Spectrometer
SD1024G Series

High Performance
SD1024G

High Performance
Wide Wavelength Range
SD1024GS

Ultra Performance
SD1024GH

High Performance
High Resolution
SD2048GH

Medium Performance
SD1024GM

Medium Performance
High Resolution
SD2048GM

General Purpose
SD1024GL

General Purpose
High Resolution
SD2048GL

Verity
INSTRUMENTS, INC.

Spectrometer SD1024G Series

Summary

SD2048GH™
- For demanding high resolution applications
- Scientific grade TE cooled CCD
- Same optics as SD1024GH

SD1024GH™
- For the most demanding applications
- Same as SD1024G, except:
  - Higher throughput optics
  - Lower system readout noise

SD1024G™
- For demanding applications
- Single or multi-fiber input
- Scientific grade TE cooled CCD
- Low system readout noise

SD1024GS
- Wide Range, 250-1100 nm
- Single or multi-fiber input
- Scientific grade TE cooled CCD
- Low system readout noise

SD1024GM™
- For moderately demanding applications
- Single or multi-fiber input
- Mid-grade not TE cooled CCD
- Same optics as SD1024G

SD2048GM™
- For high resolution applications
- Single or multi-fiber input
- Mid-grade not TE cooled CCD
- Same optics as SD1024G

SD1024GL™
- For general purpose applications
- Similar to SD1024FL
- Uses different CCD from SD1024FL
  - SD1024FL CCD is obsolete

SD2048GL™
- For high resolution applications
- Bright source emission required
- Similar to SD2048DL
- Uses different CCD from SD2048DL
  - SD2048DL CCD is obsolete

Features and Benefits

- Wide range of spectrometer options
- Use with existing SpectraView™ software
- Use for endpoint detection, fault detection, and process diagnostics
- 200 – 800 or 900 nm range (to 1100 nm with the SD1024GS)

Description

The SD1024G Series uses common electronics, application software and enclosures. The differences between the different spectrometer models are the charge coupled device (CCD), optical platform and embedded software parameters.

The **SD1024G** was designed for demanding semiconductor process applications. Its optical system employs a 1024-element, scientific-grade CCD array designed for multi-channel spectroscopy, offering high performance at a moderate cost. The advantages of the SD1024G include excellent ultraviolet (UV) response (down to 200nm), stability against degradation under UV exposure, high sensitivity, wide dynamic range and superior output linearity. The **SD1024GS** is very similar to the SD1024G, but the optical elements are changed to support a 250-1100 nm range.

The **SD2048GH** is similar to the SD1024G. However, it uses a 2048-element high performance CCD, the “H” high optical throughput optics, a narrower slit, and reports spectral data in 0.25 nm increments.

The **SD1024GH** incorporates special high throughput optics and lower systematic noise as compared to the SD1024G. The optics used in the SD1024GH increase optical throughput by about 75%. The SD1024GH is recommended for applications that require maximum signal to noise, especially when measuring relatively low intensity signals (see performance data on next page).

The **SD1024GM** is similar to the SD1024G. However, it uses a 2048 element mid-grade CCD. Since the CCD is 2 dimensional the SD1024GM can support multi fiber applications.

The **SD2048GM** is nearly identical to the SD1024GM, but reports spectral data in 0.25nm increments instead of 0.5nm readings as with the SD1024GM. Compared to the SD1024GM, the SD2048GM features a narrower inlet slit and modified embedded software parameters. Although the SD2048GM has better resolution than the SD1024GM, its sensitivity is significantly less.

