, 50/60Hz, 60W<br>220/230/240V, 50/60Hz @ 0.5A optional. |
| f/# | 7.8 | | |
| Reciprocal Dispersion | 1.60nm/mm (with 1200 g/mm grating) | Interface | RS232 standard |
| Wavelength Drive | Worm and wheel with microprocessor control and anti backlash gearing.<br>Bi directional. Usable in positive or negative grating orders. | Weight | 45lbs |
| | | Warranty | One year |
| Wavelength Precision and reproducibility | 0.007nm (with 1200g/mm grating) | Options | ▸ DKBS Bi lateral slits<br>▸ DKGPIB IEEE 488 communication interface (internal)<br>▸ DK2400 and Hand held controllers for local control<br>▸ IR480 Gold optics<br>▸ DK2PORT Bifurcated fiber bundle for attaching 2 devices to 1 port.<br>▸ AB300 Automated 6 position filter wheel<br>See options and accessories |
| Wavelength Accuracy | ±0.30nm standard (with 1200 g/mm grating) | | |
| Scan Speed | 1 to 1200nm/minute (with 1200g.mm grating) | | |
| Stray Light | < 0.01% at 220nm (Nal) | | |
| Slits | Unilateral, computer controlled, curved entrance and straight exit standard.<br>Width 10$\mu$m to 3000$\mu$m<br>Height 2mm to 20mm | | |
| Max Resolution | 0.03nm (with 1200 g/mm grating) | | |
| Gratings | One to three gratings (68 x 68mm standard, 68 x 84mm optional) must be purchased. See DK Gratings. | | |

**Ordering Information :** Please indicate product number plus description when ordering
**DK242** 1/2 meter Monochromator

# Standard Ruled Gratings

## for installation in Digikrom DK series Monochromators

### DK Standard Ruled Gratings Size = 68 x 68 mm

| SP Part # | Ruling (g/mm) | Peak (nm) | Range(nm) @ > 30%T | Peak %T |
|---|---|---|---|---|
| AG2400 00240 686 | 2400 | 240 | 180 680 | 70 |
| AG1200 00200 686 | 1200 | 200 | 180 450 | 65 |
| AG1200 00250 686 | 1200 | 250 | 180 460 | 70 |
| AG1200 00300 686 | 1200 | 300 | 200 750 | 72 |
| AG1200 00500 686 | 1200 | 500 | 330 1000 | 83 |
| AG1200 00600 686 | 1200 | 600 | 400 1500 | 80 |
| AG1200 00750 686 | 1200 | 750 | 480 1500 | 85 |
| AG1200 01000 686 | 1200 | 1000 | 550 1500 | 75 |
| AG0600 00500 686 | 600 | 500 | 350 1300 | 80 |
| AG0600 01200 686 | 600 | 1200 | 800 3000 | 85 |

| SP Part # | Ruling (g/mm) | Peak (nm) | Range(nm) @ > 30%T | Peak %T |
|---|---|---|---|---|
| AG0600 01600 686 | 600 | 1600 | 950 3000 | 93 |
| AG0300 00500 686 | 300 | 500 | 310 1100 | 80 |
| AG0300 02000 686 | 300 | 2000 | 1200 4000 | 88 |
| AG0300 02500 686 | 300 | 2500 | 1500 6000 | 88 |
| AG0300 03000 686 | 300 | 3000 | 1800 6000 | 80 |
| AG0150 00500 686 | 150 | 500 | 320 980 | 72 |
| AG0150 04000 686 | 150 | 4000 | 2500 9000 | 93 |
| AG0075 08000 686 | 75 | 8000 | 5000 15000 | 82 |
| AG0050 00600 686 | 50 | 600 | 400 1200 | 78 |
| AG0050 12000 686 | 50 | 12000 | 7500 20000 | 82 |

See Appendix A for grating efficiency curves

NOTE: Ruled gratings blazed at different wavelengths and Holographic gratings are available on request - call for prices and availability.
Wide gratings (68 x 84mm) are available at 40% above list price, add “W”at the end of the part number.
Response curves also available on request.

### AG-686-KIT

Backplate mounting kit, required for user installation of DK gratings.

# DK Series Options and Accessories

### DKBS

Bi-lateral slit option for DK240/ 242/480. Both sides of slits are automatically controlled for maintaining image centering when wider slits are necessary (tolerance ± 10$\mu$m)

### DKGPIB

Internal IEEE-488/GPIB communication interface option for DK240/242/480. Separate output connector from Monochromator.

### IR240

For use with DK240. Infrared (gold) coatings on optics for DK240. Enhances transmission by up to 40% between 600 -1100nm. Not suitable for work below 600nm.

### IR240SP

Same as above, for use with DKSP240.

### IR242

For use with DK242. Infrared (gold) coatings on optics for DK242. Enhances transmission by up to 80% between 600 - 1100nm.

### IR242SP

Same as above, for use with DKSP242.

### IR480

For use with DK480. Infrared (gold) coatings on optics for DK480. Enhances transmission by up to 40% between 600 -1100nm.

### IR480SP

Same as above, for use with DKSP480.

### DK2401

Hand-held monochromator controller for DK240/242/480. Allows local control of monochromator when computer is not available or in series with a computer.

### DK24PS

RS232 Cable assembly for PS/2 style computer.

### DK24MA

RS232 Cable assembly for MAC style computer

### DK24IC

IEEE-488/GPIB universal cable assembly.

### AB300

Six position, 1” diameter automatic filter wheel assembly that bolts directly to DK entrance. Recieves power and commands directly through DK unit. See page 92 for more information.

### DKSP-TO-DK

Attachment to allow DKSP Spectrograph to operate as a monochrometor. It includes CM standard 6-fixed slit set (page 17).

### AB200

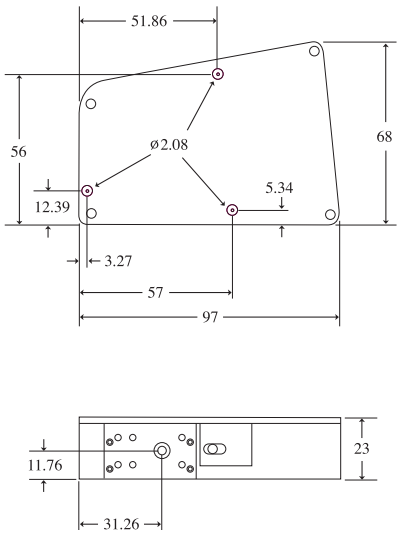
Single filter carrier that mounts directly between DK unit and accessories

# Section Ⅲ : SM Series Spectrometers

# SM200 / SM400

## OEM CCD Spectrometer

- Best performance cost ratio in the industry
- Designed from the ground up for OEM integration
- Small impact resistant optical bench
- Flexible light input direct to slit or via fiber.
- Fully customizable.
- Sony ILX511 CCD for SM200 or Toshiba TCD1304 CCD for SM400 allows up to a 900 nm measurement window between 200nm and 1050nm (800 nm measurement window size possible for some applications)
- USB 1.1 and 2.0 interface with 16-bit dynamic range available!
- Support up to 8 USB multi-channel configuration
- **NEW** UV enhancing coating


## The Choice for Intergation with OEM Products

The SM200/SM400 is a miniature spectrometer designed for custom OEM applications. It offers a high performance to cost ratio for new systems designs. It can accept light directly through its built in slit or via optical fiber. A removable fiber coupler faceplate allows use of standard SMA 905, FC and custom fiber connectors. This faceplate also allows direct attachment to dedicated systems and a number of SMX Accessories. A durable aluminum housing encloses the SM200/SM400 optical bench; through careful design this housing provides stable device operation over a wide range of temperatures.

The spectrometer sensor array and array driver electronics are mounted inside the SM200/SM400 housing, from there a flex cable connects to exterior support electronics. The standard sensor array used is the Sony ILX511 for SM200 and the Toshiba TCD1304 for SM400. The driver electronics have been designed for highly sensitive yet stable operation. The design of the SM200/SM400 also allows the use of custom arrays for special applications, including photodiode assemblies and alternative CCD arrays, as well as the use of customer's own data acquisition electronics instead of using SP's.

Standard interfaces to the SM200/SM400 include a USB 2.0 interface with 16 bit extended dynamic range and a PCI card interface with 16 bit dynamic range sampling. Our USB board can support multichannel configuration up to 8. With this multichannel configuration, a high resolution for wide range or a dual spectrometer system (one for measurement and the other for reference) is possible.

Spectral Products applies new UV enhancing coating on the CCD to increase the UV sensitivity below 450nm comparing with the conventional UV coating that is widely used in CCD spectrometers. By the help of this new UV coating, the signal sensitivity below 500nm can get improved ~20 50% more in general.

Software support includes custom DLLs for dedicated applications development and our SM32Pro windows based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced acquisition programming and external triggering.

## Specifications :

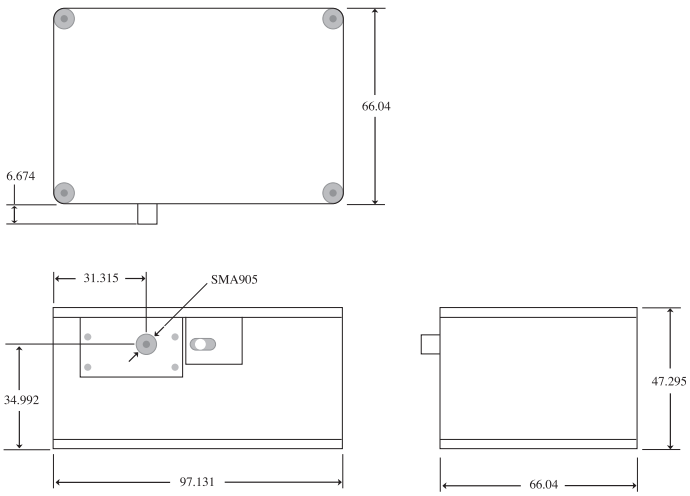
| Feature | Value | |
|---|---|---|
| | SM200 | SM400 |
| Detectors | Sony ILX511<br>▸Number of Pixels : 2048<br>▸Sensing Pixel Size : 14μm X 200μm<br>▸Sensitivity : 200V/(lx s) under 3200K uniform illumination | Toshiba TCD 1304<br>▸Number of Pixels : 3648<br>▸Sensing Pixel Size : 8μm X 200μm<br>▸Sensitivity :160V/(lx s) under daylight fluorescent illumination |
| Spectrograph f# | 2.7 | |
| Dark Noise RMS | <50 RMS counts in 16bit @ 35msec integration time | |
| Signal to Noise Ratio | 250:1 | |
| Fiber Coupler | SMA905 or FC standard | |
| Effective Spectral Range | 200 to 1050nm | |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage | |
| Spectral Resolution | 0.3~10nm FWHM | |
| Stray Light | <0.05% at 632nm (<0.1% overall) | |
| Computer interface | ▸USB 1.1/2.0 compatible<br>▸PCI bus NI PCI 16bit 250KHz | |
| Minimum integration time | 1msec | |
| Trigger Mode | Free Run Mode<br>External Trigger Mode | |
| Dimensions (inches) | 97mm X 68mm X 23mm (3.83 X 2.67 X 0.93) | |
| Weight | 0.2kg | |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg | |

**Ordering Information :** Please indicate product number plus description when ordering
**SM200** OEM CCD Spectrometer
**SM400** OEM CCD Spectrometer

# SM242/SM442

## Preconfigured CCD Spectrometer

- New compact, pre-configured model
- Can be handheld or securely mounted
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- Impact resistant housing
- High performance electronics
- Standard design allows up to 200-1050nm range
- Support up to 8 USB multi-channel configuration
- **NEW** UV enhancing coating


## The Choice for Spectral Applications

The SM242/SM442 is a new compact design CCD Spectrometer for use with a PC. Based on SP's special optical bench design, it supports many different applications where spectral or color measurements are required, including high dynamic range applications.

The SM242/SM442 can accept light directly through its built-in slit or via optical fiber. The durable aluminum housing that encloses the SM242/SM442 provides stable optical bench operation over a wide range of temperatures. The standard sensor arrays used are the Sony ILX 511 for SM240 and the Toshiba TCD1304 for the SM440. The array driver electronics have been designed for highly sensitive yet stable operation. This array (in conjunction with our special UV coating process and customized order sorting filters) allows up to a 850nm measurement window from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity). Thanks to the more pixel numbers, the SM442 is more preferable for the applications requiring higher resolution. The better sensitivity of the CCD makes the SM242 more suitable for the applications with lower light signals.

Standard interface to the SM242/SM442 is a USB 1.1/2.0 compatible interface with 16-bit extended dynamic range. Our USB board can support multichannel configuration up to 8. With this multichannel configuration, a higher resolution for wide range or a dual spectrometer system (one for measurement and the other for reference) is possible. Spectral Products applies new UV enhancing coating on the CCD to increase the UV sensitivity below 450nm comparing with the conventional UV coating that is widely used in CCD spectrometers. By the help of this new UV coating, the signal sensitivity below 500nm can get improved ~20-50% more in general. The SM242/SM442 is a pre-configured model so if the desired wavelength range matches one of the standard wavelength ranges, SP can ship the unit within a couple of days. Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows-based spectral acquisition and analysis software.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

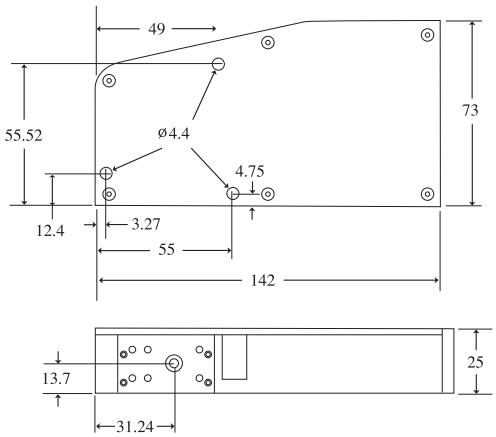
| Feature | Value | |
|---|---|---|
| | SM242 | SM442 |
| Detectors | Sony ILX 511<br>▸Number of Pixels : 2048<br>▸Sensing Pixel Size : 14μm X 200μm<br>▸Sensitivity : 200V/(lx s) under 3200K uniform illumination | Toshiba TCD 1304<br>▸Number of Pixels : 3648<br>▸Sensing Pixel Size : 8μm x 200μm<br>▸Sensitivity : 160 V/(lx s) under daylight fluorescent illumination |
| Spectrograph f# | 2.7 | |
| Dark Noise RMS | <50 RMS counts in 16bit @ 35msec integration time | |
| Signal to Noise Ratio | 250:1 | |
| Fiber Coupler | SMA905 or FC standard | |
| Effective Spectral Range | 200 to 1050nm | |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage | |
| Spectral Resolution | 0.25~10nm FWHM | |
| Stray Light | <0.05% at 632nm (<0.1% overall) | |
| Computer interface | ▸USB 1.1/2.0 compatible<br>▸PCI bus NI PCI 16bit 500KHz | |
| Minimum integration time | 8msec (General Mode), 0.01msec (Shutter Mode) | |
| Trigger Mode | Free Run Mode<br>External Trigger Mode | |
| Dimensions (inches) | 97mm X 66mm X 47mm (3.82 X 2.6 X 1.86) | |
| Weight | 0.4kg | |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development | |

**Ordering Information :** Please indicate product number plus description when ordering
**SM442** Preconfigured Compact CCD Spectrometer

# SM240 / SM440

## Hand-Held CCD Spectrometer

- Compact system, can be handheld or securely mounted
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for applications
- Impact resistant housing
- High performance electronics
- Standard design allows up to a 850nm measurement window between 200nm and 1050nm
- USB 1.1 and 2.0 interface with 16-bit dynamic range available!
- Support up to 8 USB multi-channel configuration
- **NEW** UV enhancing coating


## The Choice for Spectral Applications

The SM240/SM440 is a compact CCD Spectrometer for use with a PC. Based on the SM200/SM400 optical bench design, it supports many different applications where spectral or color measurements are required, including high dynamic range applications.

The SM240/SM440 can accept light directly through its built in slit or via optical fiber. The durable aluminum housing that encloses the SM240/SM440 provides stable optical bench operation over a wide range of temperatures.

The standard sensor arrays used are the Sony ILX 511 for SM240 and the Toshiba TCD1304 for the SM440. The array driver electronics have been designed for highly sensitive yet stable operation. These arrays (in conjunction with our special UV coating process and custom order sorting filters) allow up to a 850nm measurement window located from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity). Standard interfaces to the SM240/SM440 include a USB 2.0 interface and a PCI card interface with 16 bit dynamic range. Our USB board can support multichannel configuration up to 8. With this multichannel configuration, a high resolution for wide range or a dual spectrometer system (one for measurement and the other for reference) is possible. Spectral Products applies new UV enhancing coating on the CCD to increase the UV sensitivity below 450nm comparing with the conventional UV coating that is widely used in CCD spectrometers. By the help of this new UV coating, the signal sensitivity below 500nm can get improved ~20 50% more in general. The black anodized housing is available for OEM customers who are using the unit as it is with no need to install the optical bench and the electronic board separately (like SM200/SM400) in their systems. The electronic board is secured in the housing of the SM240/SM440, which is better for the electronic noise protection.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced acquisition programming and external triggering.

## Software

- SM32Pro - Windows® 98, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysi
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

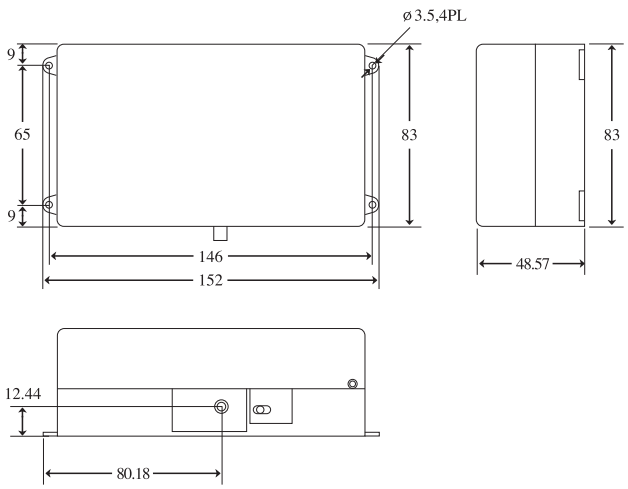
| Feature | Value | |
|---|---|---|
| | SM240 | SM440 |
| Detectors | Sony ILX511<br>▸Number of Pixels : 2048<br>▸Sensing Pixel Size : 14$\mu$m X 200$\mu$m<br>▸Sensitivity : 200V/(lx s) under 3200K uniform illumination | Toshiba TCD 1304<br>▸Number of Pixels : 3648<br>▸Sensing Pixel Size : 8$\mu$m X 200$\mu$m<br>▸Sensitivity : 160V/(lx s) under daylight fluorescent illumination |
| Spectrograph f# | 2.7 | |
| Dark Noise RMS | <50 RMS counts in 16bit @ 35msec integration time | |
| Signal to Noise Ratio | 250:1 | |
| Fiber Coupler | SMA905 or FC standard | |
| Effective Spectral Range | 200 to 1050nm | |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage | |
| Spectral Resolution | 0.3 ~ 10nm FWHM | 0.25 ~ 10nm FWHM |
| Stray Light | <0.05% at 632nm (<0.1% overall) | |
| Computer interface | ▸USB 1.1/2.0 compatible<br>▸PCI bus NI PCI 16bit 250KHz | |
| Minimum integration time | 1msec | |
| Trigger Mode | Free Run Mode<br>External Trigger Mode | |
| Dimensions (inches) | 142mm X 73mm X 25mm (5.59 X 2.87 X 0.98) | |
| Weight | 0.4kg | |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg | |

**Ordering Information :** Please indicate product number plus description when ordering
**SM240** Hand Held CCD Spectromete
**SM440** Hand Held CCD Spectromete

# SM245

## Low Noise Compact CCD Spectrometer

- Low dark noise and stray light
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- High speed data acquisition
- Standard design allows up to 200-1050nm range
- USB 1.1/2.0 interface with 16bit
- Supports up to 8 USB multi-channel configuration
- ***NEW*** UV enhancing coating


## The Choice for high speed data acquisition Applications

Spectral Products is offering the new SM245 high speed 2048 pixel array CCD spectrometer. Thanks to the enhanced design on the electronic board of the SM245, the dark current noise level as well as the data acquisition speed have improved. Based on SP's special optical bench design, it supports many different applications where spectral or color measurements are required, including high speed data acquisition.

The SM245 can accept light directly through its built in slit or via optical fiber. The durable aluminum housing that encloses the SM245 provides stable optical bench operation over a wide range of temperatures. This array (in conjunction with our special UV coating process and customized order sorting filters) allows up to a 850nm measurement window from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity).

Standard interface to the SM642 is a USB 1.1/2.0 compatible interface with 16 bit. Our USB board can support multichannel configuration up to 8. With this multichannel configuration, a high resolution for wide range or a dual spectrometer system (one for measurement and the other for reference) is possible.

Spectral Products applies new UV enhancing coating on the CCD to increase the UV sensitivity below 450nm comparing with the conventional UV coating that is widely used in CCD spectrometers. By the help of this new UV coating, the signal sensitivity below 500nm can get improved ~20 50% more in general.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows based spectral acquisition and analysis software.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

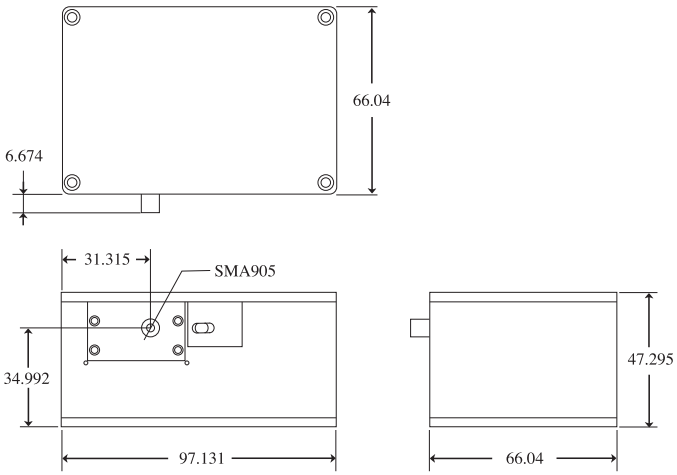
| Feature | Value |
|---|---|
| Detectors | Sony ILX511 CCD<br>▸Number of Pixels : 2048<br>▸Sensing Pixel Size : 14㎛ X 200㎛<br>▸Sensitivity : 180V/ (lx s) @660nm<br>▸Well depth : 62,500e |
| Spectrograph f# | 2.7 |
| Dark Noise RMS | <35 RMS counts in 16bit @35msec integration time |
| Signal to Noise Ratio | >250: 1 |
| Fiber Coupler | SMA905 or FC standard |
| Effective Spectral Range | 200 to 1050nm |
| Order Sorting Filter | Longpass filter or linear variable filter installed per wavelength coverage |
| Spectral Resolution | 0.3 ~ 10nm FWHM |
| Stray Light | <0.3% at 632nm (<0.1% Ave) |
| Computer interface | USB 1.1/2.0 compatible |
| Minimum integration time | 1msec |
| Trigger Mode | Free Run Mode<br>Software Trigger Mode<br>External trigger mode |
| Dimensions (inches) | 152mm X 83mm X 49mm (5.98 X 3.28 X 1.93) |
| Weight | 0.6kg |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg |

**Ordering Information :** Please indicate product number plus description when ordering
**SM245** Low Noise Compact CCD Spectrometer

# SM255

## Economical CCD Spectrometer

- New compact, Economical pre-configured model
- Can be handheld or securely mounted
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- Impact resistant housing
- High performance electronics


## The Choice for economic solution on Spectral Applications

The SM255 is a new compact CCD Spectrometer for users who are looking for an economical solution with a limited budget. Based on SP's special optical bench design, it supports many different applications where spectral or color measurements are required.

The SM255 can accept light directly through its built in slit or via optical fiber. The durable aluminum housing that encloses the SM255 provides stable optical bench operation over a wide range of temperatures.

The standard sensor arrays used are the Sony ILX 511 for SM255. The array driver electronics have been designed for highly sensitive yet stable operation. Spectral Products applies a standard UV coating on the CCD to use down to 200nm. This array in conjunction with the standard UV coating and customized order sorting filter allows the two most popular covering ranges, 200 900nm and 380 760nm.

Standard interface to the SM255 is a USB 1.1/2.0 compatible interface with 16 bit extended dynamic range. The USB board used in the SM255 does not support multichannel configuration but just single channel mode. However, most applications that just need a single spectrometer will be fine with this model.

Software support includes SDK examples and DLL for dedicated applications development and our SM32Pro Windows based spectral acquisition and analysis software.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

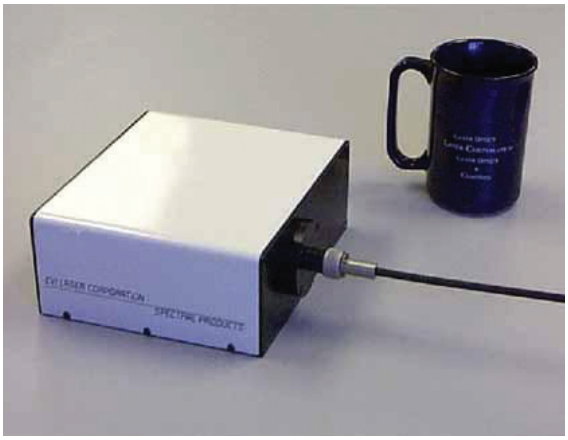
| Feature | Value |
|---|---|
| Detectors | Sony ILX511<br>▸ Number of Pixels : 2048<br>▸ Sensing Pixel Size : 14μm x 200μm<br>▸ Sensitivity : 200V/(lx s) under 3200K uniform illumination |
| Spectrograph f# | 2.7 |
| Dark Noise RMS | <50 RMS counts in 16bit @35msec integration time |
| Signal to Noise Ratio | 250:1 |
| Fiber Coupler | SMA905 or FC standard |
| Effective Spectral Range | ▸380 760nm (SM255 VIS)<br>▸200 900nm (SM255 UVR) |
| Order Sorting Filter | Long pass filter or linear variable filter installed |
| Spectral Resolution | ~0.5nm for SM255 VIS, ~1.2nm for SM255 UVR |
| Stray Light | <0.05% @ 632nm (<0.1% overall) |
| Computer interface | USB 1.1/2.0 16 bit 500KHz |
| Minimum integration time | 1msec |
| Trigger Mode | Free Run Mode<br>External Trigger Mode |
| Dimensions (inches) | 97mm X 66mm X 47mm (3.82 X 2.6 X 1.86) |
| Weight | 0.4kg |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development |

**Ordering Information :** Please indicate product number plus description when ordering.
**SM255** Economical CCD Spectrometer

# SM520 / SM540

## High Resolution CCD Spectrometer

- Optical input direct to slit or via fiber
- Allows higher resolution spectral measurements in up to a 700nm measurement window between 200nm and 1050nm - double the resolution of the SM200 and SM240
- USB 2.0 interface with 16-bit dynamic range available
- Support up to 8 USB multi-channel configuration
- ***NEW*** UV enhancing coating





## The Choice for High resolution Spectral Applications

The SM540 is a CCD based spectrometer that offers more than double the resolution of the SM440. This resolution is achieved using oversized (30mm x 30mm) optical bench components. These components offer approximately four times the effective collimation, grating and focusing area than what is used in the SM400 and SM440. As with all spectrometers, effective resolution increases as window size decreases. A 100 nm window will have approximately 0.05nm resolution (as opposed to 0.15nm for the SM400 and SM440). The larger optical bench of the SM540 makes it possible to have a narrow window size in NIR and get a higher resolution, which is basically impossible in the smaller optical benches like the SM400/SM440 due to the limitation of the grating diffraction angle.

Standard interfaces include a USB 2.0 interface and a PCI card interface with 16 bit extended dynamic range. Our USB board can support multichannel configuration up to 8. With this multichannel configuration, a high resolution for wide range or a dual spectrometer system (one for measurement and the other for reference) is possible.

Spectral Products applies new UV enhancing coating on the CCD to increase the UV sensitivity below 450nm comparing with the conventional UV coating that is widely used in CCD spectrometers. By the help of this new UV coating, the signal sensitivity below 500nm can get improved ~20 50% more in general.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced acquisition programming and external triggering.

## Software

- SM32Pro - Windows® 98, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance and absorbance measurements
- Data export, zoom in and out, spectrum overlays and many more features
- Color analysis tools included
- Signal average and integration time control
- SDK and DLLs abailable for easy custom software development

## Specifications :

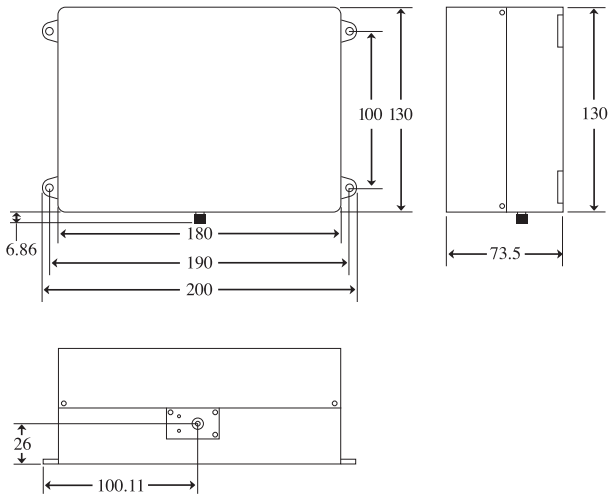
| Feature | Value | |
|---|---|---|
| | SM520 | SM540 |
| Detectors | Sony ILX511<br>▸ Number of Pixels : 2048<br>▸ Sensing Pixel Size : 14μm x 200μm<br>▸ Sensitivity : 200V/(lx s) under 3200K uniform illumination | Toshiba TCD1304<br>▸ Number of Pixels: 3648<br>▸ Sensing Pixel Size : 8μm x 200μm<br>▸ Sensitivity : 160 V/(lx s) under daylight fluoresecent illumination |
| Spectrograph f# | 3.9 | |
| Dark Noise RMS | <50 RMS counts in 16bit @35msec integration time | |
| Signal to Noise Ratio | 250:1 | |
| Fiber Couple | SMA905 or FC standard | |
| Effective Spectral Range | 200 to 1050nm | |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage | |
| Spectral Resolution | 0.15 ~ 10nm FWHM | |
| Stray Light | <0.05% @ 632nm (<0.1% overall) | |
| Computer interface | ▸USB 1.1/2.0 compatible<br>▸PCI bus NI PCI 16 bit 500KHz | |
| Minimum integration time | 1msec | |
| Trigger Mode | Free Run Mode<br>External Trigger Mode | |
| Dimensions (inches) | 177.8mm X 171.45mm X 76.2mm (7.0 X 6.75 X 3.0) | |
| Weight | 1.8kg | |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development | |

**Ordering Information :** Please indicate product number plus description when ordering.
**SM540** High Resolution CCD Spectrometer

# SM642

## Low Noise Non TE-Cooled Backthinned Spectrometer

- Scientific-grade high performance with low cost
- Low dark noise and stray light
- Good dynamic range and high signal to noise ratio
- High Ultra-violet Quantum efficiency
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- High speed data acquisition
- Standard design allows up to 200-1050nm range


## The Choice for Low Signal Level Applications

Spectral Products is offering the new SM642 non TE cooled back-thinned 2048 pixel array CCD spectrometer. The SM642 provides high quantum efficiency in UV and high dynamic range. The detector used in the SM642 has 2048 pixels and helps to get better resolution. It is ideal for UV/VIS/NIR spectrometry that requires high signal to noise ratio and/or high dynamic range. The back-thinned CCD has excellent sensitivity in UV and allows deep UV application, even below 200nm. Well designed housing allows a wide measurement window like from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity) with low stray light. Standard interface to the SM642 is a USB 1.1/2.0 compatible interface with 16-bit.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows-based spectral acquisition and analysis software.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

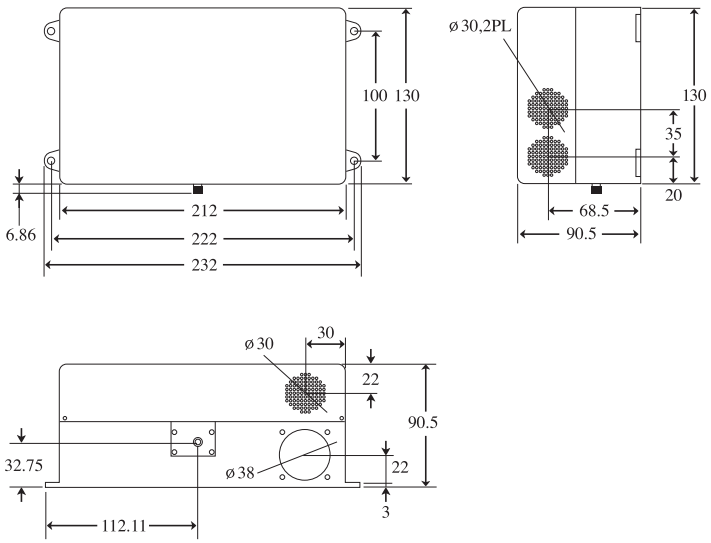
| Feature | Value |
|---|---|
| Detectors | Hamamatsu S10420 1106 10 non TE Cooled backthinned CCD<br>▸umber of Pixels: 2048 X 64<br>▸Sensing Pixel Size : 14μm X 14μm<br>▸Pixel well depth :200Ke<br>▸Quantum efficiency : >90% @650nm, 65% @250nm |
| Spectrograph f# | 3.3 |
| Dark Noise RMS | <7 RMS counts in 16bit @35msec integration time |
| Signal to Noise Ratio | 450 : 1 |
| Fiber Coupler | SMA905 or FC standard |
| Effective Spectral Range | 200 to 1050nm |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage |
| Spectral Resolution | 0.25 ~ 7nm FWHM |
| Stray Light | <0.01% at 632nm (<0.5% Ave) |
| Computer interface | USB 1.1/2.0 compatible |
| Minimum integration time | 7msec |
| Trigger Mode | Free Run Mode<br>Software Trigger Mode<br>External trigger mode(9 pin connector) : TTL Edge trigger input/digital output for monitoring |
| Dimensions (inches) | 200mm X 130mm X 73.5mm (7.87 X 5.12 X 2.83) |
| Weight | 1.5kg |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg |

**Ordering Information :** Please indicate product number plus description when ordering
**SM642** Low Noise Non TE Cooled Backthinned Spectrometer

# SM303

## High Performance TE-Cooled Backthinned Spectrometer

- Scientific-grade high performance
- Extremely low dark noise and stray light
- Wide dynamic range and high signal to noise ratio
- High Ultra-violet Quantum efficiency
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- High speed data acquisition
- Standard design allows up to 200-1050nm range


## The Choice for Low Signal Level Applications

Spectral Products is offering the new SM303 TE cooled back-thinned 1024 pixel array CCD spectrometer. The SM303 is ideal for UV/VIS/NIR spectrometry that requires very high signal to noise ratio and/or high dynamic range, like fluorescence, Rama, LED property testing applications. The back-thinned CCD has excellent sensitivity in UV and allows deep UV application. Well designed housing allows up to a 850nm measurement window from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity) with very low stray light. The TE cooled detecor also help to measure very low light signals by reducing the noise level in long integration times. Thanks to the hidynamic range and the low noise, the SM303 is also ideal for radiometric measurement applications. Standard interface to the SM303-Si is a USB 1.1/2.0 compatible interface with 16-bit.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows-based spectral acquisition and analysis software.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

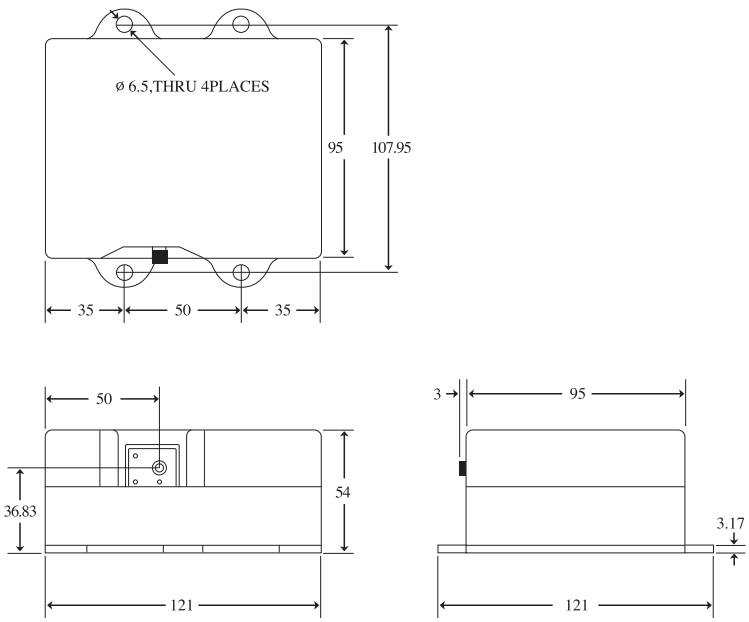
| Feature | Value |
|---|---|
| Detectors | Hamamatsu S7031 1006S TE Cooled backthinned CCD<br>▸umber of Pixels: 1024 X 58<br>▸Sensing Pixel Size : 24μm X 24μm<br>▸Pixel well depth :300Ke (Vertical) 600 Ke (Horizontal)<br>▸Quantum efficiency : >90% @650nm, 65% @250nm<br>▸Sensitivity : ~0.065 counts/e<br>▸Cooling : One stage TE Cooled ( 10℃) |
| Spectrograph f# | 3.3 |
| Dark Noise RMS | <2 RMS counts in 16bit @35msec integration time |
| Signal to Noise Ratio | 1000 : 1 |
| Fiber Coupler | SMA905 or FC standard |
| Effective Spectral Range | 200 to 1050nm |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage |
| Spectral Resolution | 0.3 ~ 7nm FWHM |
| Stray Light | <0.01% at 632nm (<0.05% Ave) |
| Computer interface | USB 1.1/2.0 compatible |
| Minimum integration time | 7msec |
| Trigger Mode | Free Run Mode<br>Software Trigger Mode<br>External trigger mode(9 pin connector) : TTL Edge trigger input/digital output for monitoring |
| Dimensions (inches) | 232mm X 130mm X 90.5mm (9.13 X 5.11 X 3.56) |
| Weight | 2.7kg |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg |

**Ordering Information :** Please indicate product number plus description when ordering
**SM303** High Performance TE Cooled Backthinned Spectrometer

# SM241

## NIR Laser CCD Spectrometer

- Less expensive alternative to Germanium or InGaAs systems
- Compact system, can be handheld or securely mounted
- Flexible optical input direct to slit or via fiber
- High performance electronics
- Allows spectral measurements between 900nm and 1700nm
- USB 2.0 interface with 16-bit dynamic range available!
- Support up to 8 multi-channel configuration


## The Choice for Spectral NIR Laser Applications

The SM241 is a compact CCD based Spectrometer designed for NIR laser applications. Spectral Products' IR up-conversion phosphor CCD coating breaks the standard Silicon-based CCD detectors array sensitivity barrier of 1100nm to allow spectral measurements up to 1700nm. This technology makes the SM241 a lower cost alternative to Germanium or InGaAs systems. The SM241 optical bench includes oversized gold plated mirrors and gratings to accommodate NIR light collection and analysis. Maximum spectral coverage with this spectrometer is 900 nm to 1700 nm (reduced coverage window size within 900-1700nm will increase spectral resolution and light sensitivity). But although the SM241 can measure up to 1700nm, due to its low sensitivity, it is limited only to use in the applications measuring very narrow band-width and strong lights like lasers in this NIR range. Standard interfaces include a USB 2.0 interface and a PCI card interface with a 16-bit extended dynamic range.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro windows based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced acquisition programming and external triggering.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

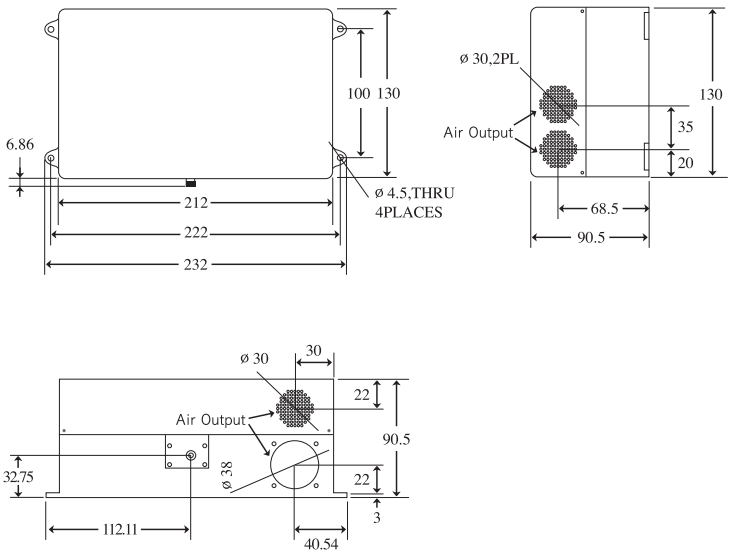
| Feature | Value |
|---|---|
| Detectors | Sony ILX511<br>▸Number of Pixels : 2048<br>▸Sensing Pixel Size :14$\mu$m X 200$\mu$m<br>▸Sensitivity : 30 V/mJ/cm$^2$ |
| Spectrograph f# | 3.5 |
| Dark Noise RMS | <50 RMS counts in 16bit @ 35msec integration time |
| Signal to Noise Ratio | 250:1 |
| Fiber Coupler | SMA905 or FC standard |
| Effective Spectral Range | 900 to 1700nm |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage |
| Spectral Resolution | 5nm with standard slit configuration |
| Stray Light | better than $10^{3}$ |
| Computer interface | ▸USB 1.1/2.0 compatible<br>▸PCI bus NI PCI 16bit 250KHz |
| Minimum integration time | 1msec |
| Trigger Mode | Free Run Mode<br>External Trigger Mode |
| Dimensions (inches) | 121mm X 121mm X 54mm (4.75 X 4.75 X 2.11) |
| Weight | 0.7kg |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg |

**Ordering Information :** Please indicate product number plus description when ordering
**SM241** NIR Laser CCD Spectrometer

# SM304

## Near-Infrared InGaAs Spectrometer

- Scientific-grade high performance
- Extremely low dark noise and stray light
- Wide dynamic range and high signal to noise ratio
- High stability
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- High speed data acquisition
- Various NIR range from 900nm to 2500nm


## The Choice for Low Signal Level NIR Applications

Spectral Products is offering the new SM304 TE cooled InGaAs array spectrometers. The SM304 series are ideal for NIR spectrometry that requires very high signal to noise ratio and/or high dynamic rang. The high performance with low-noise level of the SM304 series makes it possible to apply in very demanding applications. The good sensitivity of the detectors used in the SM304 series allows various broad-band applications like, measuring optical properties of various samples in NIR range, analyzing chemicals/moisture detection, as well as a narrow band applications like NIR laser characterization. Standard interface to the SM304 series is a USB 1.1/2.0 compatible interface with 16-bit.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows-based spectral acquisition and analysis software.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

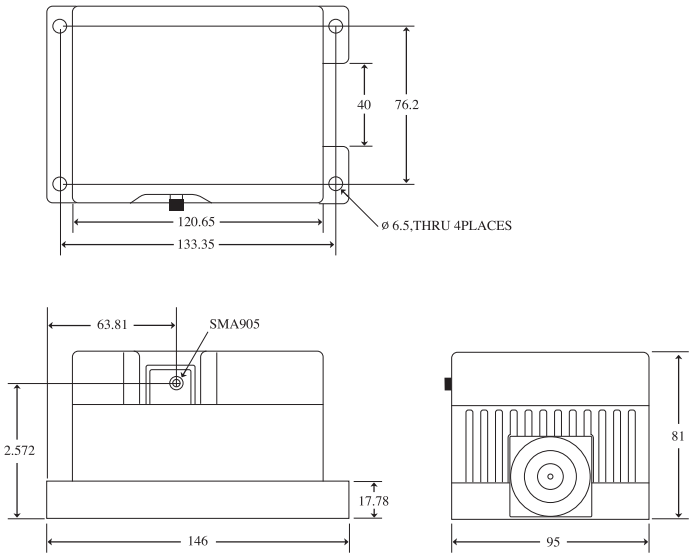
| Feature | Value | | | | |
|---|---|---|---|---|---|
| Model | SM304 512 | SM304 512 2.2 | SM304 512 2.5 | SM304 256 2.1 | SM304 256 2.5 |
| Detectors | G9204 512 | G9206 512 | G9208 512 | G9206 256 | G9208 256 |
| Pixel Size | 25 X 500μm | 25 X 250μm | | 50 X 500μm | |
| Spectrograph f# | 3.3 | | | | |
| Dark Noise RMS | <10 RMS counts in 16bit @35msec integration time | | | | |
| Signal to Noise Ratio | >15,000:1 @100msec | >10,000:1 @100msec | | | >7,500:1 @10msec |
| Fiber Coupler | SMA905 or FC standard | | | | |
| Effective Spectral Range | 0.9 1.7μm | 0.9 2.2μm | 0.9 2.5μm | 0.9 2.05μm | 0.9 2.5μm |
| Order Sorting Filter | Longpass filter or linear variable filter installed per wavelength coverage | | | | |
| Spectral Resolution | >3nm overall | >5nm overall | >6.5nm overall | >7nm overall | >9nm overall |
| Stray Light | <0.01% at 632nm (<0.05% Ave) | | | | |
| Computer interface | USB 1.1/2.0 compatible | | | | |
| Minimum integration time | 1msec | | | | |
| Trigger Mode | Free Run Mode<br>Software Trigger Mode<br>External trigger mode (9 pin connector) : TTL Edge trigger input/digital output for monitoring | | | | |
| Dimensions (inches) | 232mm X 130mm X 90.5mm (9.13 X 5.11 X 3.56) | | | | |
| Weight | 2.7kg | | | | |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg | | | | |

**Ordering Information :** Please indicate product number plus description when ordering
**SM304-512** Near Infrared InGaAs Spectrometer
**SM304-512-2.2** Near Infrared InGaAs Spectrometer
**SM304-512-2.5** Near Infrared InGaAs Spectrometer
**SM304-256-2.1** Near Infrared InGaAs Spectrometer
**SM304-256-2.5** Near Infrared InGaAs Spectrometer

# SM301/SM301-EX

## PbS/ PbSe NIR Spectrometer

- Low Noise
- Cooled, Stable Operation
- 256 Detection Elements
- Accommodates spectral measurements in the 1.0 to 3.0 micron (PbS) or 1.5 to 5.0 micron (PbSe) region
- Optical input direct to slit or via fiber


## The Choice for NIR Spectral Applications

The SM301/SM301-EX is a versatile, high performance PbS/PbSe array spectrometer. Its active components include a TE cooler and a 256-element PbS/PbSe detector element array. Operation of the unit for research applications is easy with the included SM32Pro - Windows based analysis software. The system is ideal for spectroscopic applications in the 1.0 to 3.0 micron (PbS) or 1.5 to 5.0 micron (PbSe) region. The SM301/SM301-EX includes thermoelectric cooling to guarantee long-term operational stability. The SM301/SM301-EX employs a multiplexed PbS/PbSe array as its NIR detection element. The array is cooled and temperature stabilized at around -4oC which ensures long-term operation stability. Dark signal can thus be automatically measured by the built-in electronics periodically and subtracted automatically. Compared with conventional scanning NIR spectrometers the SM301/SM301-EX provides the multi-channel detection advantage, both in reducing the measurement time and enhancing measurement signal-to-noise ratio. The SM301/SM301-EX can operate at a readout rate of 2MHz or faster allowing fast measurement and averaging operation to be performed in a short period of time.

