Fiber-Optic Spectrometers

Fiber-optic spectrometers are optical instruments designed to measure light intensity in the ultraviolet, visible, and infrared spectral regions. Spectroscopic measurements are used to measure color, to determine the type and concentration of chemical components in a sample, and to analyze electromagnetic radiation, along with many other applications.

A spectrometer generally consists of an entrance slit or aperture, a collimator, a dispersive element such as a grating or prism, focusing optics, and a detector array.

CVI Melles Griot spectrometer systems consist of dedicated electronics, an optical bench, and a detector array. The 13 FOS 100-series spectrometer uses a 102-pixel linear photodiode array; the high-resolution 13 FOS 200-series and 13 FOS 201-series spectrometers use a linear charge-coupled detector (CCD) array with 2048 pixels.

OPTICAL BENCH DESIGN

CVI Melles Griot fiber-optic spectrometers are symmetrical Czerny-Turner instruments with either a 45-mm or 75-mm focal length optical bench. The light enters the optical bench through a standard SMA 905 connector and is collimated by an aspheric mirror. A plane grating diffracts the collimated light, and a second spherical mirror focuses the resulting diffracted light onto a linear detector array.

The optical bench can be configured in many ways, depending on the intended application. The choice of diffraction grating, entrance slit, order-sorting filters, and detector coatings will influence system performance. Gratings and detectors are permanently installed and must be specified at the time of purchase.

GRATINGS

A diffraction grating is an optical element that separates incident polychromatic radiation into its constituent wavelengths. A grating consists of a series of equally spaced, parallel grooves formed in a reflective coating deposited on a suitable substrate. There are two main types of gratings: ruled and holographic. Ruled gratings are physically cut into the grating substrate on a ruling machine using a diamond tool. Holographic gratings are formed in a photolithographic process. A photoresist is exposed using a laser interference process, then the grooves are chemically etched into the grating substrate.

DETECTOR ARRAYS

CVI Melles Griot spectrometers come with either a CCD or a photodiode linear detector array. Both are silicon-based detectors and cover the wavelength range from 200 to 1100 nm. The detectors enable rapid determination of the spectrum without the need for a moving grating.

CCD Detector

The CCD detector stores a charge, which is then dissipated as photons strike the photoactive surface. At the end of a controlled time interval (integration time), the remaining charge is transferred to a buffer, and then this signal is transferred to an analog-to-digital (A-to-D) converter. CCD detectors are naturally integrating and therefore have enormous dynamic range, limited only by the dark (thermal) current and the speed of the (A-to-D) converter.

Photodiode Arrays

A silicon photodiode array consists of a linear array of multiple photodiode elements, either 102 or 2048 pixels. When light enters the photodiode, electrons will become excited and output an electrical signal. Most photodiode arrays have an integrated signal-processing circuit with a readout/integration amplifier on the same chip.

OPTICAL RESOLUTION

Optical resolution is defined as the minimum difference in wavelength that can be separated by the spectrometer. To separate two spectral lines, it is necessary to image them at least two array-pixels apart. Because the grating determines how far different wavelengths are separated (dispersed) at the detector array, it is important to choose the correct grating for required resolution. Another important consideration is the width of the light beam entering the spectrometer. This is determined by the entrance slit in the spectrometer, or, when no slit is installed, the fiber core diameter. Other considerations aside, the narrower the slit, the higher the resolution will be. Slits can be installed with widths of 10, 25, 50, 100, or 200 μm.

SECOND-ORDER EFFECTS

Second-order effects can become an important factor for gratings with low groove frequency and therefore a lower dispersion. These effects are usually caused by the grating's second-order diffracted beam. The effects of these higher-order beams can often be ignored, but sometimes they can cause difficulties. The best practice is to limit the light to the region of the spectra where order overlap is not possible.

Second-order effects can be filtered out by using a permanently installed long-pass optical filter in the SMA entrance connector. For UV wavelength range applications, an order-sorting coating option is available.

How to Select your Spectrometer

- Select Optical Bench
  - Resolution
  - Wavelength Range
  - Light Level
- Select Grating
  - Resolution
  - Wavelength Range
- Select Slits
  - Resolution
- Select Options
  - Detector Collection Lens
  - UV or DUV Option
  - Order-Sorting Coatings
  - Order-Sorting Filter

Standard Fiber-Optic Spectrometer

This CVI Melles Griot standard fiber-optic spectrometer is based on the symmetrical Czerny-Turner design with a 45-mm focal length optical bench and a 102-pixel photodiode array. The spectrometer has a standard SMA fiber-optic entrance connector, a collimating and focusing mirror, and diffraction grating. Seven different gratings are available, each with different dispersion and blaze angles, to cover applications in the 360- to 1100-nm range. The photodiode array is connected to an electronics board with a 14-bit A-to-D converter and USB interface. The main application for this instrument is simple color measurement. A 15-pin digital I/O connector facilitates external triggering and the control of shuttered and pulsed light sources.

The standard fiber-optic spectrometer systems include basic software, a users manual, and USB interface cable. Additional application software can be ordered separately. This instrument runs on USB power and does not need an additional power supply.

SPECIFICATIONS:
Standard Fiber-Optic Spectrometer

Optical Bench	Symmetrical Czerny-Turner, 45-mm focal length
Stray Light	<0.3%
Sensitivity	1000 counts/msec integration time
Detector	
Type	Photodiode array
Number of Pixels	102 with 85-μm pitch
Pixel Size	77 × 85 μm
Signal-to-Noise Ratio	1000:1
A-to-D Converter	14 bit; 2 MHz
Integration Time	1 msec to 60 sec
Interface	USB 1.1; 12 MByte/sec
Data Transfer Speed	6–7 msec/scan
Digital I/O	DB-15 connector, 2 digital in, 12 digital out
Status LED	Green for power; yellow for scan
Dimensions	175 × 110 × 44 mm (6.9 × 4.3 × 1.7 in.)
CE Compliance	Compliant