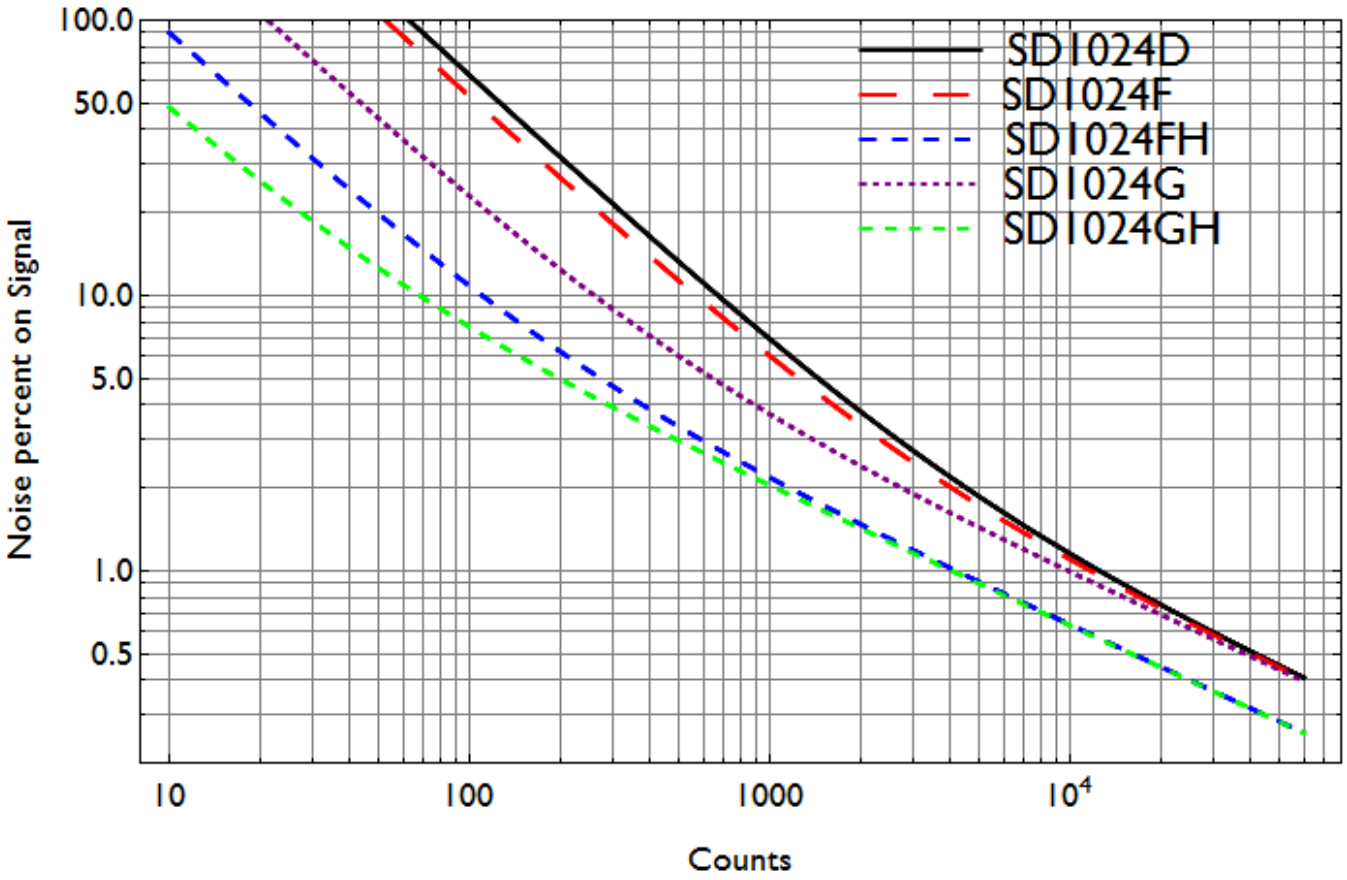
The **SD1024GL** uses a general purpose CCD and was designed for general purpose semiconductor process applications.

The **SD2048GL** is nearly identical to the SD1024GL, but reports spectral data in 0.25nm increments instead of 0.5nm readings as with the SD1024G and SD1024GL. Compared to the SD1024GL, the SD2048GL features a narrower inlet slit and modified embedded software parameters. Although the SD2048GL has better resolution than the SD1024GL, its sensitivity is significantly less.