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

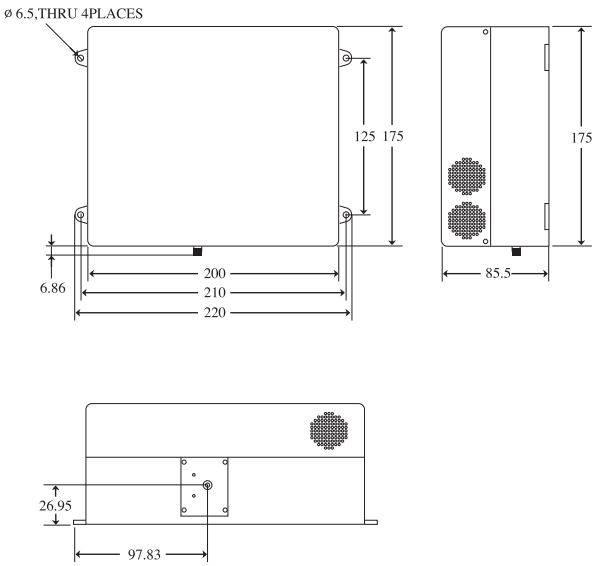
| Feature | Value | |
|---|---|---|
| | SM301 | SM301-EX |
| Detectors | PbS<br>▸Number of Pixels: 256<br>▸Sensing Pixel Size: 45μm x 450μm<br>▸Peak Detectivity (D*): $1x10^{11}cmHz^{0.5}W^{-1}$<br>▸Pixel Clock: 2MHz max. for 4MHz data output<br>▸Linearity: >90%<br>▸Response uniformity (peak to peak): ±10% of array single mean | PbSe<br>▸Number of Pixels : 256<br>▸Sensing Pixel Size : 45μm x 450μm<br>▸Peak Detectivity (D*) : $1x10^{10}cmHz^{0.5}W^{-1}$<br>▸Pixel Clock: 2MHz max. for 4MHz data output<br>▸Linearity: >90%<br>▸Response uniformity (peak to peak) : ±10% of array single mean |
| Spectrograph f# | 3.5 | |
| Dark Noise RMS | ~20 RMS counts in 16bit (After Balancing) | |
| Fiber Coupler | SMA905 or FC standard | |
| Effective Spectral Range | 1.0 to 3.0μm / 1.0 ~ 2.0um | 1.5 to 5.0μm |
| Spectral Resolution | ~20nm (1.0~3.0um) / 10nm (1.0~2.0um) | ~20nm (1.5~5.0um) |
| Stray Light | Better than 0.1% | |
| Computer interface | USB 1.1/2.0 compatible | |
| Minimum integration time | 0.01 to 200msec (on board) | |
| TE Cooling temperature | 4℃ ARO | |
| Dimensions (inches) | 146mm X 95mm X 81mm (5.75 X 3.75 X 3.17) | |
| Weight | 1.5kg | |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg | |

**Ordering Information :** Please indicate product number plus description when ordering
**SM301** PbS NIR Spectrometer
**SM301-EX** PbSe NIR Spectrometer

# SM642-HRS

## High Resolution Low Noise Spectrometer

- **High resolution optical bench**
- Scientific-grade high performance with low cost
- Low dark noise and stray light
- Good dynamic range and high signal to noise ratio
- High Ultra-violet Quantum efficiency
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- High speed data acquisition
- Standard design allows up to 200-1050nm range


## The Choice for Low Signal Level Applications

Spectral Products is offering the new SM642 non TE cooled back-thinned 2048?pixel array CCD spectrometer. The SM642 provides high quantum efficiency in UV and high dynamic range. The detector used in the SM642-HRS has 2048 pixels and helps to get better resolution. It is ideal for UV/VIS/NIR spectrometry that requires high signal to noise ratio and/or high dynamic range. The back-thinned CCD has excellent sensitivity in UV and allows deep UV application, even below 200nm. Well designed housing allows up to 75nm measurement window within 200~1050nm for 0.2nm optical resolution with very low stray light. The backthinned detector to measure very low light signal by reducing the noise level in long integration time

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

## Specifications :

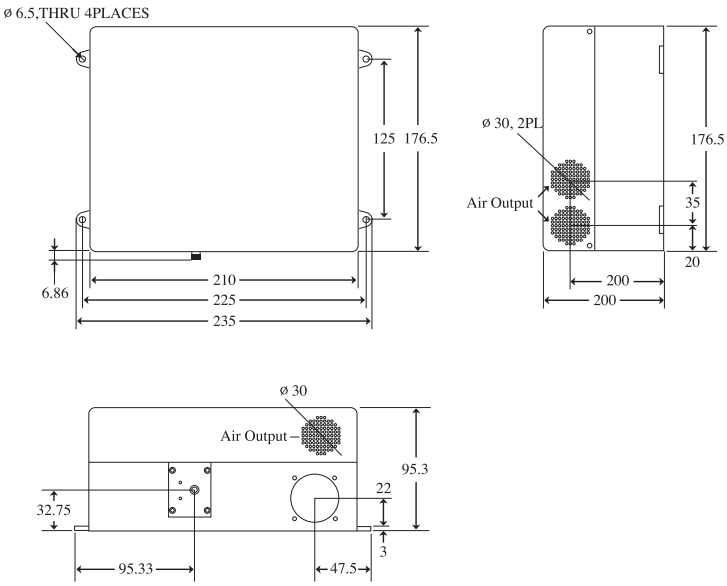
| Feature | Value |
|---|---|
| Detectors | Hamamatsu S10420 1106 10 non TE Cooled backthinned CCD<br>▸Number of Pixels : 2048 X 64<br>▸Sensing Pixel Size :14㎛m X 14㎛m<br>▸Pixel well depth: 200Ke<br>▸Quantum efficiency: >90% @650nm, 65% @250nm |
| Spectrograph f# | 3.3 |
| Dark Noise RMS | <7 RMS counts in 16bit @35msec integration time |
| Signal to Noise Ratio | 450 : 1 |
| Fiber Coupler | SMA905 or FC standard |
| Effective Spectral Range | 75nm measurement window within 200~1050nm |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage |
| Spectral Resolution | 0.1 to 7nm depending on the slit and grating choices |
| Stray Light | <0.01% at 632nm (<0.05% Ave) |
| Computer interface | USB 1.1/2.0 compatible |
| Minimum integration time | 7msec |
| Trigger Mode | Free Run Mode<br>Software Trigger Mode<br>External trigger mode(9 pin connector) : TTL Edge trigger input/digital output for monitoring |
| Dimensions(inches) | 220mm X 175mm X 85.5mm (8.66 X 6.88 X 3.37) |
| Weight | 3.0kg |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg |

**Ordering Information :** Please indicate product number plus description when ordering
**SM642-HRS** High Resolution Low Noise Spectrometer

# SM303-HRS

## High Resolution Low Noise Spectrometer

- **High resolution optical bench**
- Scientific-grade high performance
- Extremely low dark noise and stray light
- Wide dynamic range and high signal to noise ratio
- High Ultra-violet Quantum efficiency
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- High speed data acquisition
- Standard design allows up to 200-1050nm range


## The Choice for Low Signal Level Applications

Spectral Products is offering the new SM303 TE cooled back-thinned 1024 pixel array CCD spectrometer. The SM303 is ideal for UV/VIS/NIR spectrometry that requires very high signal to noise ratio and/or high dynamic range, like fluorescence, Raman, LED property testing applications. The back-thinned CCD has excellent sensitivity in UV and allows deep UV application. Well designed housing allows up to 75nm measurement window within 200~1050nm for 0.2nm optical resolution with very low stray light. The TE cooled detector also help to measure very low light signal by reducing the noise level in long integration time

## Software

- SM32Pro - Windows® 95, 2000, XP, 7 based software (supporting 32bit & 64bit) for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

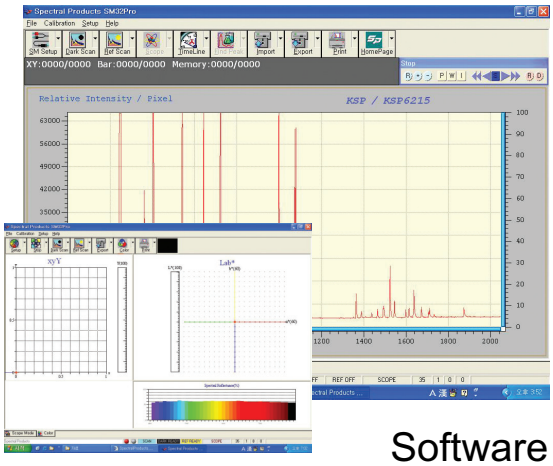
## Specifications :

| Feature | Value |
|---|---|
| Detectors | Hamamatsu S7031 1006S back thinned CCD<br>▸Number of Pixels : 1024 X 58<br>▸Sensing Pixel Size :24㎛m X 24㎛m<br>▸Pixel well depth: 300Ke (Vertical) 600 Ke (Horizontal)<br>▸Quantum efficiency: >90% @650nm, 65% @250nm<br>▸Sensitivity: ~0.065 counts/e<br>▸Cooling: One stage TE Cooled ( 10℃) |
| Spectrograph f# | 3.3 |
| Dark Noise RMS | <2 RMS counts in 16bit @35msec integration timeSignal to Noise Ratio |
| Signal to Noise Ratio | 1000 : 1 |
| Fiber Coupler | SMA905 or FC standard |
| Effective Spectral Range | 75nm measurement window within 200~1050nm |
| Order Sorting Filter | Long pass filter or linear variable filter installed per wavelength coverage |
| Spectral Resolution | 0.2 to 7nm depending on the slit and grating choices |
| Stray Light | <0.01% at 632nm (<0.05% Ave) |
| Computer interface | USB 1.1/2.0 compatible |
| Minimum integration time | 7msec |
| Trigger Mode | Free Run Mode<br>Software Trigger Mode<br>External trigger mode(9 pin connector) : TTL Edge trigger input/digital output for monitoring |
| Dimensions (inches) | 235mm X 176.5mm X 95.3mm (9.25 X 6.95 X 3.75) |
| Weight | 3.7kg |
| Software | SM32Pro (free with spectrometer)<br>Includes DLL libraries and SDKs for easy custom application development 0.5kg |

**Ordering Information :** Please indicate product number plus description when ordering
**SM303-HRS** High Resolution Spectrometer

# SM32Pro Software

- Displays percent of reflectance.
- Calculates XYZ, Yxy, L*a*b*, L*C*h°, △L*a*b*, △L*C*h*, △ELab and △ ECMC
- Illuminant conditions A and D65.
- CIE 2° and 10° standard observers.
- View up to 6 reflectance traces on a single graph, with multiple graphs tiled on a single screen.
- Prints in color or black & white.
- Offers easy custom wavelength calibration function.
- Control signal averages and integration time
- Save color files, export color files, and print color matching files.
- Exports graph or data to other Windows™, software and to most DOS software.
- Has rubber-band zoom and auto-peak find.
- Features intuitive menu system and tool bars.
- Includes comprehensive documentation
- 32-bit Windows? SDK software and LabView developer libraries are available.




Software

## SM32Pro

General-purpose data acquisition and processing software for SM200, SM240, SM241, SM520, and SM301 units. SM32Pro allows Reflectance,Transmission and Absorbance measurements. Additionally CIE color values such as X Y Z, and Lab, may be obtained-using A and D 65 illuminant conditions with the software package. Data may be saved as a graph, or exported to ASCII text files for import to spreadsheet applications for further analysis. Graphing functions include zooming, basic text annotation, and plot overlays on a single graph. Color values may be compared to a user selectable standard in order to obtain Delta values. Spectrometer calibration can be handled easily through use of the software combined with a traceable light source.

## SM32Pro SDK, 32/64 Bit

Available for customers who wish to use SM hardware with custom designed software. The SDKs are available in 32-bit formats, and include our dynamic linked libraries in addition to several various code samples (VC++, VB and LabView) on how to use the functions the DLLs contain. A manual that details the functions available is also included.

# Spectrometer Options/Accessories

Spectral Products provides a wide selection of various options/accessories for SP's spectrometers. Some useful accessories for various applications are available on "Sampling Accessories" section in catagories.

## 1. A/D Cards, USB2.0 Converters and Cables

### NI PCI-6023E/NI DAQCard-6024E (PCMCIA)

16 analog inputs at 200 kS/s, 12-bit resolution
Up to 2 analog outputs, 12-bit resolution
8 digital I/O lines (5 V/TTL/CMOS); two 24-bit counter/timers
Digital triggering
4 analog input signal ranges
NI-DAQ driver simplifies configuration and measurements

### USB2.0 PCI/PCMCIA Cards

Hi-Speed USB 2.0 Adapter support for Mac OS X v10.1, Windows 98SE/Me/2000/XP.
Up to 480 Mbps of data transfer rate; 40 time faster than USB 1.1 (11Mbps) device.
Fully backward compatible with older 12 Mbps USB devices.

### USB External Trigger Cable

BNC type connector

## 2. Inside Options

SM-QZWIN : Quartz (Fused Silica) CCD Window, The detector's standard window (BK7) is replaced with a quartz (fusted silica) window for UV (200nm ~ 350nm) applications.

SM-ARWIN : Anti-Reflection coated CCD Window, AR coating will reduce the reflectance and enhance the tranmittance efficiency of the CCD window in given wavelength range. To view the reflectance curve of each AR coating, Click Here.

DU : Deep UV range (200nm ~ 250nm)
UV : UV range(250nm ~ 400nm)
VS : Visible range, Shorter(320nm ~ 600nm)
VL : Visible range, Longer(400nm ~ 700nm)
IS : NIR range, Shorter(650nm ~ 1100nm)
IL : NIR range, Longer(1050nm ~ 1700nm)

SM-CCD-UV/SM-CCD-NIR : UV/NIR enhancing coating on CCD, SP's UV/IR up-conversion phosphor CCD coating breaks the standard Silicon-based CCD detectors array sensitivity barrier of 400~1100nm to allow spectral measurements down to 200nm (UV application) or up to 1700nm (NIR application, SM241).

### UV/NIR coated CCDs and cylidrical focusing lens

SM-AT-F1 : CCD Decter Array Focusing Lens, SP's cylindrical UV grade fused silia (quartz) lens increases light-collection efficiency.

SM-SLT : Entrance Slits, SP provides various widths and 1mm tall slits. The standard widths are 10um, 25um, 50um, 100um, 200um and 400um.

SM-OSF : Order Sorting Filter, SP's order sorting filter consists of various combinations of 250nm/300nm/440nm/590nm/780nm long pass filters. The broadband spectrum showed a strange dip or peak at the junction part of each filter before. But with the use of SP's unique technique, the induced dip or peak at the junction part was removed (except the junction part of the deep UV of below 250nm & UV/VIS range). Considering the lower sensitivity of the CCD (Sony ILX511) in UV and NIR range, SP also offers varius partially anti-reflection coated substrates.

SM-OSF2 : 2 position order sorting filter. Ex, 350nm ~ 800nm

SM-OSF2-UV : 2 position order sorting filter, UV quartz substrates. Ex, 300nm ~ 700nm

SM-OSF2-AUV : 2 position order sorting filter, UV AR coated quartz substrates. Ex, 250nm ~ 850nm

SM-OSF2-ADU : 2 position order sorting filter, Deep UV AR coated quartz substrates. Ex, 200nm ~ 600nm

SM-OSF2-AIR : 2 position order sorting filter, NIR AR coated quartz substrates. Ex, 450nm ~ 1000nm

SM-OSF3 : 3 position order sorting filter. Ex, 350nm ~ 1050nm

SM-OSF3-UV : 3 position order sorting filter, UV quartz substrates. Ex, 300nm ~ 1000nm

SM-OSF3-AUV : 3 position order sorting filter, UV AR coated quartz substrates. Ex, 250nm ~ 1050nm

SM-OSF3-ADU : 3 position order sorting filter, Deep UV AR coated quartz substrates. Ex, 200nm ~ 850nm

SM-OSF3-AIR : 3 position order sorting filter, NIR AR coated quartz substrates. Ex, 400nm ~ 1050nm

SM-OSF3-AUN : 3 position order sorting filter, UV & NIR partial AR coated quartz substrates. Ex, 200nm ~ 850nm, 250nm ~ 950nm

SM-OSF4-UV : 4 position order sorting filter, UV quartz substrates. Ex, 200nm ~ 950nm

SM-OSF4-ADU : 4 position order sorting filter, Deep UV AR coated quartz substrates. Ex, 200nm ~ 950nm

SM-OSF4-AUN : 4 position order sorting filter, UV & NIR partial AR coated quartz substrates. Ex, 200nm ~ 1050nm

SM-LPF : Long Pass Filters, SP's long pass filter is installed permanently in the SMA 905/FC connector (face plate) of SM series spectrometers. Various long pass filters are available from 280nm to 1000nm .

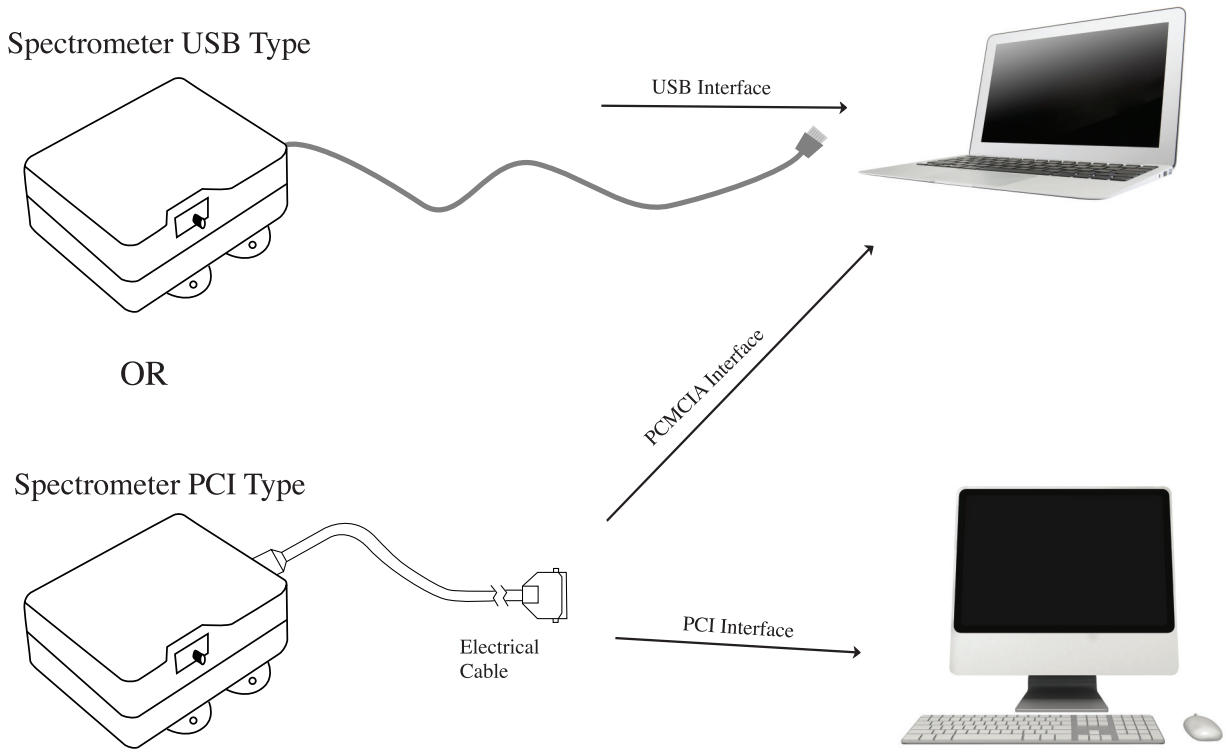
SM-EQF : CCD System Equalizer Filter, SP's equalizer filter flattens the general intensity distribution of CCD detector.

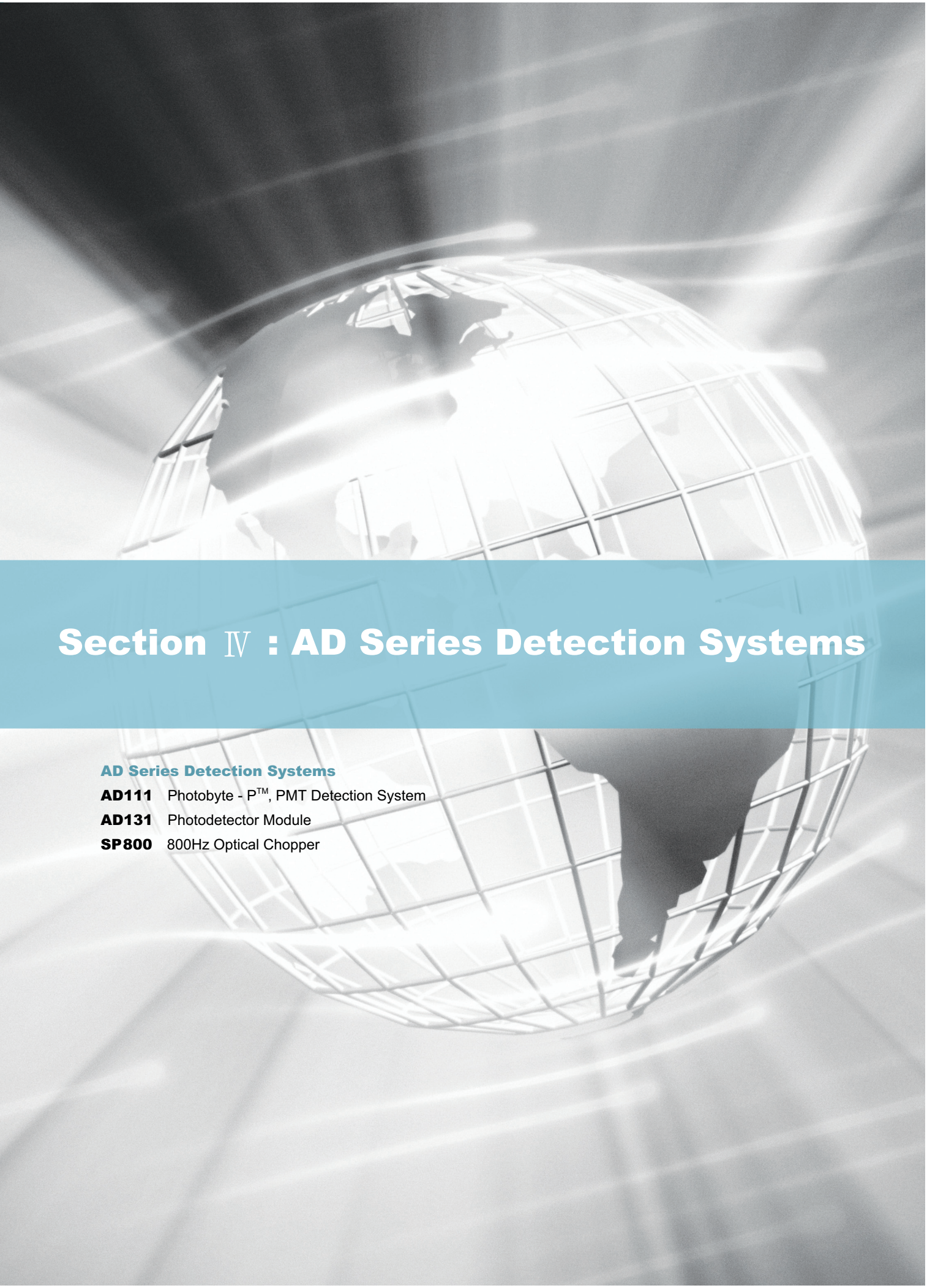
# Special Coating Options

SP's pioneering coating technologies also allow us to take another step further to reduce energy lost between optical surfaces. For customers' special applications, SP provides special coating options.

SM-PG600 : Special Gold Coating on mirror optics installed in spectrometer to enhance the reflectance (R>95%) in 600nm ~ range.
SM-PS400 : Special Silver Coating on mirror optics installed in spectrometer to enhance the reflectance (R>95%) in 380nm ~ range.
SM-BBDS3501100 : Special BBDS Coating on mirror optics installed in spectrometer to enhance the reflectance (R>98.5%) in 350nm ~ 1100nm.
Anti-Reflection Coating Options : SP provides various Anti-Reflection coating options. This coating helps to enhace the transmittance efficiency of focusing lens or CCD window. Typical reflectance of optics is ~4% per each interfacing surface but this AR coating will reduce the reflectance less than 0.5% (at normal incidence).
DU : Deep UV range (200nm ~ 250nm), UV : UV range(250nm ~ 400nm), VS : Visible range, Shorter(320nm ~ 600nm),
VL : Visible range, Longer(400nm ~ 700nm), IS : NIR range, Shorter(650nm ~ 1100nm), IL : NIR range, Longer(1050nm ~ 1700nm)

# Spectrometer Interface





# Section Ⅳ : AD Series Detection Systems

**AD Series Detection Systems**

**AD111** Photobyte - P™, PMT Detection System

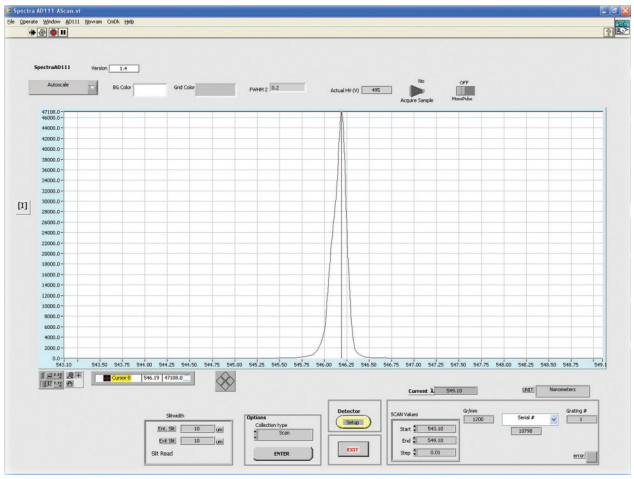
**AD131** Photodetector Module

**SP800** 800Hz Optical Chopper

# AD111

## Photobyte - P™ Photomultiplier Detection System

- Provides a complete detection system for SP's Digikrom monochromators.
- Easy USB2.0 interface.
- Wide selection of PMT's.

Data Acquisition ScreenShot



## Compact, Convenient, Affordable

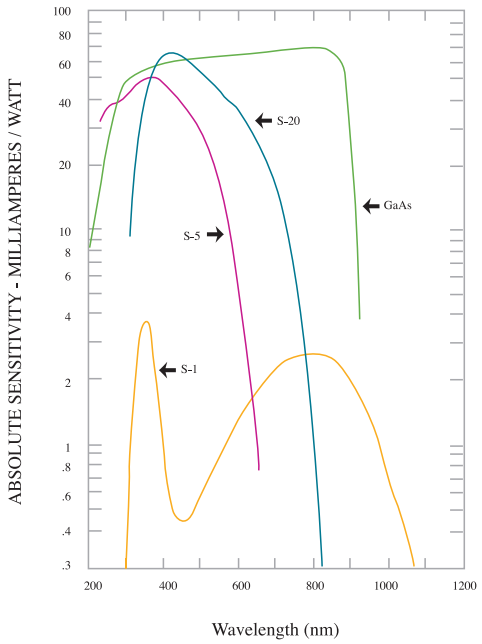
The AD111 is a convenient computer controlled photomultiplier detection system for use with Spectral Products Digikrom line of monochromators. It features a detector housing that has a dynode divider chain and direct anode connection, mounts directly to exit-slit ports of Digikrom monochromators, and accommodates side-on photomultiplier tubes. (PMT's must be ordered separately.) It also features the Photomultiplier Amplifier, a compact electronic unit containing the preamplifier and high voltage power supply for the PMT. Coaxial cables for the high voltage and PMT output current signals connect between the detector housing and the amplifier unit. The entire operation, including wavelength and bandpass selection, is controlled with a customer-supplied PC. (The Digikrom monochromator and the AD111 utilize one serial for monochromator and one USB port for AD111) An easy to use program is also included that allows full control of both PMT and monochromator. It graphically displays wavelength versus intensity, intensity versus time and allows ASCII data storage for importing to other user interfaces as desired.

## SP offers the following PMTs for use with the AD110

| AP Part# Code | PMT Type | Wavelength Range and Spectral Response |
|---|---|---|
| AD311 | * R928P | 185 900nm; S 20 (extended) |
| AD321 | R 212 | 185 650nm; S 5 |
| AD322 | R 406 | 400 1100nm; S 1 |
| AD323 | R 777 | 185 850nm; S 20 |
| AD324 | R 636 | 185 930nm; GaAs (extended) |

* selected for low noise

Other PMTs are available from SP by request




Typical Photocathode Spectral Response Characteristics

## Specifications :

| Feature | Value |
|---|---|
| **Wavelength Range** | Per PMT detector (see below) |
| **High Voltage Rang** | 0 1000 VDC |
| **A/D Resolution** | 16 bit (Successive Approximation) |
| **Response Rate** | USB2.0 |
| **High Voltage Resolution** | 244mV |
| **Input Voltage** | ± 5 VDC |
| **Data Resolution** | 76.3μV, (data range = 0 5V) |
| **Time Constant per step** | Selectable from 1μS to 10 sec |
| **Conversion time** | 2μS (Maximum) |
| **USB 2.0 Transfer Rate** | 480 Mbits/sec |
| **Amplification Gains** | x1 to x10 (programmable) |
| **Supply Voltage** | 100 240 VAC |
| **Current Input Range** | 0 to 5μA |

**Ordering Information :**

Please indicate product number plus description when ordering.

**AD111** Photobyte P™, Photomultiplier Detection System
**AD100** PMT Housing, for 1 1/8" side on PMTs from AD3xx series
**AD311** PMT Type R 928
**AD321** PMT Type R 212
**AD322** PMT Type R 406
**AD323** PMT Type R 777
**AD324** PMT Type R 636

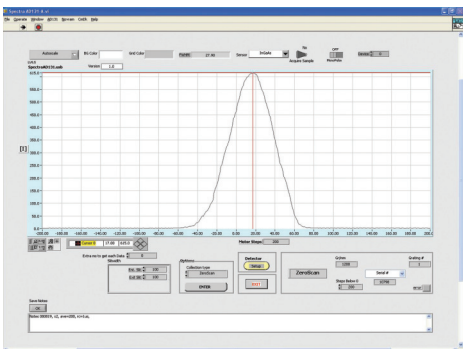
# AD131

## Photodetector Module 190nm to 4.8$\mu$m


- Combines SP photodiode detector, programmable charge integrator, and data conversion in a compact package.
- Expandible with add-on modules for cooled sensor capability.
- Null function for background noise subtraction.
- Programmable gain ranges.
- Windows® based data acquisition software included.
- Easy to install and use on any SP Monochromator
- Internal data averaging.

## Compact, Convenient, Affordable

The AD131 is a computer controlled data acquisition device for photodiode detectors, covering a wide wavelength range with Si, InGaAs, PbS, and PbSe photocells from the AD4x series. The unit contains an internal programmable charge integration amplifier, a 20-bit A/D converter, and a microprocessor with a RS232 interface. Signal processing functions take place internal to the AD131 to greatly reduce the noise level of the measured signal, including Correlated Double Sampling (CDS) and signal oversampling for digital filtering. Windows® based software allows for stand-alone operation or integrated control and data acquisition with any of the Digikrom line of monochromators. Adding the AD131-TC Thermoelectric Controller module to the AD131 enables the use of AD4x series heads with cooling capability (designated by a "−C" on the model name). AD4x heads are easily exchanged on the same AD131 unit.

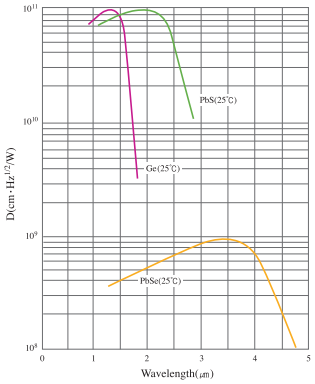


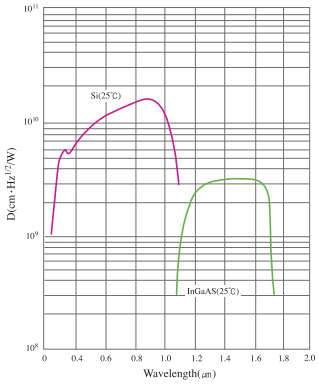
Data Acquisition ScreenShot

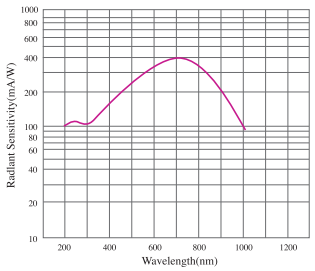
| SP Part # | Detecter Type | Size | Range | Temp | Sensitivity | Dark resistance or current |
|---|---|---|---|---|---|---|
| AD421 | Si | 5.8 x 5.8 | 190 1000 | 25℃ | 0.4 A/W at 720nm | 20 pA |
| AD427* | PbS | 3 x 3 | 1000 2900 | 25℃ | 5 x $10^4$ V/W at 2200nm | 0.5 to 2.5MΩ |
| AD429* | PbSe | 3 x 3 | 1500 4800 | 25℃ | 5 x $10^2$ at 4 $\mu$m | 0.3 to 1.5MΩ |
| AD430 | InGaAs | 3 dia | 800 1700 | 25℃ | 0.95 A/W at 1.55 $\mu$m | 15 nA |
| AD431 | Si/InGaAs | 2.4 x 2.4 | 300 1700 | 25℃ | 0.45 A/W at 0.94 $\mu$m | 30 pA |
| | | 1 dia | | 25℃ | 0.55 A/W at 1.55 $\mu$m | 1 nA |
| The following require the AD131 TC Thermoelectric Controller module in addition to the AD131 Photodetector module | | | | | | |
| AD427 C* | Cooled PbS | 4 x 5 | 1000 2900 | 10℃ | 8 x $10^4$ V/W at 2.2 $\mu$m | 0.5 to 10MΩ |
| AD429 C* | Cooled PbSe | 3 x 3 | 1500 4800 | 10℃ | 1 x $10^3$ at 4 $\mu$m | 1.7 to 7MΩ |
| AD430 C | Cooled InGaAS | 3 dia | 800 1700 | 10℃ | 0.95 A/W at 1.55 $\mu$m | 1 nA |
| AD431 C | Cooled Si/InGaAS | 2.4 x 2.4 | 300 1700 | 25℃ | 0.45(25℃) at 0.94 $\mu$m | 30 pA |
| | | 1 dia | | 10℃ | 0.55 at 1.55 $\mu$m | 0.07 nA |

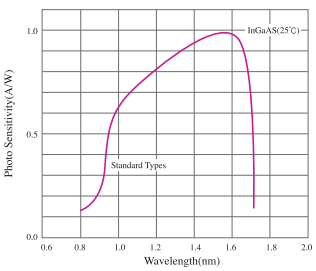
* Requires 450 Hz chopped optical signal

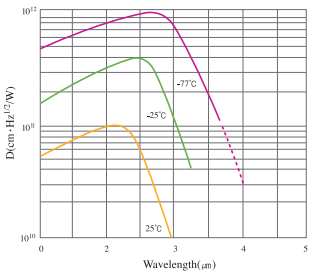
# Typical Spectral Response Characteristics

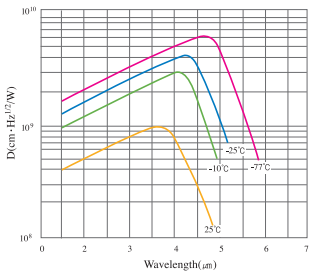



# Specifications :

| Feature | Value |
|---|---|
| **Wavelength Range :** | Depends on Sensor type |
| **A/D Resolution :** | 16 bit |
| **A/D Conversion Rate :** | 500kSPS |
| **Response Rate :** | USB 2.0 |
| **Time Constant :** | 10μS, 100μS, 1mS, 10mS (selectable) |
| **Low Pass Filter :** | 1/3Hz, 1Hz, 10Hz, 100Hz (selectable) |
| **Phase Shift :** | 0 180 degrees (selectable) |
| **Amplification Gain :** | x1 to x10 (selectable) |
| **Phase Lock Loop Voltage Input :** | 0 5V optical chopper reference signal |
| **Trigger Input Voltage :** | 0 5Vdc TTL |
| **Supply Voltage :** | 100 240 Vac |
| **USB2.0 Transfer Rate :** | 480 Mbits/S |
| **Software :** | Windows® control program for stand alone use or integrated with SP Mono chromators. |

**Ordering Information:** Please indicate product number plus description when ordering.

**AD131** Photodetector Module
**AD131-220V** Photodetector Module (220VAC input)
**AD131-TC** Thermoelectric Controller Module

(order detector heads separately)

**AD421** Detector Head Type - Si
**AD427** Detector Head Type - PbS
**AD429** Detector Head Type - PbSe
**AD430** Detector Head Type - InGaAs
**AD431** Detector Head Type - Si/InGaAs

The following detector heads are for use with the AD131-TC Thermoelectric Controller Module

**AD427-C** Detector Head Type - PbS, TE Cooled
**AD429-C** Detector Head Type - PbSe, TE Cooled
**AD430-C** Detector Head Type - InGaAs, TE Cooled
**AD431-C** Detector Head Type - Si/InGaAs, TECooled

# SP800

## 800Hz Optical Chopper

- Provides 800Hz chopped optical signal for use with PbS and PbSe Infrared Detectors.
- Mounts directly to all Spectral Products monochromators, detectors, light sources, filter wheels and filter carriers.
- High Reliability
- Light Spectrum Purity
- Low Profile
- Small Footprint when integrated with light source or detector
- Low Power
- High Shock Resistance
- High Temperature Resistance




The Spectral Products' 800 Hz optical chopper provides many unique advantages over a motorized chopper wheel or reciprocating blade. In an industrial product, the compact size, frequency stability and reliability permit many tough applications to become possible. The aperture motion or chopper window is produced by a high-Q resonating tuning fork that is highly resistant to vibration and shock. There is basically no moving part to jam or to wear down.

SP' choppers will quickly reach stability after "power-on" in less than 2 seconds. Power consumption is typically around 20mW. Due to the compact size and special alloys, Spectral Products choppers can be mounted in close proximity to many hot filament sources.

# Section Ⅴ : AS Series Light Sources

**Broadband Light Source**

**ASB-W-005** Tungsten-Halogen (TH) / **ASB-W-020** Tungsten-Halogen (TH)
**ASB-W-030** Tungsten-Halogen (TH) / **ASBN-W** Tungsten-Halogen (TH)
**ASBN-D130/230** Deuterium(D2) / **ASB-XE 175** Xenon (Xe)
**ASB-IR-12K/18K** IR Emitter (CFIR)

**Hybrid Light Source**

**ASBN-DW-MINI** Miniature Deuterium & Tungsten-Halogen
**ASB-D1-W** Single Deuterium & Tungsten-Halogen / **ASB-D2-W** Dual Deuterium & Tungsten-Halogen

**Calibration Light Source**

**ASC-DC** Portable Wavelength Calibration Source / **ASC Series** Spectral Calibration Lamps & Assemblies

**Uniform & Diffused Light Source**

**AT-IS-1.5** Integrating Sphere with Tungsten-Halogen

**Wavelength Tunable Light Source**

**AST-W** Tungsten-Halogen Based / **AST-D** Deuterium Based
**AST-XE** 175W Xenon Based / **ASTN-D1/D2** Deuterium & Tungsten-Halogen Hybrid Based

# ASB-W-005

## High Stability Visible Lamp Assembly

- Provides optimal illumination to fiber optics for remote applications
- Offers excellent color temperature stability
- Use with SP's SM Series spectrometers
- Contains internal current regulation

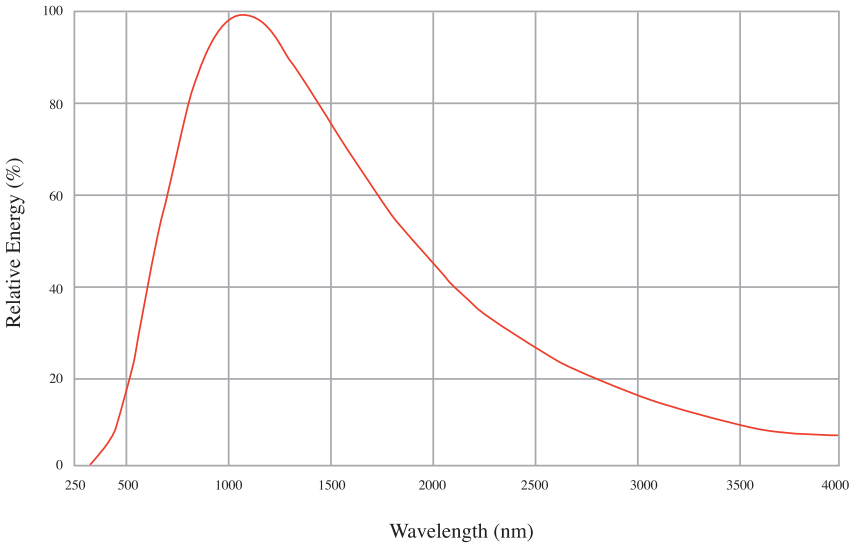


## Optimum Illumination for SP's SM Series Spectrometers

This lamp is a near Black Body source of light in the visible to near IR spectral region. It has been designed to produce the maximum illumination from a Black Body source into a fiber bundle.

The lamp assembly comes in a 5 watt (ASB-W-005) tungsten/halogen lamp configuration, an aluminum housing, and a wall transformer as a power supply. The power input is regulated inside the lamp housing to assure a ±0.4% stability over the current range. Current regulation ensures color temperature stability.

The tungsten/halogen lamp used inside the lamp has a nominal color temperature of 2800°K and an average life of 10,000 hours at this color temperature.




Spectral Distrbution of Light Emmitted by Blackbody at 2800° K.

## Specifications :

Lamp : Tungsten-halogen
Power : Wall transformer, 115 VAC, 50/60 Hz to 12 VDC at 0.8 amps 220 VAC version available
Current Regulation : ±0.4%
Mean Spherical Candlepower : 3.3
Color Temperature : 2800°K
Bulb Life : 10,000 hrs. average
Housing : Aluminum, convection cooled, 1/4"-20T in base for post mounting.
Connector : SMA Fiber connector Type 905
Size : Longth 3.8 inches (9.8cm)
Highth 2.3 inches (5.9cm)
Wideth 2.1 inches (5.7cm)
Weight : 11 ozs. (0.3 kgs.)
Options : Specify SM, FC, ST, CL, or CS for specific fiber couplers.

**Ordering Information:** Please indicate product number plus description when ordering.

**ASB-W-005** 5 watt Tungsten-halogen Visible Light Assembly
**ASB-W-005B** Spare Bulb, 5 watt

# ASB-W-020

## High Stability Tungsten-Halogen Fiber Light Source

- Offers excellent color temperature stability
- Provides illumination for applications through optical fiber
- Focus adjustable light source SMA and fiber bundle adaptor
- Features built in current regulation


## Optimum Illumination for Your Fiber Optic Needs

The ASB-W-020 is a complete light source assembly with a tungsten-halogen lamp that emits in the 300 to 2500 nanometer (nm) wavelength region. It has been designed to transfer the maximum possible illumination to a variety of fibers. The tungsten-halogen lamp of the ASB-W-020 is a near blackbody source of light with a built-in fused silica lens that focuses the light to the fiber. Figure 1 shows blackbody spectral distributions at various color temperatures in Kelvin (K). The ASB-W-020 spectral distributions resemble those of Figure 1 out to about 2500nm, beyond which the transmission of the fused silica lens limits the output.

In addition to the 20 Watt tungsten-halogen lamp (SP # ASB-W-020B), the ASB-W-020 features a lamp housing and a current regulator to assure a stable output. The housing contains an adjustable lamp mount. A variety of flanges allow the mounting of different fiber terminations, from a single fiber to bundles.

The 20 Watt tungsten-halogen lamp used in the ASB-W-020 has a nominal color temperature of 3100 K and the regulated power input assures an average life of 2000 hours.

The power supply provided with the ASB-W-020 is a wall plug-in type.

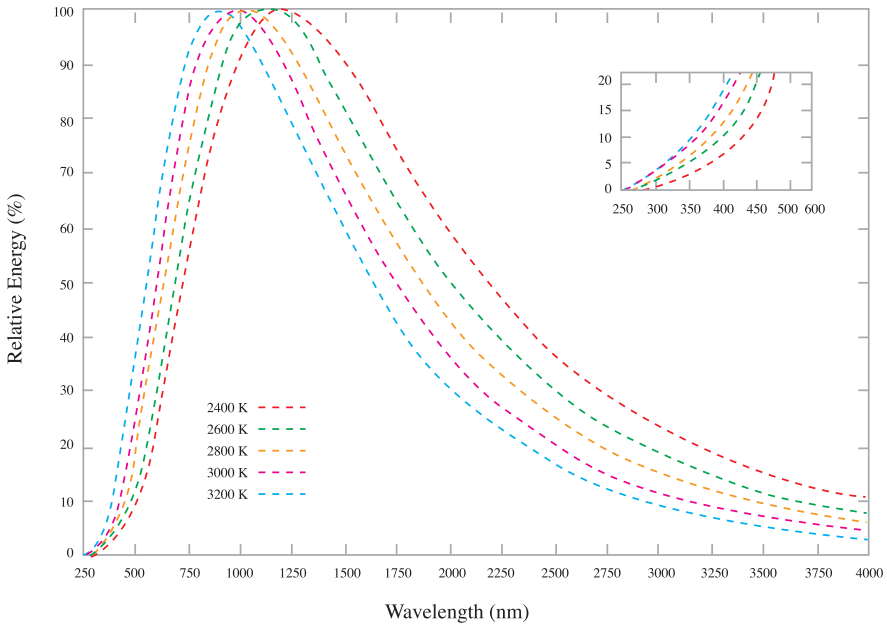



Figure 1. Spectral distribution of light emitted by blackbodies at various color temperatures indicated in Kelvin (K)

## Specifications :

**Lamp :** Tungsten-Halogen
**Power :** Wall transformer, 120 VAC, 50/60 Hz to 24 VDC at 2.0 amps.
220 VAC version available
Current : Built-in, ±0.4%
Color Temperature : 3100°K
Bulb Life : 2,000 hrs. average (nominal)
Spectral distribution: near blackbody
**Housing :** Aluminum, forced air cooled, Limited focus adjustment
Connector: SMA Fiber connector Type 905
**Dimension:** Length 3.8 inches (9.8cm) Height 2.3 inches (5.9cm) Width 2.1 inches (5.7cm)
Weight : 11 ozs. (0.3 kgs.)
**Options :** · Spare lamp ASB-W-020B
· Mounting flange for 10mm fiber bundle
· Optical bench mounts
Specify FC, ST or CS for specific fiber couplers.
**Warranty :** One year

**Ordering Information:** Please indicate product number plus description when ordering.

**ASB-W-020** Visible Source Assembly
**ASB-W-020B** Spare Lamp, 20 Watt Tungsten-Halogen

# ASB-W-030

## High Stability Tungsten-Halogen Light Source

- Provides optimal illumination to monochromators
- Offers excellent color temperature stability
- Features adjustable constant current power supply
- Contains focusable fused silica lens assembly
- Uses AF Series for remote fiber optic illumination

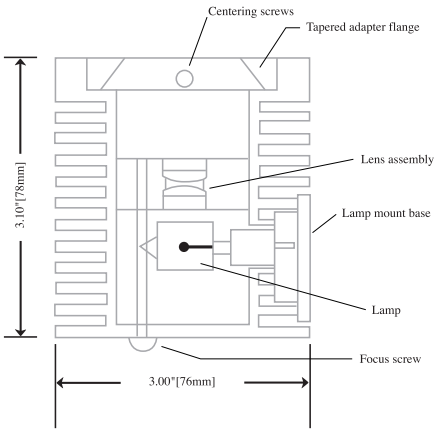




Figure 2. Lamp cross section

## Optimum Illumination for Your Monochromator

The ASB-W-030 is a complete light source assembly with a tungsten-halogen lamp that emits in the 300 to 2600 nanometer (nm) wavelength region. It has been designed to transfer the maximum possible illumination from a tungsten-halogen lamp to Digikrom monochromators. The tungsten-halogen lamps of the ASB-W-030 are near blackbody sources of light with fused silica envelopes around the lamp filaments. Figure 1 shows blackbody spectral distributions at various color temperatures in Kelvin (K). The ASB-W-030 spectral distributions resemble those of Figure 1 out to about 2600nm, beyond which the transmission of the fused silica lamp envelope limits the output.

In addition to the 30 Watt tungsten-halogen lamp (SP type ASB-W-030B), the ASB-W-030 features a housing for the lamp and an adjustable constant current power supply. The housing contains a focusable fused silica lens assembly selected for optimum coupling to the monochromator. The focus adjustment also allows for flexible mounting configurations for the ASB-W-030, with output focusing adjustable over a wide range of focal lengths. This also makes the ASB-W-030 an excellent light source for illumination of samples.

The 30 Watt tungsten-halogen lamp used in the ASB-W-030 has a nominal color temperature of 3100 K and an average life of 400 hours at this temperature. The color temperature of the lamp is directly proportional to the lamp current which may be varied ±25% with a control knob on the power supply. Over this range, both illumination and average life will change by approximately ±50%.

The optics of the ASB-W-030, in combination with the 30 Watt lamp, provide maximum illumination for monochromators. Higher power lamps have larger filaments, but no greater brightness per unit area. A filament larger than the 30 Watt size would simply overfill the entrance slit.