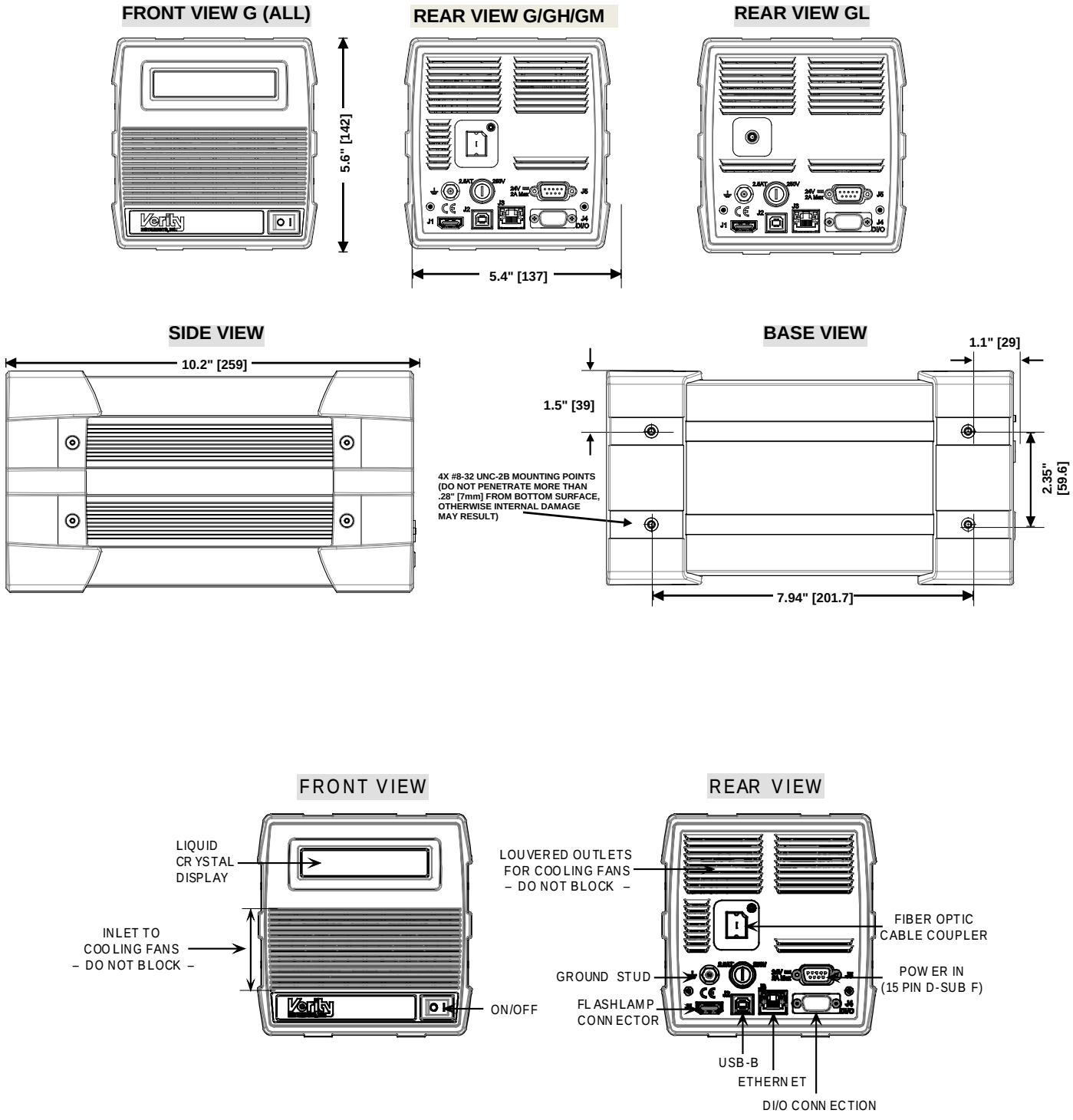
Performance Data – SD1024G & SD1024GH

As compared to the SD1024F, the SD1024G features a significant reduction of system readout noise, thus providing improved signal to noise ratio. To optimize the signal to noise ratio, especially for low light applications, the SD1024GH is recommended.

The noise shown below is the typical peak to peak noise taken at two standard deviations, which is based on the standard intensity setting. Alternate gain calibrations will yield different results. The RMS noise is 75% less than the noise shown below.