The power supply provided with the ASB-W-030 is a DC current regulated power supply. Current regulation optimizes color temperature stability.

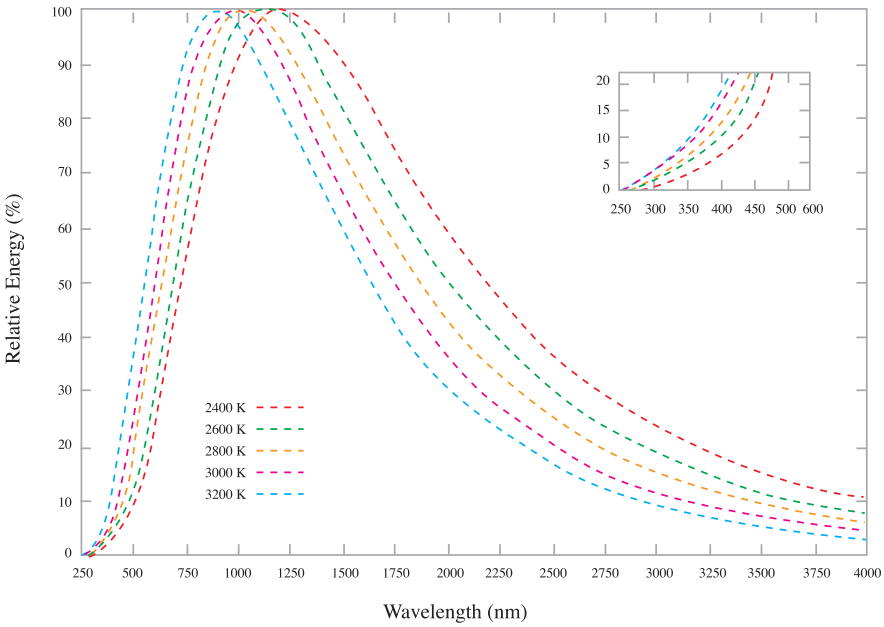



Figure 1. Spectral distribution of light emitted by blackbodies at various color temperatures indicated in Kelvin (K)

## Specifications :

**Lamp :** Tungsten-Halogen
Filament size : 1mm x 4mm
Power : 30 Watts (nominal)
Light Output : 800 lumens (nominal)
Current : 2.75 amp (nominal)
Color Temperature : 3100°K
Average Life : 400 hours (nominal)
Spectral distribution : near blackbody
**Mount :** Tapered flange, adjustable, Post mounting for standalone operation
**Housing :** Air cooled with focusable fused silica doublet collection lens, f/1.9 collection and f/3.9 output. (lamp cross section)
**Power Input :** 115 VAC, 50/60 Hz, 1 amp (standard)
220 VAC, 50/60 Hz, 0.5 amp (optional)

**Power Output :**
Type : constant current DC
Range : 2.0 amp to 3.5 amp
Regulation : 0.05%
**Warrant :** One year
**Options :** Spare lamp ASB-W-030B
AF Series for remote fiber optic illumination.

An infrasil lens assembly is available by request for better lamp emission at wavelengths beyond 2600nm. Contact the SP sales team if you have special requirements.

**Ordering Information:** Please indicate product number plus description when ordering.

**ASB-W-030** Visible Source Assembl
**ASB-W-030B** Spare Lamp, 30 Watt Tungsten-Halogen

# ASBN-W

## High power Tungsten-Halogen Light Source Series

- Provides optimal illumination to monochromators
- Offers excellent color temperature stability
- Features adjustable constant current power supply
- Contains focusable fused silica lens and UV protected Al coated mirror assembly


## Optimum Illumination for Your Monochromator

The ASBN-W high power tungsten-halogen series are complete light source assemblies with 50W/75W/100W/150W tungsten-halogen lamps that emit in the 300 to 2600 nanometer (nm) wavelength region. They have been designed to transfer the maximum possible illumination from a tungsten-halogen lamp to Digikrom monochromators. The tungsten-halogen lamps of the ASBN-W high power series are near blackbody sources of light with fused silica envelopes around the lamp filaments.

The housing contains a 1" UV grade fused silica lens (f#/1.2) and UV protected Al coated mirror (f  12.5mm) assembly selected for optimum coupling to the monochromator or the fiber, a regulated power supply and a cooling fan. The power supply provided with the ASB-W-030 is a DC current regulated power supply. Current regulation optimizes color temperature stability.

# Specifications :

**Lamp :**

| Power input | Light output | Color Temp. | Life Time | Filament size |
|---|---|---|---|---|
| 50W | 900 lumens | 3,000°K | 2,000 hours | 4.2mm X 2.5mm |
| 75W | 1,400 lumens | 3,000°K | 2,000 hours | 5.0mm X 1.6mm |
| 100W H | 3,000 lumens | 3,400°K | 50 hours | 5.3mm X 3.0mm |
| 100W L | 2,000 lumens | 3,000°K | 2,000 hours | 5.2mm X 2.3mm |
| 150W H | 6,000 lumens | 3,400°K | 50 hours | 6.2mm X 3.1mm |
| 150W L | 5,000 lumens | 3,200°K | 300 hours | 5.8mm X 3.0mm |

**Housing :**
Air cooling fan with a regulated power supply,
1" UV grade focusable fused silica collection lens (f#/1.2)
1" UV protected Al coated mirror (f 12.5mm)
Dimension : 8" X 10" X 5"

**Power Input:**
Input Voltage : 85-264 VAC (110V/220V compatible)
Input Frequency : 47-63Hz
Inrush Current : 30A/100V, 40A/200V
Over-voltage Protection : Clamp, 115-135%
Current Limit : 105-150% typ, Self-reset Fold back
Safety : UL / TUV / CE
Oper. Temp.: 0 to 50 °C

**Power Output :**
Type : constant current DC
VDC : 12V (24V for 150W)
Max. Current : 12.5A (8.4A for 150W)
Ripple/Noise (20MHz BW) : 100mV Pk-Pk, typ.
Regulation : ±0.5%, typ.

**Warranty :** One year

**Options :**
Spare lamp : ASBN-WB-050/075/100-H/100-L/150
Input power controller : ASBN-W-PV (including voltage indicator)
Needed to be specify the fiber coupling or collimated output
Focusing lens set for monochromator : ASBN-W-FL (1" UV fused silica lens)

**Ordering Information:** Please indicate product number plus description when ordering.

**ASBN-W050**(F/C) 50W High Power Tungsten-halogen
**ASBN-W075**(F/C) 75W High Power Tungsten-halogen
**ASBN-W100**(F/C) - (H/L) 100W High Power Tungsten-halogen
**ASBN-W150**(F/C) - (H/L) 150W High Power Tungsten-halogen

F : Fiber Coupling C : Collimated
H : High Color Temp. L : Low Color Temp.

# ASBN-D130 / ASBN-D230

## deep UV Deuterium Light Source Assembly

- Provides maximum possible illumination
- Contains 1" quartz doublet assembly for optimum coupling
- Assures maximum stability and lifetime of lamp




## Optimum UV Illumination for Fiber Optics

The ASBN-D130/230 is a deep UV ultraviolet deuterium light source for the 180-400nm (max. 160-400nm) region. It has been designed to provide the maximum possible illumination either directly or through an optical fiber.

The ASBN-D130 consists of one 30 watt deep UV deuterium lamp, a housing and a regulated power supply. The housing contains a 1" quartz doublet (f#/1.0, 1X) assembly for maximum possible illumination to the optical fiber.

The ASBN-D230 consists of two 30 watt deep UV deuterium lamps, a housing and two regulated power supplies. The housing contains two 1" quartz doublet (f#/1.0, 1X) assemblies. One is for focusing the second deuterium lamp on the first lamp and the other is for maximum possible illumination to the optical fiber. The first deuterium lamp has a "see-through" hole to allow the light from a secondary source to pass through the same light path as the first one.

The 30 watt deuterium lamp used in the ASBN-D130/230 has an average lifetime of 1,000 hours under regulated conditions. The life end is defined as the time when the UV region radiant intensity falls below 50% of its initial value or when output fluctuation exceeds 0.03%.

The power supply provided with the ASBN-D130/230 is a dc current regulated one. This assures maximum stability and lifetime of the lamp.

# Specifications :

**Lamp :**

Type : Deuterium with fused silica jacket, mounted and pre-aligned.

Power input : 30 Watt (nominal) per each lamp

Lamp current : 300 ° ±30 mA DC

Average Life : 1000 hours (nominal)

**Housing :**

1" quartz doublet (f#/1, 1X) collection lens.

Convection cooled.

Dimension : 6" X 5" X 10"

**Power Supply :**

Power input :115 vac, 50/60 Hz, 3 amps. 230 vac, 50/60 Hz, 1 amp, optional

Power output : Constant current dc, 60-120vdc selectable, 300 mA DC

Regulation : + 10 mA

Stability : 100 ppm/°C

Operating Temperature : 5-35°C

**Warranty :** One year

**Options :**

Spare lamp (mounted and pre-aligned),

Specify SM, FC, ST, CL, or CS for specific fiber couplers.

**Ordering Information:** Please indicate product number plus description when ordering.

**ASBN-D130**-(F/M) Single deep UV Deuterium
**ASBN-D230**-(F/M) Double deep UV Deuterium

F : Fiber Coupling
M : Monochromator f/# matching

# ASB-XE-175

## Xenon Fiber Optic Light Source

- Provides optimum illumination to fiber optics for remote applications
- High intensity (5600°K) Xenon output
- Contains CERMAX® high intensity xenon lamp

### FEATURES :

- High Color Temperature (5600°K)
- CERMAX® Collimated
- Xenon Lamp
- Brightness Control (0 - 100%)
- Portable and Light Weight

### APPLICATIONS:

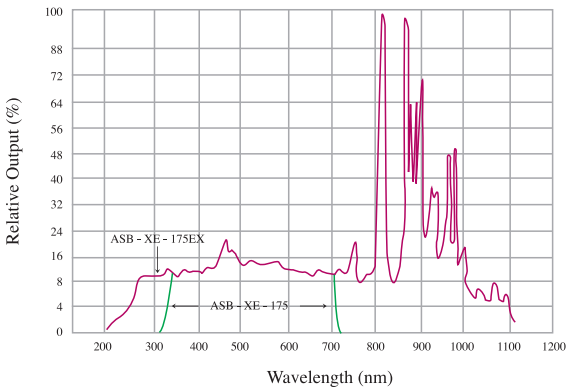
- Spectroscopy
- Microscopy
- Visual Inspection
- Boroscopes
- Machine Vision
- Optical Scanning
- Data and Video Projection

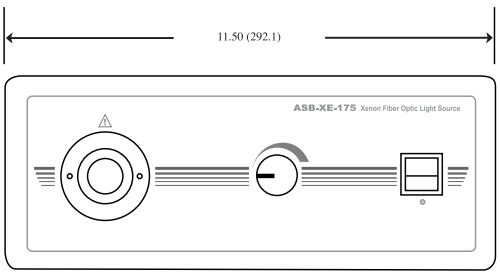

## Optimum Remote or Direct Illumination

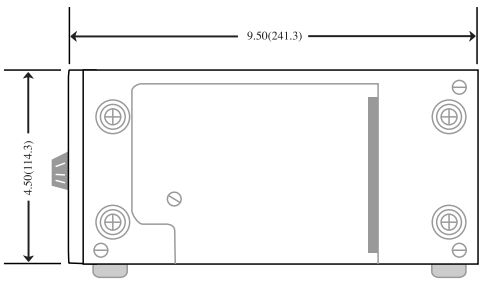
The ASB-XE-175 is a compact and light weight high intensity fiber optic light source. It is especially suitable as a light source for spectroscopy, microscopy, optical scanning, medical and industrial uses, as well as for use with SP's popular Digikrom monochromators and spectrographs.

The ASB-XE-175 uses a CERMAX® compact high intensity xenon lamp, state of the art optics and a high efficiency lightweight switching power supply in one compact package.

The 175W short-arc xenon lamp provides broadband output from 200 to 2200nm (dominantly, from 250 to 1100nm). This lamp is compact, rugged, and easily focused to a liquid light guide (sold separately). The lamp efficiency is enhanced by the integral parabolic reflector which provides precision system alignment and maximum transition of light energy. Beam stability is achieved instantly following lamp ignition and the ASB-XE-175 provides instant re-ignition without an imposed time delay.




Dimensions in inches (millimeters)

# Specifications :

**Lamp :**
Type : CERMAX® LX175F
Power : 200 Watts (maximum)
Power Range : 150-200 W
Color Temperature : 5600°K
Current : 14 amps DC (nominal)
Average Life : Typically 1000 hours (500 hours minimum)
Voltage : 12-17V (14V nominal)
Trigger Voltage : 25 Kilovolts
Boost Voltage : 140-200 Volts
Current Leakage : < 300mA

- ASB-XE-175-EX : UV extended, 200nm ~ 2200nm (dominant, 250nm ~ 1100nm)
- ASB-XE-175-BF : Ozone blocking, 320nm ~ 700nm
- ASB-XE-175-BFEX : NIR extended, Ozone blocking, 320nm ~ 2200nm (dominant, 320nm~1100nm)

**Weight :** 7.5 lbs. (3.4 kg)
**Input Line :** 95-136 VAC, 50/60 Hz (only)
**Input Current :** 3.5 amp.
**Environment :**
Operating : +6 to +45°C
Storage : -40 to +70°C
**Front Panel :** Brightness Control (0-100%)
Output Aperture
**Side Panel :**
Main Power (On/Off)
Line Cord Jack (IEC 320)
(US to IEC Line Cord included)
Fuse Holder - MDL-5
**Caution :** Damage to glass or fused silica fiber optic lightguides can occur due to high temperatures associated with Xenon lamps. Use our liquid light guides (order separately).

**Ordering Information:** Please indicate product number plus description when ordering.

**ASB-XE-175EX** Extended Xenon Source (200-2200nm)
**ASB-XE-175-BF** Ozone Blocking Xenon Source (320-700nm)
**ASB-XE-175-BFEX** NIR extended, Ozen Blocking Xenon Sourie (320-2200nm)

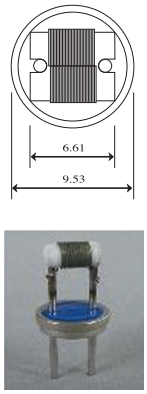
**ASB-XE-175BUV** Replacement Extended bulb
**ASB-XE-175BF** Replacement Ozone Blocking bulb

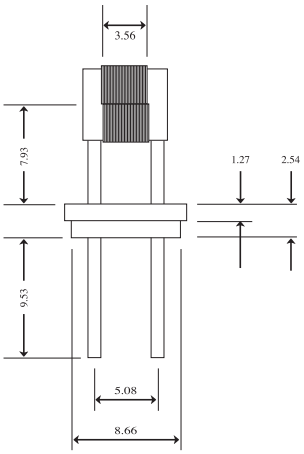
**AF5000-50001111-S10S** Liquid Light Guide (270-720nm) S Type
**AF5000-50001111-V10S** Liquid Light Guide (340-750nm) V Type

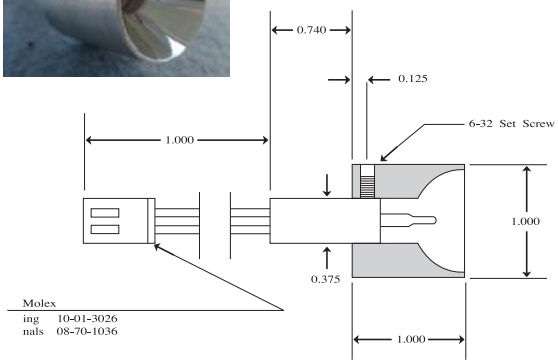
Please see the AF series section in this catalog for more details about Liquid Light Guides and other Fiber Assemblies.

# ASB-IR-12R/18K IR Emitter

- Supported, Coil-Wound
- Rugged and Reliable
- ASB-IR-12K operates at 975°C when powered with 11 watts
- ASB-IR-18K operates at 1200°C when powered with 20 watts






## Optimum Illupnination for IR range Spectroscopy

The coiled filament operates at approximately 975°ΔC when powered with 11 watts for the ASB-IR-12K and 1200°ΔC when powered with 20 watts for the ASB-IR-18K. The radiating element of the ASB-IR-12K is a coil of resistance wire which has a high emissivity in the Infrared spectral region. The coil is supported on a grooved cylindrical substrate of alumina, resulting in the windings being electrically insulated from each other. This contributes to a more uniform radiating source. The unit does not require operation in a sealed atmosphere. The header is fabricated from cold-rolled steel. The support pins are hermetically sealed in glass.

The ASB-IR-18K is designed for those customers who require higher temperatures and greater output from their infrared source. These emitters are manufactured using a patented silicon nitride material. The advanced ceramic technology ensures a very stable product. Their robust design ensures intrinsic physical and thermal strength. When operated at 12 volts/20 watts the ASB-IR-18K reaches 1200°C. These silicon nitride emitters are mounted in a 1 inch parabolic reflector for extremely efficient collimation of energy. This unit is our highest output IR product.

| Feature | Value | |
|---|---|---|
| Part Number | ABS-IR-12K | ABS-IR-18K |
| Voltage | 6.0V (AC or DC) | 12.0V (AC or DC) |
| Temperature | 975°C | 1200°C |
| Current | 1.8A | 1.7A |
| Power | 11.0W | 20.0W |
| Emissivity | 0.80 | 0.75 |
| Active area | 3.5mm X 3.5mm | 1.52mm dia., 4.06mm length |

**Ordering Information :** Please indicate product number plus description when ordering.
**ASB-IR-12K** 11W Coiled filament IR emitter
**ASB-IR-18K** 20W Coiled filament IR emitter

# Miniature hybrid light source

- Small size
- Low power consumption (6W)
- Low heat generation
- Easy coupling to optical fibers, measuring cells and capillaries
- Long life time
- Robust mode of operation


## Optimum Illumination for SP's SM Series Spectrometers

The ASBN-DW-MINI is a miniature UV-VIS light source a continuous spectrum covering the whole range from deep UV to near Infrared ( spectrum curve ). This light source was developed in response to customer requests for a small UV-Light source with negligible heat generation. The features of this light source open the way for new solutions in small spectroscopy equipment and UV optics. Features are small size low power consumption (6 W) low heat generation easy coupling to optical fibers, measuring cells and capillaries lifetime up to 3 years robust mode of operation.

The ASBN-DW-MINI incorporates a miniature Deuterium Lamp ? an electrode-less high frequency excited gas discharge lamp. The Deuterium Lamp features small size, 3Watt power consumption, and negligible heat generation. It is a complete UV-VIS light source with a shine-through design deuterium lamp, a 0.25 Watt tungsten lamp, shutter, optical system and SMA 905 connector or collimating output les set. All elements are mounted on a printed circuit board driven by an external 12 Vdc/600 mA power supply. Both lamps and the shutter can be controlled by a TTL signal.

## Specifications :

**Lamp :** 3W Deuterium, 185-400nm
0.25W Tungsten-Halogen, 400-1100nm
**Power :** Approx. 6W.
12Vdc/0.6Adc
Relative Humidity : Max. 90%, non-condensing
Ambient Temperature : 5 - 35˚C
Shutter : Lamp off/dark current measurement, TTL controlled
Functions : Deuterium and tungsten-halogen lamp can be triggered separately by a TTL signal

Bulb Lifetime : Deuterium: >1,000 hours (50% intensity loss)
Tungsten : >2,000 hours
Connector : SMA 905 Fiber connector or collimated output

**Ordering Information:** Please indicate product number plus description when ordering.

**ASB-DW-MINI** Miniature Deuterium & Tungsten - Halogen Light Source

# Single Deuterium and Tungsten-halogen Hybrid Light Source

ASBN-D1-W series, single deuterium and Tungsten-halogen hybrid light source consists of one 30W deep UV deuterium lampand a high power tungsten-halogen lamp. The specially designed "see-through" deuterium lamp can allow the light from a secondary source to pass through the same light path as the deuterium lamp. SP uses a proper focusing/collimating doublet lens set to obtain maximum optical power of the secondary light source (Tungsten-halogen) through the small "see-thgough" hole.

| | |
|---|---|
| ASBN-D1-W050F | 30W deep UV Deuterium lamp and 50W Tungsten-Halogen (3000°K /2000hours / 900 lumens) light source, 180nm ~ 2.6μm. |
| ASBN-D1-W050M | w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D1-W075F | 30W deep UV Deuterium lamp and 75W Tungsten-Halogen (3000°K / 2000hours / 1400 lumens) light source, 180nm ~ 2.6μm. |
| ASBN-D1-W075M | w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D1-W100F-H<br>ASBN-D1-W100DF-L | 30W deep UV Deuterium lamp and 100W Tungsten-Halogen light source, 180nm ~ 2.6μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH. |
| ASBN-D1-W100M-H<br>ASBN-D1-W100M-L | w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>H: High color temperature (3400°K / 50 hours / 3000 lumens)<br>L: Low color temperature (3000°K / 2000 hours / 2000 lumens)<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D1-W150F-M<br>ASBN-D1-W150F-L | 30W deep UV Deuterium lamp and 150W Tungsten-Halogen light source, 180nm ~ 2.6μm. |
| ASBN-D1-W150M-H<br>ASBN-D1-W150M-L | w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>H: High color temperature (3400°K / 50 hours / 6000 lumens)<br>L: Low color temperature (3400°K / 300 hours / 5000 lumens)<br>F: fiber coupling,<br>M: monochromator f# matching. |

# Dual Deuterium and Tungsten-halogen Hybrid Light Source

ASBN-D2-W series, dual deuteriums and Tungsten-halogen hybrid light source consists of two 30W deep UV deuterium lamps and a high power tungsten-halogen lamp. The specially designed "see-through" deuterium lamp can allow the light from secondary sources to pass through the same light path as the deuterium lamp. SP uses proper focusing/collimating doublet lens sets to obtain maximum optical power of the secondary light sources through the small "see-thgough" holes.

Generally, the optical power of deuterium is lower than that of tungsten-halogen. In some special applications that need high power UV light, these light sources will be useful.

| | |
|---|---|
| ASBN-D2-W050F<br><br>ASBN-D2-W050M | Two 30W deep UV Deuterium lamps and 50W Tungsten-Halogen (3000°K / 2000 hours / 900 lumens) light source, 180nm ~ 2.6μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D2-W075F<br><br>ASBN-D2-W075M | Two 30W deep UV Deuterium lamps and 75W Tungsten-Halogen (3000°K / 2000 hours / 1400 lumens) light source, 180nm ~ 2.6μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D2-W100F-H<br>ASBN-D2-W100F-L<br>ASBN-D2-W100M-H<br>ASBN-D2-W100M-L | Two 30W deep UV Deuterium lamps and 100W Tungsten-Halogen lightsource, 180nm ~ 2.6μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>H: High color temperature (3400°K / 50 hours / 3000 lumens)<br>L: Low color temperature (3000°K / 2000 hours / 2000 lumens)<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D2-W150F-H<br>ASBN-D2-W150F-L<br>ASBN-D2-W150M-H<br>ASBN-D2-W150M-L | Two 30W deep UV Deuterium lamps and 150W Tungsten-Halogen light source, 180nm ~ 2.6μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>H: High color temperature (3400°K / 50 hours / 6000 lumens)<br>L: Low color temperature (3400°K / 300 hours / 5000 lumens)<br>F: fiber coupling,<br>M: monochromator f# matching. |

# ASC-DC

## Portable Wavelength Calibration Source

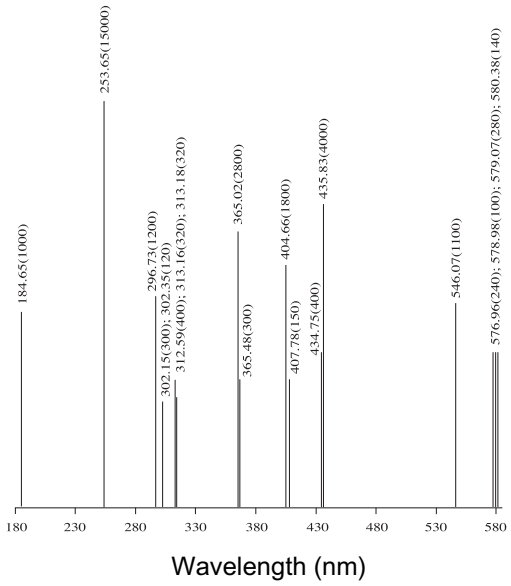
- Argon enhanced Mercury portable calibration lamp
- Highly repeatable wavelength, linewidth, and intensity calibration standard
- Easily mounts to SP monochromaters and spectrographs
- Couples to SP AF Series coupler for fiber optic output
- Convenient Battery with AC adapter for use in the field


## Optimal Solution for Calibrating SP's SM Spectrometers

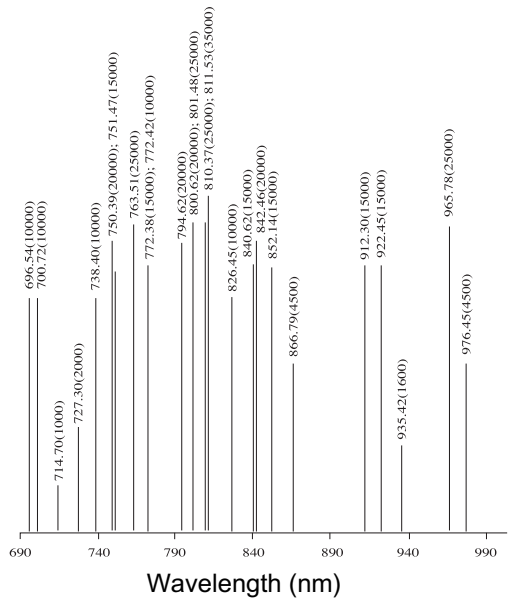
The atomic emission of the ASC Series lamps consists of discrete spectral lines of defined wavelength, spectral width, and relative intensity. Their stability makes them extremely useful for calibration, alignment, and resolution testing of spectrophotometric instrumentation, including monochromators, spectrographs, spectrophotometers, and detectors. Portable battery operation for field use. The installed rechargeable battery can be easily recharged by the built-in recharging system.

The argon enhanced mercury lamp installed emits strong lines throughout UV to NIR (~180-1000nm), which makes it the best solution for resolution testing or calibrating on a UV/VIS/NIR spectrometer or a monochromator.

Hg Spectral Calibration Data




Ar Spectral Calibration Data




## Specifications :

Lamp : Atomic emmission lamps with double bore fused silica tubing
Housing : Black anodized Aluminum
Dimensions : 4.125" x 1.25" x 0.875" (HxWxD)
AC Power : Wall transformer, 120 VAC, 50/60 Hz to 9 VDC
Battery : 9 V (rechargeable)
Battery Life : 25-45 minutes On-time
Options : AF Series fiber optic couplers

**Ordering Information:** Please indicate product number plus description when ordering.

**ASC-HGAR-DC** Argon enhanced Mercury Spectral Calibration Lamp

# ASC Series

## Spectral Calibration Lamps and Assemblies

- Accommodates compact pencil-style calibration lamps. Offering various lamp selections.
- Provides highly repeatable wavelength, linewidth, and intensity calibration standards.
- Allows quick-on/quick-off instrument mounting. Features post mount for optical bench.
- Five elemental emitters - Hg, Ne, Xe, Ar, and Kr.



## A Complete Spectral-Line Source

The ASC Series spectral calibration lamp and lamp assembly constitute a complete spectral-line source. The AS260 lamp assembly consists of a power supply and lamp housing for the AS Series calibration line-source lamps.

As a reference standard, the atomic emission of the AS Series lamps consists of discrete spectral lines of defined wavelength, spectral width and relative intensity. The stability makes them extremely useful for calibration, alignment, and resolution testing of spectrophotometric instrumentation, including monochromators, spectrographs, spectrophotometers and detectors.

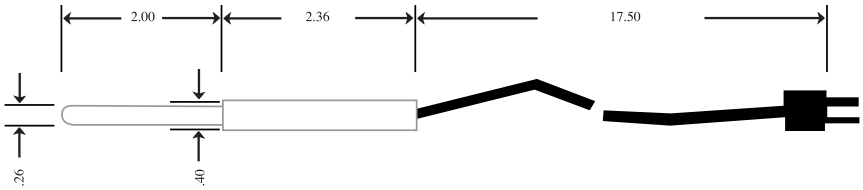
Five different calibration lamps are available: Mercury (Hg); Neon (Ne); Argon (Ar); Krypton (Kr); and Xenon (Xe). The Mercury lamp has strong spectral lines throughout the UV-VIS region.

The Neon lamp has a large number of lines of mid to high intensity in the 800nm to 3400nm range, which makes it useful for resolution testing in the NIR region . There are also a number of closely spaced lines of similiar intensity over this wavelength range.

The Xenon lamp's distribution of lines of moderate intensity between 800nm and 3500nm is useful for calibration in the IR. These emission lines are relatively close to wavelengths used by fiber optic communication systems for data transfer. Testing of fibers and detectors for these systems can be performed without the inherent high cost of lasers for light sources.

The Argon line spectrum features a number of lines of consistent high intensity between 700nm and 1000nm. These lines at such a high intensity are excellent for calibration in that region. There are also several lines spaced less than 1 nm apart that can be used for resolution testing.

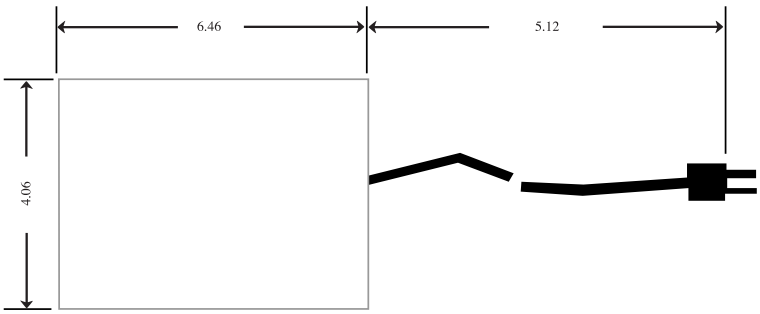
AS Series Lamps




Dimensions in inches

Note : These lamps produce intense ultra-violet radiation and require that appropriate precautions be taken when used. Avoid prolonged exposure of eyes or skin to the lamps' rays.

AS Series Power Supply

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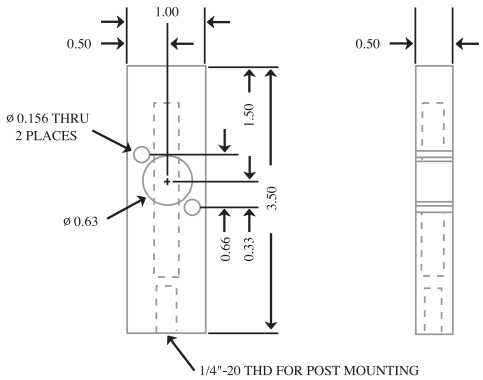
AS Series Lamp Holder




Note: Output cord has a polarized cap, the large pin receptacle is ground. DO NOT use power supply from unground mains. The transformer used in the AS260 Power Supply is manufactured to NEMA standards for Class A transformer operation.

## Specifications :

Package : Sealed double bore fused silica tubing.
Warmup : 2-4 minutes
Lamp Lifetime : 5000 hours (500 hours for Neon)
Power Supply : 110 to 230 VAC, 50/60 Hz
Line Cord : 6 ft. (1.83m), 3-wire ground type SJ
Output Connection : 16" (40.6 cm) cord with polarized female connectors
Output Voltage : 1600V rms, +10%, -0%
Output Current : 0.018 Amp, +10%, -0%
Max Ambient Temperture : 35°C
Min Ambient Temperature : 15°C
Options : AF2 Series Fiber Optic Couplers.

**Ordering Information :** Please indicate product number plus description when ordering.

**ASC-AC** Spectral Calibration Lamp Assembly
Includes power supply and lamp housing
**ASC-HG** Mercury (Hg) Spectral Calibration Lamp
**ASC-NE** Neon (Ne) Spectral Calibration Lamp
**ASC-XE** Xenon (Xe) Spectral Calibration Lamp
**ASC-AR** Argon (Ar) Spectral Calibration Lamp
**ASC-KR** Krypton (Kr) Spectral Calibration Lamp

# ASC Series

## Calibration Lamp Spectral Data

### Mercury (Hg) - ASC-HG

| Wavelength Å | Relative Intensity |
|---|---|
| 1849.50 | 1000 |
| 2536.52 | 15000 |
| 2967.28 | 1200 |
| 3650.15 | 2800 |
| 3654.84 | 300 |
| 4046.56 | 1800 |
| 4347.49 | 400 |
| 4358.33 | 4000 |
| 5460.74 | 1100 |
| 10139.75 | 2000 |

### Neon (Ne) - ASC-NE

| Wavelength Å | Relative Intensity |
|---|---|
| 7936.996 | 700 |
| 7943.181 | 2000 |
| 8082.458 | 2000 |
| 8118.549 | 1000 |
| 8128.911 | 600 |
| 8136.406 | 3000 |
| 8259.379 | 2500 |
| 8266.077 | 2500 |
| 8267.117 | 800 |
| 8300.326 | 6000 |
| 8365.749 | 1500 |
| 8377.606 | 8000 |
| 8417.159 | 1000 |
| 8418.427 | 4000 |
| 8463.358 | 1500 |
| 8495.360 | 5000 |
| 8571.352 | 1000 |
| 8591.259 | 4000 |
| 8634.647 | 6000 |
| 8647.041 | 3000 |
| 8654.383 | 15000 |

### Neon (Ne) - ASC-NE *continued*

| Wavelength Å | Relative Intensity |
|---|---|
| 8655.522 | 4000 |
| 8679.492 | 5000 |
| 8681.921 | 5000 |
| 8704.112 | 2000 |
| 8771.656 | 4000 |
| 8780.621 | 12000 |
| 8783.753 | 10000 |
| 8853.867 | 7000 |
| 8865.306 | 1000 |
| 8865.755 | 1000 |
| 8919.501 | 3000 |
| 8988.57 | 2000 |
| 9148.67 | 6000 |
| 9201.76 | 6000 |
| 9220.06 | 4000 |
| 9221.58 | 2000 |
| 9226.69 | 2000 |
| 9275.52 | 1000 |
| 9300.85 | 6000 |
| 9310.58 | 1500 |
| 9313.97 | 3000 |
| 9326.51 | 6000 |
| 9373.31 | 2000 |
| 9425.38 | 5000 |
| 9459.21 | 3000 |
| 9486.68 | 5000 |
| 9534.16 | 5000 |
| 9547.40 | 3000 |
| 9665.42 | 1000 |
| 10562.41 | 2000 |
| 10798.07 | 1500 |
| 10844.48 | 2000 |
| 11143.020 | 3000 |
| 11177.528 | 3500 |
| 11390.434 | 1600 |
| 11409.134 | 1100 |

### Neon (Ne) - ASC-NE *continued*

| Wavelength Å | Relative Intensity |
|---|---|
| 11522.746 | 3000 |
| 11525.020 | 1500 |
| 11536.344 | 950 |
| 11614.081 | 1200 |
| 11766.792 | 2000 |
| 11789.044 | 1500 |
| 11789.889 | 500 |
| 11984.912 | 1000 |
| 12066.334 | 3000 |
| 12689.201 | 1000 |
| 12912.014 | 1100 |
| 18083.21 | 1000 |
| 18276.68 | 2500 |
| 18282.62 | 2000 |
| 18303.97 | 1200 |
| 18384.85 | 1200 |
| 18389.95 | 2000 |
| 18402.84 | 1000 |
| 18422.39 | 1200 |
| 18591.55 | 900 |
| 18597.70 | 1600 |
| 21041.295 | 1200 |
| 22530.40 | 2250 |
| 23260.30 | 1000 |
| 23373.00 | 1050 |
| 23636.52 | 3500 |
| 23709.2 | 1100 |
| 23951.42 | 1800 |
| 23956.46 | 600 |
| 23978.12 | 1000 |
| 24365.05 | 1500 |
| 24371.60 | 800 |
| 33901.00 | 1300 |
| 33912.10 | 2200 |

# ASC Series

## Calibration Lamp Spectral Data

| Xenon (Xe) — ASC-XE | | Argon (Ar) — ASC-AR | | Krypton (Kr) — ASC-KR | |
|---|---|---|---|---|---|
| Wavelength Å | Relative Intensity | Wavelength Å | Relative Intensity | Wavelength Å | Relative Intensity |
| 8231.635 | 10000 | 6965.431 | 10000 | 4273.969 | 1000 |
| 8266.52 | 500 | 7067.218 | 10000 | 4318.551 | 400 |
| 8280.116 | 7000 | 7068.736 | 100 | 4319.579 | 1000 |
| 8346.82 | 2000 | 7147.042 | 1000 | 5570.288 | 2000 |
| 8409.19 | 2000 | 7272.936 | 2000 | 5870.914 | 3000 |
| 8819.41 | 5000 | 7383.980 | 10000 | 7587.411 | 1000 |
| 8952.25 | 1000 | 7503.869 | 20000 | 7601.544 | 2000 |
| 9799.70 | 2000 | 7514.652 | 15000 | 7685.244 | 1000 |
| 9923.19 | 3000 | 7635.106 | 25000 | 7694.538 | 1200 |
| 12623.391 | 2500 | 7723.761 | 15000 | 8059.503 | 1500 |
| 13657.055 | 2000 | 7724.207 | 10000 | 8104.364 | 4000 |
| 14142.444 | 1250 | 7948.176 | 20000 | 8112.899 | 6000 |
| 14732.806 | 3000 | 8006.157 | 20000 | 8190.054 | 3000 |
| 15418.394 | 2500 | 8014.786 | 25000 | 8263.240 | 3000 |
| 16053.28 | 1000 | 8103.693 | 20000 | 8281.050 | 1500 |
| 16728.15 | 1500 | 8115.311 | 35000 | 8298.107 | 5000 |
| 17325.77 | 1500 | 8264.522 | 10000 | 8508.870 | 3000 |
| 20262.242 | 3000 | 8408.210 | 15000 | 8776.748 | 6000 |
| 23193.33 | 1250 | 8424.648 | 20000 | 8928.692 | 2000 |
| 24824.71 | 1800 | 8521.442 | 15000 | 9751.758 | 2000 |
| 30475.46 | 1500 | 8667.944 | 4500 | 11819.377 | 1500 |
| 31069.23 | 6000 | 9122.967 | 35000 | 13177.412 | 1100 |
| 32739.26 | 1800 | 9224.499 | 15000 | 13622.415 | 1000 |
| 33666.69 | 3500 | 9354.220 | 1600 | 13634.220 | 2400 |
| 35070.25 | 5000 | 9657.786 | 25000 | 14426.793 | 2000 |
| | | 9784.503 | 4500 | 14734.436 | 1600 |
| | | 10470.054 | 1600 | 14762.672 | 550 |
| | | 13313.210 | 1000 | 14765.472 | 450 |
| | | 13367.111 | 1000 | 15239.615 | 1700 |
| | | 13504.191 | 1000 | 15334.958 | 1500 |
| | | 13718.577 | 1000 | 15372.037 | 700 |
| | | | | 16785.128 | 2000 |
| | | | | 16853.488 | 1000 |
| | | | | 16890.441 | 2400 |
| | | | | 16896.753 | 1600 |
| | | | | 16935.806 | 1800 |
| | | | | 18167.315 | 2600 |
| | | | | 21902.513 | 1800 |

# AT-IS-1.5

## Integrating Sphere w/Built-in Tungsten Light Source

- 1.5" Integrating Sphere combined with an 5W regulated Tungsten Halogen Light Source
- Detector Port with SMA interface
- 1/2" Full Size Port

Designed for color applications, this compact 1.5" integration sphere and light source can also be used as a low cost diffuse (uniform) light source. Standard unit includes SMA detector port connection and detector collection optic. 1/2" Full Size Port can be place aganist surface to be analyzed; small objects can also be inserted for analysis.

Detector port can also be directly interfaced to Spectral Products SM200 and SM241 spectrometers

Ordering Information: Please indicate product number plus description when ordering.

AT-IS-1.5 1.5”Uniform Light Source

# Wavelength Tunable Light Sources

- Computer controlled via standard RS232 interface.
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV.
- May be configured for optimal fiber optic illumination.
- 4 models for UV, VIS, and IR. Modular design allows for reconfiguring.
- Couples to SP Spectral Products equipment.

## 1.Tungsten-Halogen Based

- Variable narrowband light output selection from Near UV (300nm) to Near IR (2.6$\mu$m)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Couples to Spectral Products equipment


## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' high power tungsten-halogen light sources.

## Models

AST-W-030 : 30W tungsten-halogen model.
ASTN-W-050 : 50W tungsten-halogen model.
ASTN-W-075 : 75W tungsten-halogen model.
ASTN-W-100-L : 100W low color temperature tungsten-halogen model.
ASTN-W-100-H : 100W high color temperature tungsten-halogen model.
ASTN-W-150 : 150W tungsten-halogen model.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings )<br>Interface : RS232 standard |
| Light Source | Model : ASB-W-030/ASBN-W050/075/100-L/100-H/150<br>Power : 30/50/75/100/150 Watts<br>Bulb Light Power : 800 ~ 4,700 lumens<br>Bulb Life : 50 ~ 2,000 hours.<br>Bulb Color Temp. : 3,000°K ~ 3,400°K |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |

# 2.Deuterium Based

- Variable narrowband light output selection in UV range (180nm - 400m)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Couples to Spectral Products equipment

## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' deep UV 30W deuterium light sources.

## Models

AST-D-030 : 30W deep UV deuterium model (conventional).
ASTN-D130 : One 30W deep UV deuterium model.
ASTN-D230 : Two 30W deep UV deuterium model.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings )<br>Interface : RS232 standard |
| Light Source | Model : ASBN-D130/230<br>Power input : 30 Watts (nominal)<br>Lamp current : 300 ±30 mA DC<br>Average Life : 1000 hours (nominal) |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |

# 3.175W Xenon Based

- Variable narrowband light output selection from UV (200nm) to Near IR (2.2$\mu$m)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Attenuation control
- Couples to Spectral Products equipment


## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' 175W Xenon light sources.

## Models

AST-XE-175EX : 175W UV/NIR Extended Xenon based model, 200nm ~ 2,200nm range.
AST-XE-175BFEX : 175W NIR Extended Xenon based model, 320nm ~ 2,200nm range. Ozone free.
AST-XE-175BF : 175W Ozone blocking Xenon based model, 320nm ~ 750nm range.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings)<br>Interface : RS232 standard |
| Light Source | Model : ASB-XE-175EX, ASB-XE-175BF, ASB-XE-175BFEX<br>Power : 175 Watts<br>Bulb Light Power : 800 ~ 4,700 lumens<br>Bulb Life : 1000 hours typical, 500 hours minimum |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |

# 4. Deuterium & Tungsten-Halogen Hybrid Based

- Variable narrowband light output selection from deep UV (180nm) to Near IR (2.6$\mu$m)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Couples to Spectral Products equipment

## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' Deuterium & Tungsten-Halogen hybrid light sources.

## Models

ASTN-D1-W050 : One 30W deep UV Deuterium & 50W Tungsten-Halogen model.
ASTN-D1-W075 : One 30W deep UV Deuterium & 75W Tungsten-Halogen model.
ASTN-D1-W100-L : One 30W deep UV Deuterium & 100W low color temperature Tungsten-Halogen model.
ASTN-D1-W100-H : One 30W deep UV Deuterium & 100W high color temperature Tungsten-Halogen model.
ASTN-D1-W150 : Two 30W deep UV Deuterium & 150W Tungsten-Halogen model.
ASTN-D2-W050 : Two 30W deep UV Deuterium & 50W Tungsten-Halogen model.
ASTN-D2-W075 : Two 30W deep UV Deuterium & 75W Tungsten-Halogen model.
ASTN-D2-W100-L : Two 30W deep UV Deuterium & 100W low color temperature Tungsten-Halogen model.
ASTN-D2-W100-H : Two 30W deep UV Deuterium & 100W high color temperature Tungsten-Halogen model.
ASTN-D2-W150 : Two 30W deep UV Deuterium & 150W Tungsten-Halogen model.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings)<br>Interface : RS232 standard |
| Light Source | Model : ASBN-D1-W series, ASBN-D2-W series<br>Power : Deuterium: 30 Watts, Tungsten-Halogen: 50 ~ 150 Watts<br>Bulb Life : Deuterium: 1000 hours typical, 500 hours minimum,<br>Tungsten-Halogen: 50 ~ 2,000 hours |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |

# Section VI : AB Series Filter Wheels

**AB Series** Automated Filter wheels

**AB300-T** - Automated Six Position Filter Wheel

**AB301-T** - Stand-alone Automated Six Position Filter Wheel

**AB302-T** - Stand-alone Automated Five Position Filter Wheel

**AB303-T** - Stand-alone Automated Twelve Position Filter Wheel

**AB304-T** - Stand-alone Automated Fourteen Position Filter Wheel

**AB Series** Order Sorting Filters

**AB202** Double Filter Box

# AB Series

## Automated Filter Wheels

- Low cost!
- High performance!
- USB2.0 controlled.
- Multiple Filter Wheel systems available.
- Threaded capture rings allow easy change of filters.


① AB300-T Plug-in and Go with Digikrom DK240/242/480. 6 positions - 1”filters.


③ AB302-T Stand - alone , 2”filters. 5 positions

② AB301-T Stand - alone , 1”filters. 6 positions

④ AB303-T Stand - alone , 1/2”filters. 12 positions

⑤ AB304-T Stand - alone , 1”filters. 14 positions

## Versatile Computer Controlled Filter Wheels

**AB300-T** A six position wheel that integrates with SP’s popular Digikrom and monochromators. Plugging directly into the Digikrom, resident software commands allow easy manipulation to filter higher order energy. It can also be controlled by your hand-held controller. The AB300 uses 1” diameter filters.

**AB301-T** stand-alone, six position 1” filter wheel that is stepper motor controlled via USB2.0 and can be used with SP’s 1/8 meter compact monochromators for order sorting purposes.

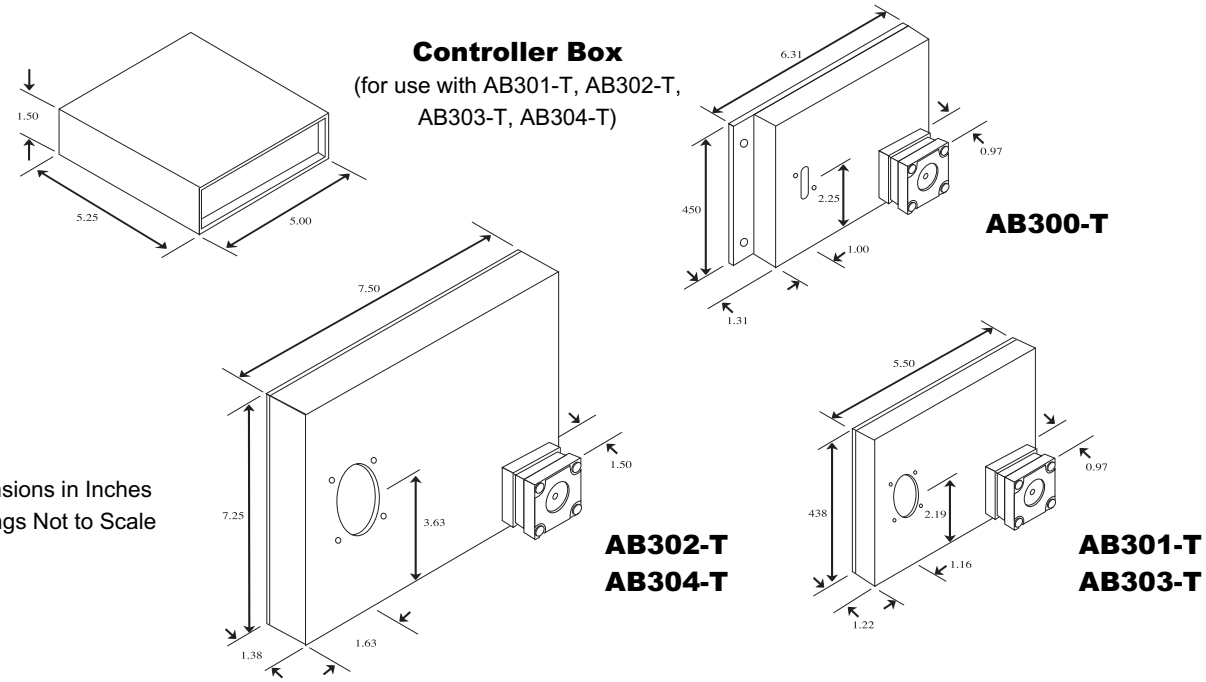
**AB302-T** A stand-alone, five position 2” filter wheel that is ideal for LIDAR applications. Stepper motor controlled, it can be combined with AB301-T's, AB302-T's, or AB303-T's in multiple filter wheel systems.