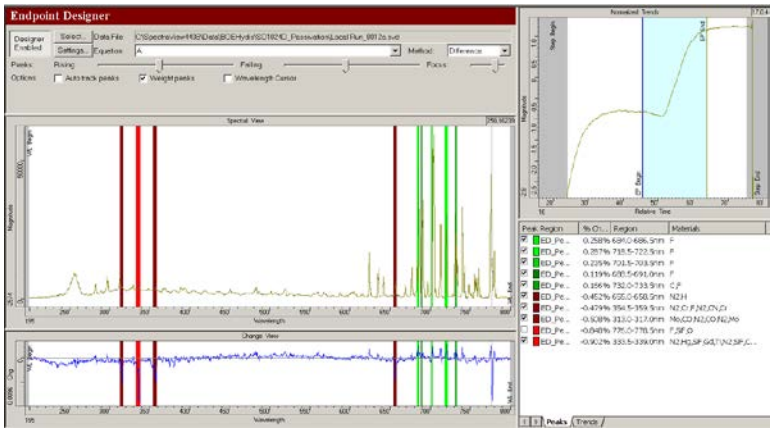
Dimensions – SD1024G/ SD1024GH/ SD2048GH/ SD1024GS/ SD1024GM/ SD2048GM



The rear view shown immediately above is for the SD1024G/GH/GM/GS. The rear panel connectors for the SD1024G Series spectrometers are the same except for the fiber optic cable connection.

SpectraView™ Software

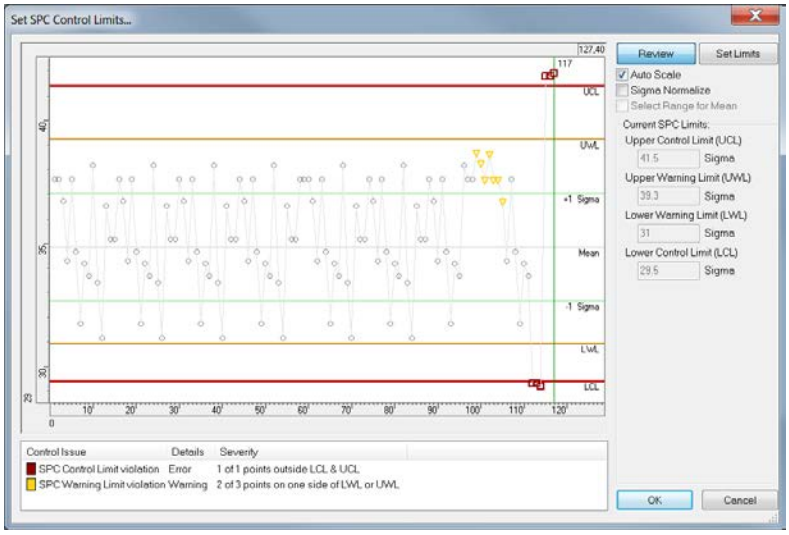
SD1024G Series can be used with current and most prior versions of Verity's SpectraView™ applications software. SpectraView offers many advanced features some of which are listed below.



EPdesigner

EPdesigner is used for the quick generation of endpoint trend lines. Once the "before endpoint" and "after endpoint" cursors are positioned, EPdesigner automatically generates an endpoint trend line based on the spectral changes between the after endpoint cursor and the before endpoint cursor. As part of this process all endpoint regions and trend equations are generated.

In order to improve the endpoint trace signal to noise ratio, selected wavelengths that are used as part of the endpoint trend equation can be removed or added back. A materials database is included to confirm the selected peaks are consistent with the process chemistry.

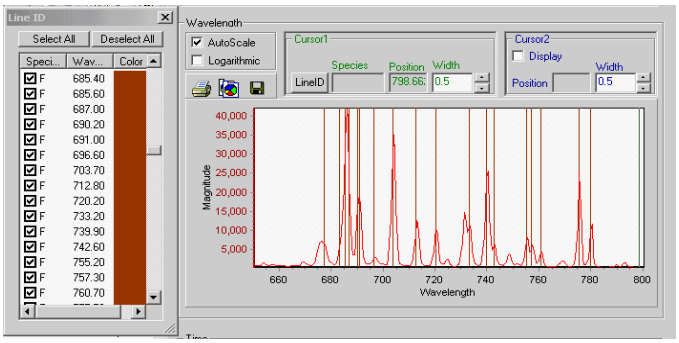


SPC Charting

SPC Charting allows the tracking of variables such as endpoint time over many wafer runs. Using SPC charting, Upper and Lower Control and Warning limits are entered and the selected data is tracked.