**AB303-T** A stand-alone, twelve position 1/2" filter wheel that is stepper motor controlled. Ideal for multiple monochromatic illumination applications.

**AB304-T** A stand-alone, twelve position 1” filter wheel that is stepper motor controlled. Ideal for multiple monochromatic illumination applications.

**Inexpensive Monochromators** When used with narrowband interference filters, you can select up to twelve specific bandpasses for monochromatic illumination. This provides maximum throughput with excellent stray light rejection.

**Applications** Not only are these filter wheels ideal for use with monochromators, spectrographs and spectrophotometers, but they can be easily integrated with microscopes, flow cytometers, fluorimeters, and fluorescence photometers. Neutral density filters will allow for photometric linearity and dynamic range studies. Modern communication multiplexing capabilities provide the capability of combining any number of these filter wheels together in an integrated system. Call with your custom or OEM requirements.




## Specifications :

Accuracy :
AB300-T/AB301-T/AB303-T/AB304-T
± 0.004" from center of optical axis
AB302-T
± 0.030" from center of optical axis

Filter Change Speed :
AB300-T 0.5 second per position
AB301-T 0.5 second per position
AB302-T 1.1 second per position
AB303-T 0.25 second per position
AB304-T 0.50 second per position

Drive : Stepper Motor

Capacit :
AB300-T Six 1.0" diameter filters
AB301-T Six 1.0" diameter filters
AB302-T Five 2.0" diameter filters
AB303-T Twelve 0.5" diameter filters
AB304-T Twelve 1.0" diameter filters

Clear Aperture/Maximum Filter Thickness :
AB300-T Slot 1.0" x 0.44" / 0.25" thick
AB301-T 0.875" ∅ / 0.25" thick
AB302-T 1.825" ∅ / 0.50" thick
AB303-T 0.400" ∅ / 0.25" thick
AB304-T 0.875" ∅ / 0.25" thick

Control : DCE, 8 bits protocol, no parity, 1 stop bit, USB2.0 (GPIB optional), baud rates programmable.

Software : Demo program and LabView® driver provided.

Manual Control : Push button switch with 1 position advance

**Ordering Information:** Please indicate product number plus description when ordering.

**AB300-T** Six position, 1" diameter Automatic Filter Wheel Assembly, for use with Digkrom DK240/242/480 monochromators. Power and Control supplied through monochromator.

**AB301-T** Six position, 1" diameter Automatic Filter Wheel Assembly, for use with Digikrom CM110/112 monochromators, stand-alone, or in multiple systems.

**AB302-T** Five position, 2" diameter Automatic Filter Wheel Assembly, for use as stand-alone or in multiple Filter Wheel systems.

**AB303-T** Twelve position, 1/2" diameter Automatic Filter Wheel Assembly, for use as stand-alone or in multiple Filter Wheel systems.

**AB304-T** Twelve position, 1" diameter Automatic Filter Wheel Assembly, for use as stand-alone or in multiple Filter Wheel systems.

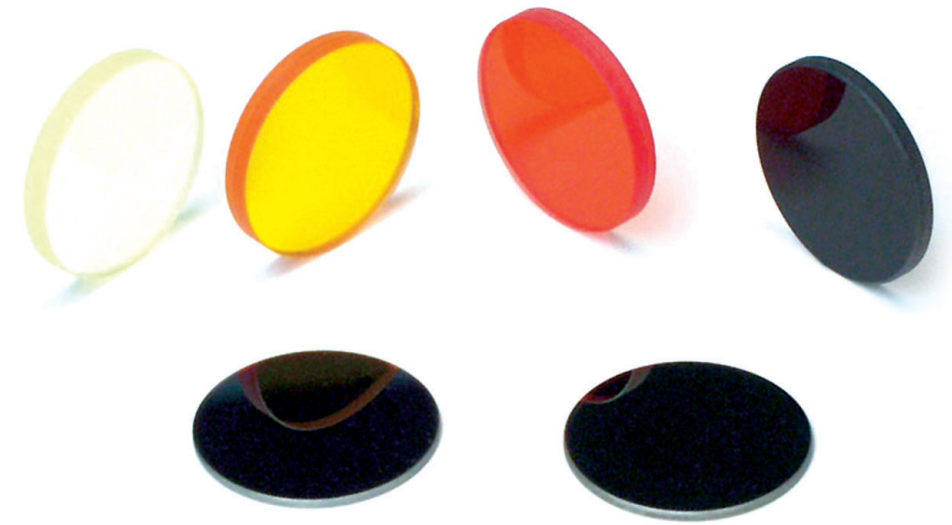
(All Filter Wheels come with appropriate cabling, power supply, and mounting flanges for turn-key operation. Cable to computer supplied by customer or selected separately from Price List.)

**Options AB Series Filters**
Blocking plugs - Call for Quote.
Multiple Systems - Call with Requirements.

# AB Series

## Order Sorting Filters

- Provides blocking of light radiation below filter specific transition or cut-on wavelength.
- Made from semi-conductor material.
- Allows for various mounting options.
- Offers several filter choices.



## Select Light Radiation Easily

The AB30XX Series of Long Pass Order Sorting Filters provide blocking of light radiation below the filter specific transition or cut-on wavelength.

They can be mounted in the AB202 Filter Carrier or in the AB300 Automated Six Position Filter Wheel. The AB202 Filter Carrier is inserted into the AB200 Filter Mount Assembly. The AB3032, AB3058, AB3066. AB3072, and AB3085 are long-wave pass, color glass filters and are available in 25.4 mm diameter.

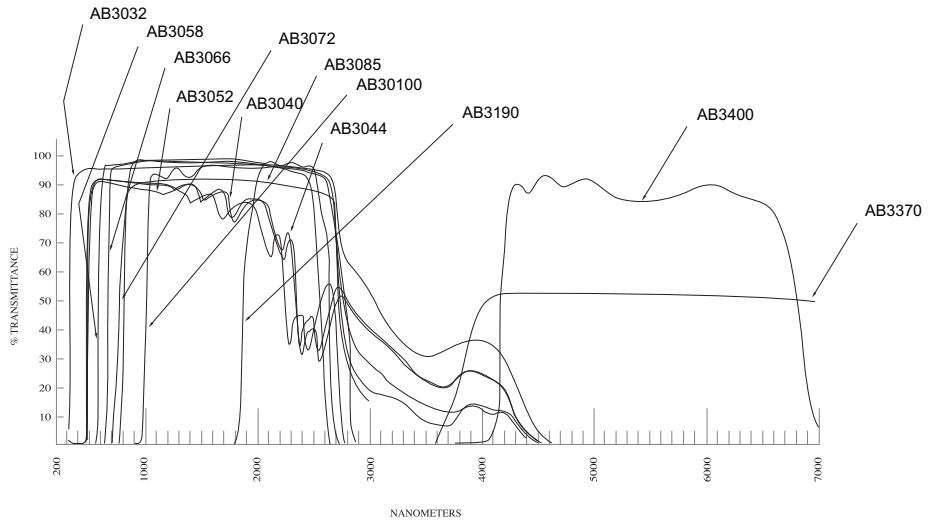
The average high transmittance (TH) of the color glass filters is greater than 90%. The average high transmittance value is the average transmittance of the filter between the first peak after the cut-on wavelength to the peak before the cut-off wavelength. The transition interval of the AB30XX Series Filters is listed in the following table. The transition interval is the distance (nm) from the cut-on wavelength to the cut-on peak.

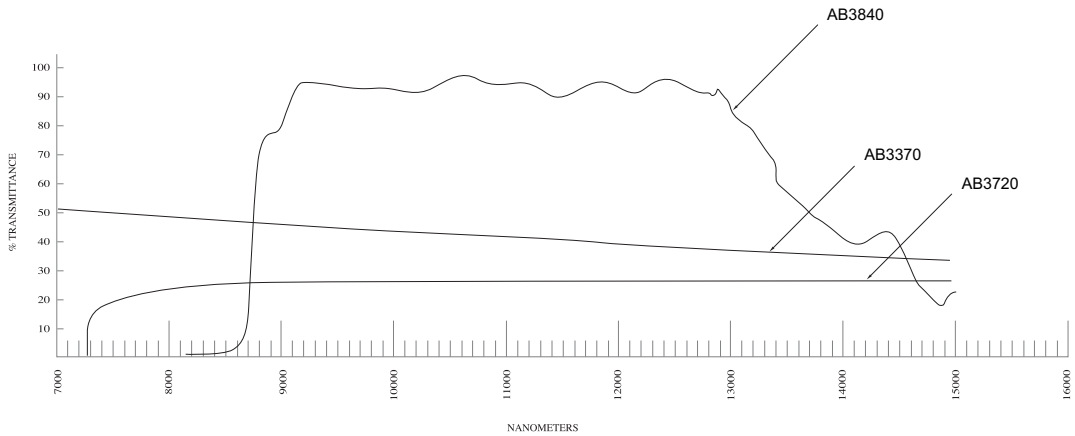
The AB3100, AB3190, AB3300, AB3370, AB3720, AB3400, and the AB3840 Order Sorting Filters are made of semiconductor materials. These long-wave pass filters are anti-reflection coated for operation from the longpass wavelength to at least twice that wavelength.

The average high transmittance for the AB3100, AB3190, AB3400, and AB3840 filters is greater than 75%.

These long-pass semiconductor filters are 1 inch (25.4mm) diameter with a thickness of 0.083" or less (2.1mm). These filters can also be mounted in the AB201 Filter Carrier or in the AB300 Automated Six Position Filter Wheel.

The blocking average for all of the filters is 0.1% below the passband through the UV wavelengths.




Transmittance curves of Order Sorting Filters

## Specifications :

Size : 25.4mm ∅
Thickness : 2.1mm typical
Material : Schott optical glass or equivalent
Surface Quality : Commercial polish
Mounting Options : AB300 Series Automated Filter Wheels

Check out our Filter catalog for Many More Filter option.

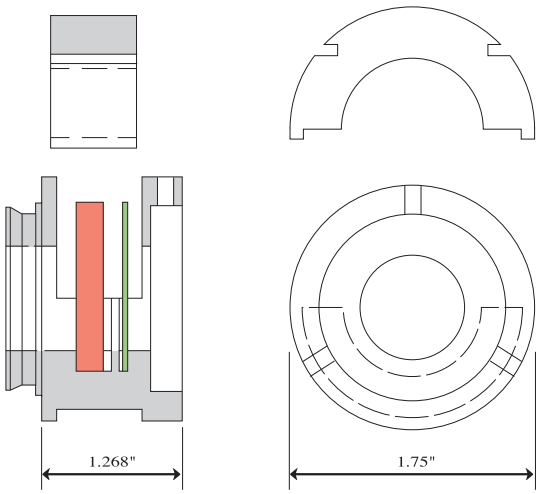
**Ordering Information :** Please indicate product number plus description when ordering.

| Part Number | Transition $\lambda$ $\lambda_T$ (nm) | Transition Tolerance ($\pm$ nm) $\triangle\lambda_T$ |
|---|---|---|
| AB3032 | 320 | 7 |
| AB3040 | 400 | 7 |
| AB3044 | 440 | 7 |
| AB3052 | 520 | 10 |
| AB3058 | 580 | 5 |
| AB3066 | 660 | 5 |
| AB3072 | 720 | 10 |
| AB3085 | 850 | 10 |
| AB3100 | 1000 | 25 |
| AB3190 | 1900 | 35 |
| AB3300 | 3000 | 50 |
| AB3370 | 3700 | 80 |
| AB3400 | 4000 | 150 |
| AB3580 | 5800 | 100 |
| AB3720 | 7200 | 185 |
| AB3840 | 8400 | 300 |

# AB202

## Double Filter Box

- Connects to SP Spectral Products instruments including monochromators, light sources, and detectors
- Cost effective method for order sorting
- Holds one 2.5mm thick filter and one 0.25" thick filter
- can adapt a collimating/focusing lens
- Fast and Easy filter changing




## Solution for mounting order sorting filters on a monochromator

The AB202 was basically designed to install an order sorting filter that is needed to use with a monochromator. But also it can be used with any SP's instrument depending on the requirements.
It can hold two filters with different thicknesses. The filter chamber has enough space so fast and easy filter changing is possible.
The AB202 can accommodate a lens matching the F# of a monochromator to collimate the output lights or focusing collimated input light onto a detector.

**Ordering Information :** Please indicate product number plus description when ordering.
**AB202** Double Filter Box

# Section VII : Sampling Accessories

**Integrating Spheres**

AT-IS-1

AT-IS-1.5

ISC/ISQ

**Attatchment**

AT-DIF

**References**

AT-WRS/AT-BRS

**Sample Holders**

AT-SHC

AT-SHC-4

AT-SHF

**Cuvette**

AT-2-Q-10

AT-4-Q-10

**Lens Assemblies**

AT-SHL-C

AT-SHL-F

# Integrating Spheres

**AT-IS-1**

**1" diameter Integrating Sphere**


- 1" Spectralon Integrating Sphere
- SMA Detector Port
- SMA Illumination Port
- 1/4" Full Size Port

The AT-IS-1 is an ultra compact integrating sphere. Custom milled Spectralon interior provides excellent diffuse reflectance from 250nm to 2.5$\mu$m. It is an excellent light sampling accessory for low level light application that requires the use of an integrating sphere.

**AT-IS-1.5**

**1.5" Integrating Sphere w/Built-in Tungsten Light Source**


- 1" diameter Integrating Sphere
- 1" Spectralon Integrating Sphere
- SMA Detector Port
- SMA Illumination Port
- 1/4" Full Size Port

Designed for color applications, this compact 1.5" integration sphere and light source can also be used as a low cost diffuse (uniform) light source for short distance applications. Standard unit includes SMA detector port connection and detector collection optic. 1/2" Full Size Port can be place aganist surface to be analyzed; small objects can also be inserted for analysis. Custom milled Spectralon interior provides excellent diffuse reflectance from 250nm to 2.5$\mu$m. Detector port can also be directly interfaced to Spectral Products' SM2xx series and SM4xx series spectrometers.

**ISC/ISQ Integrating Spheres**

**1" diameter Integrating Sphere**


- Integrating sphere with classical exterior or cubical exterior.
- Machined port plugs match interior sphere curvature.
- Post mount or slit flat (for cubical model).

ISC series are classical spherical type integrating spheres and they come standard with Ba2SO4 coating (effective from 400nm-2400nm and four orthogonal ports. Wall construction is cast aluminum (allows use of set screws).
ISQ series use the heavy duty construction. Each sphere is composed of two halves, each machined from solid aluminum stock. Like ISC series, standard ISQ spheres come with Ba2SO4 coating, four orthogonal ports. Sphere can sit flat on work surface or be mounted on an optical mount post.
Depending on the application situation, some port plugs, port reducers, or a fiber adapter can be provided. The available models are as follows.

| Model | ISC Series | | | ISQ Series | | |
|---|---|---|---|---|---|---|
| | ISC-020 | ISC-040 | ISC-060 | ISQ-020 | ISQ-040 | ISQ-060 |
| Diameter | 2" | 4" | 6" | 2" | 4" | 6" |
| Port size | 0.5" | 1.0" | 1.5" | 0.5" | 1.0" | 1.5" |

**How to Select and Size an Integrating Sphere**
In order to select the Spectral Products Integrating Sphere that is best suited for your application, several factors must be taken into consideration. The most important factors include the following:

**Diameter/Source Ratio** The diameter of the sphere should be at least 1.5 times the largest dimension of any device mounted within the sphere.

**Surface-to-Port Area** If ports cover more than 5% of the Integrating Sphere's surface, the Integrating Sphere may not integrate properly. If port requirements are greater than 5% of the sphere, a larger sphere should be purchased.

The following formulas can determine port area and sphere surface area:

- r Port radius, D Sphere Diameter
- Port Area $\pi\rho\perp 2$
- Sphere Surface Area $4\pi\Delta\perp 2$

**Integrating Sphere Coatings** The coating of a Spectral Products Integrating Sphere is a high efficiency diffuse reflector that delivers reliable integration and low throughput loss. The reflectance is high in order to minimize absorption loss from multiple reflections, yet it must not reflect light specularly.
Spectral Products Integrating Sphere Coatings offer reflectance efficiencies between 95 and 99%. A Lambertian Source is a perfect diffuse source. When a perfect diffuse reflector is illuminated with uniform intensity, it acts as a Lambertian Source. Spectral Products uses a proprietary Ba2SO4 coating, effective from 380 up to 2400 nm, to provide these state-of-the-art Lambertian properties.

# Attachments

**AT-450**

Reflectance attachment 5W tungsten-halogen light source built-in 45° illuminating and 0° viewing geometr Diffused reflectance/Color measurement


# References

**AT-WRS/AT-BRS**

White / Black reflectance standards for diffused reflectance measurement use.

# Sample Holders

**AT-SHC**

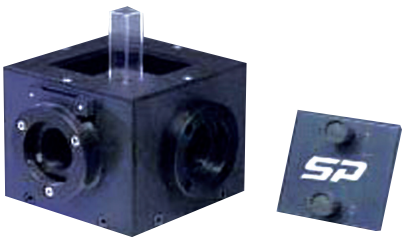
Two Port Cuvette Holder.
Supports 1/2" x 1/2" cuvettes Supports SMA or FC fiber connection

The AT-SHC Two Port Cuvette Holder allows FC or SMA fiber connection for sample transmission and absorbtion studies.
Included cover excludes ambient light.
Holder also allows insertion of a reference filter (1.5"x1.25"x.075" max. dimensions) for system calibration.

**AT-SHC-4**

Four Port Cuvette Holder.
Supports 1/2" x 1/2" cuvettes
Supports SMA or FC fiber connection

The AT-SHC-4 Four Port Cuvette Holder allows FC or SMA fiber connection for sample transmission, absorbtion and especially fluorescence studies.
Included cover excludes ambient light.
Holder also allows insertion of a reference filter (1.5"x1.25"x.075"max. dimensions) for system calibration.




**AT-SHF**

Two Port Filter Holder.
Reconfigurable design fits almost any 1.00" filter up to 6mm thick filter

The AT-SHF Two Port Filter Holder allows FC or SMA fiber connection for sample transmission and absorbtion studies. Included cover excludes ambient light.

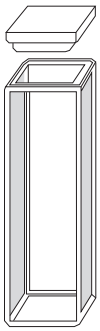
# Cuvette

**AT-2-Q-10**

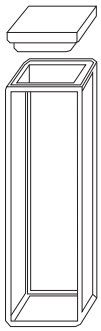
UV Quartz Cuvette, 12.5mm X 12.5mm X 45.0mm,
170nm ~ 2700nm, 2 polished window, 10mm path length,
For Absorption and Transmittance Application

**AT-4-Q-10**

UV Quartz Cuvette, 12.5mm X 12.5mm X 45.0mm,
170nm ~ 2700nm, 4 polished window, 10mm path length,
For Absorption, Transmittance and Fluorescence Application




| AT-2-Q-10 |



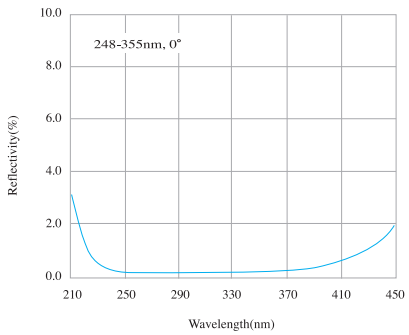

| AT-4-Q-10 |

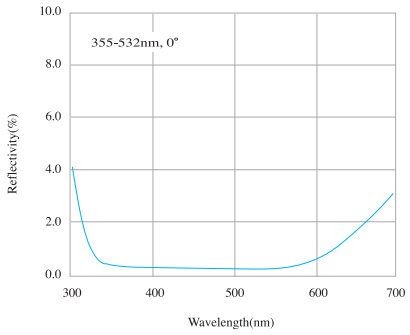
# Collimating / Focusing assembly with lens for sample holders

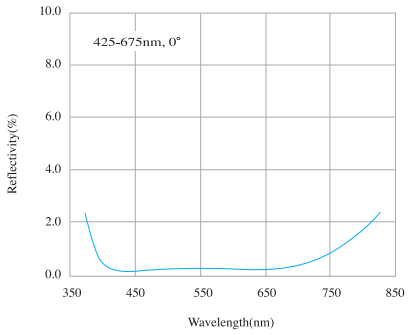
**AT-SHL-C** 1/2" Collimating/Focusing assembly with one lens. UV grade Fused Silica (200nm ~ 2000nm)

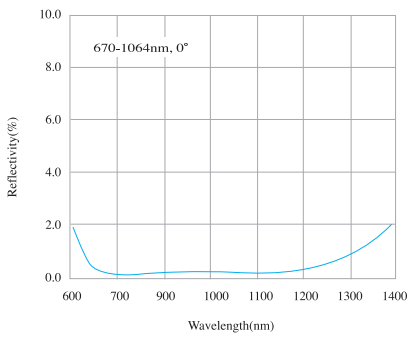
**AT-SHL-F** 1/2" Focusing assembly with two lenses. UV grade Fused Silica (200nm ~ 2000nm). For Fluorescence application.

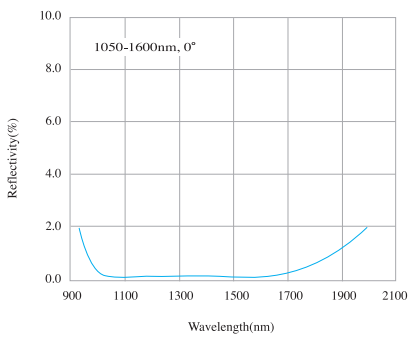
**Anti-Reflection Coatings** available.




**DU** : Deep UV range (200nm~250nm),

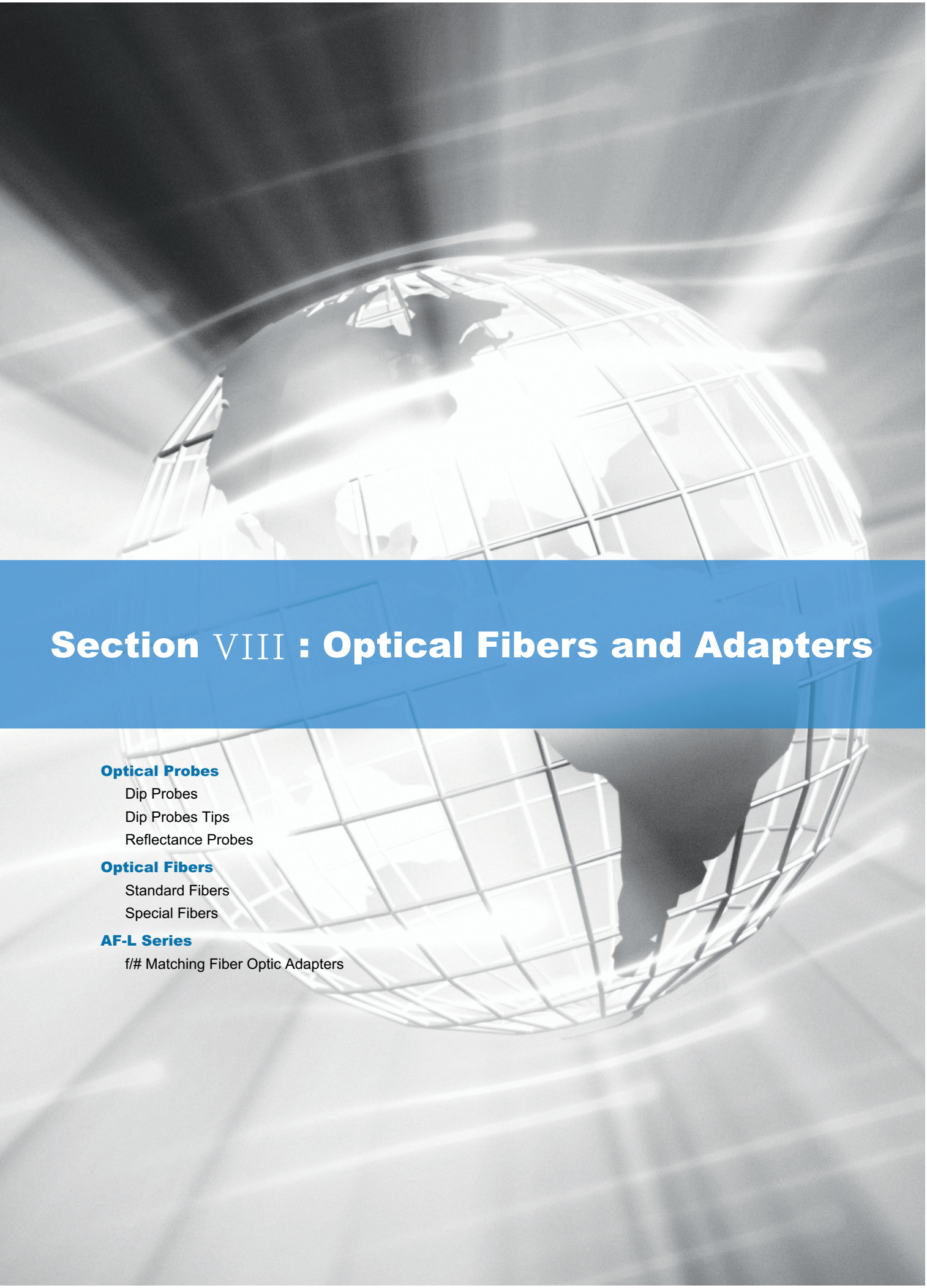
**UV** : UV range (250nm~400nm),

**VS** : Visible range, Shorter (320nm~600nm),

**VL** : Visible range, Longer (400nm~700nm),

**IS** : NIR range, Shorter (650nm~1100nm),

**IL** : NIR range, Longer (1050nm~1700nm)



# Section VIII : Optical Fibers and Adapters

# Optical Probes

Spectral Products offers fiberoptic probes for use in fluorescence / Raman / diffuse reflection applications (reflection probes) absorbtion / transflectance applications (dip probes).

These dip probes offer the highest throughput in the industry.

Throughput data (transmission efficiency) sent with every probe.
Superior design minimizes stray lights : bubbles & trapped liquid
Available in all industry standard terminations
Custom instrument / process interfaces or configurations.
Fixed pathlength or removable tip for dip probes
Same unit can be used for several measuring techniques
UV, UV/VIS and VIS/NIR versions
Custom configurations available.



## Part number Notation

## (R or D)P(OOOO)-(XX)(YY)-(U or I)(oo)(-NS)

| Keyword | Description |
|---|---|
| **Probe Type (R or D)** | Reflectance Probe: RP<br>Dip Probe: DP |
| **Core Size (OOOO)** | OOOO micron, ex) 0600: 600um |
| **Connector Type (XX)(YY)** | SMA-905: SM<br>FC: FC<br>Ferrule: FR<br>ex) SMFC : one SMA-905 end and one FC end<br>In Case of the bifurcated fiber, "XX" is for the bifurcated ends and "YY" is for the joint end. |
| **Wavelength range (U or I)**<br>**Fiber length (oo)**<br>**Non-solarizing option (-NS)** | U: UV / VIS (250-1150nm), I: VIS / NIR (400-2250nm)<br>oo: oo/10 meter, ex) 20: 2.0m, 15: 1.5m<br>NS: Non-solarizing for deep UV (190-1150nm) |

## 1. Dip Probes

| Part Numbers | Description |
|---|---|
| DP0200-SMFR-U20 | Std Transflection Dip Probe for 200μm 2m length, UV / VIS (Requires a Tip) |
| DP0200-SMFR-U20-NS | Std Transflection Dip Probe for 200μm 2m length, UV / VIS NonSola rizing (Requires a Tip) |
| DP0200-SMFR-I20 | Std Transflection Dip Probe for 200μm 2m length, VIS / NIR (Requires a Tip) |
| DP0400-SMFR-U20 | Std Transflection Dip Probe for 400μm 2m length, UV / VIS (Requires a Tip) |
| DP0400-SMFR-U20-NS | Std Transflection Dip Probe for 400μm 2m length, UV / VIS NonSola rizing (Requires a Tip) |
| DP0400-SMFR-I20 | Std Transflection Dip Probe for 400μm 2m length, VIS / NIR (Requires a Tip) |
| DP0600-SMFR-U20 | Std Transflection Dip Probe for 600μm 2m length, UV / VIS (Requires a Tip) |
| DP0600-SMFR-U20-NS | Std Transflection Dip Probe for 600μm 2m length, UV / VIS NonSola rizing (Requires a Tip) |
| DP0600-SMFR-I20 | Std Transflection Dip Probe for 600μm 2m length, VIS / NIR (Requires a Tip) |

## 2. Dip Probe Tips

| Part Numbers | Description |
|---|---|
| DPT-002 | Transflection Dip Probe Tip Path Length 2μm |
| DPT-005 | Transflection Dip Probe Tip Path Length 5μm |
| DPT-010 | Transflection Dip Probe Tip Path Length 10μm |
| DPT-020 | Transflection Dip Probe Tip Path Length 20μm |

## 3. Reflectance Probes

| Part Numbers | Description |
|---|---|
| RP0100-SMFR-U20 | 100μm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0100-SMFR-I20 | 100μm 6 around 1 Stainless Steel Probe Body VIS/IR |
| RP0200-SMFR-U20 | 200μm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0200-SMFR-I20 | 200μm 6 around 1 Stainless Steel Probe Body VIS/NIR |
| RP0400-SMFR-U20 | 400μm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0400-SMFR-I20 | 400μm 6 around 1 Stainless Steel Probe Body VIS/NIR |
| RP0600-SMFR-U20 | 600μm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0600-SMFR-I20 | 600μm 6 around 1 Stainless Steel Probe Body VIS/NIR |

# Optical Fibers

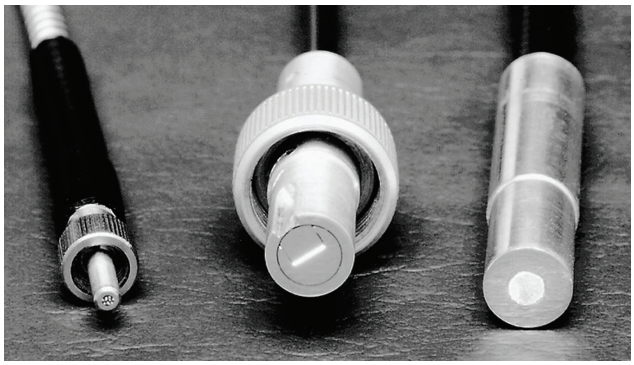
Spectral Products offers a complete line of silica core optical fibers and patch cord assemblies. Standard assemblies are listed below. Please call if you don't see what your looking for, have questions, or have a custom requirement!
Standard assemblies are sheathed in crush resistant black PVC covered flexible galvanized steel monocoil.

**Fiber core sizes :**

- Single Fibers: 50um, 100um, 200um, 400um, 600um and 1000um. Other core sizes (up to 1000nm) are possible
- Bifurcated Fibers: 100um, 200um and 400um.

**Sheathing options :** PVC with Kevlar reinforcement , PVC Monocoil (Standard) , Flexible stainless steel interlock , Polyimide Tefzel , Acrylate , Nylon

**Connector options :** SMA-905 (Standard) , 10mm ferrule , FC (Standard) , Other custom connectors are available



**Part number Notation :**

## 1. Standard Fibers

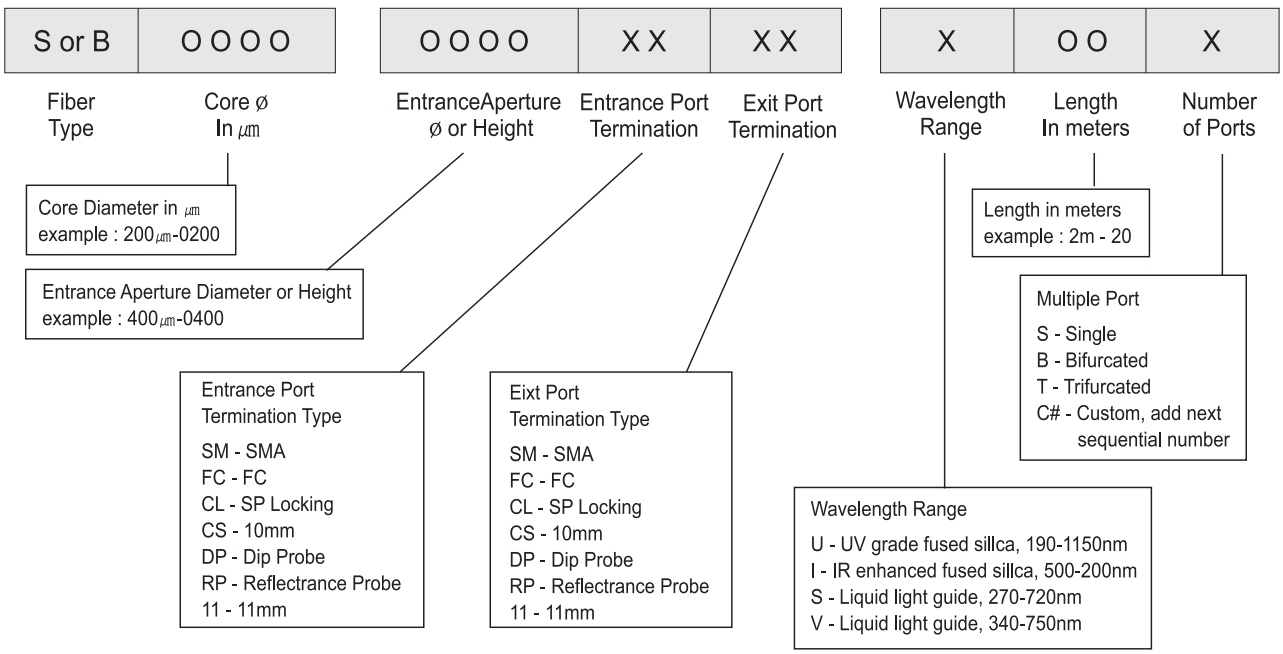
## (S or B)F(OOOO)-(XX)(YY)-(U or I)(oo)(-NS)

| Keyword | Description |
|---|---|
| **Fiber Type (S or B)** | Single Fiber: SF<br>Bifurcated Fiber: BF |
| **Core Size (OOOO)**<br>**Connector Type (XX)(YY)** | OOOO micron, ex) 0600: 600um<br>SMA-905: SM<br>FC: FC<br>ex) SMFC: one SMA-905 end and one FC end<br>Note :<br>In case of the bifurcated fibers, "XX" is for the bifurcated ends and "YY" is for the joint end. |
| **Wavelength range (U or I)**<br>**Fiber length (oo)**<br>**Non-solarizing option (-NS)** | U : UV / VIS (250-1150nm), I: VIS / NIR (400-2250nm)<br>oo : oo/10 meter, ex) 20: 2.0m, 15: 1.5m<br>NS : Non-solarizing for deep UV (190-1150nm) |

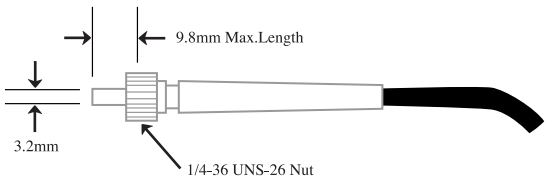
Ex)
SF0100-SMFC-U20 : single fiber, 100um core size, SMA (905) to FC fiber connection type, UV / VIS range, 2.0m length
BF0200-FCFC-I10 : bifurcated fiber, 200um core size, FC to FC fiber connection type, VIS / IR range, 1.0m length

## 2. Special Fibers

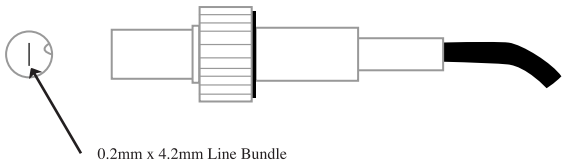
| Part Number | Description |
|---|---|
| AF5000-50001111-DUV10S | Liquid-guided, Round-Round, 0.43 NA (1.2 F#), Ferrule, 1m, S Type (220nm ~ 600nm) |
| AF5000-50001111-UV-Vis10S | Liquid-guided, Round-Round, 0.59 NA (0.85 F#), Ferrule, 1m, V Type (300nm ~ 650nm) |
| AF5000-50001111-Vis10S | Liquid-guided, Round-Round, 0.59 NA (0.85 F#), Ferrule, 1m, V Type (340nm ~ 800nm) |
| AF5000-50001111-Vis-NIR10S | Liquid-guided, Round-Round, 0.52 NA (0.96 F#), Ferrule, 1m, I Type (420nm ~ 2000nm) |



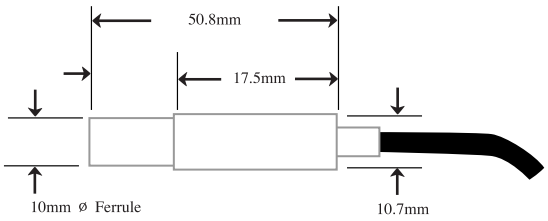
SMA



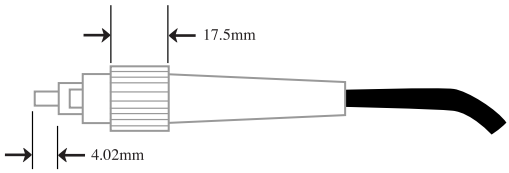

SP Locking Ferrule (Line)

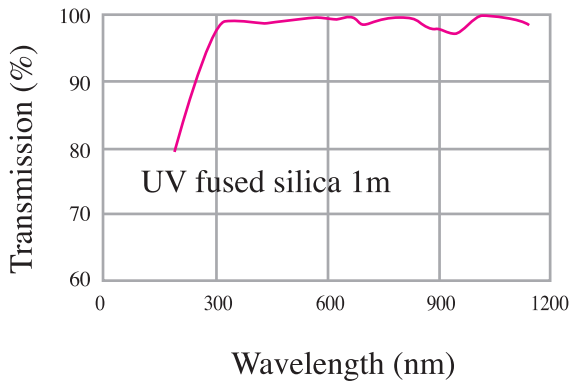


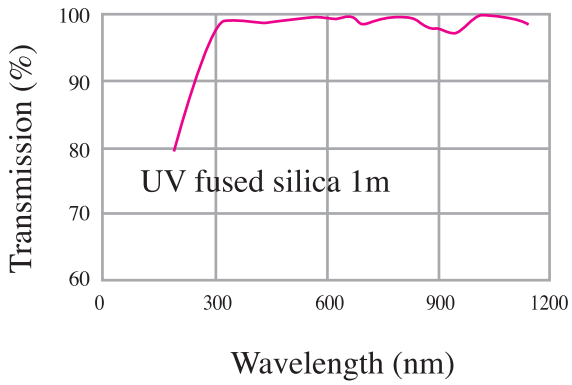

10mm Ferrule




FC



# AF-L Series

## f/# Matching Fiber Optic Adapters

- High efficiency.
- Enables precise alignment.
- Provides a broad spectral range with UV grade lenses.
- Allows quick connect/disconnect while maintaining alignment.
- Use on input or output ports.
- Connects SMA, FC/PC, ST, or 10mm diameter Fiber Connectors.

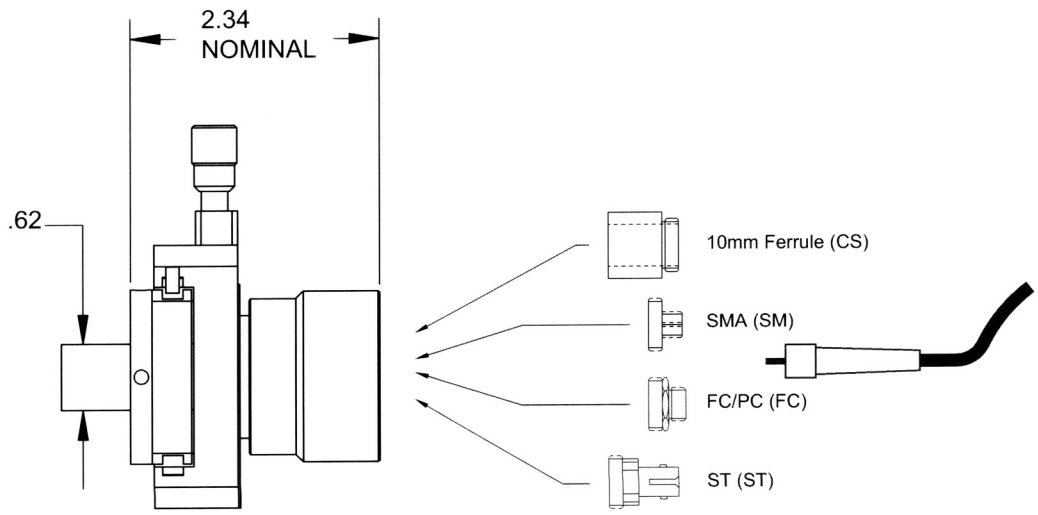

The AF-L Series of Fiber Optic Adapters will optically match the Numerical Aperture of a SP fiber (NA 0.22) to the f/# of a SP Monochromator or spectrograph while mechanically joining the two.

As an input adapter, the AF-L Series focuses the light from the fiber onto the entrance slit. The magnified fiber image fills more of the slit. All of the light entering the slit strikes the grating. The efficiency of this coupling is 4 to 20 times better than a direct non-matched coupling.

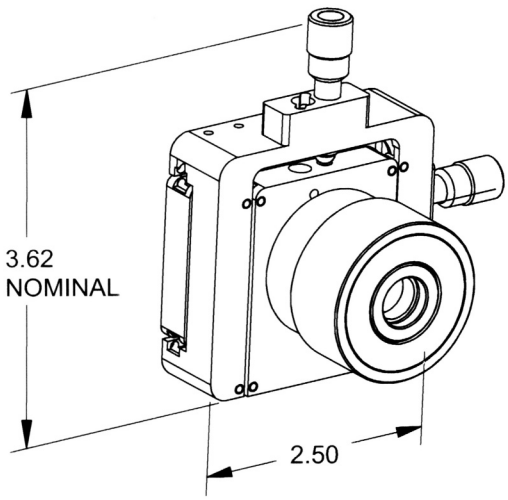
As an output adapter, the AF-L Series focuses the light from the exit slit onto the fiber. The demagnified slit image concentrates light onto the fiber's face and takes advantage of the fiber's "faster" collection angle. The efficiency of this coupling is 2 to 4 times better than direct non-matched coupling.

These dramatic increases in efficiency support applications where low light levels make direct fiber coupling impractical. Fluorescence analysis, spectral analysis of LEDs and laser diodes, and detector characterization all benefit from this efficiency. Fibers used as detection probes with the AF-L Series can take full advantage of their inherent wide acceptance angle for increased light collection. Fibers used as illumination probes with the AF-L Series can deliver up to 4 times more intensity than with direct coupling. In addition, the fiber will illuminate over its full Numerical Aperture.

The AF-L Series **allow three axes of precise fiber translation translation**. Precision of better than 0.001" in linear movement is typical. Because UV lenses are standard, the AF-L Series provides better than 90% transmission from 200nm to 1900nm.




*Dimensions in inches*




## Specifications :

Adjustment :

X and Y Axes : 80-pitch adjustment screws, 0.0002" linear movement for 5° of adjustment screw rotation; 10mm range

Z-Axis : 0.0005" linear movement for 5° of collar rotation; 5mm range

Wavelength Range : 200-1900nm @ >90% transmission

Warranty : One year

Ordering Information: Please indicate product number plus description when ordering.

f/# matching Fiber Optic Adapter for CMSeries monochromators/spectrographs

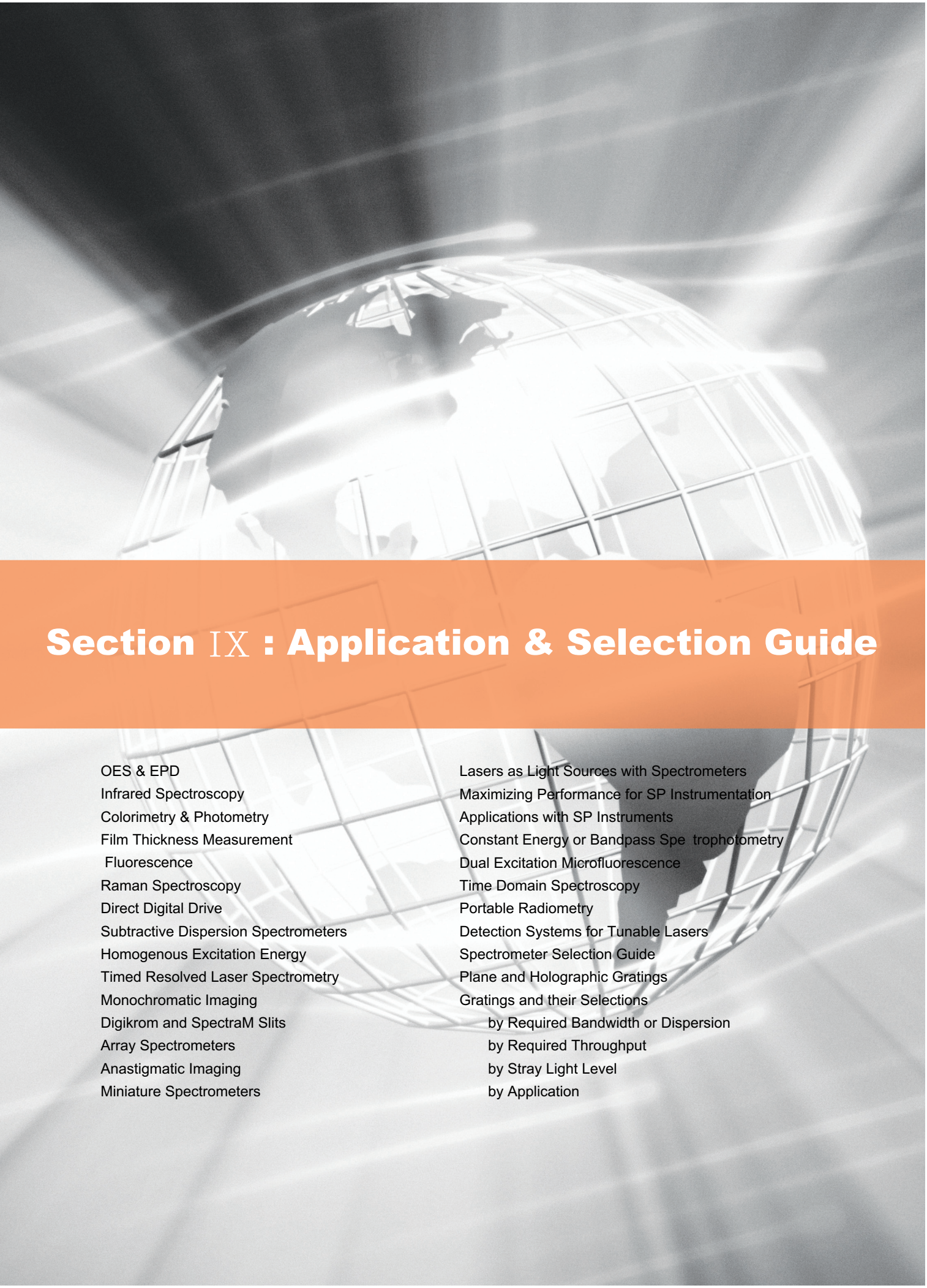
AFCM-L-SM with SMA end plate
AFCM-L-FC with FC/PC end plate
AFCM-L-ST with ST end plate
AFCM-L-CS with 10mm ferrule end plate

f/# matching Fiber Optic Adapter for DK240/DK242 monochromators/spectrographs

AFDK240-L-SM with SMA end plate
AFDK240-L-FC with FC/PC end plate
AFDK240-L-ST with ST end plate
AFDK240-L-CS with 10mm ferrule end plate

f/# matching Fiber Optic Adapter for DK480 monochromators/spectrographs

AFDK480-L-SM with SMA end plate
AFDK480-L-FC with FC/PC end plate
AFDK480-L-ST with ST end plate
AFDK480-L-CS with 10mm ferrule end plate



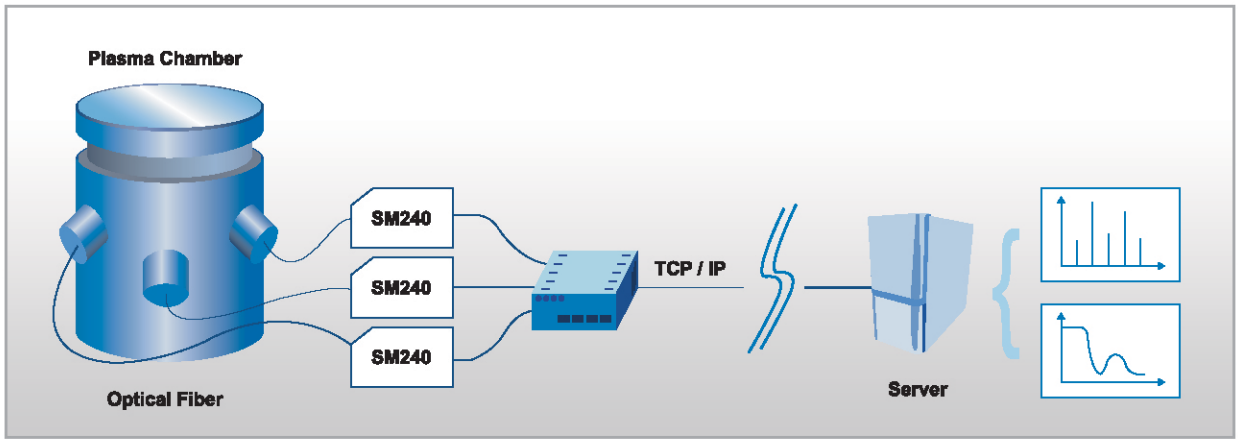
# Section IX : Application & Selection Guide

# OES & EPD

In semiconductor manufacturing, spectrometers can measure the emission spectrum from a plasma chamber in real time and can be used for the diagnosis of manufacturing processes and analysis of materials such as OES(optical emission spectrometer) and EPD(end point detection)

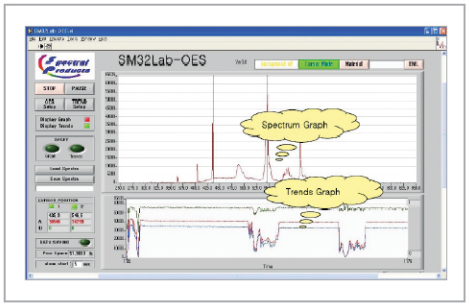
Spectrometers monitor time trends of specific wavelengths related with gases in plasma chambers. The manufacturing process can be optimized by the detection of a change in the plasma state, control of the process variables, and leak detection.

SPOES(self-plasma optical emission spectrometer) combines a plasma generator and an OES system. It can also be used for diagnosis of non-plasma process. Our spectrometers (SM240 etc) are used for sensing modules of SPOES systems. Our NIR spectrometer (SM303-InGaAs etc) can be used for analysis of NIR phenomenon of gases in plasma chambers.




| Diagram of Application |


| Multi-Channel OES System with SM240 |



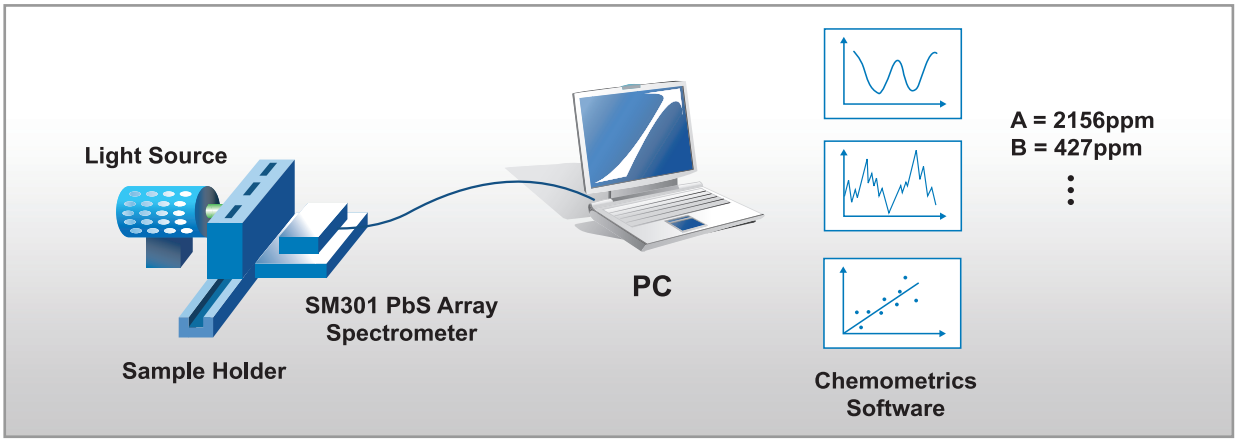

| OES & EPD Software |

| Near-infrared Spectrum of Gases in Plasma Chamber |

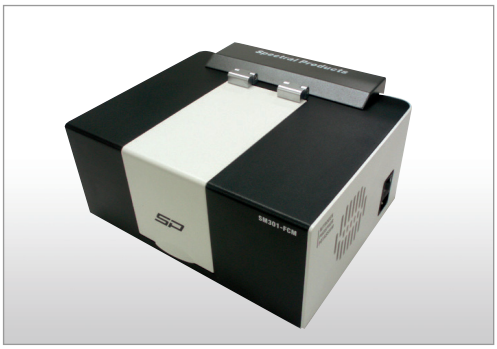
# Infrared Spectroscopy

Our NIR(Near-Infrared) spectrometers use various NIR array detectors(InGaAs, PbS, PbSe) and measure spectral ranges from 0.9um to 5.0um. By measuring the NIR spectrum, we can analyze the components of a material quantitatively. With scientific algorithms like chemometrics, we can realize higher repeatability and faster analysis than traditional physical and chemical analysis methods.

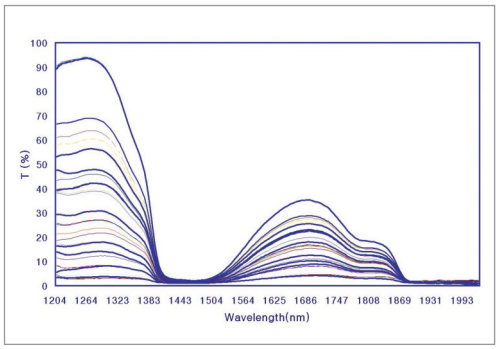
We developed an NPK analyzer with our NIR spectrometer (SM301) to measure the amount of nitrogen, phosphor and potassium in livestock liquid manure. It analyzes the correlation between acquired values from traditional physical and chemical method and NIR spectrum data with statistical algorithms.



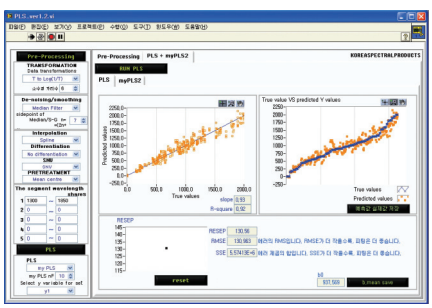

| Diagram of Application |



| Near-Infrared NPK analyzer |




| Software of NPK analyzer |

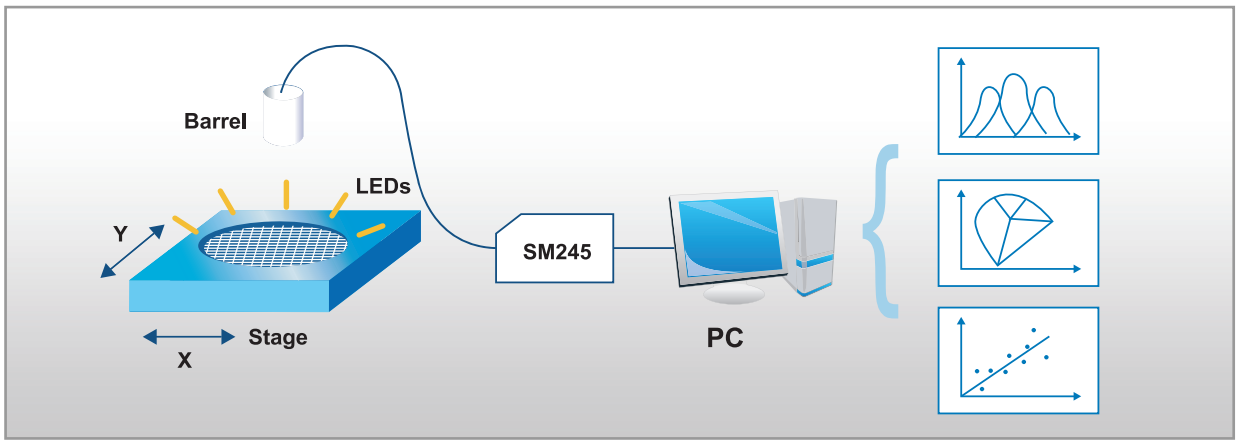


| Chemometrics Algorithm |

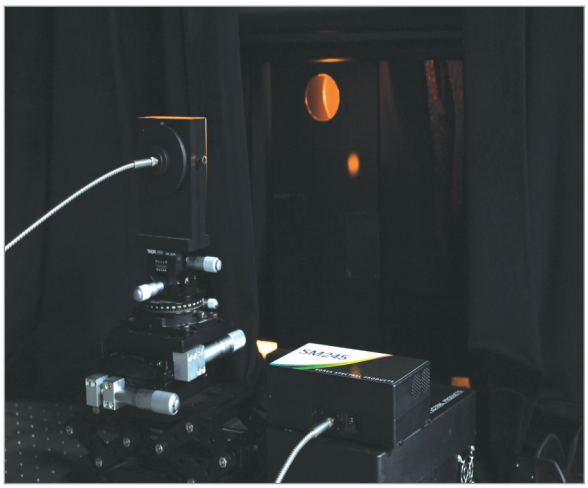
## Colorimetry & Photometry

Spectrometers can measure and analyze colorimetric and photometric characteristics of LED (Light-Emitted Diode), OLED(Organic LED) and display devices. By quantitative analysis of radiometric and photometric values, we can measure optical properties and maintain the quality of color devices using CIE color coordinates.

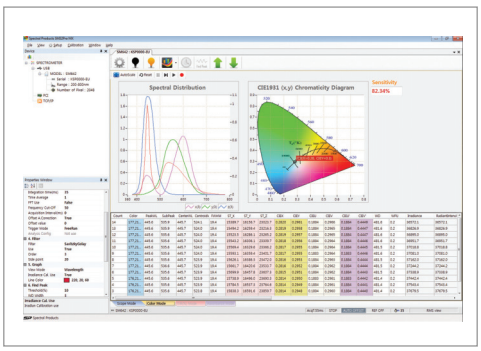
Now, the demand for LED light sources is tremendously explosive and our spectrometers are widely being used in various LED measurement systems for standardized color quality control in industrial field.




| Diagram of Application |



| Simple Measurement System for CIE color values |

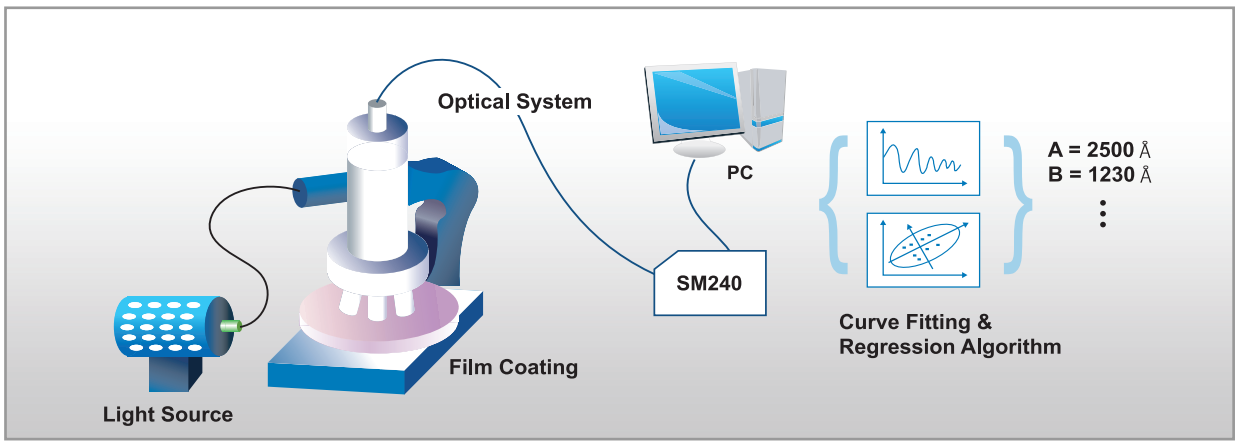


| Software for Color Measurement |

# Film Thickness Measurement

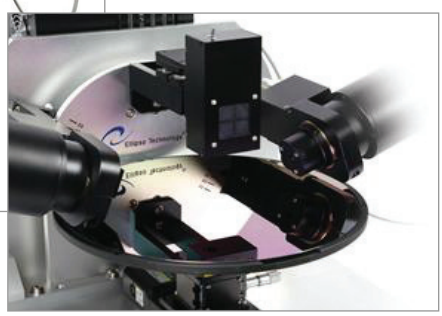
By use of our spectrometer in reflectometric and ellipsometric systems, we can measure film thickness, index of refraction, and various optical properties of films.

Spectrometers are being used in the manufacturing of semiconductor and display devices, optical monitoring of optical coating, and SPR(surface plasma resonance) systems. As well as spectrometers, our monochromators (CM110 etc) are used as the main OEM module for semiconductor inspection and spectroscopic ellipsometer systems.



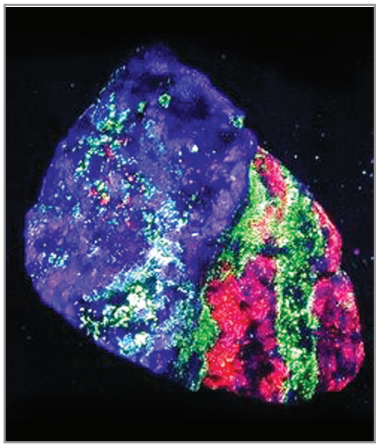

| Diagram of Application |

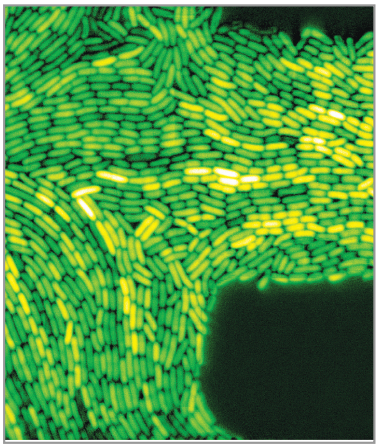
| Spectroscopic Ellipsometer |



| Spectroscopic Ellipsometer |

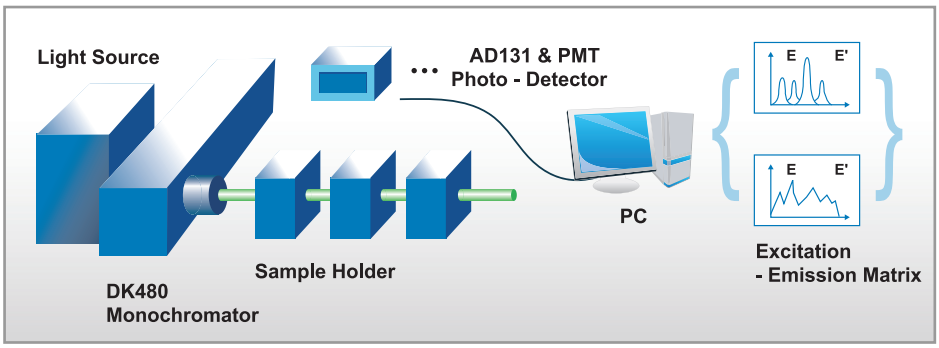
## Fluorescence





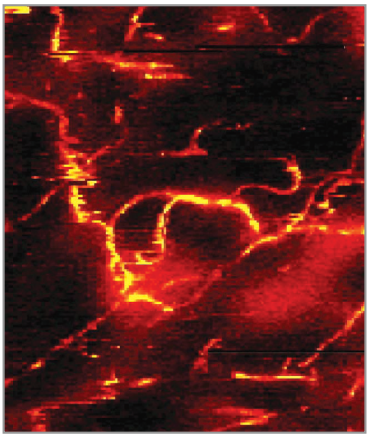
The measurement of fluorescence, phosphorescence, and opto-chemical emission spectrum are required in many applications like organic and inorganic fluorescence property studies, chemical property analysis, and the research for the components and their lifetimes of some gases.

The array detector based or monochromator based spectrometer systems are basically used in this field. And the application of the spectrometers is being expended to the studies of the DNA structures and testing the condition of foods, and many more biological and medical applications.?Our spectrometers are also used in various luminescence applications.




| Diagram of Application |

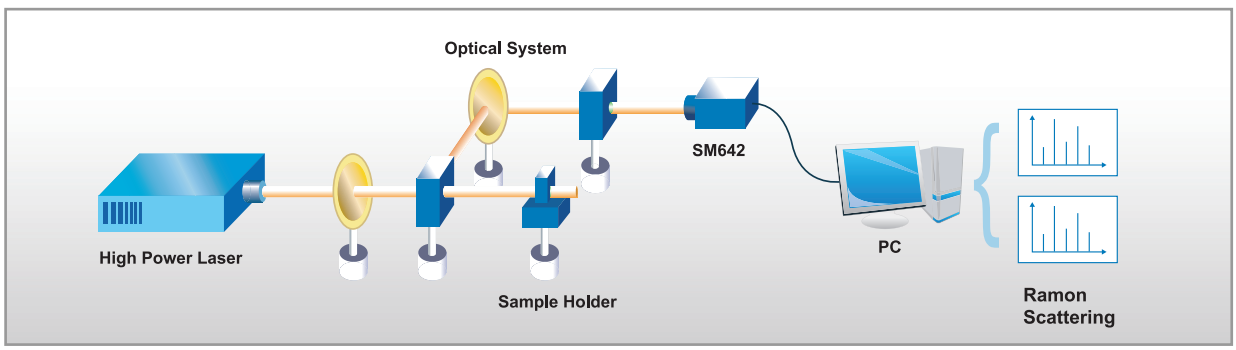
# Raman Spectroscopy



Spectrometer systems are also the basic instruments for measuring Raman scattering in the chemical components analysis, the researches for the structure, stability and biological properties of various materials. Because there is no interference between Raman scattering and water, Raman spectroscopic method can acquire a lot of information from any solid, liquid and gas materials more easily than any traditional FT-IR methods.

There are a lot of needs for the portable Raman systems in these days. Spectral Products' back-thinned TE Cooled CCD spectrometer (SM303) has a compact design with high signal to noise ratio and high dynamic range so it can be a good candidate for the portable Raman applications.

The Fluorescence and Raman spectroscopy require good cut-off filters. With the accumulated experiences of our Optics Division (Spectral Optics) in the optical coating industry, we believe that we can serve and fulfill customers' requirements and demands in confidence.




| Diagram of Application |

# Direct Digital Drive for Digikrom Products - Simple, Rugged, Reliable

In 1987 We introduced the first change in grating drives in more than 50 years. Using digital electronics, We replaced the unreliable mechanical linkages that were used to translate the rotary motion of the drive motor into the sine motion needed for wavelength linearity. Photo 1 shows a typical direct drive grating table that SP manufactures. SP named this method Direct Digital Drive and incorporated it into a new line of Digikrom monochromators and spectrographs.

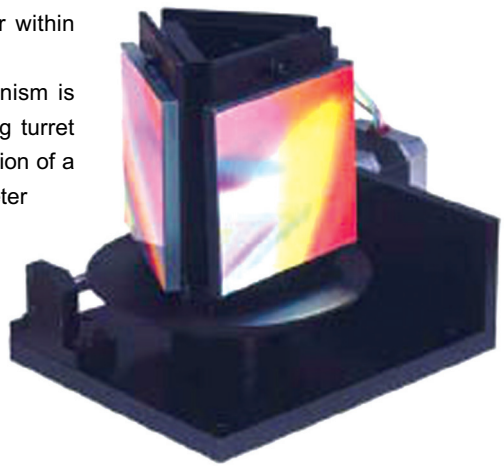
The equation relating grating angle ($\theta$) and wavelength ($\lambda$) is the well known non-linear equation,

$$m\lambda \quad 2d\sin\theta\cos\varnothing/2$$

where $\varnothing$ is the angle between the central incident ray and the central exiting ray that reaches the exit slit, and $\theta$ is the grating rotation from zero order.

In a spectrometer the rotary motion of the drive motor and associated reduction gears linearly determines theta. In sine-drive instruments a second mechanism, a cam or a sine arm, creates the sine function.

SP Laser replaced the mechanical sine mechanism with digital electronic calculation of sine (theta). When a wavelength is input to a Digikrom monochromator, the internal microprocessor calculates the required sine (theta) and the corresponding angle theta. In about 500 microseconds this calculation finds the number of stepping motor steps required to reach the angle corresponding to the wavelength. This would not have been possible without the microprocessor revolution that permits inclusion of a micro-controller within each instrument at a reasonable cost.



The advantages of Direct Digital Drive are significant. The mechanical mechanism is simpler and more reliable. Calibration is easier and more accurate. A multi-grating turret with automatic grating change becomes a simple, inexpensive option. Finally, inclusion of a micro-controller with each spectrometer makes computer control of the spectrometer easy. These advantages come with a price reduction because of the replacement of expensive mechanical parts with inexpensive, reliable electronics.

Both Direct Digital Drives and conventional sine drives use a stepping motor, which typically rotates 0.9 degrees per step. The stepper motor rotation is reduced via gear reduction. But, at this point the traditional sine-drive becomes complex.

In the traditional sine-drive, the gear reduction is typically a 5:1 worm and wheel. This output then rotates a lead screw that moves a nut along the opposite side of a right triangle. A precision slide is needed to prevent the nut from rotating as it translates. A hypotenuse arm pivots around the axis of rotation of the grating to follow the nut. As the arm pivots, it rotates the grating proportional to the sine of the angle.

In Direct Digital Drive, a 120:1 worm and wheel gear reduction connects the stepping motor directly to the rotational shaft of the grating. No other mechanism is necessary. Only a single precision worm and wheel is used. There are fewer parts to wear or break and no tolerance errors accumulate as in cascaded mechanisms.

Calibration is easier with the Direct Digital Drive. Only two points - the slope and intercept - need to be specified to calibrate the grating equation. The intercept is optical zero; at optical zero, theta is zero, m is zero, the grating acts like a mirror, and the spectrometer transmits white light. The slope, $2d\cos\varnothing/2$ is found from the angle $\theta$ at a known wavelength.

In the traditional sine drive it is quite difficult to make the mechanical zero of the sine function mechanism equal to the optical zero. While optical ero can be determined precisely as the point of specular reflection, the mechanical zero can only be determined with mechanical gauges or complicated calculations derived from the errors at multiple calibration wavelengths. In fact, a separate rotational adjustment is needed on each grating in a sine-drive system to make the mechanical and optical zeros coincide.

In Direct Digital Drive, the sine function is electronic, and the electronic sine function is reset to begin at the optical zero. The correspondence between the optical zero and the zero of the sine function is then exact. When power is applied to a SP Spectrometer, a predetermined position in the mechanical rotation - the home position - is detected. The grating then rotates to optical zero. The offset angle between home and optical

zero has been previously stored in the microprocessor memory. If the optical zero is incorrect - for example, if gratings were changed - the user commands further grating rotation until optical zero is identified. The micro-controller remembers the new offset angle. Calibration is thus simple and exact.

Direct Digital Drive also allows the option of a multiple grating turret with automatic grating change, see Photo 1. This is a tremendous advantage when a wide spectral range needs to be covered because the entire range can be studied without disassembling, realigning and recalibrating the spectrometer to replace gratings.

The worm and wheel mechanism allows 360° rotation of the grating turret, so it is possible to have two or more gratings on the same turret. This is not possible with the traditional sine-drive, which is limited to about 70 degrees of total rotation. Direct Digital Drive makes the multiple grating turret simple and inexpensive.

In addition, with proper design of the dual or triple grating turret, no vignetting results from the translation on the front face of the grating as it rotates around the central axis. The final enhancement of the Direct Digital Drive is the additional capacity inherent in including a micro-controller in the spectrometer. The included micro-controller allows a simple interface, motorized slit control and automatic grating change at little additional cost. The simple interface is the biggest advantage. It is now unnecessary for the user to build a stepper motor interface or to buy additional motor drive boxes. The micro-controllers in Digikrom spectrometers accept simple commands over an RS232C serial interface from any computer.

The advantages of Direct Digital Drive are clear. The mechanics are simple and more reliable. Calibration is easier and more accurate. A multi-grating turret with automatic grating change is a simple, inexpensive option. Inclusion of a micro-controller with each spectrometer makes computer control easy. Finally, with expensive mechanics replaced by low cost electronics, the price is less.

## Subtractive Dispersion Spectrometers

When we think of a spectrometer we envision white light entering and being dispersed by a prism or grating and exiting in a dispersed spectrum across an arc.This is the archetype of spectral dispersion. If we reverse this process, an arc of color enters the prism or grating and a homogenous white light exits. This reversal is called spectral recombination. When we couple this spectral dispersion followed by spectral recombination we have created an optical curiosity called subtractive dispersion.Today, time-resolved spectroscopy and imaging applications are reviving interest in this technique. (Figure 1) Two Digikrom models, the DK242 and the CM112, employ it.

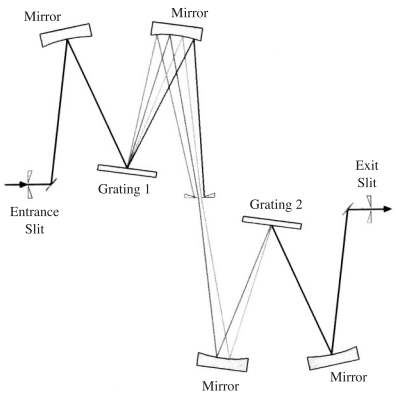



Figure 1. Diagram of a subtractive monochromator.

A simple subtractive dispersion monochromator appears in the figure at right. The instrument consists of coupled grating monochromators. White light enters the entrance of the first monochromator and is dispersed across the shared intermediate slit. The intermediate slit, for example, blocks red and blue but passes yellow and green. The second monochromator is designed for spectral recombination. The yellow and green rays that enter the intermediate slit at different positions and angles are recombined into a beam that is spectrally homogenous across the exit. The second monochromator has no influence on the spectral transmission. The entrance and intermediate slits determine the bandpass. The exit slit is almost superfluous; yet the light emerging from the exit has a very useful uniformity.

## Homogenous Excitation Energy

One of the earliest applications of subtractive dispersion was in the excitation side of spectrofluorometers. In a typical spectrofluorometer, light from an arc lamp is filtered by a monochromator and directed to a sample cuvette (Figure 2). This narrow bandwidth energy induces fluorescence at different wavelengths. A monochromator/detector combination looks at this emitted fluorescence. If the excitation section of the fluorometer uses an ordinary monochromator, then the illumination of the cuvette will vary spectrally with the position of the cuvette.

Subtractive dispersion homogenizes the beam so that each area in the cuvette sees the same spectral excitation, resulting in increased accuracy. Similar considerations apply to both the detection half of fluorometers and to spectrophotometers. In both, subtractive dispersion has been used to make spectral transmission independent of physical position.

A bonus in the use of subtractive dispersion in fluorometry is reduction of stray light. Stray light in a monochromator originates primarily in scattering at the surface of the grating. Not only is the diffracted light of the desired wavelength directed to the exit slit, but also light that is scattered from scratches, pits, dust and imperfections from the ruling process. The second monochromator acts as a filter for this scattered light reducing it by almost the square of the ratio for a single instrument.

## Timed Resolved Laser Spectrometry

The advent of time-resolved laser spectroscopy in the sub-nanosecond regime has created a new application for subtractive dispersive instruments. A conventional single monochromator introduces not only spectral dispersion, but temporal dispersion as well. The temporal dispersion originates in the unequal optical path lengths in the diffraction from the grating.

In Figure 3, the plane wave AB strikes the grating and the diffracted wave is CD. The path of the light that is diffracted from the left edge of the grating, ALC, is longer than the path of the light that strikes the right edge of the grating, BRD. The path difference, W * sin $\theta$, gives a temporal dispersion of W * sin $\theta$/c. With a typical 68mm wide grating used near 30 degrees, a temporal broadening of l00 picoseconds is the result. A subtractive dispersion instrument removes this instrumentally induced temporal dispersion. The second monochromator introduces an equal and opposite delay across the face of its grating. The degree of cancellation is only limited by the optical aberrations of the systems. In the DK242 and CM112, sub-picosecond residual broadening results.

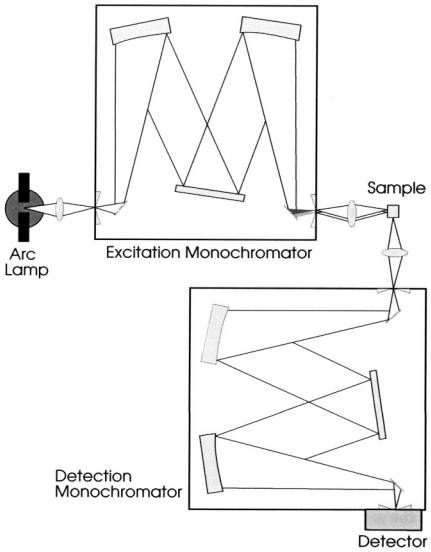



Figure 2. Diagram of a typical fluorometer.

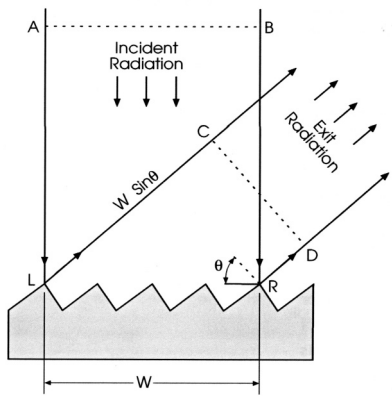



Figure 3. Temporal broadening caused by a grating

## Monochromatic Imaging

Monochromatic imaging can also benefit from subtractive dispersion. Imaging objects at monochromatic wavelengths has grown from its roots in the Lyman-alpha mappings of the sun. Fluorescent imaging of biological materials now permits direct measurements of positively charged ion concentrations in living cells. Combustion analysis also relies upon optical mapping. In many cases this mapping is being done with filters because of the image smear introduced by a conventional monochromator. Imaging through monochromators uses one of two methods: the object is imaged near the entrance slit, or the object is imaged on the grating (at infinity). In the first method, different wavelength images overlap at the exit slit. In the second method, the monochromatic images that are passed by the monochromator exit at wavelength dependent angles.

The subtractive dispersion instrument cancels both effects, making either form of monochromatic imaging possible. Unlike the conventional monochromator, the subtractive dispersion instrument offers a one-to-one wavelength-independent correspondence between the positions and angles of rays at the exit and entrance.

The Digikrom double monochromators employ a single intermediate slit, housing the two optical paths in one integral unit. This maintains the integrity of the stray light and imaging capabilities while offering ease of use and compactness. As you can see, subtractive dispersion is becoming a more commonly used technique today. Keep it in mind, whether your application is fluorescence, spectrophotometry, time- resolved spectroscopy or monochromatic imaging.

## Digikrom and SpectraM Slits - Adjustable and Fixed

Fixed-interchangeable slits are available on all SP eighth-meter monochromators and spectrometers. Computer controlled variable slits are standard on quarter-meter and larger monochromators and spectrographs. In both cases the slit jaws are thin, typically 25 microns, to reduce tunneling. The materials selected are durable, typically stainless steel, molybdenum, or berylliumcopper. The fixed slits are precisely manufactured so that the width and jaw parallelism is exact to within 5 microns for wide slits and 2 microns for slits with a width of less than 50 microns. The adjustable slits are interferometrically adjusted at SP to better than 2 micron parallelism and width accuracy.

Separation of the slit jaws must be precisely known so that the bandwidth will be exactly known. The slit jaws must be parallel so that the bandwidth for light will be the same at the top and bottom of the slit. The entrance and exit slits must be parallel because the entrance slit is imaged onto the exit slit as the grating is rotated. The slit jaws should be thin compared to their separation, so that tunneling does not reduce the acceptance angle of incident light.

The adjustable slits are computer controlled. A stepping motor and precision lead screws are used to change the separation of the slit jaws thereby adjusting the slit width and the monochromator bandpass. When power is first applied to the instrument, the slit jaws automatically self-calibrate then assume a 50 micron separation. The user from a controller or computer may then program slit width and therefore bandwidth.

## Array Spectrometers - Multi-channel Detection with Impr Improved Signal to noise

In recent years the combination of array detector and spectrograph has become the system of choice for spectroscopy. The major advantage of the array detector is improvement in detection signal-to-noise (S/N) ratio.

An array of N elements has the capability of collecting N times the signal of a single detector. Observation of N units of time with a spectrograph allows a potential improvement in S/N to $N^{\frac{1}{2}}$ opposed to a single detector sampling for one unit of time. Alternatively, N wavelength bands can be sampled in just 1/N the time required for a single detector to do sequentially for identical S/N. This is termed the Fellgate advantage.

In practice the improvement in S/N may be reduced due to the following reasons:

1) Currently available array elements have limited heights, for example 1 to 2 millimeters at most as opposed to 10 to 20 millimeters for a non-array detector.
2) Frequently, only 20% of the array elements have an interesting signal.
3) The switching noise associated with the multiplexed readout of some arrays will frequently double the noise level.
4) When the array element width is smaller than the desired bandwidth, several elements must be combined.

Combining the above effects implies a reduction in the estimated improvement by a factor of 10 to 300. Therefore, for an array with small number of elements, this improvement becomes insignificant.

Array detection has some other advantages. Very rapid multiple wavelength sampling is possible. Moving parts as in a scanning monochromator are eliminated.

SP provides the Digikrom line of high performance spectrographs and a wide selection of CCD and InGaAs cameras covering spectral ranges from UV to NIR.

Our SpectraM product line suits your need for a compact, low cost and high performance CCD spectrometer.

(a) (b)

Figure 4. Entrance slit images at the exit with
(a) regular optics and, (b) anastigmatic optics

## Anastigmatic Imaging - Keeping the Images Sharp

Spectrometers, like other optical instruments, exhibit aberrations. Coma, spherical aberration and astigmatism are usually the worst offenders to a spectrometer performance. A spectrometer such as a Czerny-Turner spectrometer employs a diffraction grating together with collimating and focusing mirrors. Any aberration introduced by the mirrors will be transformed by diffraction to the exit focal plane. Using appropriate design parameters can compensate coma in a Czerny-Turner spectrometer. Astigmatism causes a point at the entrance slit to extend tangentially at the exit after image transfer, see Figure 4(a). This extension is primarily attributed to the higher order aberrations associated with the use of spherical mirrors. In a spectrograph application a two-dimensional detector array is usually employed at the exit focal plane of a spectrometer. The astigmatism can thus cause a serious energy spread. limiting the multi-channel spectrometer to a device for virtually single input at the entrance. SP Digikrom series spectrographs offer astigmatism corrected options. The use of specially designed aspherical optics corrects for astigmatism in the wavefront produced by spherical mirrors, Figure 4(b). The anastigmatic optics in turn result in highly energy concentrated images at the exit and tightly focused spots. Multiple inputs along the entrance slit are thus made possible with SP anastigmatic spectrographs.

Figure 5(a) demonstrates a multiple spectral input Raman application by use of a SP spectrograph equipped with a two-dimensional CCD camera. Four fiber inputs are presented at the entrance as shown in Figure 5(b). SP anastigmatic spectrographs allow for inexpensive versatile and multi- functional spectro scopic applications.

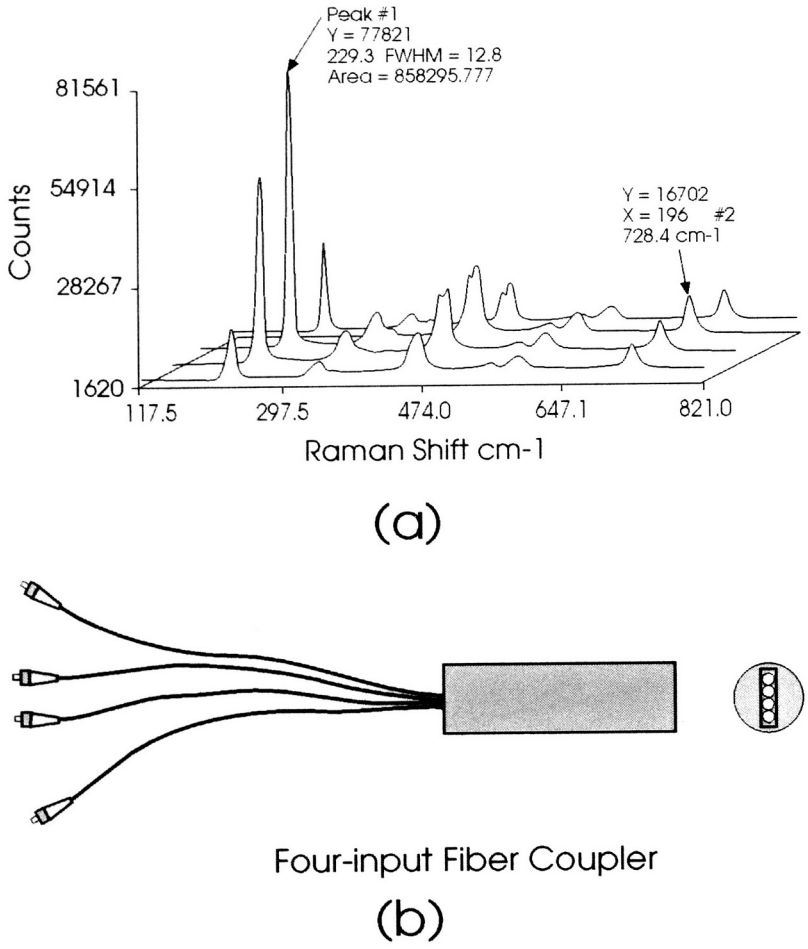



Figure 5. Raman spectrometer with anastigmatic imaging and a multiple input fiber.

## Miniature Spectrometers - Compact, Stable, Sensitive, Unique and Low Cost

SP SpectraM miniature spectrometers are packed with great features and performance in a small footprint. The SM series spectrometers are based on a crossed Czerny-Turner configuration as shown in Figure 6. A light input through the slit, either fiber coupled or direct coupling is collimated by the first mirror and directed to a diffraction grating. The diffracted ligh is collected by the camera mirror and focused onto a detector array for detection. The spectrograph is enclosed in a rugged aluminum housing for stability. Connections between the spectrometer and the computer interface are made via a shielded electrical cable. Detector arrays are also included in the same housing in hand held versions. SM spectrometers can be interfaced to computers via ISA, PCI, PCMCIA, etcetera. By use of a PCMCIA interface with a notebook computer, Figure 7, the SM spectrometers place a powerful portable spectrometer system at your fingertips.

It is known that all detectors exhibit “dark signals” originated from thermally agitated electrons. A temperature increase of 7°C can result in a doubled dark signal in a silicon-based detector. SP offers cooled SM spectrometers for greater temperature stability for demanding applications. Uncooled SM spectrometers are also available for low cost detection use. The separation of the spectrometer module from a heat source such as a computer ensures reasonable temperature stability.

SM spectrometers employ detector arrays with high sensitivity. A sensing element height of 200mm to 2.5mm maximizes the detector light collection capability. A cylindrical focusing lens in front of the detector array further enhances the effective pixel size. In addition, for UV and near IR regions where silicon detector response is inherently weak, we provide a variety of sensitivity enhancement coatings for detector arrays. Our pioneering optics and coating technologies also allow us to take another step further to reduce energy lost between optical surfaces.

As discussed before, all gratings generate higher orders. By use of SP°Øs unique variable filters in SM spectrometers, a wide simultaneous wavelength coverage is achieved free of higher order interferences. Our continuous product development effort is adding to the uniqueness of our spectrometer line everyday. For example the compact double Czerny-Turner spectrometer from SP, which needs only one detector array, is the first in the world.

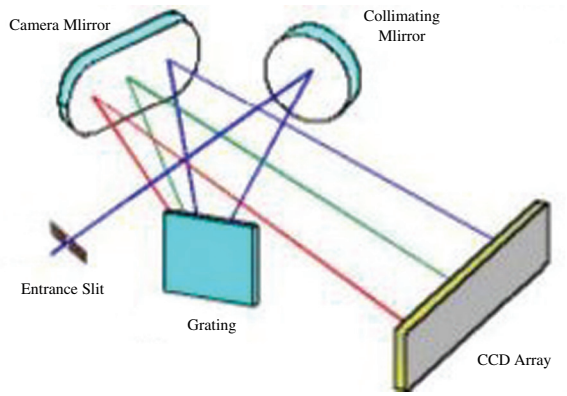



Figure 6. Diagram for a crossed Czerny-Turner spectrograph as employed in SM spectrometers.

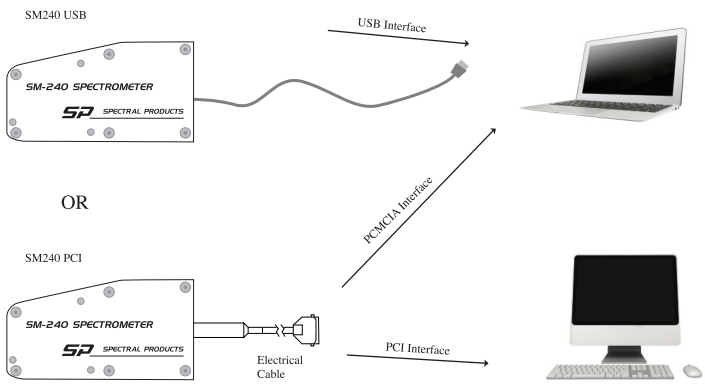



Figure 7. Diagram for SM computer-based miniature spectrometers.

## Issues with Using Lasers as Light Sources with Spectrometers

1. Underfilling the grating. The resolution of a monochromator is limited by the number of grating grooves that are illuminated. Written mathematically:

R mN

As an example, an unexpanded HeNe laser with a beam diameter of about 0.3mm used directly on a 1200 groove-per-millimeter grating in a monochromator will have a best resolution of:

633.2 [nm]/(1200 * 0.3) 0.8[nanometer]

Expanding a 0.3mm laser beam to fill a 68mm grating can be difficult. One of the simplest ways is to place a diffuser near the slit or use an integrating sphere, and illuminate that diffuser with a moderately expanded beam. For an f/4 monochromator with a diffuser 4 millimeters from the slit, the beam spot on the diffuser needs to be only a 1 millimeter diameter.

2. Melting the slits. The slits of monochromators are typically stainless steel that tapers to a 0.001" thickness at the tip. Experience with pinholes has shown that even a few hundred milliwatts (CW) or a fraction of a Joule (Pulsed) will melt 0.001" thick stainless steel. The best solution is to use a beamsplitter to send only a small fraction of the beam to the monochromator. The 0.3% reflection from an antireflection coated plate is usually more than sufficient for measurement. Another solution is to not use the slit. The laser beam, focussed at the slit plane, will act as its own slit. Be warned, however, that the laser beam will be refocussed by the monochromator at the exit slit. That exit slit then is in danger of melting.

3. Melting the grating. Grating surfaces are typically micron thick aluminum that is bonded to the glass substrate by a thin epoxy resin; the aluminum will have about 6% absorption. At high CW powers (about 20kW/cm$^2$) the thermal heating due to the absorption will cause the epoxy to melt. At high pulsed power (about 2 MW/cm$^2$) the aluminum will ablate. In either case the grating is destroyed.

The solutions are the same as given in cases One and Two above. The power input into the monochromator can be attenuated. The beam can be expanded to use the whole grating area. Note that the area of a 68mm grating, 46 cm$^2$, is sufficient for pulse powers of about 0.1 GW.

## Maximizing performance for SP Instrumentation

SP spectrometers are designed to meet the highest performance standards. To ensure the designed performance is achieved, it is also important that the instruments are set up and optimized.

1. When coupling light into and out of a spectrometer, f# matching is helpful for efficient coupling. f# matching helps to minimize stray light introduced by overfilling the spectrometer optics. In many instances, a simple aperture behind the coupling optics works efficiently for this purpose. Figure 8 depicts a spectrometer light coupling system which uses f# matching optics together with a mechanical aperture.

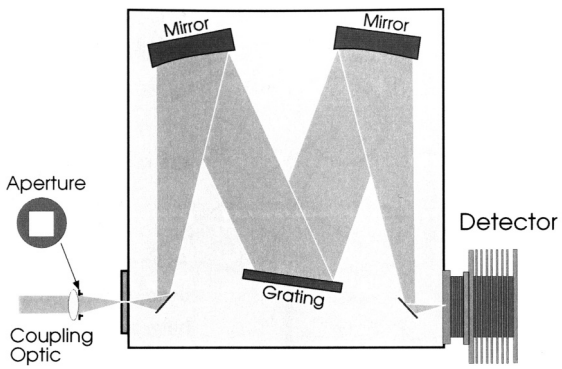



Figure 8. Diagram illustrating the use of f# matching optics and mask for coupling light into spectrometers

2. Incident radiation into a spectrometer with a band broader than necessary may have a negative impact on the instrument°Øs stray light performance. A tungsten halogen lamp, for example, emits radiation from about 320nm to over 2000nm. In applications where only the visible spectrum, 400 to 700nm, is concerned the use of a band pass filter can minimize the stray light arising from dumping the entire band into a spectrometer. Measurement signal to noise ratio can thus be improved.

3. All grating instruments exhibit higher diffraction orders originating from the use of diffraction gratings (see also Spectrometer Basics section). Ignoring the higher orders, especially the second order contribution may result in serious errors. Use of SP filters or filter wheels may remove the second order. The optimum position for the placement of such a filter is in front of the instrument entrance whenever possible.

4. Filter wheels are not limited to order sorting purposes. SP's automatic filter wheels are ideal for usein variable ratio beam splitting, variable beam attenuation and other applications when mounted with appropriate optics.

5. Fibers operate based on total internal reflections, Figure 9. Light transmitting characteristics for fibers may change with bending curvature and positioning of coupling. When fiber input is selected for SP spectrometers it is a good practice to minimize the change in fiber bending curvature during operation. Fibers with precision positioning couplers, such as offered by SP, are highly recommended for repeatability and maximum light coupling.

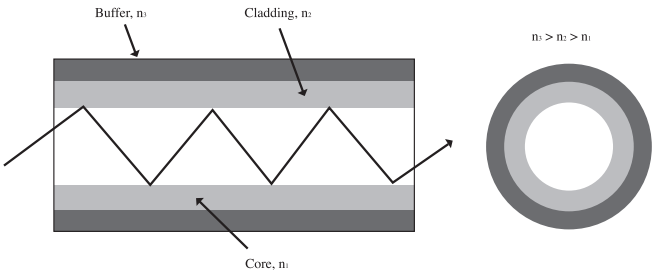



Figure 9. Fiber operate based on total internal reflections

6. When using scanning monochromators be aware that resolution will be lost if data is not collected at sufficiently fine wavelength increments. In a continuous scan mode the maximum scan rate at which the instrument resolution will be maintained is also dictated by the Nyquist theorem. Instrument resolution will degrade with an increase in scan speed exceeding the Nyquist limit.

7. Gratings and other optical components are delicate and precise optics. Any attempt to clean them with inappropriate methods may cause scratches and other damage, leading to performance degradation.

8. The relationship between the slit widths and bandpasses can be calculated by multiplication of reciprocal dispersion with the slit width. For example, a monochromator configured with 0.25 millimeter slits and a grating displaying a reciprocal dispersion of 8 nm/mm has a bandpass of 8 * 0.25  2nm.

9. In array detection on a spectrograph such as a CCD camera mounted onto the DKSP240 spectrograph or a SM240 spectrometer, the minimum resolution element is three array elements (pixels). As pixels are typically 14 microns wide, the effective slit width is 42 microns in this case. This would equate to 0.3 nanometers on a 1/8 meter spectrograph utilizing a 1200 g/mm grating.

## Applications with SP Instruments

SP instrument products have found wide applications in many areas for light illumination, light detection and other usage. It is beyond the scope of this catalog to attempt to cover all these aspects. However for the benefit to our customers, we demonstrate here some general application configurations.

Figure 10 illustrates a tunable light source, which consists of a wide band light source and a SP scanning monochromator. The output wavelength can be programmed for continuous scan or a selected narrow band.