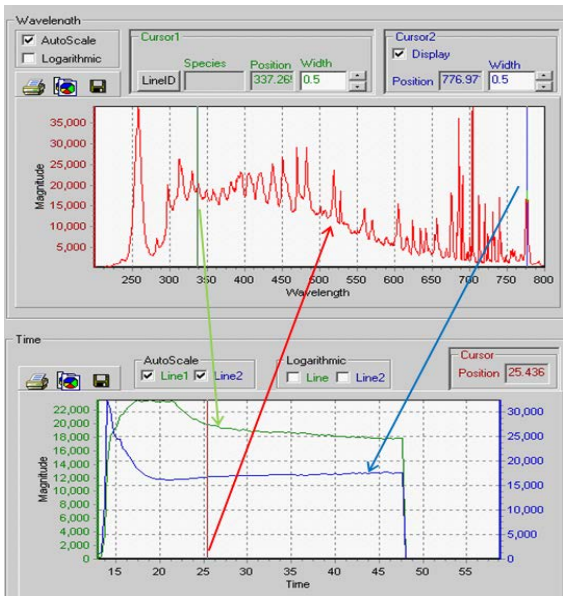
In the event of an excursion, the tool can be notified via Advanced Status Messaging (ASM) so that corrective action may be taken.

SpectraView™ Software



Line ID

Line ID functionality helps identify a gas species by examination of the optical spectrum at a wavelength or group of wavelengths. A default Library is included, and the user can define custom library entries.

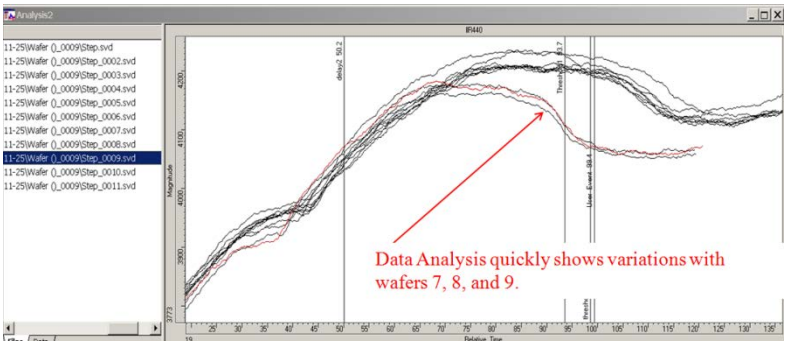


Spectral Viewer

Spectral Viewer consists of two windows, one of which is a spectral graph (wavelength vs. intensity at a selected point in time) and the other displays up to two trend lines (time vs. intensity for the selected trends).

This feature allows the user to view trend lines with dynamic updates based on the green and blue cursor's position in the spectral graph relative to wavelength.

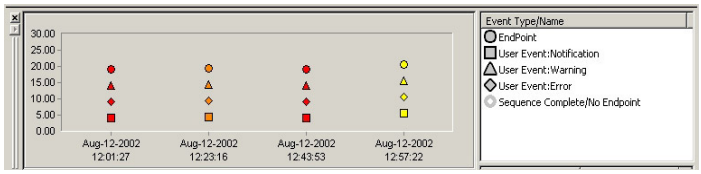
Additionally, if the red cursor in the trend graph is repositioned (relative to time), the spectral graph is immediately updated to reflect the spectrum at the point in time selected in the trend graph.



Data Analysis

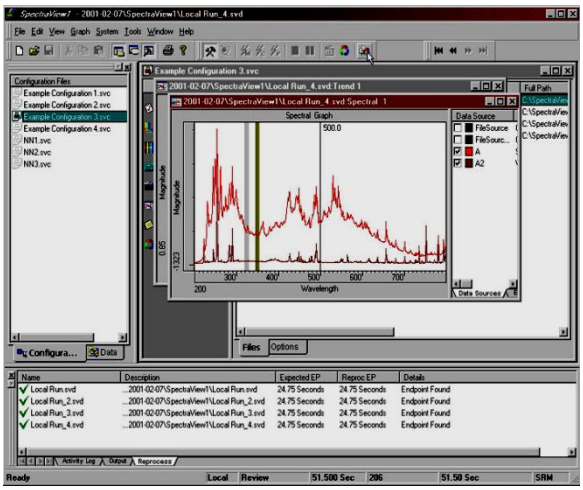
Data Analysis allows large numbers of files to be analyzed simultaneously. By contrasting results of data files against one another, a variety of equations and other parameters can be compared over time.

SpectraView™ Software



Event Statistics

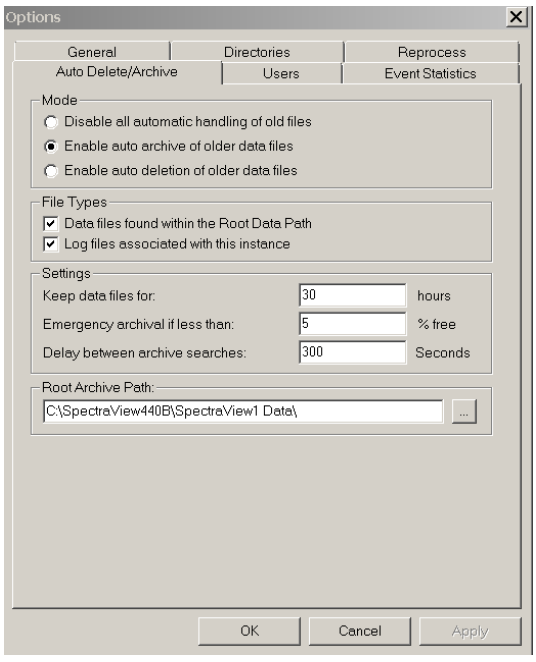
Event Statistics is useful for visually comparing multi-step processes on individual wafers over the entire production cycle.



Reprocess List

Reprocess List automatically tests several data files in a list against a configuration to see how each performs, relative to the selected configuration.

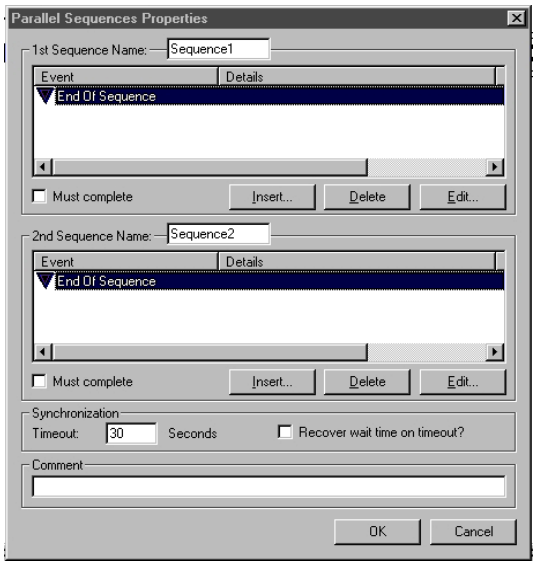
While reprocessing the data files, a notation is made in the form of a check mark or an X at the left of the file name, showing success or failure of the reprocess function.



Auto Delete/Auto Archive

Auto Delete/Auto Archive is a tool for managing and maintaining drive space. Auto Delete/Auto Archive operates in the background and is assigned the lowest CPU priority. This utility can be tailored to utilize extra disk space for archiving data, or to manage the most useful data files in a system with limited drive space.

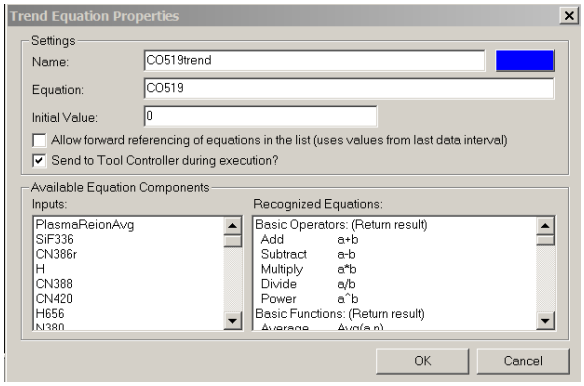
New in SpectraView version 6.0 is the addition of an “Auto-Copy” with delayed Auto Delete, which allows for immediate (when idle) copies of data and log files to be copied to a desired location. This new feature enables the prompt review of files without needing to access the tool computer.



Parallel Sequence

At any point in the list of sequence conditions, the user can insert a *Parallel Sequence* command to create two threads of concurrent processing. Each of these sequence threads will be executed concurrently after all the equations are completely processed following the receipt of each new spectrum.

Parallel Sequences are used, for example, when it is desirable to monitor the chamber condition at the same time as monitoring for endpoint.