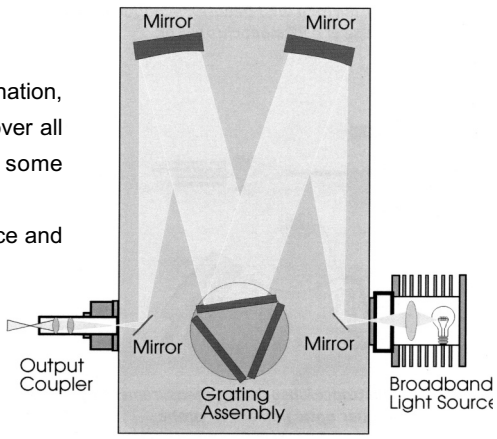



Figure 10. Tunable light source with a SP monochromator

Figure 11 (next page) shows the above tunable light source equipped with a bifurcated fiber for a dual beam type of arrangement. One of the fibers can be used to couple the narrow band light to a sample channel for transmittance, reflectance, absorption or other measurement use. The second fiber directly introduces a portion of the narrow band output from the monochromator into a reference detection channel. Using the reference channel can compensate any possible fluctuation in the output light intensity in the measurement channel, since they are all derived from the same source. In this sense a so-called “dual beam” or “double beam” system can be established. With SP fiber couplers, light can be introduced in and out of SP spectrometers for flexibility and remote capability.

On the next pages, Figures 12 through Figures 18 review some typical application arrangements with SP SM spectrometers for transmittance, reflectance, and emission measurements.

SP's monochromators and spectrographs have features that are unduplicated in any other spectrometers. For this reason, they have been applied in unique applications. The following are a few examples.

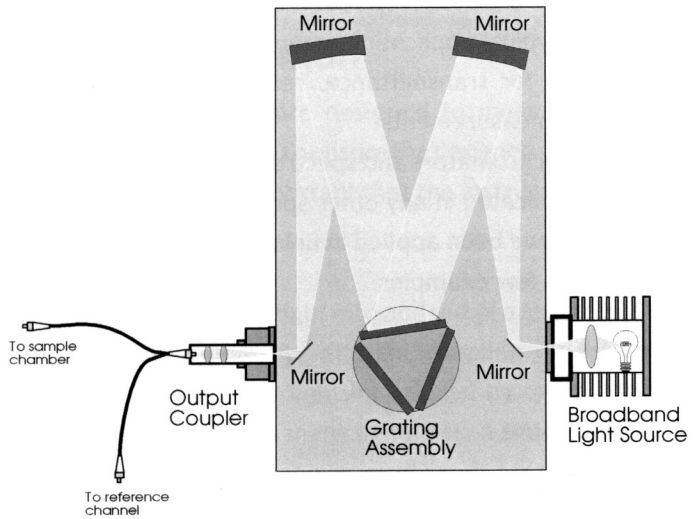



Figure 11. Diagram for a dual-beam illumination source by use of a SP monochromator.

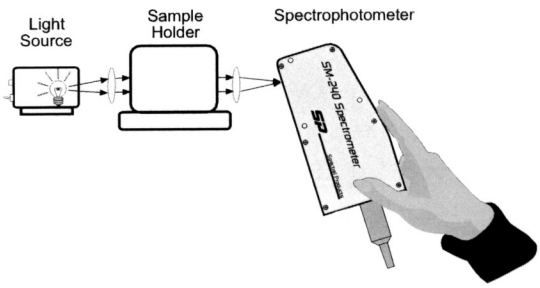



Figure 12. Diagram transmittance / absorbance measurement with SM spectrometers

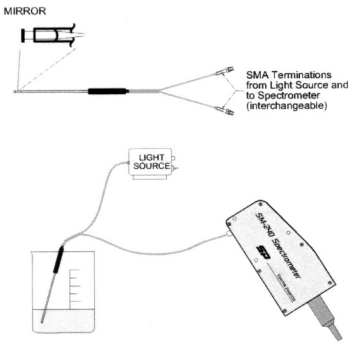



Figure 13. Transmittance / absorbance measurement by use of a fiber optic immersive probe

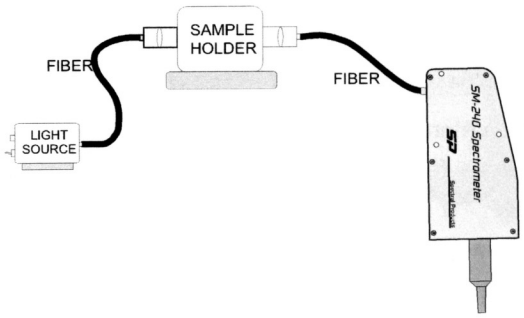



Figure 14. Transmittance / absorbance measurement with SM spectrometers via optical fibers.

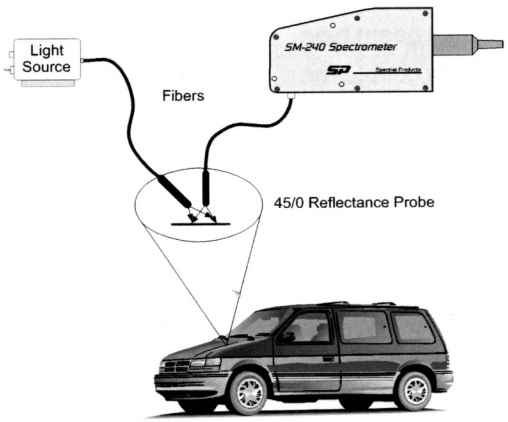



Figure 15. Refiectance measurement with SM spectrometers by use of 45° configuration via optical fibers.

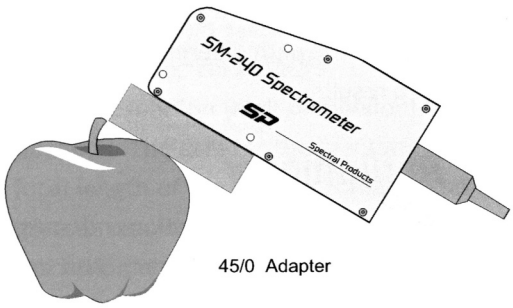



Figure 16. Direct reflectance measurement performed with a 45° attachment and an SM 240 spectrometer

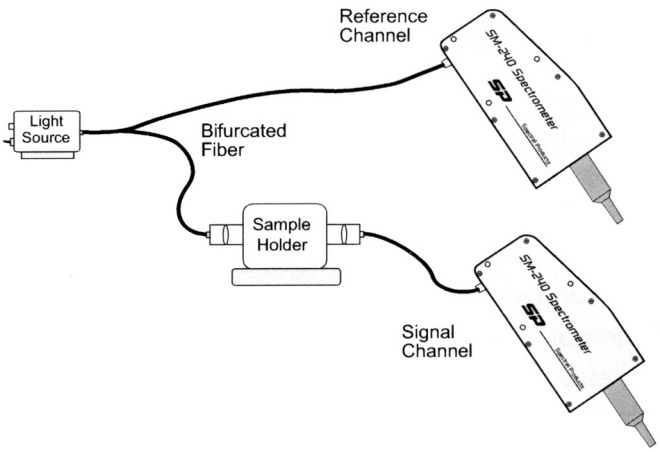



Figure 17. Dual-beam transmittance / absorbance setup involving two SM240 spectrometers connected via fibers.

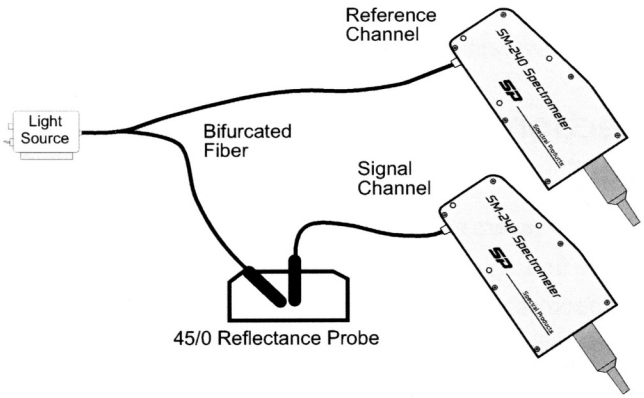



Figure 18. Dual-beam 45° reflectance measurement by use of two SM240 spectrometers via fiber connection.

## Constant Energy or Bandpass Spectrophotometry

The slits in SP's larger monochromators are computer controlled. Usually, the slits are set for a particular width. However, when the monochromator is used in a spectrophotometer it is possible to adjust the slits to maintain constant energy or constant bandpass.

The spectrophotometer consists of a lamp, the monochromator, a sample, and a detector. The overall system response is not flat over the entire spectral range. By adjusting the slit width at each wavelength increment during a scan, constant signal size can be maintained. The same settings can then be used for reference or sample measurements.

In the above adjustment fashion the actual spectrometer bandpass is varied with the slit width since the grating dispersion changes with the wavelength. In applications where constant bandpass is necessary, the slit width on SP monochromators can be adjusted via computer control.

## Dual Excitation Microfluorescence

The compact size and low price of SP's 1/8 meter monochromators enables them to be used in place of filters. The simple, internal computer interface allows these monochromators to be much more than a fixed filter replacement.

For example, in a dual-excitation micro-fluorescence system, two xenon arc lamps direct light into two SP 1/8 meter monochromators. The exits are coupled through fast shutters into two halves of a bifurcated fiber bundle. The exit of the bundle provides fast, tunable, dual-wavelength, epifluorescent illumination for a Zeiss microscope. By using SP's 1/8 meter monochromator, the system has been made compact and computer controlled.

## Time Domain Spectroscopy

Pulsed laser fluorescence spectroscopy is increasingly interesting because of the extra information that the time domain provides. However, if a conventional monochromator is used to clean up the excitation beam or analyze the emission, the monochromator will broaden the pulse by several hundred picoseconds.

Single monochromators introduce temporal dispersion in pulses. The optical paths using the left and right sides of the grating are unequal. SP's double monochromators eliminate the temporal dispersion when used in their subtractive dispersion mode. The optical path differences in the second monochromator entirely compensate for the path differences in the first. Zero temporal dispersion results.

## Portable Radiometry

Field measurements of lamps, reflection and transmission frequently require more range, accuracy and computer compatibility than a commercial colorimeter will provide. With SP's 1/8 meter monochromator and AD130 smart detector, or an SM spectrometer and a notebook computer, a research grade radiometer can be slipped into a briefcase. The briefcase would still have room for standards, notes, and perhaps an AF series fiber optic probe and interface to make sampling easy. Both approaches make a complete computer compatible system in a very small package.

## Detection Systems for Tunable Lasers

Tunable lasers such as Ti:sapphire and optical parametric lasers are finding more applications as excitation sources in laser spectroscopy. SP scanning monochromators and array spectrometers are capable of synchronized detection in such experiments. In one application a Digikrom monochromator was programmed to follow the wavelength scan of an OPO laser for detecting fluorescence. In another setup with a Ti:sapphire laser tuning through a spectral range, an SM spectrometer was used to monitor the laser radiation wavelength in a real time mode.

## A Guide to Spectrometer Selection

The choice of a spectrometer must be guided by the application requirements. The parameters that delineate most applications are listed below:

1. Is the needed output a single wavelength or a dispersed spectrum? Monochromators select single wavelengths, spectrographs have dispersed spectral outputs.
2. Is high resolution (high dispersion) or low resolution (low dispersion) needed? The greater the resolution that is needed, the longer the focal length of the monochromator should be. A spectrograph with greater resolution will necessarily have a smaller bandpass. High resolution also dictates a narrow slit width in array spectrometers.
3. Does the spectrometer need to select a weak signal in a strong light background? If stray light rejection is important, then a double monochromator may be necessary.

## Table 1. Selsction Chart by Applications

| Application | Requirements | Recommended |
|---|---|---|
| Fluorescence | | |
| Fluorescence in liquids (emission or excitation) | 1 20nm bandwidth Good stray light rejection | CM110 1/8 meter monochromator or SM spectrometer for emission detection |
| Fluorescence in biological materials (emission or excitation) | 1 20nm bandwidth Excellent scattered light rejection | CM112 1/8 meter monochromator or SM spectrometer with special filter |
| Fluorescence in solids (emission or excitation) | 0.2 3.0nm bandwidth Good stray light rejection | DK240 1/4 meter monochromator or SM GT2 spectrometer for detection |
| Weak fluorescence in solids, liquids (emission) | Array detection for high sensitivity 0.2 3.0nm bandwidth | DKSP240 1/4 meter spectrogrsph with array detection system |
| Weak fluorescence in scattering biomaterials (emission or excitation) | High stray light rejection High sensitivity | DKSP240 1/4 meter monochromator |
| Phosphorescence, fluorescence kinetics (emission) | Array detection for time resolution | DKSP240 1/4 meter spectrograph with array detection system |

## Table 1. (continued) Selsction Chart by Applications

| Application | Requirements | Recommended |
|---|---|---|
| Spectrophotometry | | |
| Spectrophotometry of clear liquids, optics | 1 20nm bandwidths 0.1% transmission | Cm110 1/8 meter monochromator or SM spectrometers |
| Spectrophotometry of gases, traces in clear solids | To 0.01% transmission, 0.05 1.0nm bandwidth | DK240 1/4 meter monochromator |
| Spectrophotometry of dense objects | To 0.01% transmission, 1 20nm bandwidth | DK240 1/4 meter monochromator |
| Time varying spectrophotometry (thin film monitoring) | Array detection | DKSP240 1/4 meter spectrogrsph with array detection system or SM spectrometers |

| Application | Requirements | Recommended |
|---|---|---|
| Laser Spectrometry | | |
| Picosecond studies liquids, biological materials | Preserving pulse width 1 20nm bandwidths | CM110, CM112 monochromator |
| Picosecond studies solids, gases | Preserving pulse width 0.2 20nm bandwidths | DK240 1/4 meter monochromator |
| Tuning, wavelength checking, diode lasers | Resolution, accuracy to 1.0nm | CM110 1/8 meter monochromator |
| Tuning, wavelength checking, gas and dye lasers | Resolution, accuracy to 0.1nm | CM140 1/4 meter monochromator |
| Diode laser mode structure | Resolution to 1.0nm | CM110 1/8 meter monochromator |

## Table 1.(countinued) Selsction Chart by Applications

| Application | Requirements | Recommended |
|---|---|---|
| Emission Spectrometry, Radiometry | | |
| Arc, spark, or plasma spectroscopy | Resolution to 0.03nm | DK480 1/2 meter monochromator |
| Arc, spark, or plasma spectroscopy of small traces | Resolution to 0.03nm array capability | DK480 1/2 meter monochromator and spectrograph |
| LEDs, incandescent lamps, fluorescent lamps, phosphors | 1 20nm bandwidth | CM110 1/8 meter monochromator or SM spectrometer |
| Raman spectrometry | 0.3 10cm $^{1}$ bandwidth Excellent stray light rejection | CM110 1/8 meter monochromator with special filter, CM112 double monochromator |

| Application | Requirements | Recommended |
|---|---|---|
| Infrared Spectrometry | | |
| Fiber analysis, LED analysis source or detector | 1 20nm bandwidths 200 2500nm tunability | CM110, DK240 monochromators or multiple SM spectrometers |
| NIR spectrophotometry | 1 20nm bandwidths 700 1100nm tunability | CM110, DK240 monochromators or SM spectrometers |

| Application | Requirements | Recommended |
|---|---|---|
| General purpose | | |
| Teaching, general lab use | Array capability 200 20000nm tunability 0.3 30nm bandwidth | CM110, DK240 monochromators and spectrographs or SM spectrometers |

## Notes

Biological samples frequently scatter almost 100% of the incident light. To detect a weak fluorescence signal in this environment requires a double monochromator, frequently on both the excitation and emission sides.

Array detection can potentially multiply the signal collected by the number of detector elements, N. The signal to noise ratio potentially improves by the square root of N.

## Plane and Holographic Gratings

In recent years spectrometers using corrected concave holographic gratings have been heavily promoted. The advantages of these instruments are compactness, few optical elements and aberration correction that improve resolution.

Why has the plane-grating spectrometer survived? For the UV, for the IR, for wide spectral ranges, and for radiometry in which absolute intensity of a signal is important, the plane-grating spectrometer is superior.

Corrected concave-gratings offer good resolution over a wavelength octave, typically 350nm to 700nm. Outside of this region, the aberrations are much worse than those in a plane-grating instrument are. A typical Czerny-Turner monochromator with a 1200 groove-per-millimeter plane grating will have a good resolution from 250nm to 1500nm, over three times the wavelength range of itsconcave grating counterpart. The plane-grating spectrometer offers superior resolution in the UV and IR.

Concave-grating instrument designs are generally good for one spectral region only. Changing gratings is not possible. Plane-grating spectrometers can change their spectral region by changing gratings. A Czerny-Turner spectrometer with a triple grating turret can span 200 to 2000nm with good resolution and good efficiency.

Concave-grating spectrometers have transmission efficiencies that vary greatly with the input angle. This makes them poor choices for radiometric studies in which the intensity at each wavelength is critical and uniform illumination of the grating cannot be guaranteed. Because the groove profiles of corrected concave gratings vary greatly across the grating surface, the diffraction efficiency also varies greatly across the surface.

This contrasts with the plane-grating which has the same efficiency at all points on the surface. Unless the light enters a concavegrating instrument in exactly the same distribution each time, the instrument will have varying transmission efficiency. Fifty-percent changes from central illumination to edge illumination have been measured.

Corrected concave-gratings average half the diffraction efficiencies of plane-gratings.The groove profile of a ruled-plane grating is designed for high efficiency within narrow limits. Ion etching has been used to sharpen the groove profiles of corrected concave-gratings, but this is akin to making a lens from a glass plate by sandblasting. The profile improves, but the surface and scatter are horrible.

While corrected-concave-grating spectrometers occupy an important niche in spectroscopy, plane-grating instruments remain the workhorses.

## Gratings and Their Selections

From the foregoing discussion on grating equation it is clear that the longest wavelength that will be diffracted by a grating is 2*d. This places a long wavelength limit on the spectral range of a grating. The table below illustrates this limit. Loss of light as the grating is rotated to a steep angle usually limits the actual range to about 90% of the long wavelength limit listed.

The wavelength dependence of grating efficiency also constrains the spectral range. SP has a complete set of diffraction efficiency curves for all of its standard and custom gratings, and the appropriate curves should be reviewed if spectral range is important.

## Table 2. Grating Density and Long Wavelength Limit

| Grating Density (g/mm) | Groove spacing (nm) | Long wavelength Limit (nm) |
|---|---|---|
| 3600 | 277.78 | 555.56 |
| 2400 | 416.67 | 833.33 |
| 1800 | 555.56 | 1,111.11 |
| 1200 | 833.33 | 1,666.67 |
| 600 | 1,666.67 | 3,333.33 |
| 300 | 3,333.33 | 6,666.67 |
| 150 | 6,666.67 | 13,333.33 |
| 75 | 13,333.33 | 26,666.66 |
| 50 | 20,000.00 | 40,000.00 |

## Selection by Required Bandwidth or Dispersion

A table giving typical reciprocal linear dispersions near the center of the spectral range is given below.

The bandwidth transmitted by a monochromator will be the dispersion times the slit width. Given two of the three variables-bandpass, slit width and dispersion-the third can be calculated.

Most applications are light starved, and it is useful to open the slits to the greatest width that is compatible with the desired bandwidth. To increase the slit width while retaining the bandwidth, one can select a higher groove density. For example, at 340nm and a 10nm bandwidth in a 1/8 meter monochromator, a 1200 g/mm grating will allow a 1.4nm slit width, but a 2400 g/mm grating will allow a 2.8 millimeter slit width at the same bandpass.

Occasionally, the bandwidth may be constrained by the maximum slit width. A typical 1/4 meter monochromator might have a maximum slit width of four millimeters; a 14 nanometer bandpass would result with a 1200 g/mm grating. If a 28nm bandwidth was desired, a 600 g/mm grating would give the required bandpass.

For spectrographs, a particular dispersion is frequently desired. To cover 400 to 700 nanometers on a 25mm array detector would require a dispersion of 12nm/mm. The grating suitable for this dispersion for an SM2XX spectrometer would be a 1200 g/mm.

A particular resolution might also be required in a spectrograph. To resolve 0.3 angstroms in three pixels (75 microns) would require a dispersion of:

(.03/. 075) 1.3nm/mm.

This dispersion would be typical of an 1800 g/mm grating in a 1/2 meter spectrograph.

## Selection by Required Throughput

One frequently needs to obtain the maximum grating efficiency for a particular wavelength band. It would be useful to be able to design a groove profile to provide that efficiency profile. Unfortunately, this problem has not yet been solved. In practice, the efficiencies of many gratings have been measured; one selects from the grating with the desired efficiency curve.

For ruled gratings and blazed holographic grating the efficiencyprofile is generally triangular. The grating is most efficient

at a blaze wavelength, λb While a number of blaze wavelengths are generally available, the most common is 1/3 of the long wavelength limit. (For a 1200g/mm grating, this would be at 500 nanometers.) The peak at λb usually 90%, and the efficiency falls to about 20% at 67 *λb and at 1.5 *λb

Holographic gratings generally have flat efficiency profiles. The mean efficiency is about 30% over a range of .33 *λb to 1.5 * λb. In both cases, real efficiencies show complicated polarization dependence. The ratio of efficiency for polarization parallel to the groove to that perpendicular to the grooves may be 3:1 over a large spectral range.

In Figure 19, typical efficiency curves for a standard SP grating are presented. These curves span a wide range of wavelengths from UV to IR. These curves do not account for loss of solid angle of the grating as it is rotated. In addition to the curves included here, SP has measured efficiencies for both polarized and unpolarized light on a wide variety of other gratings; this data is available upon request.

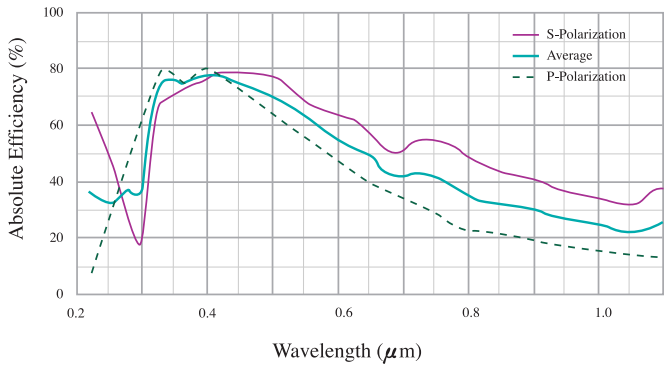



Figure 19. Typical grating efficency curves.

## Selection by Stray Light Level

Both scatter and extraneous spectral features (ghosts) may result from grating imperfections (see Stray Light discussion in Spectrometer Basics section). These imperfections result from the grating manufacturing processes. In general there are five types of gratings available; interferometrically ruled, ruled, holographic, sheridan blazed holographic and ion-etched holographic.

Interferometrically ruled gratings, holographic gratings and sheridan blazed gratings have comparable levels of stray light. All three are generally free of ghosts.

Exposing photoresist with a laser generated interference pattern makes the holographic gratings. The interference sinusoidaSheridan blazed gratings are produced by exposing the photoresist from both sides. A triangular profile results; these gratings have good efficiency. However, the technique will only produce UV blazed gratings. In ruling gratings, a pointed diamond is used to burnish the groove profile into a gold film on a quartz substrate. The position of the diamond is controlled by an interferometer as each groove is cut.

Classical ruled gratings are ruled without interferometric control. These gratings tend to have small, periodic errors in their groove profile.

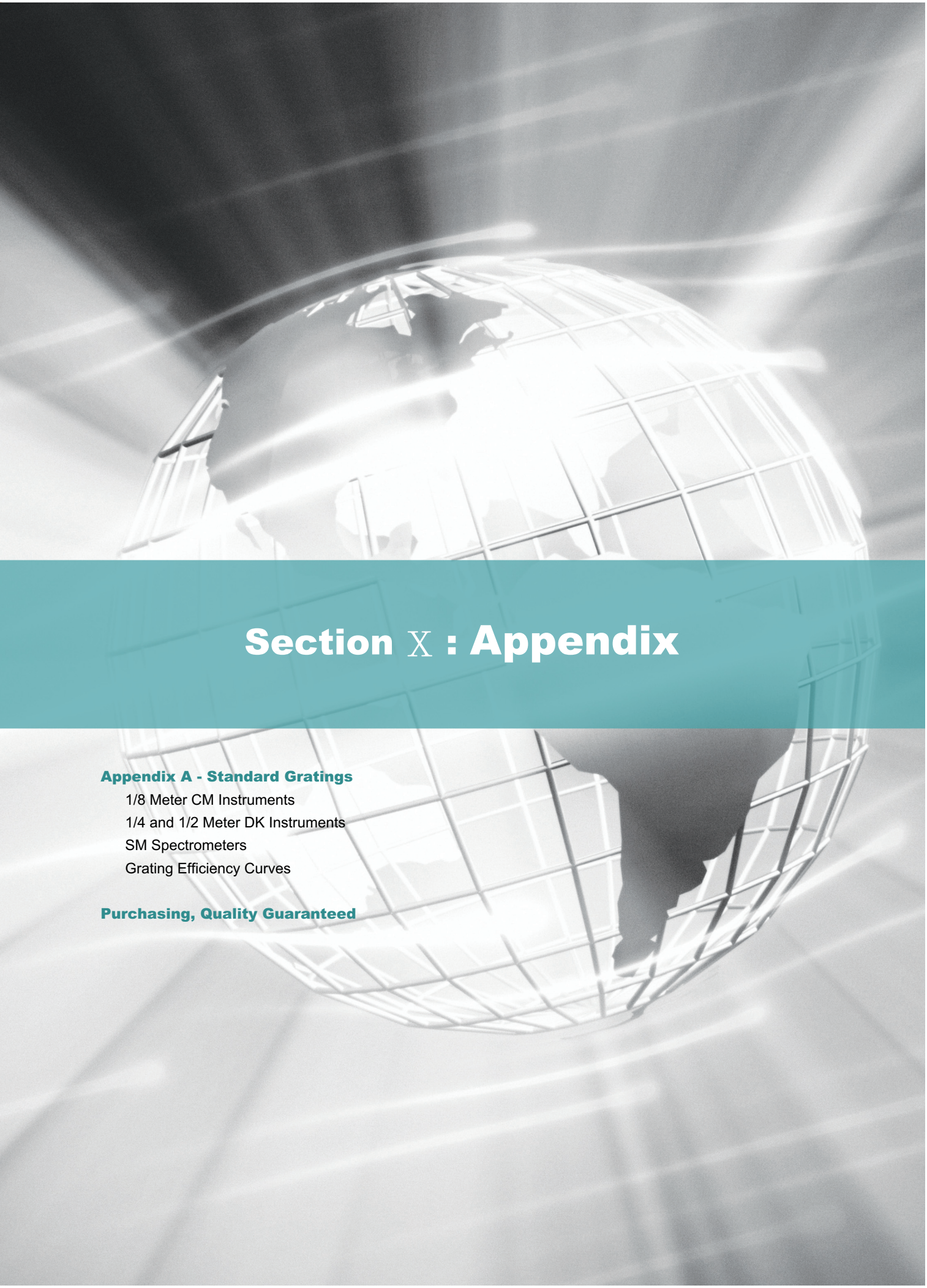
SP's standard gratings are listed in Appendix A. Standard DK24 series gratings are 68mm x 68mm. Wide gratings (64mm x 84mm) are available. SP's standard DK12 series gratings are 30mm x 30mm. For gratings not listed consultSP.

Recommended applications are listed at right for ruled diffraction gratings using spectral range, bandwidth, throughput and stray light selection criteria discussed above,

# Selection by Application

## Table 4. Selection of Gratings by Applications

| Application | Grating g/mm | Grating Blaze Wavelength (nm) | DK | CM | SM | Rearks |
|---|---|---|---|---|---|---|
| Fouorescent illumination | 2400 | 240 | x | x | | Highest UV through put |
| Fluorescent detection | 1200 | 500 | x | x | | Effcient over emission range |
| NIR laser analysis | 600 | 1000 | x | x | | Effcient over emission range |
| NIR laser analysis | 1200 | 1000 | | | x | Effcient over emission range |
| Raman | 1800 | 500 holographic | x | x | | Fair effciency, good stray light performance |
| NIR Raman | 600 | 1100 | x | x | | Good effciency, good stray light performance |
| UV VIS Array | 300 | 300 | x | x | | Good effciency, good UV and part of visible |
| UV VIS Array | 1200 | 250 | | | x | Good effciency, good UV and part of visible |
| VIS Array | 300 | 500 | x | x | | Good effciency, covers entire visible region |
| VIS Array | 600 1200 | 550 | | | x | Good effciency, covers entire visible region |



# Section X : Appendix

# Standard Gratings

## Standard Ruled Gratings for CM 1/8 Meter Instruments (including SM300, AD300, and SM302)

Table 1. Standard Gratings for CM monochromators / spectrographs

| Part Number | Density (g/mm) | Peak I (nm) | Range (nm) @ > 30%T | Peak T% |
|---|---|---|---|---|
| AG2400-00240-303 | 2400 | 240 | 180-680 | 70 |
| AG1200-00200-303 | 1200 | 200 | 180-450 | 65 |
| AG1200-00300-303 | 1200 | 300 | 200-750 | 72 |
| AG1200-00500-303 | 1200 | 500 | 330-1000 | 83 |
| AG1200-00600-303 | 1200 | 600 | 400-1500 | 80 |
| AG1200-00750-303 | 1200 | 750 | 480-1500 | 85 |
| AG0600-00500-303 | 600 | 500 | 350-1300 | 80 |
| AG0600-01250-303 | 600 | 1200 | 800-3000 | 85 |
| AG0300-00500-303 | 300 | 500 | 310-1100 | 80 |
| AG0300-02500-303 | 300 | 2500 | 1500-6000 | 88 |
| AG0150-00500-303 | 150 | 500 | 320-980 | 72 |
| AG0150-04000-303 | 150 | 4000 | 2500-9000 | 93 |
| AG0075-01700-303 | 75 | 1700 | 1100-2800 | 85 |
| AG0075-08000-303 | 75 | 8000 | 5000-15000 | 82 |
| AG0045-01750-303 | 45 | 1750 | 1100-3000 | 78 |

# Standard Ruled Gratings for DK 1/4 & 1/2 Meter Instruments

Table 2. Standard Gratings for DK monochromators / spectrographs

| Part Number | Density (g/mm) | Peak I (nm) | Range (nm) @ > 30T% | Peak T% |
|---|---|---|---|---|
| AG2400-00240-686 | 2400 | 240 | 180-680 | 70 |
| AG1200-00200-686 | 1200 | 200 | 180-450 | 65 |
| AG1200-00250-686 | 1200 | 250 | 180-460 | 70 |
| AG1200-00300-686 | 1200 | 300 | 200-750 | 72 |
| AG1200-00500-686 | 1200 | 500 | 330-1000 | 83 |
| AG1200-00600-686 | 1200 | 600 | 400-1500 | 80 |
| AG1200-00750-686 | 1200 | 750 | 480-1500 | 85 |
| AG1200-01000-686 | 1200 | 1000 | 550-1500 | 75 |
| AG0600-00500-686 | 600 | 500 | 350-1300 | 80 |
| AG0600-01200-68 | 600 | 1250 | 800-3000 | 85 |
| AG0600-01600-686 | 600 | 1600 | 950-3000 | 93 |
| AG0300-00500-686 | 300 | 500 | 310-1100 | 80 |
| AG0300-02000-686 | 300 | 2000 | 1200-4000 | 88 |
| AG0300-02500-686 | 300 | 2500 | 1500-6000 | 88 |
| AG0300-03000-686 | 300 | 3000 | 1800-6000 | 80 |
| AG0150-00500-686 | 150 | 500 | 320-980 | 72 |
| AG150-04000-686 | 150 | 4000 | 2500-9000 | 93 |
| AG0075-08000-686 | 75 | 8000 | 5000-15000 | 82 |
| AG0050-00600-686 | 50 | 600 | 400-1200 | 78 |
| AG0050-1200-686 | 50 | 12000 | 7500-20000 | 82 |

## Standard Ruled Gratings for SM Spectrometers

Table 3. Standard Gratings for SM spectrometers

| Part Number | Density (g/mm) | Peak I (nm) | Range (nm) @ > 30T% | Peak T% |
|---|---|---|---|---|
| AG0600-00300-163 | 600 | 300 | 200-650 | 71 |
| AG0600-00400-163 | 600 | 400 | 250-1000 | 77 |
| AG0600-00500-163 | 600 | 500 | 300-1100 | 77 |
| AG0600-00750-163 | 600 | 750 | 500-1700 | 72 |
| AG0600-01000-163 | 600 | 1000 | 600-3000 | 74 |
| AG0600-01200-163 | 600 | 1200 | 800-3200 | 76 |
| AG0600-01600-163 | 600 | 1600 | 950-3200 | 87 |
| AG0830-00800-163 | 830 | 800 | 450-2350 | 76 |
| AG0830-01200-163 | 830 | 1200 | 600-2350 | 75 |
| AG1200-00250-163 | 1200 | 250 | 200-650 | 69 |
| AG1200-00300-163 | 1200 | 300 | 200-700 | 70 |
| AG1200-00400-163 | 1200 | 400 | 200-900 | 71 |
| AG1200-00500-163 | 1200 | 500 | 300-1650 | 71 |
| AG1200-00750-163 | 1200 | 750 | 460-1650 | 71 |
| AG1200-01000-163 | 1200 | 1000 | 520-1650 | 69 |
| AG1800-00500-163 | 1800 | 500 | 300-1075 | 67 |

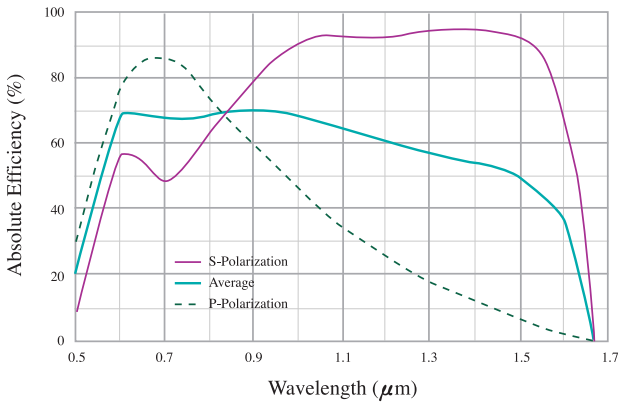
## References

M.V.R.K. Murty, Theory and Principles of Monochromators, Spectrometers, and Spectrographs, Optical Engineering, Vol.13, No.1, Jan 1974

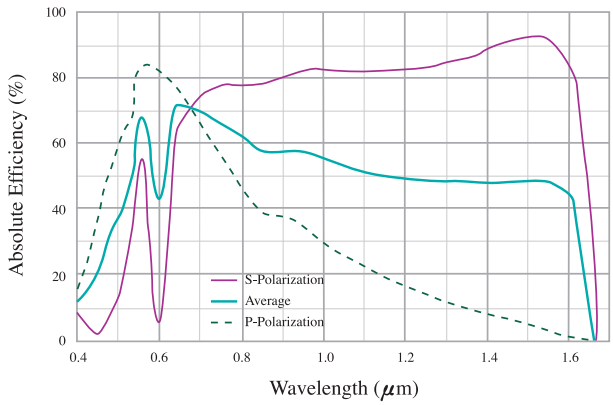
T.M. Niemczyk and G.W. Gobeli, Characteristics of a Direct Grating Drive, Applied Spectroscopy, Vol. 42, No. 5, 1988

# Grating Efficiency Curves

## Grating Efficiency Curves




AG1200-01000

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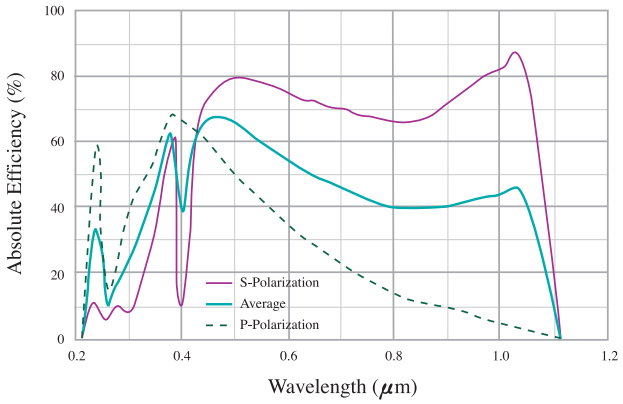


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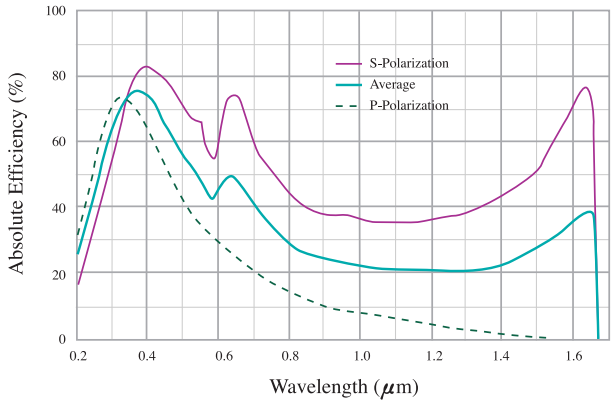


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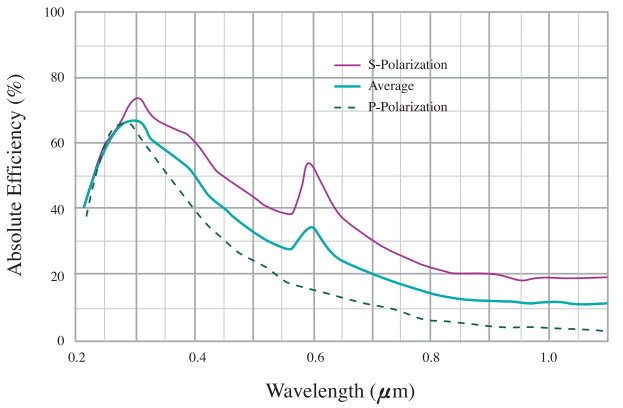
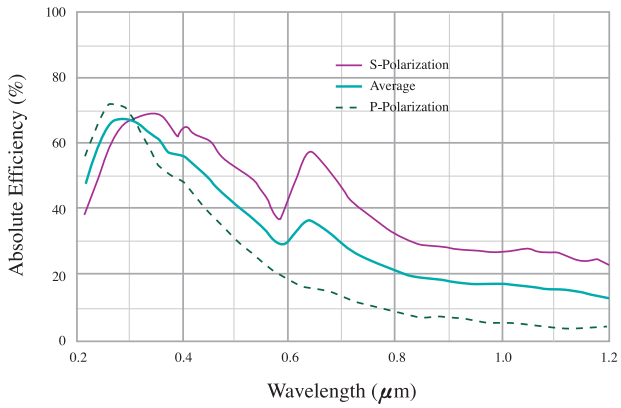
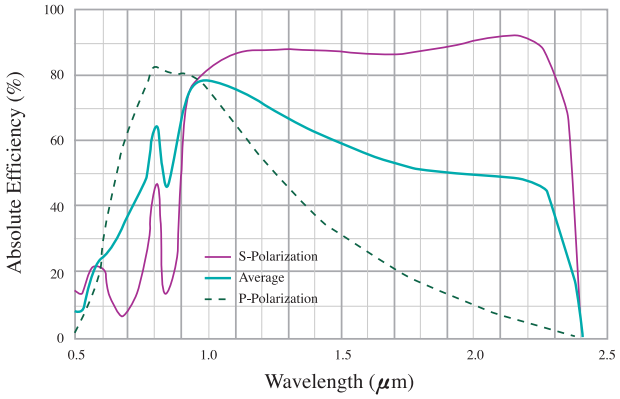


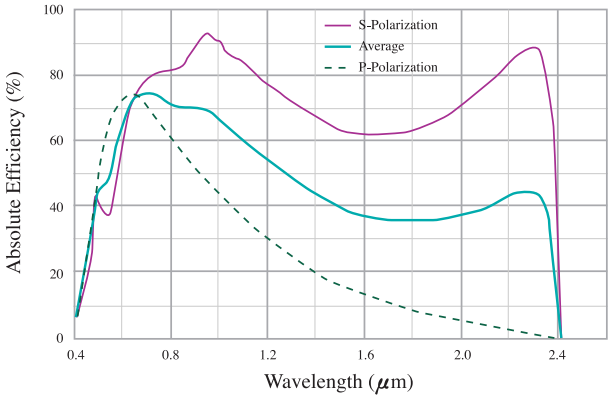

AG1200-00300




AG1200-00250




AG0830-01200

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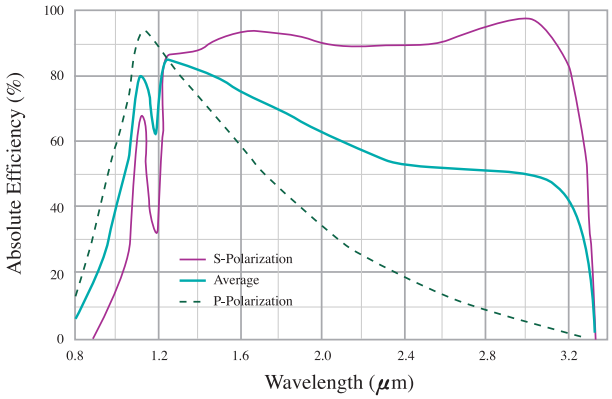


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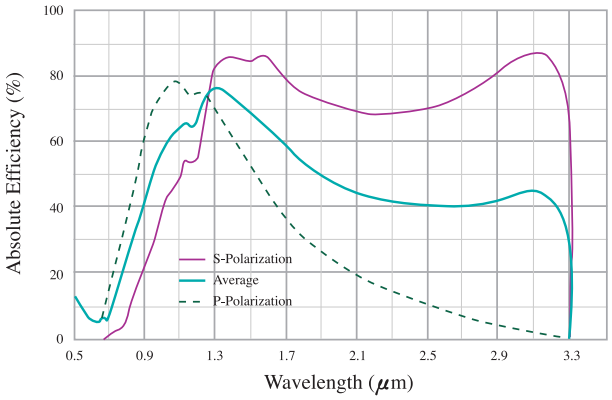


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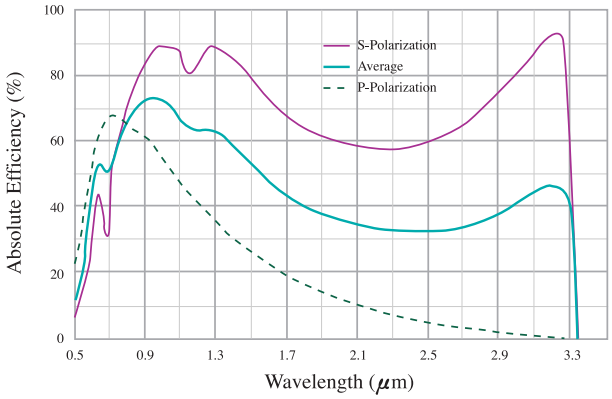


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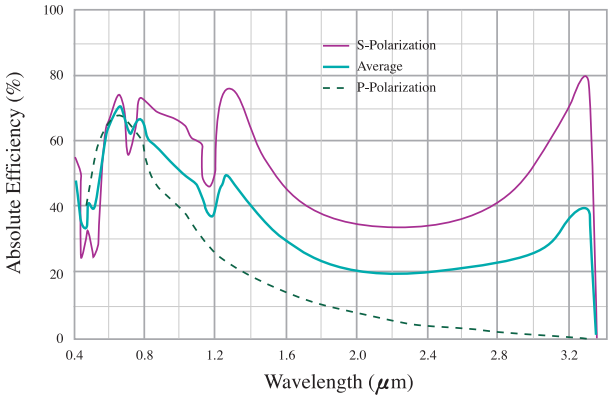


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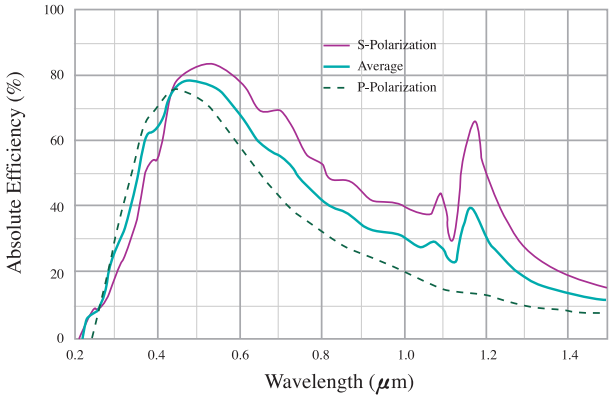


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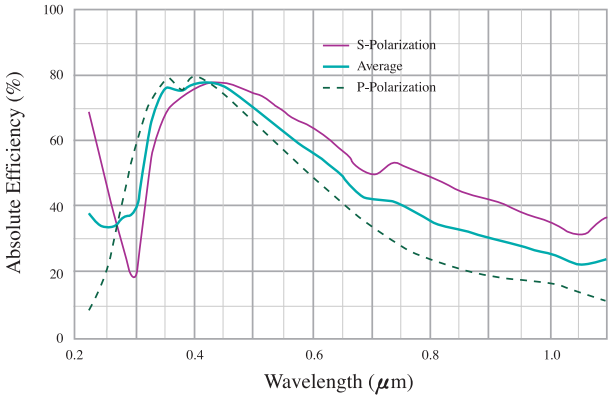


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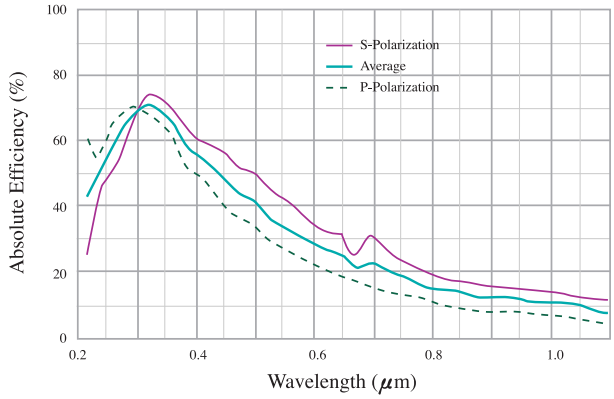


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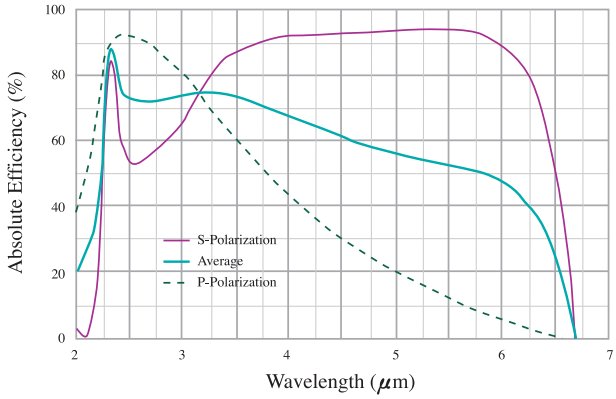


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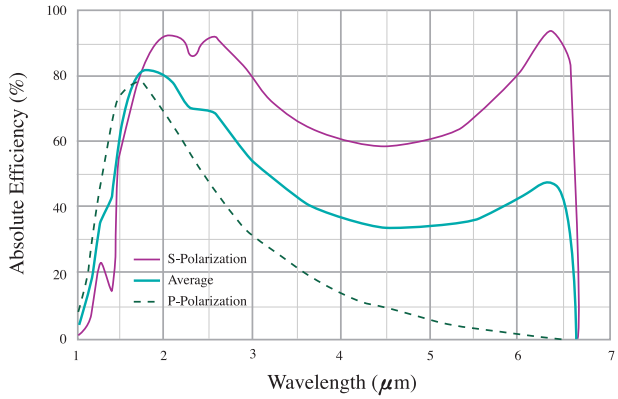


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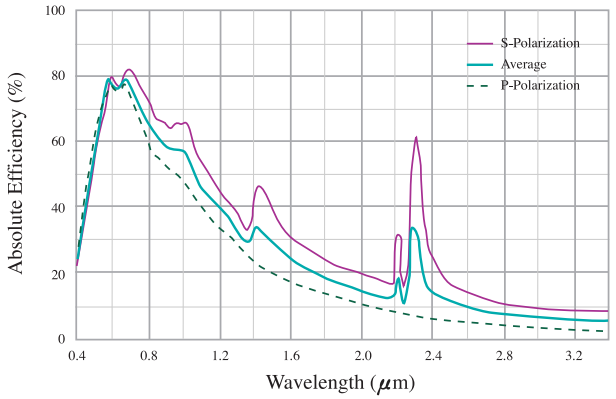


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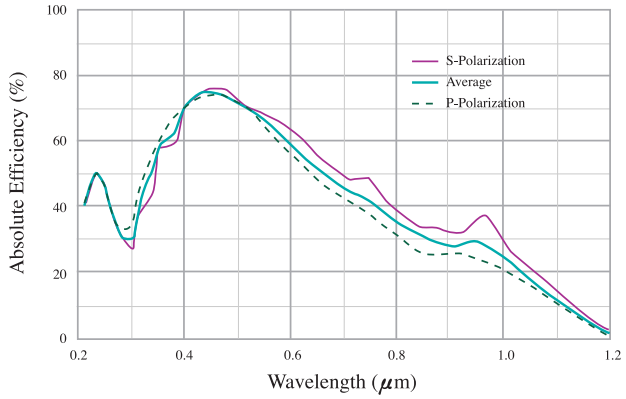


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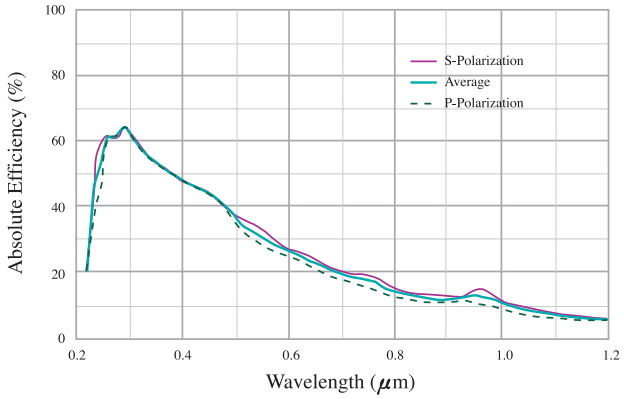


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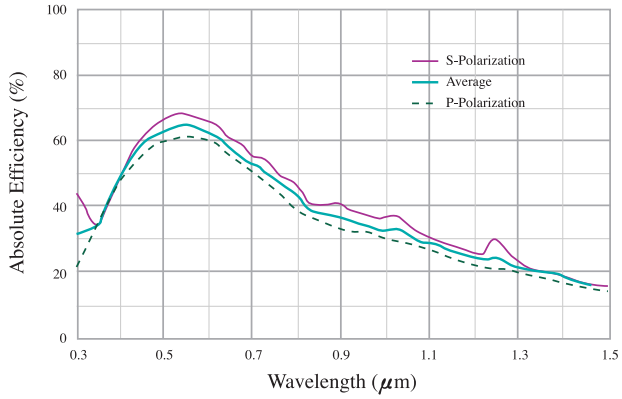


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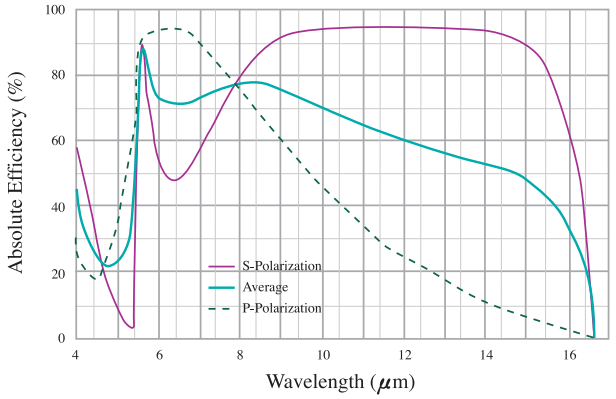


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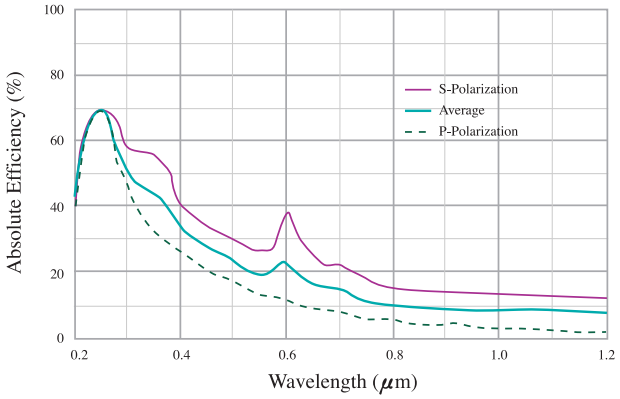
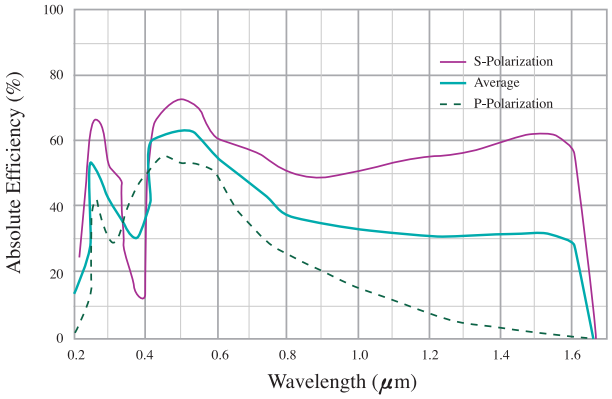



AG1200-U (Holographic)

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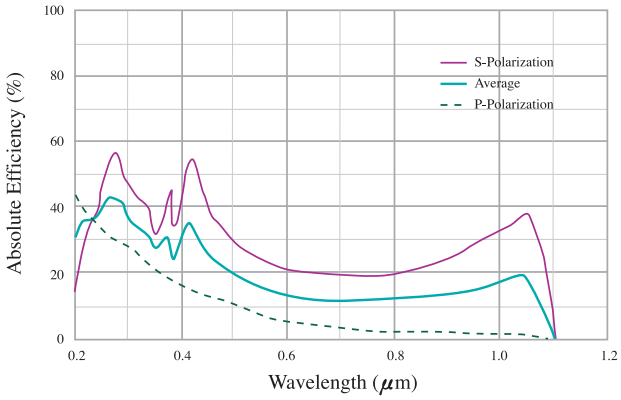


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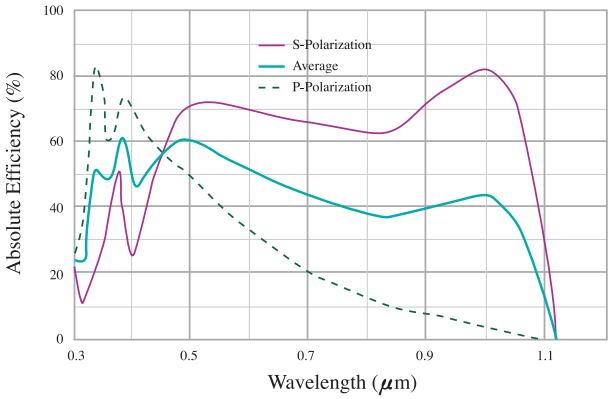
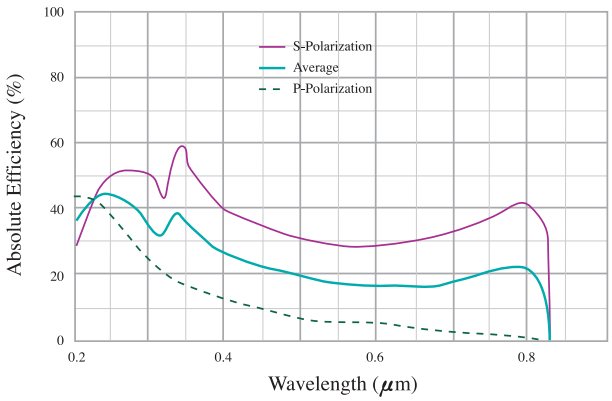
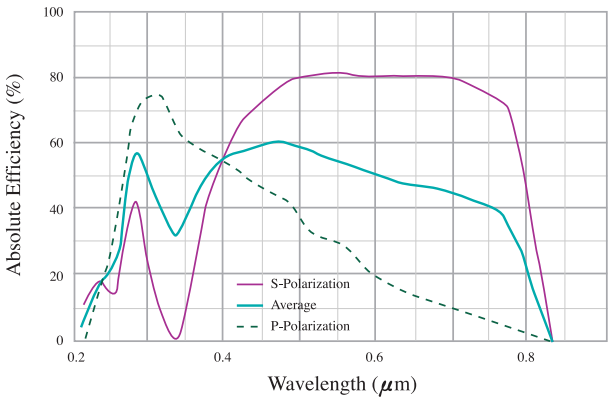



AG1800-V (Holographic)




AG2400-U (Holographic)

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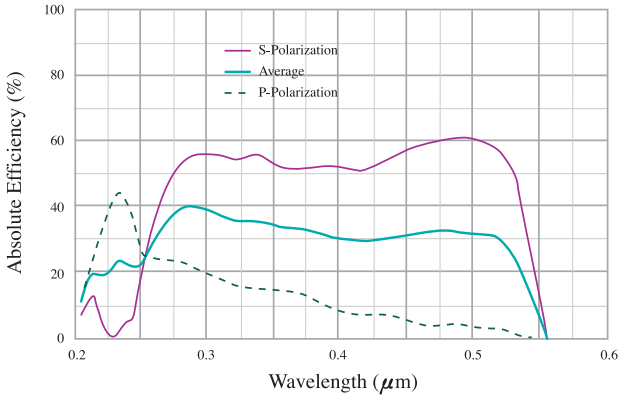



AG3600-U (Holographic)

# Working with SP Spectral Products

SP sales and technical staff will be glad to provide product pricing and application information. For a quick response and assistance please contact SP Spectral Products.

### Purchase Orders

Place orders by phone, mail, e-mail or fax. Hard copies of the custom purchase order may be required. To minimize errors, please provide the SP part number, description, purchase order number, ship-to and bill-to address and shipping method desired.

### Payment Methods

Open Accounts: For business, government agencies, universities and colleges an open account with approved credit limit is available. Please contact SP for further information.

Credit Cards: Orders placed with MasterCard or VISA card may be accepted. Please provide the information of account number and expiration date that appears on the card.

Delivery (COD): Orders may be shipped via UPS or Federal Express on a COD basis. Cash, a money order or a bank or company check is required at the time of delivery.

Prepaid: Prepayment by money order, wire transfers, bank check, company check or personal check may be accepted. For international orders a prepayment or a letter of credit (L/C) is required. The customer will be responsible for the charges incurred by the L/C.

### Quotations

All quotations written or verbal are valid for 30 days from the date of quotation unless stated otherwise. Prices are based on your requested specifications and quantities, and are subject to change if any changes are made from the original request.

### Delivery

Rush orders placed by phone (for items in stock at time of order) will be shipped within 2 working days. Most other standard items can be shipped within 2 weeks. Delivery times for special orders will be established per quotation.

### Shipping

Federal express, UPS and airfreight are available. UPS regular service will be used unless the buyer instructs otherwise. SP prepays the freight and then adds that amount to the invoice. Special handling charges may be added if appropriate. SP's responsibility is to deliver our products to your requested destination. Shipment errors, damage in transit, or cosmetic defects must be reported to SP within 15 days after delivery.

### Quantity Discounts

Contact our Sales department for quantity or educational discounts.

### Warranty

All catalog products are guaranteed to meet SP's published specifications and to be free of defects in materials and workmanship as defined in the specifications for one year after delivery. The buyer's exclusive remedy and the limit of SP's liability for any loss whatsoever shall not exceed the purchase price paid by the buyer for the goods to which a claim is made. SP does not give any implied warranties of merchantability or of fitness for a particular purpose in connection with the sale of any SP products.

### Returns

A Return Material Authorization number (RMA) is required for any returned goods. Please have your original ordering information ready and the nature of the problem before obtaining an RMA. This includes the original purchase order number, date of shipment and serial number. All the returns should be shipped with the original packaging materials and bear the assigned RMA number(s). A restocking fee may be charged for all returned goods. No product(s) will be accepted for restocking after 90 days. The repaired or replaced product(s) will be returned to you at SP's' expense for products covered by warranty. For out-of-warranty repairs please contact SP for a cost estimate. All shipping and handling costs involved are the user's responsibilities.

### Cancellation Fee

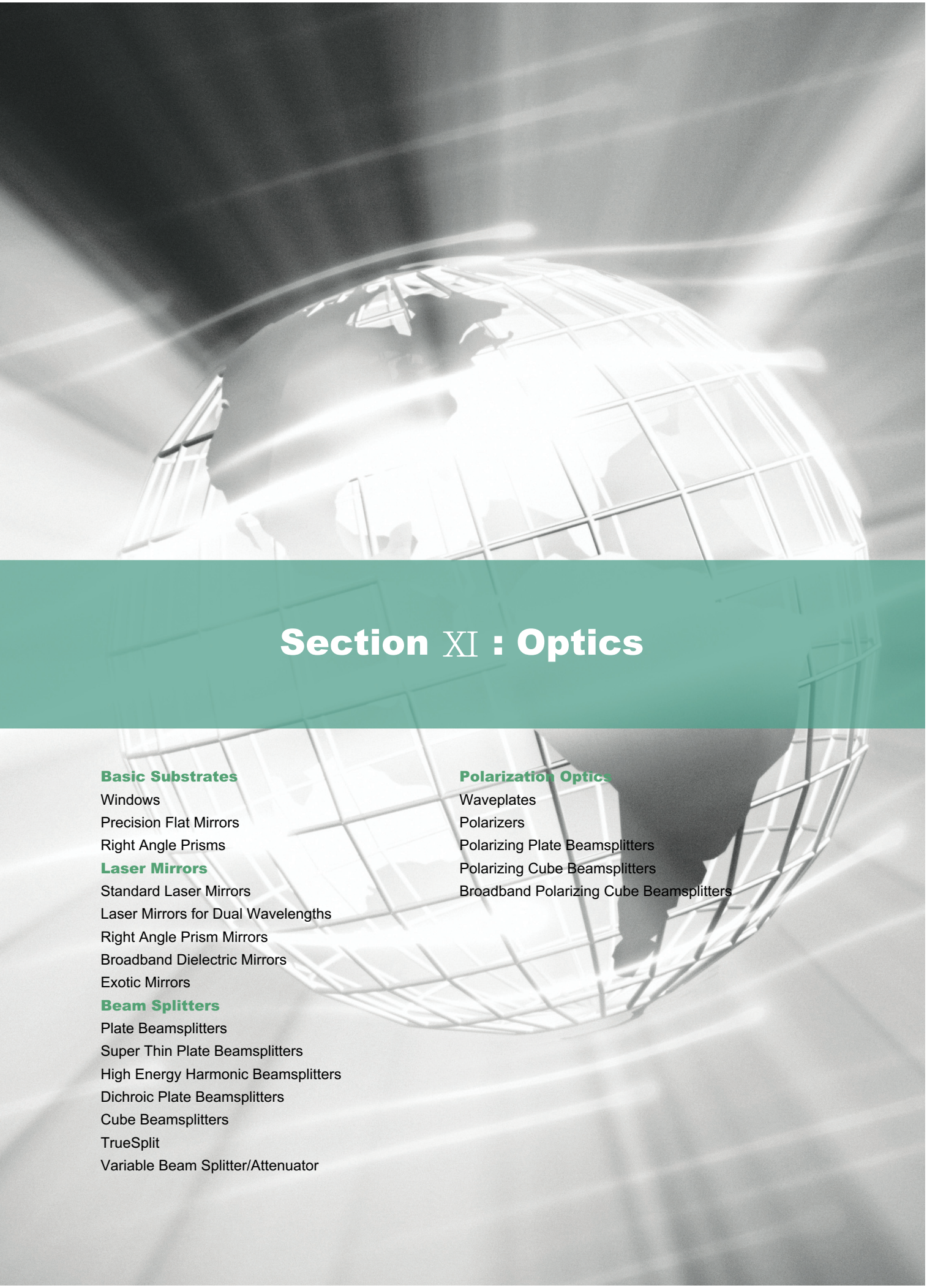
Should it become necessary to cancel or modify special orders prior to shipment, your sales representative will determine the appropriate cancellation fee. A restocking the original request. fee may be charged on goods accepted by SP for return to stock.Specially designed instruments damaged by the customer may not be returned.

### Prices

Prices for catalog stock items are shown in the current price list. They are F.O.B. factory. Special items will be individually priced per provided specifications. All published prices are subject to change without notice. For international orders an extra 20% handling fee on each item is applied. Invoices are payable 30 days from the date of the
invoice.

### International Customers

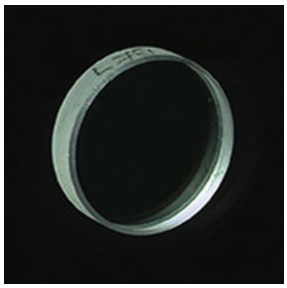
Please make payment in United States dollars to be drawn on a United States Bank. Certain items may be subject to export control and require a validated export license.



# Section XI : Optics

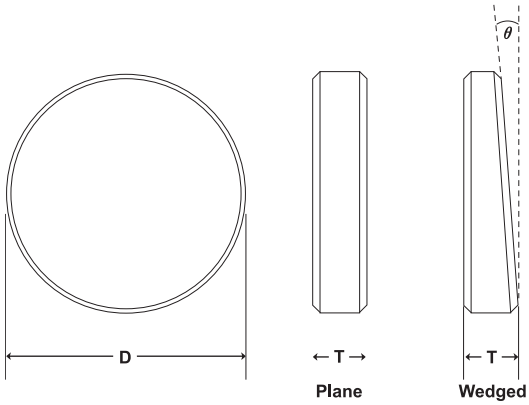
# Basic Substrates

(for Laser Optics) Spectral Optics produces a full line of standard size laser optics covering all common applications. The most important basic and fundamental substrates for the laser optics are windows for plate polarizing or dichroic beam splitters, precision flat mirror substrates for most of the laser mirrors, and the right angle prisms used for cube polarizing beam splitters.
Please check up each web page for the detailed specification.

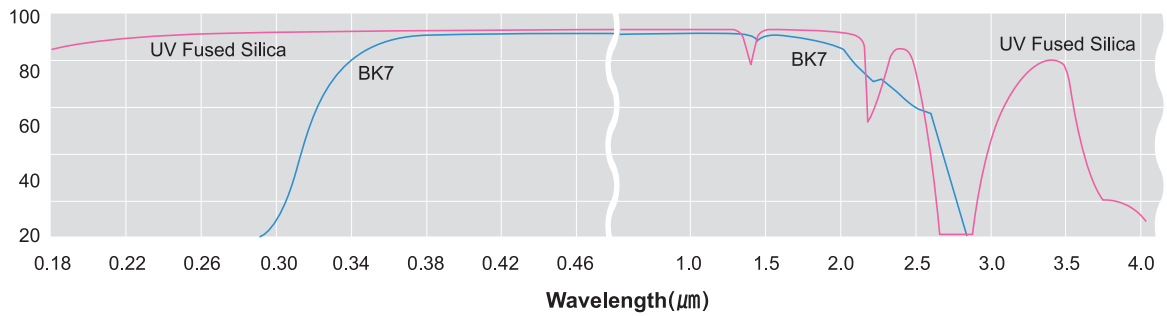


## Windows

- Clear Aperture: larger than central 85% of diameter
- Surface Quality: 10-5 Scratch-Dig
- Surface Flatness: λ/10 @633nm over clear aperture
- Diameter tolerance: +0.000/-0.010" (+0.00/-0.25mm)
- Thickness tolerance: ±0.010" ( ±0.25mm)
- Bevel: <0.5mm @45° typical
- Wedge: ≤5 arc min, ≤10 arc sec, 30±5 arc min




Spectral Optics provides high precision laser-quality regular plane ( ≤5 arc min), extremely parallel plane (≤10 arc sec), and wedged (30±5 arc min) windows fabricated from UV fused silica or BK7. These windows are polished on both sides with high flatness and high surface quality to handle high power laser applications as well as various industrial applications.




**They can be used as laser windows with a proper anti-reflection coating and can become various coated products, such as, plate beam splitters, dichroic filters, and partial reflectors.**

## Product Lists

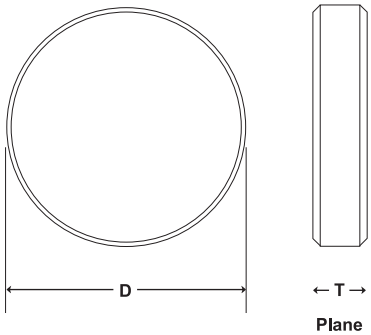
| Windows | | | | |
|---|---|---|---|---|
| **Diameter(D)** | **Thickness(T)** | **Meterial** | **Wedge( $\ell$ )** | **Part Number** |
| 0.5" (12.7mm) | 1/4" (6.35mm) | Fused silica | ≤5 arc min | PW1 0525 FS |
| | | | ≤10 arc sec | PW2 0525 FS |
| | | | 30 ±5 arc min | PW3 0525 FS |
| | | BK7 | ≤5 arc min | PW1 0525 BK |
| | | | ≤10 arc sec | PW2 0525 BK |
| | | | 30 ±5 arc min | PW3 0525 BK |
| 1.0" (25.4mm) | 1/4" (6.35mm) or 3/8" (9.53mm) | Fused silica | ≤5 arc min | PW1 1025 FS<br>PW1 1037 FS |
| | | | ≤10 arc sec | PW2 1025 FS<br>PW2 1037 FS |
| | | | 30 ±5 arc min | PW3 1025 FS<br>PW3 1037 FS |
| | | BK7 | ≤5 arc min | PW1 1025 BK<br>PW1 1037 BK |
| | | | ≤10 arc sec | PW2 1025 BK<br>PW2 1037 BK |
| | | | 30 ±5 arc min | PW3 1025 BK<br>PW3 1037 BK |
| 1.5" (38.1mm) | 1/4" (6.35mm) or 3/8" (9.53mm) | Fused silica | ≤5 arc min | PW1 1525 FS<br>PW1 1537 FS |
| | | | ≤10 arc sec | PW2 1525 FS<br>PW2 1537 FS |
| | | | 30 ±5 arc min | PW3 1525 FS<br>PW3 1537 FS |
| | | BK7 | ≤5 arc min | PW1 1525 BK<br>PW1 1537 BK |
| | | | ≤10 arc sec | PW2 1525 BK<br>PW2 1537 BK |
| | | | 30 ±5 arc min | PW3 1525 BK<br>PW3 1537 BK |
| 2.0" (50.8mm) | 1/4" (6.35mm) or 3/8" (9.53mm) | Fused silica | ≤5 arc min | PW1 2025 FS<br>PW1 2037 FS |
| | | | ≤10 arc sec | PW2 2025 FS<br>PW2 2037 FS |
| | | | 30 ±5 arc min | PW3 2025 FS<br>PW3 2037 FS |
| | | BK7 | ≤5 arc min | PW1 2025 BK<br>PW1 2037 BK |
| | | | ≤10 arc sec | PW2 2025 BK<br>PW2 2037 BK |
| | | | 30 ±5 arc min | PW3 2025 BK<br>PW3 2037 BK |
| 3.0" (72.6mm) | 1/2" (12.7mm) | Fused silica | ≤5 arc min | PW1 3050 FS |
| | | | ≤10 arc sec | PW2 3050 FS |
| | | | 30 ±5 arc min | PW3 3050 FS |
| | | BK7 | ≤5 arc min | PW1 3050 BK |
| | | | ≤10 arc sec | PW2 3050 BK |
| | | | 30 ±5 arc min | PW3 3050 BK |
| 4.0" (101.6mm) | 1/2" (12.7mm) | Fused silica | ≤5 arc min | PW1 4050 FS |
| | | | ≤10 arc sec | PW2 4050 FS |
| | | | 30 ±5 arc min | PW3 4050 FS |
| | | BK7 | ≤5 arc min | PW1 4050 BK |
| | | | ≤10 arc sec | PW2 4050 BK |
| | | | 30 ±5 arc min | PW3 4050 BK |

## NOTE:

1. Usually 0.5-2.0" diameter substrates are in stock. Please check up the delivery for the larger substrates with us. It usually takes ~3-5 weeks if we don't have any in stock.
2. Some other sizes and/or thicknesses may be available. Please contact us for other custom size windows.
3. Spectral Optics provides anti-reflection coating services on these windows. Please refer to our coating services, V-coating and Broadband anti-reflection coating for the details. The price of the anti-reflection coating is $45.00 per each surface for our standard substrate sizes and wavelengths.
4. A custom substrate will need the fixture machining charge (~$200-300). The coating lot charge (~$400-500 per each lot) will be applied for a special wavelength.

## Precision Flat Millors

- Material : UV fused silica, BK7
- Clear Aperture : larger than central 85% of diameter
- 1st Surface : λ/10 @633nm over clear aperture, 10-5 Scratch-Dig
- 2nd Surface : Commercial polish
- Diameter tolerance : +0.000/-0.010" (+0.00/-0.25mm)
- Thickness tolerance : ±0.010" (±0.25mm)
- Wedge : ≤5 arc min
- Bevel : <0.5mm @45° typical




Spectral Optics provides precision flat mirrors are designed to be used as dielectric laser mirrors or metal coated mirrors. These are an excellent choice for optical path folding applications, various imaging systems, and laser applications.

## Product Lists

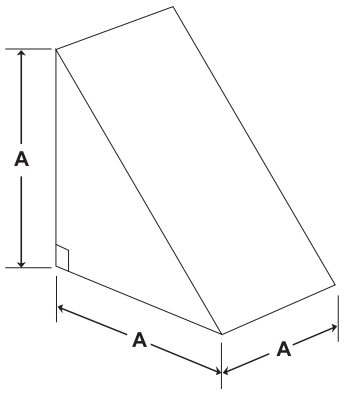
| Windows | | | |
|---|---|---|---|
| **Diameter(D)** | **Thickness(T)** | **Meterial** | **Part Number** |
| 0.5" (12.7mm) | 1/4" (6.35mm) | Fused silica | PM0525 FS |
| | | BK7 | PM0525 BK |
| 0.75" (19.1mm) | 1/4" (6.35mm) | Fused silica | PM0725 FS |
| | | BK7 | PM0725 BK |
| 1.0" (25.4mm) | 1/4" (6.35mm) or 3/8" (9.53mm) | Fused silica | PM1025 FS<br>PM1037 FS |
| | | BK7 | PM1025 BK<br>PM1037 BK |
| 1.5" (38.1mm) | 1/4" (6.35mm) or 3/8" (9.53mm) | Fused silica | PM1525 FS<br>PM1537 FS |
| | | BK7 | PM1525 BK<br>PM1537 BK |
| 2.0" (50.8mm) | 1/4" (6.35mm) or 3/8" (9.53mm) | Fused silica | PM2025 FS<br>PM2037 FS |
| | | BK7 | PM2025 BK<br>PM2037 BK |
| 3.0" (76.2mm) | 1/2" (12.7mm) | Fused silica | PM3050 FS |
| | | BK7 | PM3050 BK |
| 4.0" (101.6mm) | 1/2" (12.7) | Fused silica | PM4050 FS |
| | | BK7 | PM4050 BK |

## NOTE:

1. Usually 0.5-2.0" diameter substrates are in stock. Please check up the delivery for the larger substrates with us. It usually takes ~3-5 weeks if we don't have any in stock.
2. Some other sizes and/or thicknesses may be available. Please contact us for other custom size windows.
3. Please refer to the coating service section for the detailed coating specs available.

## Right Angle Prisms

- Material : UV fused silica, BK7
- Clear Aperture : larger than 85%
- Surface Quality (Scratch-Dig) : 10-5 for UV fused silica, 20-10 for BK7
- Surface Flatness : λ/10 for UV fused silica, λ/8 for BK7 @633nm
- Angular Deviation : ±3 arc min
- Bevel : <0.5mm @45° typical




Right angle prisms (RAP) are widely used for rotating image and redirecting the input light. They are the main components for polarizing and non-polarizing cube beamsplitters.
The total internal reflection (TIR) in the right angle prisms with specific anti-reflection (AR) coatings on the two leg sides make themselves the perfect alternatives of 45 degree mirrors. Please refer to our right angle prism mirror for the details.

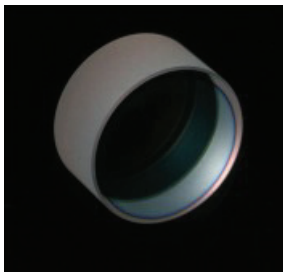
## Product Lists

| Windows | | | |
|---|---|---|---|
| **Diameter(D)** | **Meterial** | **Meterial** | **Part Number** |
| 0.5" (12.7mm) | Fused silica | λ/10, 10 5 | RAP 050 FS |
| | BK7 | ❯ λ/10, 10 5 | RAP 050 BK |
| 1.0" (25.4mm) | Fused silica | λ/10, 10 5 | RAP 100 FS |
| | BK7 | ❯ λ/10, 10 5 | RAP 100 BK |

## NOTE:

1. Some other sizes may be available. Please contact us for other custom size RAP.
2. Spectral Optics provides various coating services. Please contact us and check up the availability for any coating if needed.

# Laser Mirrors



Spectral Optics provide high-quality dielectric coated laser mirrors for use with high power/energy and or ultra-fast lasers from UV to IR spectral ranges. Most dielectric coated laser mirrors that Spectral Optics provide guarantee the state of art damage threshold and the maximum reflectance available.

Standard Laser Mirrors cover the most popular wavelengths being used in various laser applications, including high energy eximer lasers, high energy gas lasers, high power ND :YAG lasers, high performance diode lasers, and ultrafast Ti :Sapphire lasers.

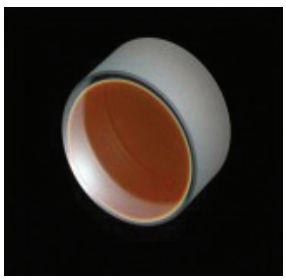
Some invisible laser applications require a tracer for aligning optics in the setup. Also some Nd : YAG laser applications need to reflect a dual wavelengths together. The laser mirrors for dual wavelengths are perfect solutions for these requirements.

In case of some 45° mirrors, especially for deep UV applications, the dielectric coating material begins to absorb and reduce the reflectance. In these applications, the right angle prism mirrors are perfect alternative solutions to replace the regular plate mirrors. They're using total internal reflection so there's no worry about losing a power. And the anti-reflection coatings are using only a couple coating layers and can minimize the absorption.

The broadband dielectric mirrors are the best solution to maximize the reflection for a certain range that regular metal coating can't achieve.

Some special applications need unusual requirements to pick out a specific harmonic or spoil a parasitic laser line. Spectral Optics can find a coating configuration and provide exotic mirrors that will solve the problems.

## Standard Laser Mirrors



- Substrate Material: UV fused silica for <400nm, BK7 for ≥400nm
- Clear Aperture: larger than central 85% of diameter
- 1st Surface: λ/10 @633nm before coating, 10-5 Scratch-Dig
- 2nd Surface: Commercial polish
- Diameter tolerance: +0.000/-0.010" (+0.00/-0.25mm)
- Thickness tolerance: ±0.010" (-0.25mm)
- Bevel: <0.5mm @45° typical
- Wedge: ≤5 arc min
- Coating technology: e-beam multilayer dielectric
- Damage threshold: 20J/cm², 20ns, 20Hz @1064nm or 10MW/cm² @1064nm

Laser mirrors are available with reflectivities >99.5% for visible and NIR wavelengths. Common laser wavelengths are standard, including YAG, HeNe, Argon and diode lasers. The mirrors are suitable for either beam steering or intra-cavity applications.

For wavelengths shorter than 355nm, Spectral Optics has developed a series of mirrors in which the coating design, coating material suite and substrate composition are carefully matched to provide the optimum combination of high reflectivity, low absorption and high damage threshold at each particular wavelength. For the best match to your application, consult a Spectral Products applications specialist. Be sure to discuss the required peak power, pulse duration and repetition rate, as well as the expected intensity distribution across the component optical aperture. Reflectivities of >99.5% can be realized for wavelengths of 248 nm and longer, while a minimum reflectance of >97% is offered below.

## Product Lists

| λ (nm) | D.T. | R(%) 0° | R(%) 45° | Size | Windows |
|---|---|---|---|---|---|
| ***ND:YAG Laser Line Mirrors, D.T:*** **(J/cm² @10ns)** | | | | | |
| 266 | 3 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 FS 266 0 |
| | | | | 1.0" (25.4mm) | PM 1037 FS 266 0<br>PM 1037 FS 266 45 |
| | | | | 2.0" (50.8mm) | PM 2037 FS 266 0<br>PM 2037 FS 266 45 |
| 355 | 5 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 355 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 355 0<br>PM 1037 BK 355 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 355 0<br>PM 2037 BK 355 45 |
| 532 | 10 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 532 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 532 0<br>PM 1037 BK 532 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 532 0<br>PM 2037 BK 532 45 |
| 1064 | 10 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 1064 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 1064 0<br>PM 1037 BK 1064 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 1064 0<br>PM 2037 BK 1064 45 |
| ***ND:YAG Laser Scanning Mirrors, 30-50°, D.T:*** **(J/cm² @10ns)** | | | | | |
| 532 | 10 | >99.5 for R | | 0.5" (12.7mm) | YSM 0525 BK 532 |
| | | | | | YSM 0525 FS 532 |
| | | | | 1.0" (25.4mm) | YSM 1037 BK 532 |
| | | | | | YSM 1037 FS 532 |
| | | | | 2.0" (50.8mm) | YSM 2037 BK 532 |
| | | | | | YSM 2037 FS 532 |
| 1064 | 10 | >99.5 for R | | 0.5" (12.7mm) | YSM 0525 BK 1064 |
| | | | | | YSM 0525 FS 1064 |
| | | | | 1.0" (25.4mm) | YSM 1037 BK 1064 |
| | | | | | YSM 1037 FS 1064 |
| | | | | 2.0" (50.8mm) | YSM 2037 BK 1064 |
| | | | | | YSM 2037 FS 1064 |
| ***Ultrafast (Femtosecond) Ti:Sapphire Laser Mirrors, D.T:*** **(J/cm² @300psec, 20Hz)** | | | | | |
| 800 | 8 | >99.5 | >99.0 | 0.5" (12.7mm) | FPM 0525 BK 800 0 |
| | | | | 1.0" (25.4mm) | FPM 1037 BK 800 0<br>FPM 1037 BK 800 45 |
| | | | | 2.0" (50.8mm) | FPM 2037 BK 800 0<br>FPM 2037 BK 800 45 |
| ***High Energy Eximer Laser Mirrors, D.T:*** **(J/cm² @10ns)** | | | | | |
| 248 | 1.5 | = 0 | >99.0 | 0.5" (12.7mm) | PM 0525 FS 248 0 |
| | | | | 1.0" (25.4mm) | PM 1037 FS 248 0<br>PM 1037 FS 248 45 |
| | | | | 2.0" (50.8mm) | PM 2037 FS 248 0<br>PM 2037 FS 248 45 |
| 308 | 5 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 FS 308 0 |
| | | | | 1.0" (25.4mm) | PM 1037 FS 308 0<br>PM 1037 FS 308 45 |
| | | | | 2.0" (50.8mm) | PM 2037 FS 308 0<br>PM 2037 FS 308 45 |
| 351 | 5 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 351 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 351 0<br>PM 1037 BK 351 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 351 0<br>PM 2037 BK 351 45 |

## Product Lists

| λ (nm) | D.T. | R(%) | | Size | Windows |
|---|---|---|---|---|---|
| | | 0° | 45° | | |
| ***High Energy Gas Laser Mirrors, D.T.:*** **(MW/cm² cw)** | | | | | |
| 244 257 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 FS 250 0 |
| | | | | 1.0" (25.4mm) | PM 1037 FS 250 0<br>PM 1037 FS 250 45 |
| | | | | 2.0" (50.8mm) | PM 2037 FS 250 0<br>PM 2037 FS 250 45 |
| 300 308 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 FS 305 0 |
| | | | | 1.0" (25.4mm) | PM 1037 FS 305 0<br>PM 1037 FS 305 45 |
| | | | | 2.0" (50.8mm) | PM 2037 FS 305 0<br>PM 2037 FS 305 45 |
| 325 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 FS 325 0 |
| | | | | 1.0" (25.4mm) | PM 1037 FS 325 0<br>PM 1037 FS 325 45 |
| | | | | 2.0" (50.8mm) | PM 2037 FS 325 0<br>PM 2037 FS 325 45 |
| 337 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 FS 337 0 |
| | | | | 1.0" (25.4mm) | PM 1037 FS 337 0<br>PM 1037 FS 337 45 |
| | | | | 2.0" (50.8mm) | PM 2037 FS 337 0<br>PM 2037 FS 337 45 |
| 351 364 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 360 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 360 0<br>PM 1037 BK 360 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 360 0<br>PM 2037 BK 360 45 |
| 442 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 442 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 442 0<br>PM 1037 BK 442 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 442 0<br>PM 2037 BK 442 45 |
| 458 528 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 490 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 490 0<br>PM 1037 BK 490 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 490 0<br>PM 2037 BK 490 45 |
| 633 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 633 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 633 0<br>PM 1037 BK 633 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 633 0<br>PM 2037 BK 633 45 |
| 1315 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 1315 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 1315 0<br>PM 1037 BK 1315 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 1315 0<br>PM 2037 BK 1315 45 |
| ***High Performance Laser Diode Mirrors, D.T.:*** **(MW/cm² cw)** | | | | | |
| 405 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 405 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 405 0<br>PM 1037 BK 405 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 405 0<br>PM 2037 BK 405 45 |
| 635/670 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 670 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 670 0<br>PM 1037 BK 670 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 670 0<br>PM 2037 BK 670 45 |

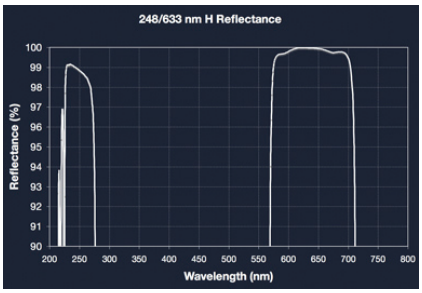
## Product Lists

| λ (nm) | D.T. | R(%) | | Size | Windows |
|---|---|---|---|---|---|
| | | 0° | 45° | | |
| 785 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 785 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 785 0<br>PM 1037 BK 785 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 785 0<br>PM 2037 BK 785 45 |
| 880 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 880 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 880 0<br>PM 1037 BK 880 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 880 0<br>PM 2037 BK 880 45 |
| 980 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 980 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 980 0<br>PM 1037 BK 980 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 980 0<br>PM 2037 BK 980 45 |
| 1480 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 1480 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 1480 0<br>PM 1037 BK 1480 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 1480 0<br>PM 2037 BK 1480 45 |
| 1550 | 1 | >99.5 | >99.0 | 0.5" (12.7mm) | PM 0525 BK 1550 0 |
| | | | | 1.0" (25.4mm) | PM 1037 BK 1550 0<br>PM 1037 BK 1550 45 |
| | | | | 2.0" (50.8mm) | PM 2037 BK 1550 0<br>PM 2037 BK 1550 45 |

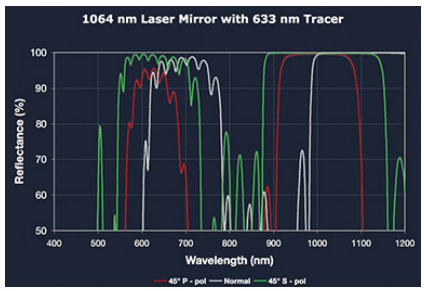
## NOTE:

1. **Other sizes and/or thicknesses are also available.** Please contact us for checking up the availability for a different size/thickness.
2. **Any other wavelength can be supplied on request.**

## Laser Mirrors for Dual Wavelengths




- Substrate Material : UV fused silica for <400nm, BK7 for ≥400nm
- Clear Aperture: larger than central 85% of diameter
- 1st Surface: λ/10 @633nm before coating, 10-5 Scratch-Dig
- 2nd Surface: Commercial polish
- Diameter tolerance: +0.000/-0.010" (+0.00/-0.25mm)
- Thickness tolerance: ±0.010" (-0.25mm)
- Bevel: <0.5mm @45° typical
- Wedge: ≤5 arc min
- Coating technology: e-beam multilayer dielectric
- Reflection :
  - Dual YAG wavelengths Laser Mirror: R>99.0% for both 532/1064nm
  - Laser Mirror with Tracer: R>99.0% for Laser wavelength, R>80.0% for Tracer
- Damage threshold: 20J/cm², 20ns, 20Hz; 10MW/cm² , CW @1064nm




Spectral Optics offers hybrid laser mirrors that provide high reflectivity and durability at both Nd:YAG and doubled YAG wavelengths at either 0° or 45° and also afford the convenience of system alignment using using visible wavelength tracer lasers.

The dual wavelengths (1064nm & 532nm) YAG laser mirrors give R>99.0% at both wavelengths. Tracer laser options for either 633 nm HeNe and 670 nm diode laser wavelengths can be provided. Reflectivity is > 99.0% at the laser wavelength and >80.0% at the tracer wavelength. Damage threshold considerations for visible and near-IR wavelengths are similar to standard mirrors. For high-power applications in the UV, consult a Spectral Optics engineer to determine the best solution.

## STANDARD COMBINATIONS with Tracer

| Laser Wavelength (nm) | Tracer Wavelength (nm) |
|---|---|
| 248, 266, 308, 355, 1064 | 633, 670 |

## Product Code:

1. Dual YAG wavelengths

| λ(nm) | AOI(°) | Size Code | Part Number |
|---|---|---|---|
| 1064 / 532 | 0 | 1.0" X 1/4" | LMDW 1064 532 0 100 BK |
| | | 1.5" X 3/8" | LMDW 1064 532 0 150 BK |
| | | 2.0" X 3/8" | LMDW 1064 532 0 200 BK |
| | 45 | 1.0" X 1/4" | LMDW 1064 532 45 100 BK |
| | | 1.5" X 3/8" | LMDW 1064 532 45 150 BK |
| | | 2.0" X 3/8" | LMDW 1064 532 45 200 BK |

2. Laser Mirror with Tracer:

| λ(nm) | | AOI(°) | Size Code | Part Number |
|---|---|---|---|---|
| 248 | 633 or 670 | 0 | 1.0" X 1/4" | LMTR 248 633 0 100 FS<br>LMTR 248 670 0 100 FS |
| | | | 1.5" X 3/8" | LMTR 248 633 0 150 FS<br>LMTR 248 670 0 150 FS |
| | | | 2.0" X 3/8" | LMTR 248 633 0 200 FS<br>LMTR 248 670 0 200 FS |
| | | 45 | 1.0" X 1/4" | LMTR 248 633 45 100 FS<br>LMTR 248 670 45 100 FS |
| | | | 1.5" X 3/8" | LMTR 248 633 45 150 FS<br>LMTR 248 670 45 150 FS |
| | | | 2.0" X 3/8" | LMTR 248 633 45 200 FS<br>LMTR 248 670 45 200 FS |

| λ(nm) | | AOI(°) | Size Code | Part Number |
|---|---|---|---|---|
| 266 | 633 or 670 | 0 | 1.0" X 1/4" | LMTR 266 633 0 100 FS<br>LMTR 266 670 0 100 FS |
| | | | 1.5" X 3/8" | LMTR 266 633 0 150 FS<br>LMTR 266 670 0 150 FS |
| | | | 2.0" X 3/8" | LMTR 266 633 0 200 FS<br>LMTR 266 670 0 200 FS |
| | | 45 | 1.0" X 1/4" | LMTR 266 633 45 100 FS<br>LMTR 266 670 45 100 FS |
| | | | 1.5" X 3/8" | LMTR 266 633 45 150 FS<br>LMTR 266 670 45 150 FS |
| | | | 2.0" X 3/8" | LMTR 266 633 45 200 FS<br>LMTR 266 670 45 200 FS |
| 308 | 633 or 670 | 0 | 1.0" X 1/4" | LMTR 308 633 0 100 FS<br>LMTR 308 670 0 100 FS |
| | | | 1.5" X 3/8" | LMTR 308 633 0 150 FS<br>LMTR 308 670 0 150 FS |
| | | | 2.0" X 3/8" | LMTR 308 633 0 200 FS<br>LMTR 308 670 0 200 FS |
| 308 | 633 or 670 | 45 | 1.0" X 1/4" | LMTR 308 633 45 100 FS<br>LMTR 308 670 45 100 FS |
| | | | 1.5" X 3/8" | LMTR 308 633 45 150 FS<br>LMTR 308 670 45 150 FS |
| | | | 2.0" X 3/8" | LMTR 308 633 45 200 FS<br>LMTR 308 670 45 200 FS |
| 355 | 633 or 670 | 0 | 1.0" X 1/4" | LMTR 355 633 0 100 FS<br>LMTR 355 670 0 100 FS |
| | | | 1.5" X 3/8" | LMTR 355 633 0 150 FS<br>LMTR 355 670 0 150 FS |
| | | | 2.0" X 3/8" | LMTR 355 633 0 200 FS<br>LMTR 355 670 0 200 FS |
| | | 45 | 1.0" X 1/4" | LMTR 355 633 45 100 FS<br>LMTR 355 670 45 100 FS |
| | | | 1.5" X 3/8" | LMTR 355 633 45 150 FS<br>LMTR 355 670 45 150 FS |
| | | | 2.0" X 3/8" | LMTR 355 633 45 200 FS<br>LMTR 355 670 45 200 FS |
| 1064 | 633 or 670 | 0 | 1.0" X 1/4" | LMTR 1064 633 0 100 BK<br>LMTR 1064 670 0 100 BK |
| | | | 1.5" X 3/8" | LMTR 1064 633 0 150 BK<br>LMTR 1064 670 0 150 BK |
| | | | 2.0" X 3/8" | LMTR 1064 633 0 200 BK<br>LMTR 1064 670 0 200 BK |
| | | 45 | 1.0" X 1/4" | LMTR 1064 633 45 100 BK<br>LMTR 1064 670 45 100 BK |
| | | | 1.5" X 3/8" | LMTR 1064 633 45 150 BK<br>LMTR 1064 670 45 150 BK |
| | | | 2.0" X 3/8" | LMTR 1064 633 45 200 BK<br>LMTR 1064 670 45 200 BK |

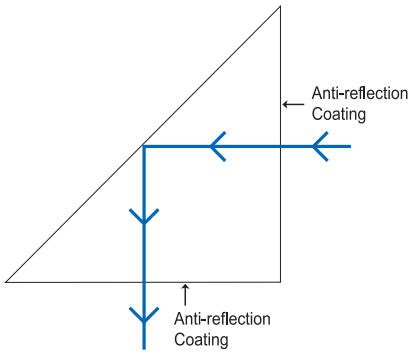
* $\lambda_1$ : Laser Wavelength, $\lambda_2$ : Tracer Wavelength

NOTE :

1. Other dual laser wavelengths or Tracer can be supplied on request.
2. Other substrate sizes and thicknesses are also available.

## Right Angle Prism Mirrors

- Material: UV fused silica or BK7
- Clear Aperture: larger than 85%
- Surface Quality (Scratch-Dig) : 10-5 for UV fused silica, 20-10 for BK7
- Surface Flatness: λ/10 @633nm for UV fused silica, λ/8 @633nm for BK7
- Angular Deviation: ±3 arc min
- Bevel: <0.5mm @45° typical
- Reflection : R ≤0.25 for V-coat, R<0.5% for BBAR




The total internal reflection (TIR) in the right angle prisms with specific anti-reflection (AR) coatings on the two leg sides make themselves the perfect alternatives of 45 degree mirrors. The TIR is independent of wavelength so the RAP mirrors can be used as high energy reflectors for broadband applications where metal mirrors are too absorbing and dielectric mirrors do not reflect a wide enough bandwidth.
The other advantage of the RAP mirror is that the input and the output lights meet the surfaces always normally so they don't make any difference per polarization. They are perfectly non-polarizing 45° bending mirrors that any dielectric coatings can't do.



## Product Lists

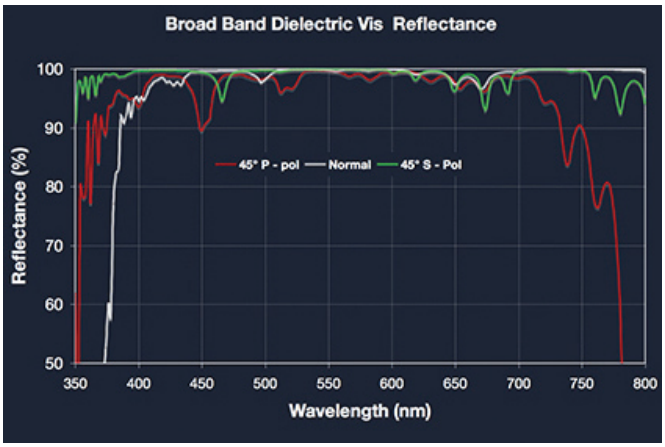
| Wavelength | AR coating type | Size | Part Number |
|---|---|---|---|
| 248 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 FS 248 |
| | | 1.0" (25.4mm) | RAPM 100 FS 248 |
| 248 355 | BBAR coating R<0.5% per surface | 0.5" (12.7mm) | RAPM 050 FS 248/355 |
| | | 1.0" (25.4mm) | RAPM 100 FS 248/355 |
| 266 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 FS 266 |
| | | 1.0" (25.4mm) | RAPM 100 FS 266 |
| 308 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 FS 308 |
| | | 1.0" (25.4mm) | RAPM 100 FS 308 |
| 355 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 FS 355 |
| | | 1.0" (25.4mm) | RAPM 100 FS 355 |
| 488 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 BK 488 |
| | | 1.0" (25.4mm) | RAPM 100 BK 488 |
| 532 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 BK 532 |
| | | 1.0" (25.4mm) | RAPM 100 BK 532 |
| 425 675 | BBAR coating R<0.5% per surface | 0.5" (12.7mm) | RAPM 050 BK 425/675 |
| | | 1.0" (25.4mm) | RAPM 100 BK 425/675 |
| 633 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 BK 633 |
| | | 1.0" (25.4mm) | RAPM 100 BK 633 |
| 800 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 BK 800 |
| | | 1.0" (25.4mm) | RAPM 100 BK 800 |
| 633 1064 | BBAR coating R<0.5% per surface | 0.5" (12.7mm) | RAPM 050 BK 633/1064 |
| | | 1.0" (25.4mm) | RAPM 100 BK 633/1064 |
| 1064 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 BK 1064 |
| | | 1.0" (25.4mm) | RAPM 100 BK 1064 |
| 1319 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 BK 1319 |
| | | 1.0" (25.4mm) | RAPM 100 BK 1319 |
| 1550 | V coating R<0.25% per surface | 0.5" (12.7mm) | RAPM 050 BK 1550 |
| | | 1.0" (25.4mm) | RAPM 100 BK 1550 |

### NOTE :

Any other wavelength can be supplied on?request.

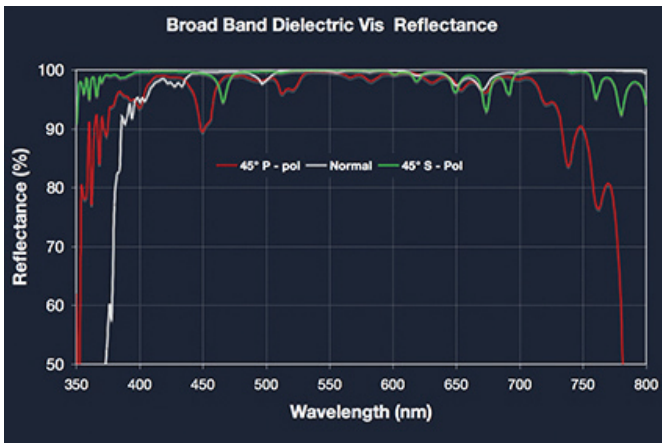
## Broadband Dielectric Mirrors

Broadband dielectric mirrors are general-purpose components useful in a wide variety of applications. Photometric response is better than 95% weighted reflectance at both normal and 45° incidence, in either polarization. High reflectivity is also provided at most common laser and LED wavelengths. Because these mirrors are composed of multi-stack e-beam dielectric materials, physical durability is excelllent, and optical response is retained for years, in contrast to the gradual degradation seen in even the best protected aluminum mirrors. The standard substrate material is BK7, although other materials can be supplied.




## Exotic Mirrors

Unusual requirements call for creative solutions. Whether you need to pick out a specific harmonic or spoil a parasitic laser line, Spectral Optics can find a coating configuration that will solve your problem. With long experience in solving the hard problems, Spectral Optics is ready to bring your innovation from the laboratory into production. Don't give up before you speak with one of our applications specialists.

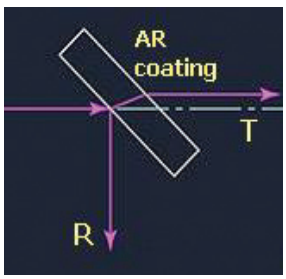


# Beam Splitters

Beam Splitters are used to split an input light beam into two separate beams with a certain reflection/transmission ratio or per different polarization. These can be used as a beam combiner combining two separate input beams into one output beam. Spectral Optics provide a wide selection range of beamsplitters. Plate beamsplitters are ideal for high power lasers that optical cemented cube beam splitters can not be used. Spectral Optics offers a super thin plate beamsplitters to minimize the beam deviation.
Cube beamsplitters split the input light into two 90° beams so they make it easy to optical alignment. Spectral Optics offers an optical cement-free bonding, molecular fusion for the use with a high power/energy laser.
Especially for high energy Nd:YAG laser applications, harmonic beamsplitters will be useful for separating a primary wavelength and its harmonic ones.
Spectral Optics' unique Truesplit makes it possible to achieve non-polarizing beam splitting for high power lasers.


## Plate Beamsplitters

1. Substrate
   - Materia l : UV fused silica or BK7 window
   - Clear Aperture : larger than central 85% of diameter
   - Surface Quality : 10-5 Scratch-Dig
   - Surface Flatness : λ/10 @633nm over clear aperture
   - Diameter tolerance : +0.000/-0.010" (+0.00/-0.25mm)
   - Thickness tolerance : ±0.010" ( ±0.25mm)
   - Bevel : <0.5mm @45° typical
   - Wedge : ≤5 arc min




2. Other Specifications
   - Coating : E-beam multilayer dielectric
   - Angle of Incidence : 45°
   - 2nd surface : Anti-reflection coating
   - Damage Threshold : 10J/cm2, 20ns, 20Hz; 1MW/cm2, CW @1064nm

In some applications cube beamsplitters are not appropriate, and instead plate-type splitters are employed. For the highest levels of wavefront fidelity and power handling, conventional coated BK7 or fused silica plates are excellent choices.
Spectral Optics provides various R/T ratio plate beamsplitters coated with an all dielectric coating. They have almost no absorption and are designed for 45° (or other angle of incidence) at a specific wavelength and a polarization (S-pol, P-pol, or unpol). The 2nd side of the window has an anti-reflection coating.

## Product Code : PBS - λ - R - AOI & Pol - Size - Material

| | λ(nm) | R(%) | AOI & POL | Size Code | Material |
|---|---|---|---|---|---|
| PBS | 248, 266, 308, 337, 355, 400, 488, 532, 633, 670, 780, 800, 850, 980, 1030, 1064, 1319, 1550, 1850, etc | 20(±5), 30(±5), 40(±5), 50(±5), 60(±5), 70(±5), 80(±5), 90(±5), 95(±5), 98(±5), 99(±5), etc | 45S, 45P, 45U, etc | 1025 (1.0" X 0.25") | FS |
| | | | | | BK |
| | | | | 1525 (1.5" X 0.25") | FS |
| | | | | | BK |
| | | | | 2025 (2.0" X 0.25") | FS |
| | | | | | BK |
| | | | | 3025 (3.0" X 0.25") | FS |
| | | | | | BK |
| | | | | 4025 (4.0" X 0.25") | FS |
| | | | | | BK |

EX, PBS-248-50-45U-1025-FS : Plate BeamSplitter, 248nm, 50% (±5) R, 45° Unpolarization, 1.0" dia X 0.25" thickness, Fused Silica.

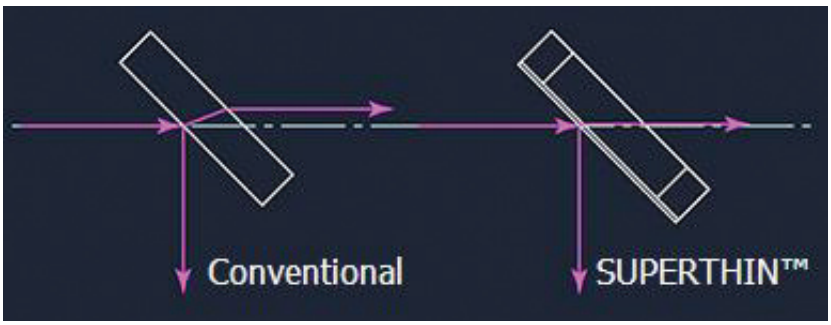
### NOTE:

1. The selection of the substrate material is dependent on the wavelength. Below 400nm, the UV fused silica is recommended.
2. Any other wavelength and R/T ratio can be supplied on request.
3. Other angle of incidence is also available.

## Super Thin Plate Beamsplitters

1. Super Thin Plate :
   - Substrate Material : BK7
   - Substrate Thickness : 0.15mm
   - Beam Displacement : 50㎛
   - Diameter : 1"
   - Surface : ~2λ/inch @633nm before coating
   - Transmitted wavefront error: >λ/4 @633nm
2. O-ring mount :
   - Material : BK7/ Pyrex
   - Outside Diameter : 1.0" (25.4mm)
   - Inside Diameter : 0.7" (17.8mm)
   - Thickness : 0.25" (6.35mm)
3. Coating :
   - E-beam Multilayer dielectric
   - 2nd surface: Anti-reflection coating
   - Angle of incidence: 45°, other angles available
   - Damage Threshold: 10J/cm², 20ns, 20Hz; 1MW/cm², CW @1064nm

In some applications cube beamsplitters are not appropriate, and instead plate-type splitters are employed. For the highest levels of wavefront fidelity and power handling, conventional coated BK7 or fused silica plates are excellent choices. However, the plate's thickness inherently causes lateral deviation of the primary beam from its original path. To avoid this, Spectral Optics has introduced the SuperThin™, splitter, which uses an extremely thin BK7 glass face sheet bonded to a precision frame to maintain adequate reflected and transmitted wavefront quality.




Any coating that can be applied to a standard plate splitter can be used with SuperThin™,, and its power handling capability approaches that of a conventional plate splitter. SuperThin™, components are also very cost competitive, making them a first choice in any compatible application.

## Product Code : STPBS - λ - R - AOI & Pol

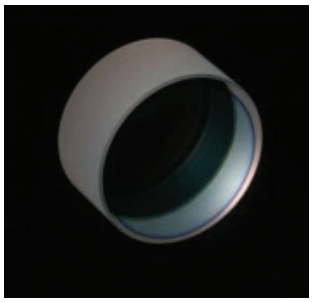
| | λ (nm) | Size Code | Part Number |
|---|---|---|---|
| STPBS | 400, 488, 527, 532, 633, 670, 694,755, 780, 800, 850, 980, 1030, 1053, 1064, 1319, 1550, 1850, etc | 20 (±5), 30 (±5), 40 (±5), 50 (±5), 60 (±5), 70 (±5), 80 (±5), 90 (±5), 95 (±5), 98 (±5), 99 (±5), | 45S, 45P, 45U, etc |

EX, STPBS-532-50-45U : Super Thin Plate BeamSplitter, 532nm, 50% (±5) R, 45 Unpolarization

NOTE :

1. Any other wavelength and R/T ratio can be supplied on request.
2. Other angle of incidence is also available.
3. Other substrate size or thickness are available. Please check up your requirements with us.

## High Energy Harmonic Beamsplitters



1. Substrate :
   - Material : UV fused silica or BK7
   - Clear Aperture : larger than 85%
   - Surface Quality(Scratch-Dig) :
     - 10-5 for regular plate windows
     - 60-40 for super thin plate windows
   - Surface Flatness :
     - $\lambda$/10 @633nm for regular plate windows
     - ~2$\lambda$/inch @633nm for super thin plate windows
   - Thickness:
     - 0.25" $\pm$0.01" for regular plate windows
     - 0.15mm $\pm$0.02mm for super thin plate windows
   - Angular Deviation: $\pm$3 arc min
   - Bevel : <0.5mm @45° typical
2. Reflectance:
   - 1st Surface: R $\geq$99.5% at user specificed wavelength
   - 2nd Surface: Anti-reflection coating, $R_p \leq 0.25\%$, $R_{unp} \leq 0.75\%$, $R_s \leq 1.3\%$ @45°
3. Transmittance: $T_{ave} \geq 90\%$
4. Angle of Incidence : 45°
5. Damage Threshold : 1MW/cm$^2$, CW ;10J/cm$^2$, 20ns, 20Hz (for R) ; 4J/cm$^2$, 20ns, 20Hz(for T) @1064nm

High energy harmonic beamsplitters are similar with regular dichroic beamsplitters. They were specially designed to separate a primary wavelength and its harmonic wavelength from a laser. Spectral Optics provide these harmonic beamsplitters for Nd:YAG and Ti : Shaaphire laser systems.

The 1st surface with a high energy dichroic coating reflects the target wavelength $\geq$99.5% and transmits other target wavelength $\geq$90%. The 2nd surface has a high energy anti-reflection coating for the target transmitting wavelength.

If the beam size is small (<5mm dia) and the minimal beam deviation is needed, our super thin plate could be a good solution.

## Product Lists

1. Regular Plate Harmonic Beamsplitter :

| Rλ(nm) | Tλ(nm) | Size | Part Number |
|---|---|---|---|
| 266 | 532 | 1.0" | RPHBS R266 T532 100 FS |
| | | 1.5" | RPHBS R266 T532 150 FS |
| | | 2.0" | RPHBS R266 T532 200 FS |
| 266 | 1064 | 1.0" | RPHBS R266 T1064 100 FS |
| | | 1.5" | RPHBS R266 T1064 150 FS |
| | | 2.0" | RPHBS R266 T1064 200 FS |
| 355 | 532 | 1.0" | RPHBS R355 T532 100 FS |
| | | 1.5" | RPHBS R355 T532 150 FS |
| | | 2.0" | RPHBS R355 T532 200 FS |
| 355 | 1064 | 1.0" | RPHBS R355 T1064 100 FS |
| | | 1.5" | RPHBS R355 T1064 150 FS |
| | | 2.0" | RPHBS R355 T1064 200 FS |
| 400 | 800 | 1.0" | RPHBS R400 T800 100 BK |
| | | 1.5" | RPHBS R400 T800 150 BK |
| | | 2.0" | RPHBS R400 T800 200 BK |
| 532 | 1064 | 1.0" | RPHBS R532 T1064 100 BK |
| | | 1.5" | RPHBS R532 T1064 150 BK |
| | | 2.0" | RPHBS R532 T1064 200 BK |
| 1064 | 532 | 1.0" | RPHBS R1064 T532 100 BK |
| | | 1.5" | RPHBS R1064 T532 150 BK |
| | | 2.0" | RPHBS R1064 T532 200 BK |

* The anti-reflection coating on the 2nd side will be for T λ (nm).

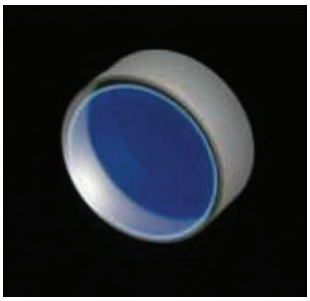
2. Super Thin Plate Harmonic Beamsplitter :

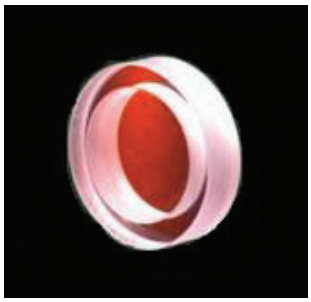
| Rλ(nm) | Tλ(nm) | Part Number |
|---|---|---|
| 355 | 532 | STHBS R355 T532 025 |
| 355 | 1064 | STHBS R355 T1064 025 |
| 400 | 800 | STHBS R400 T800 025 |
| 532 | 1064 | STHBS R532 T1064 025 |
| 1064 | 532 | STHBS R1064 T532 025 |

* The anti-reflection coating on the 2nd side will be for T λ (nm).

## Dichroic Plate Beamsplitters

**Long/Short Wave Pass Filters/Combiners**





1. Substrate :
   - Material : UV fused silica or BK7
   - Clear Aperture: larger than 85%
   - Surface Quality (Scratch-Dig) :
     - 10-5 for regular plate windows
     - 60-40 for super thin plate windows
   - Surface Flatness :
     - $\lambda$/10 @633nm for regular plate windows
     - ~2$\lambda$/inch @633nm for super thin plate windows
   - Thickness :
     - 0.25" $\pm$0.01" for regular plate windows
     - 0.15mm $\pm$0.02mm for super thin plate windows
   - Angular Deviation: $\pm$3 arc min
   - Bevel : <0.5mm @45° typical
2. Reflectance :
   - 1st Surface : R $\geq$99.5% at user specificed wavelength
   - 2nd Surface : Anti-reflection coating, $R_p \leq 0.25\%$, $R_{unp} \leq 0.75\%$, $R_s \leq 1.3\%$ @45°
3. Transmittance :
   - Long Wave Pass: $T_{ave}$ >90%
   - Short Wave Pass: $T_{ave}$ >85%
4. Damage Threshold: 10J/cm$^2$, 20ns, 20Hz; 1MW/cm$^2$, CW @1064nm

Dichroic Plate Beamsplitters are used to separate or combine two different wavelength beams. They can be called as Long Wave Pass or Short Wave Pass Filters (Combiner). When the transmittance for longer wavelength range is maximized, it is called "Long Wave Pass". The "Short Wave Pass" is when the transmittance for the shorter wavelength range is maximized.

Dichroic Plate Beamsplitters are frequently used at (near) normal or 45° incidence. The region of high reflectivity or low transmission of a dichroic beamsplitter is similar with that of a mirror.

The transmittance for longer wavelength range is always higher than that for shorter wavelength range. So it is strongly recommend to design the optical setup to use the Long Wave Pass for the applications where the light throughput is critical.

## Product Lists

### 1. Regular Plate Dichroic Beamsplitter : RPDBS - Tpol λ - Rpol λ - AOI - Size - Material

| | Tpol λ(nm) | Rpol λ (nm) | AOI | Size Code | Material |
|---|---|---|---|---|---|
| RPDBS | Ts λ, for S pol<br>Tp λ, for P pol<br>Tunp λ, for unpol.<br>Ex, Tp1064 : Transmission P pol for 1064nm | Rs λ, for S pol<br>Rp λ, for P pol<br>Runp λ, for unpol.<br>Ex, Rs633 : Reflection S pol for 633nm | 0, 45 | 100 (1.0") | FS |
| | | | | | BK |
| | | | | 150 (1.5") | FS |
| | | | | | BK |
| | | | | 200 (2.0") | FS |
| | | | | | BK |

### 2. Super Thin Plate Dichroic Beamsplitter : STDBS - Tpol λ - Rpol λ - AOI - Size

| | Tpol λ(nm) | Rpol λ (nm) | AOI | Size Code | Material |
|---|---|---|---|---|---|
| RPDBS | Ts λ, for S pol<br>Tp λ, for P pol<br>Tunp λ, for unpol.<br>Ex, Tp1064 : Transmission P pol for 1064nm | Rs λ, for S pol<br>Rp λ, for P pol<br>Runp λ, for unpol.<br>Ex, Rs633 : Reflection S pol for 633nm | 0, 45 | 100 (1.0") | FS |
| | | | | | BK |
| | | | | 150 (1.5") | FS |
| | | | | | BK |
| | | | | 200 (2.0") | FS |
| | | | | | BK |

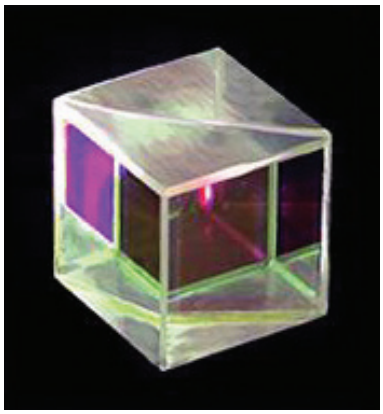
EX, RPDBS-Tp532-Rs633-45-150-BK: Regular Plate Dichroic BeamSplitter, Transmitting P-pol 532nm, Reflecting S-pol 633nm, Angle of Incidence 45° , 1.5", BK7 glass.

NOTE:

1. The selection of the substrate material is dependent on the wavelength. The transmission below 400nm is required, the material has to be UV fused silica. The reflection below 355nm is required, the material also has to be UV fused silica
2. Any wavelength can be supplied on request.
3. The Tλ and the Rλ shouldn't be too close. Please check this up with us.

## Cube Beamsplitters

- Optical Material : UV fused silica, BK7
- Surface quality : 10-5 for UV fused silica, 20-10 for BK7
- Transmitted Wavefront Error: λ/4 @ 633nm
- Clear Aperture : ≥85% of central dimension
- Anti-reflection coating: R≤0.25% on all leg sides
- Damage Threshold :
  - Optical Cement: 1J/cm², 20ns, 20Hz @1064nm; 100W/cm², CW @515nm
  - Molecular Fusion TM : >10J/cm², 20ns, 20Hz @1064nm; 1MW/cm², CW @1064nm



Cube beamsplitters offer the flexibility of a large range of coating types and different trade-offs between cost and power handling capability, as well as the convenience of near-zero beam deviation and right-angle splitting. They cause fewer ghost images than plate beamsplitters. A durable all-dielectric partial reflection coating is used at the internal interface. All external four leg surfaces have anti-reflection coating for the specific wavelength. It is recommended to use them with collimated or near collimated input light for the best spectral performance and transmitted wavefront. The cemented cube beamsplitters can be used up to 1 J/cm² at 1064nm. The NEW Spectral Optics' *Molecular Fusion™* bonding technology creates optically contacted units that are permanently bonded, with no cements or other substances to degrade coating performance. It allows to use them in very high energy/power laser application.



## Product Lists

### 1. Optical Cement : CBS-OC - λ - R - Pol - Size - Material

| | λ(nm) | R(%) | POl | Size Code | Material |
|---|---|---|---|---|---|
| CBS-OC- | 248, 257, 266, 308, 337, 355, 364, 400, 488, 532, 633, 670, 780, 800, 850, 980, 1030, 1064, 1319, 1550, etc | 20 (±5)<br>30 (±5)<br>40 (±5)<br>50 (±5)<br>60 (±5)<br>70 (±5)<br>80 (±5) | S<br>P<br>U | 50 (0.5") | FS |
| | | | | | BK |
| | | | | 100 (1.0") | FS |
| | | | | | BK |

## 2. Molecular Fusion : CBS-MF - λ - R - Pol - Size - Material

| | λ(nm) | R(%) | POl | Size Code | Material |
|---|---|---|---|---|---|
| CBS-MF- | 248, 266, 355, 400, 532, 800, 1064, 1550<br>(other wavelength can be supplied on request) | 20 (±5)<br>30 (±5)<br>40 (±5)<br>50 (±5)<br>60 (±5)<br>70 (±5)<br>80 (±5) | S<br>P<br>U | 50 (0.5") | FS |
| | | | | | BK |
| | | | | 100 (1.0") | FS |
| | | | | | BK |

EX, CBS-MF-1064-50-U-050-FS: Cube BeamSplitter with Molecular Fusion bonding, 1064nm, 50% (±5%) R, 45° Unpolarization, 0.5", Fused Silica.

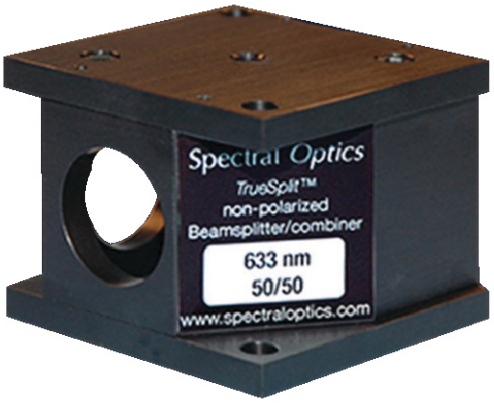
NOTE:

1. The selection of the substrate material is dependent on the wavelength. Below 400nm, the UV fused silica is recommended.
2. Any other wavelength and R/T ratio can be supplied on request.
3. Please contact us to check up the availability for the molecular fusion bonding on the 1" size.

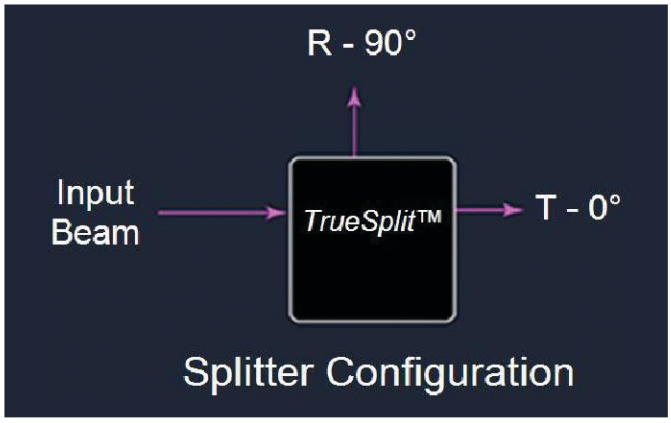
## TureSplit

**TrueSplit™ Non-Polarized Beamsplitter**

1. Substrate
   - Material : UV fused silica or BK7 window
   - Surface Quality : 10-5 Scratch-Dig
   - Surface Flatness : λ/10 @633nm over clear aperture
2. Other Specifications
   - Coating : E-beam multilayer dielectric
   - Polarization : | P-S | <2.5%
   - R/T ratio tolerance : ± 3%
   - Clear Aperture : >5/8"
   - Dimension : 2.5" X 2.5" X 2.0"
   - Damage Threshold: 20J/cm², 20ns, 20Hz; 1MW/cm², CW @1064nm




*TrueSplit™* is a breakthrough in beamsplitter technology. While most non-polarizing beamsplitters require hybrid metallic coatings or cemented interfaces which absorb energy, *TrueSplit™* has only hard dielectric coatings and no bonded interfaces. As a result, it achieves <3% P-S polarization performance with almost no absorption, and a damage threshold > 20J/cm². Furthermore, this can be realized with almost any R/T ratio (not just 50/50) and almost any wavelength.




The standard unit has a 2 ½ x 2 ½ footprint and a 5/8" clear aperture. Other sizes and configurations on request.

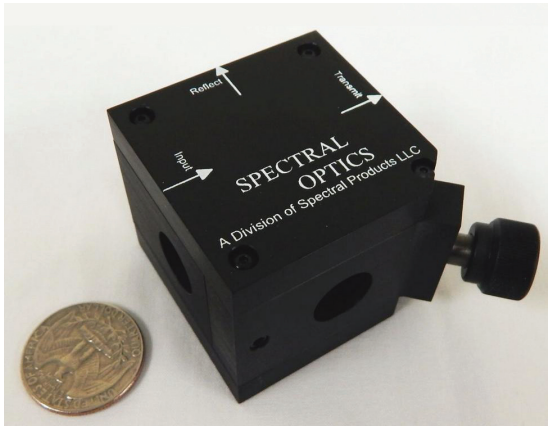
## Product List : TureSplit - λ - R

| | λ(nm) | Size Code | Part Number |
|---|---|---|---|
| TureSplit | 248, 266, 355, 400, 532, 633, 800, 850, 1064, etc | 20(±5), 30(±5), 40(±5), 50(±5), 60(±5), 70(±5), 80(±5), 90(±5), | <400nm |
| | | | ≥400nm |

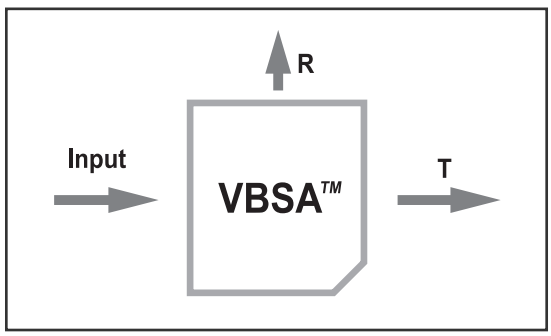
## Variable Beam Splitter/Attenuator

Spectral Optics (a division of Spectral Products) has developed a completely new and innovative type of broadband Variable Beam Splitter / Attenuator (VBSA) for High Power Laser Applications. Our unique VBSA offers the user continuous adjustment of the Reflection/Transmission (R/T) split ratio over an extremely broad range of wavelengths from the Deep UV at 193nm up to 10.6um in the Far Infrared. Both uncoated and coated versions of our innovative VBSA are available for any Laser wavelength and any polarization.

Spectral Optics exclusive high power Variable Beam Splitter / Attenuator (VBSA) can be designed with no optical coatings over the entrance and exit apertures for use in very high power Laser applications. Due to the VBSA innovative new design, the uncoated version will maintain a laser induced damage threshold nearing the actual bulk laser damage threshold of the internal substrate materials. Due to this very unique design, extremely high damage thresholds can be maintained for most all high power Lasers operating at very specific UV to FIR wavelengths.



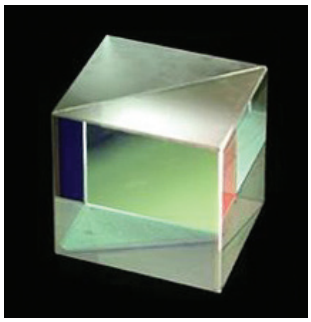

Spectral Optics exclusive high power Variable Beam Splitter / Attenuator (VBSA) can also be used as a Continuously Tunable or Fixed Ratio Attenuator with the Transmission range typically controlled from 20% T up to 80% T (minimum of ~0% T up to ~90% T) for any UV-FIR wavelength. Offered with our Anti-Reflection (AR) coatings, the % Transmission can be controlled up to >99% T over a specific wavelength range.




Spectral Optics standard VBSA Clear Aperture(C/A) standard sizes range from ¼ diameter up to ½ diameter or larger; and are available up to a 2" diameter C/A on a custom basis.

# Polarization Optics

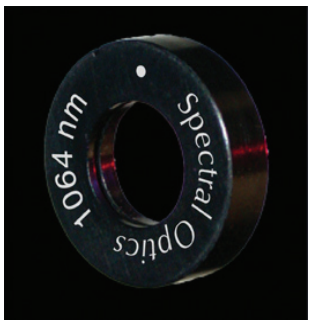
Spectral Optics has a lot of designs that allow a high degree of control over polarization properties. In addition to its standard coating list, Spectral Optics provide various polarizing plate and cube beamsplitters that are deployed in extremely varied ways in optical systems, from beam sampling to color and polarization control. Spectral Optics stocks right angle prisms in common sizes in both BK7 and Fused Silica. Fabrication of beam splitters can be done using either optical cements or standard optical contacting techniques. Along with these conventional contacting techniques, Spectral Optics has introduced its new *Molecular Fusion™*, line of optically contacted high-energy components.



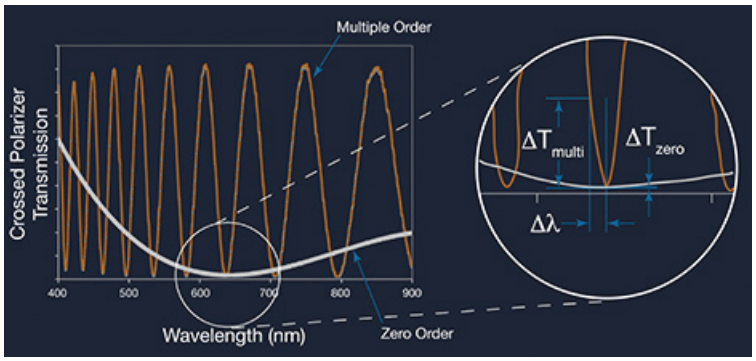
## Waveplates

**Molecular Fusion™, Zero-Order Waveplates**

Using its revolutionary new *Molecular Fusion™*, bonding process, Spectral Optics can now provide zero-order waveplates at prices comparable to ordinary multiple-order waveplate. Zero-order waveplates are far superior in temperature stability and wavelength tolerance, but have traditionally been 50 - 75% more expensive than multiple-order components. Using its new fabrication processes, Spectral Optics zero-order parts cost far less than those of other manufacturers, and only 10 - 15% more than comparable multiple-order components, even less in some applications.



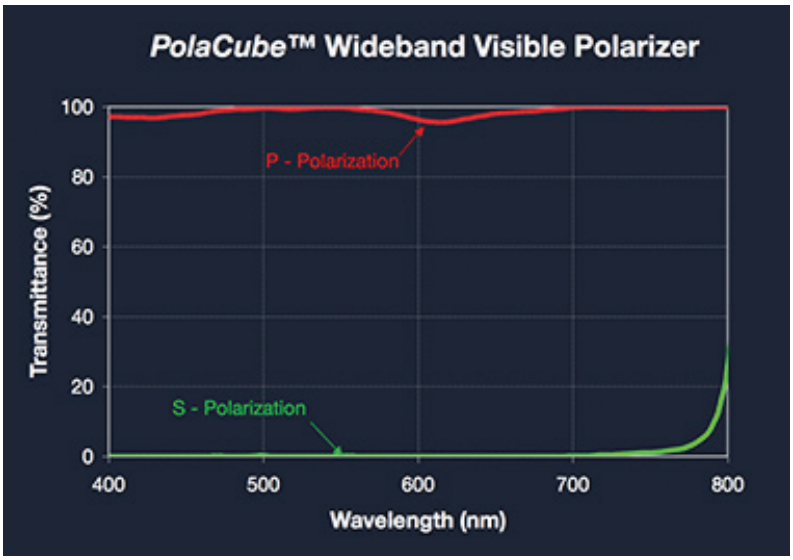

Because of their many performance advantages and new low cost, Spectral Optics is now offering only zero-order waveplates in all the standard wavelengths and sizes. There is no reason to design-in multiple-order waveplates ever again!

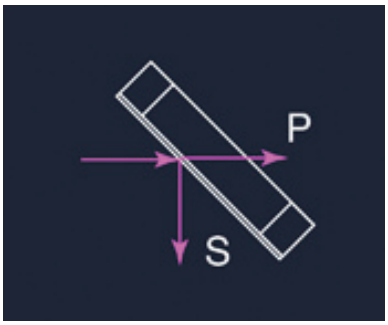


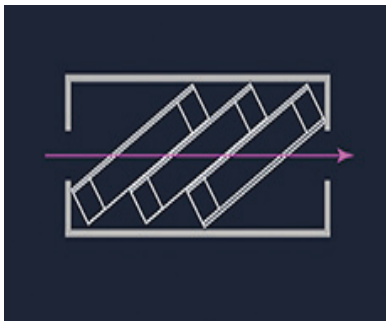

Multiple-order waveplates show rapid changes in retardation as the wavelength changes, as seen at left. For a small change $\Delta\lambda$ (or equivalent change in temperature), the multi-order waveplate shows a large transmission change $\Delta$Tmulti. By contrast, the change in retardation of the zero-order plate is very slow, so the same $\Delta\lambda$ gives a much smaller change, $\Delta$Tzero.

## Polarizer

Spectral Optics is a specialist in polarization technology. In additon to standard calcite and coated plate polarizers, Spectral Optics has developed new technologies to match any need. The *PolaCube*™, cube beamsplitter provides a high-performance wideband polarizer for low to medium power visible applications. The *SuperThin*™, technology stacked polarizer offers very high extinction ratio, low beam deviation and good power handling in a cost-effective, UV to NIR component. Spectral Optics is continually expanding its polarization product line, so be sure to inquire about how we can meet your next polarization requirement.



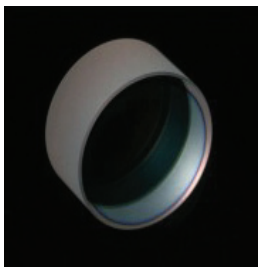



## Polarizing Plate Beamsplitters

1. Substrates :
   - Material : UV fused silica or BK7
   - Clear Aperture : larger than 85%
   - Surface Quality (Scratch-Dig) : 10-5 for regular plate windows 60-40 for super thin plate windows
   - Surface Flatness : λ/10 @633nm for regular plate windows, ~2λ/inch @633nm for super thin plate windows
   - Thickness : 0.25" ±0.01" for regular plate windows 0.15mm ±0.02mm for super thin plate windows
   - Bevel : <0.5mm @45° typical
2. Transmitted Wavefront Error : λ/8 at 633nm
3. Damage Threshold : 10J/cm², 20ns, 20Hz @1064nm ; 1MW/cm², CW @1064nm

Polarizing plate beam splitters (PPBS) separates input beam into two beams by reflecting S-polarization beam and transmitting P-polarization. These are an ideal choice for high power laser application which requires high damage threshold. Spectral Optics provide these PPBS for Brewster's angle (56°) and for 45°. The Brewster's angle PPBS give higher extinction ratio but the reflected beam has this Brewster's angle. The 45° angle PPBS have lower extinction ratio but make it easy to use in the optical setup and also can be used as beam combiners. These PPBS are mostly used for high power Nd:YAG laser applications but Spectral Optics can provide any wavelength PPBS on customer's request.





## Product Lists

### 1. Regular Plate :

| λ(nm) | AOI(°) | Material | $T_P$(%) | $T_P/T_S$ | Size | Part Number |
|---|---|---|---|---|---|---|
| 248 | 56 ± 3 | UV FS | 85 | 100/1 | 1" x1/4" | PPBS 248 1025 FS 56 |
| | | | | | 2" x1/4" | PPBS 248 2025 FS 56 |
| 266 | 56 ± 3 | UV FS | 85 | 100/1 | 1" x1/4" | PPBS 266 1025 FS 56 |
| | | | | | 2" x1/4" | PPBS 266 2025 FS 56 |
| 355 | 56 ± 3 | UV FS | 90 | 100/1 | 1" x1/4" | PPBS 355 1025 FS 56 |
| | | | | | 2" x1/4" | PPBS 355 2025 FS 56 |
| 532 | 56 ± 3 | BK7 | 95 | 200/1 | 1" x1/4" | PPBS 532 1025 BK 56 |
| | | | | | 2" x1/4" | PPBS 532 2025 BK 56 |
| | 45 | BK7 | >96 | 500/1 | 1" x1/4" | PPBS 532 1025 BK 45 |
| | | | | | 2" x1/4" | PPBS 532 2025 BK 45 |
| 1064 | 56 ± 3 | BK7 | 95 | 200/1 | 1" x1/4" | PPBS 1064 1025 BK 56 |
| | | | | | 2" x1/4" | PPBS 1064 2025 BK 56 |
| | 45 | BK7 | >97 | 500/1 | 1" x1/4" | PPBS 1064 1025 BK 45 |
| | | | | | 2" x1/4" | PPBS 1064 2025 BK 45 |

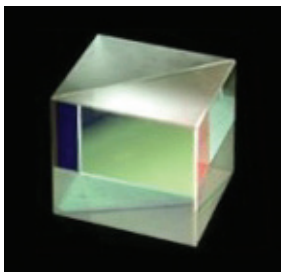
### 2. Super Thin Plate :

| λ(nm) | AOI(°) | Material | $T_P$(%) | $T_P/T_S$ | Size | Part Number |
|---|---|---|---|---|---|---|
| 532 | 56 ± 3 | BK7 | 95 | 200/1 | 25mm | STPPBS 532 025 BK 56 |
| | 45 | BK7 | >96 | 500/1 | 25mm | STPPBS 532 025 BK 45 |
| 1064 | 56 ± 3 | BK7 | 95 | 200/1 | 25mm | STPPBS 1064 025 BK 56 |
| | 45 | BK7 | >97 | 500/1 | 25mm | STPPBS 1064 025 BK 45 |

NOTE:

1. The selection of the substrate material is dependent on the wavelength

## Polarizing Cube Beamsplitters



- Optical Material : UV fused silica, BK7
- Surface quality : 10-5 for UV fused silica, 20-10 for BK7
- Transmitted Wavefront Error : λ/4 @ 633nm
- Clear Aperture : ≥85% of central dimension
- Anti-reflection coating : R≤0.25% on all leg sides
- Field of view : ±3°
- Extinction Ratio :
  - OC version : Tp/Ts > 1000:1 for λ > 450 nm, T p/T s > 500:1 for λ ≤ 450 nm
  - MF version : Tp/Ts > 5000:1 for λ > 450 nm, T p/T s > 3000:1 for λ ≤ 450 nm
- Reflection : Rs > 99.9% for λ > 450 nm, Rs > 99.5% for λ ≤ 450 nm
- Transmission : Tp > 90% for optical cement, Tp > 95% for molecular fusion
- Damage Threshold :
  - Optical Cement : 1J/cm2, 20ns, 20Hz @1064nm; 100W/cm2, CW @515nm
  - *Molecular Fusion™* : >10J/cm2, 20ns, 20Hz @1064nm; 1MW/cm2, CW @1064nm

Cube beamsplitters consist of two right angle prisms with special dielectric coating on the interface. They offer the flexibility of a large range of coating types and different trade-offs between cost and power handling capability, as well as the convenience of near-zero beam deviation and right-angle splitting. Especially polarizing cube beamsplitters are used to split a laser beam into two orthogonally polarized components or combine them into one beam. The P-polarization is transmitted strate through and the S-polarization is reflected at 90°.

For lower power applications, the cubes are assembled from coated 90° angle prisms cemented together using index-matching transparent adhesives to avoid interface losses and provide a strong, stable part. In general, it can be used up to 1J/cm$^2$ at 1064 nm. The input light beam has to come into the coated side first, which is marked on the cube.

Optically contacted cubes have much higher damage thresholds and wide wavelength response, with better beam quality since the index inhomogeneity of the optical cement is not present to degrade wavefront accuracy in the transmitted beam. However, they are more expensive and are not generally as stable mechanically, due to the fragile nature of the optically contacted interface. The new Spectral Optics Molecular Fusion™, bonding technology creates optically contacted units that are permanently bonded, with no cements or other substances to degrade coating performance.

## Product Lists

### 1. Optical Cement : PCBS - OC - λ - Size - Material

| | λ(nm) | Size Code | Material |
|---|---|---|---|
| PCBS-OC- | 257, 266, 308, 337, 351, 355, 364, 400, 488, 532, 633, 670, 780, 800, 850, 980,1030, 1064, 1319, 1550, etc | 50 (0.5") | FS |
| | | | BK |
| | | 100 (1.0") | FS |
| | | | BK |

### 2. Molecular Fusion : PCBS - MF - λ - Size - Material

| | λ(nm) | Size Code | Material |
|---|---|---|---|
| PCBS-MF- | 248, 266, 355, 400, 532, 800, 1064, 1550 (other wavelength can be supplied on request) | 50 (0.5") | FS |
| | | | BK |
| | | 100 (1.0") | FS |
| | | | BK |

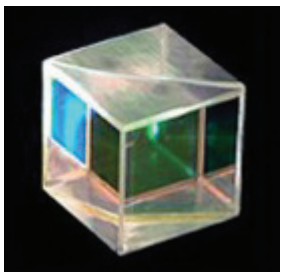
EX, PCBS-MF-1064-050-FS: Polarizing Cube BeamSplitter with Molecular Fusion bonding, 1064nm, 0.5", Fused Silica.

NOTE:

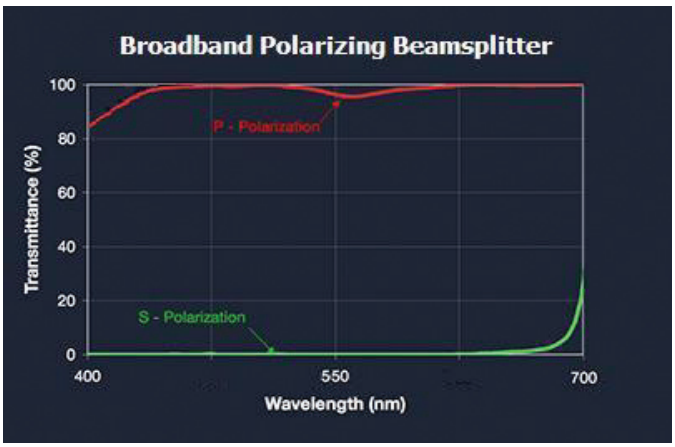
1. The selection of the substrate material is dependent on the wavelength. Below 450nm, the UV fused silica is recommended.
2. Any other wavelength can be supplied on request

# Broadband Polarizing Cube Beamsplitters

- Optical Material : SF2 glass
- Surface quality : 40-20
- Transmitted Wavefront Error : λ/4 @ 633nm
- Clear Aperture : ≥85% of central dimension
- Field of view : ±3°
- Extinction Ratio : T p/T s > 500:1
- Reflection : Rs > 99.5%
- Transmission : Tp_ave > 90%
- Damage Threshold : 1J/cm², 20ns, 20Hz @1064nm; 100W/cm², CW @515nm



Spectral Optics provides broadband polarizing beamsplitter cubes that are made from SF2 glasses. Thanks to the high refractive index of SF2 glass, it can make these cube beamsplitters provide a high-performance broadband polarization.




Due to the limitation of the material, it is applicable for low to mid power light source applications, up to 1 J/cm².

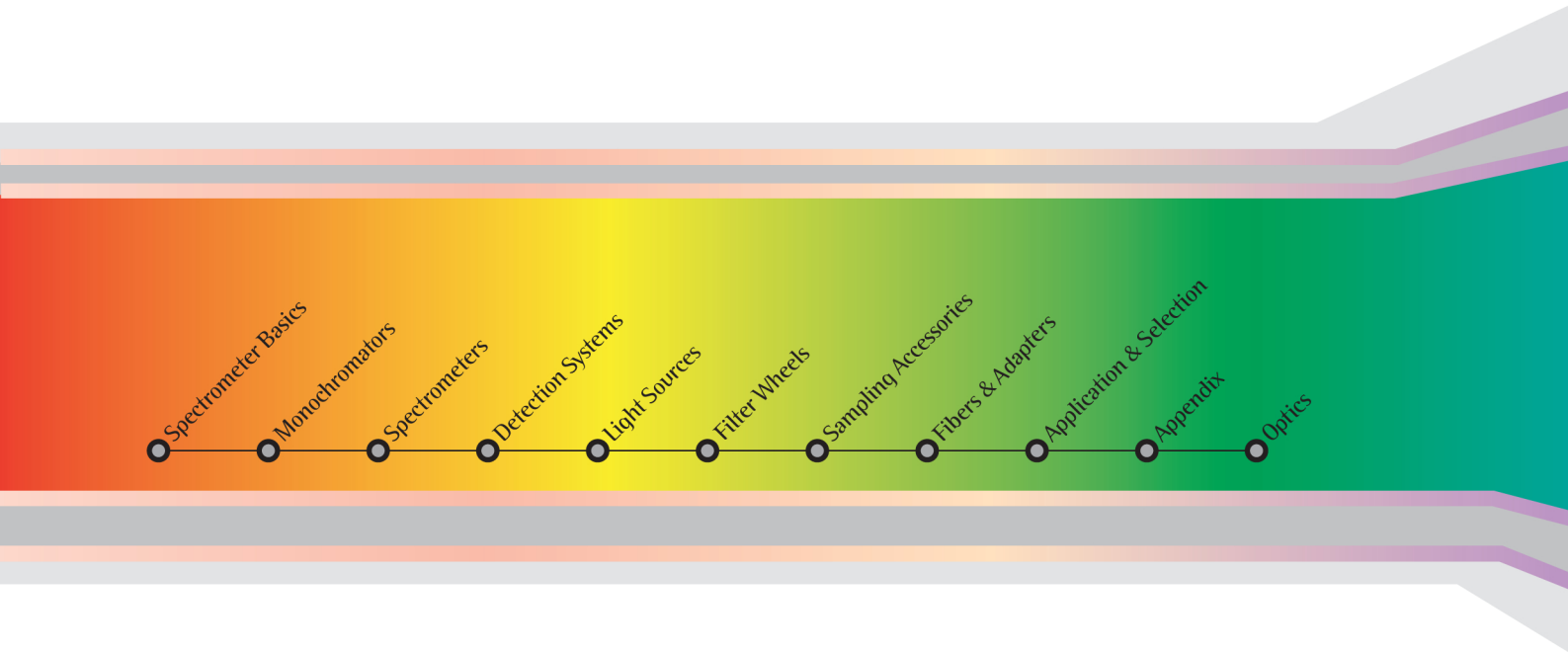
## Product List : BPCBS - Size - λ1 - λ2

| | Size Code | λ1 - λ2 (nm) | Rave |
|---|---|---|---|
| BPCBS | 50 (0.5"/12.7mm) | 450 700 | <0.5% |
| | | 700 1000 | <0.5% |
| | | 1000 1500 | <0.5% |
| | | 450 1000 | <2.0% |
| | | 450 1500 | <3.0% |
| | 100 (1.0"/25.4mm) | 450 700 | <0.5% |
| | | 700 1000 | <0.5% |
| | | 1000 1500 | <0.5% |
| | | 450 1000 | <2.0% |
| | | 450 1500 | <3.0% |

EX, BPCBS-050-450-700: Broadband Polarizing Cube BeamSplitter, 0.5" size, 450-700nm range

NOTE:

The beam has to enter through the prism marked with the dot to avoid the damage.





## Spectral Products L.L.C

111 Highland Drive Putnam, CT06260 U.S.A

www.spectralproducts.co

www.spectraloptics.com

sales@spectralproducts.com

Tel:1_860_928_5834

Fax:1_860_928_2676

## Spectral Products (Albuquerque)

2659A Pan American Freeway NE

Albuquerque, NM 87107 U.S.A

Tel:1_505_343_9700

Fax:1_505_343_9705