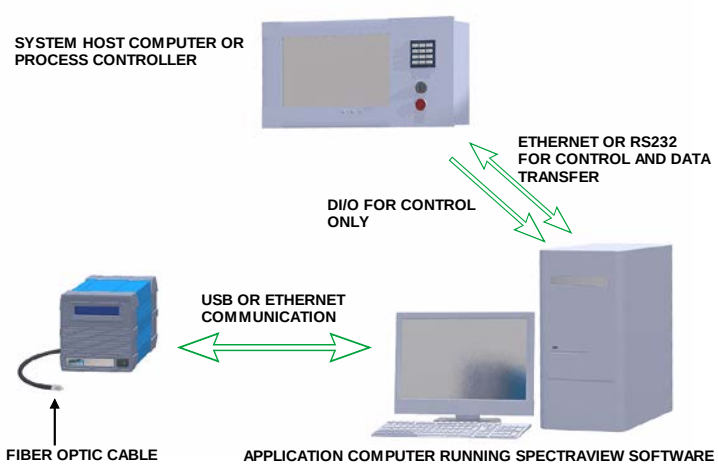


Trend Line Output

Using the Verity Standard Protocol (over Ethernet or RS232) or Verity ASCII Protocol (over RS232), selected trend lines can be sent to the tool controller. Of course, the receipt of this data must be planned for on the tool side.

System Schematic

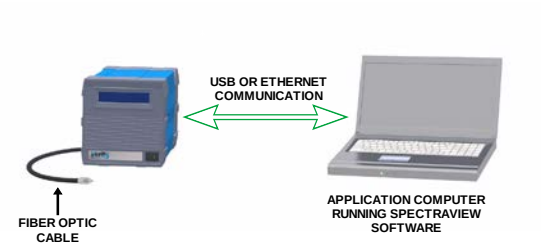
The system schematics shown below are possible using SpectraView applications software.



Partially Integrated Within a System

In a partially integrated configuration, an application computer is used to provide the user interface and data storage. Communication from the spectrometer to the application computer includes Ethernet or USB.

Control between the application computer and the system host computer can be via DI/O and/or RS232, or DI/O and/or Ethernet. In some cases, it may be desirable to use DI/O for control communication and RS232 or Ethernet to provide a data stream of trend points to the system host computer.



Non-Integrated Configuration

When used for troubleshooting or plasma diagnostic applications, the spectrometer is frequently not integrated with the process tool. Communication to the application computer is via Ethernet or USB.

Specifications

Model	SD2048GH	SD1024G/SD1024GH	SD1024GS	SD1024GM	SD2048GM	SD1024GL	SD2048GL	SE1024GL-CMOS[11]	SE2048GL-CMOS[11]
Type	High Performance & High Resolution	High/Ultra Performance	High Performance/Wide Wavelength Range	Medium Performance	Medium Performance & High Resolution	General Purpose	High Resolution	General Purpose	High Resolution
Release Date	Jan 2017	2012	September 2017	Jan 2017	Jan 2017	2012	2013	October 2016	January 2017
Detector	**Scientific Grade CCD Image Sensor 74 mm^2 TE cooled- low noise** Deep well - wide dynamic range UV sensitive- phosphor coating not required			**CCD Image Sensor 25 mm^2** Deep well-wide dynamic range UV Sensitive - phosphor coating not required		**CCD Linear Image Sensor 5.7 mm^2** Deep well-wide dynamic range UV Sensitive - phosphor coating not required		**CMOS Linear Image Sensor 5.7 mm^2** UV Sensitive- phosphor coating not required	
Number of Pixels	2048 x 256	1024 x 128	1024 x 128	2048 x 64 (read out as 1024)	2048 x 64	2048 (read out as 1024)	2048	2048 (read out as 1024)	2048
Slit Width	17 microns	21 microns	25 microns	21 microns	17 microns	50 microns	10 microns	50 microns	10 microns
Number of Channels	1-8	1-8	1-8	1-3	1-3	1	1	1	1
Wavelength Range	200- 800 nm[5] 200-900 nm	200–800 nm[5] 200-900 nm	250-1100 nm	200- 800 nm[5] 200-900 nm	200- 800 nm[5] 200-900 nm	200–800 nm[3]	200–800 nm[3]	200-800 nm[3]	200-800 nm[3]
Resolution (FWHM)[1,7] (nominal)	0.9 nm (200 - 800 nm) 1.0 nm (200-900 nm)	1.33 nm <1.6 nm limit (200 - 800 nm) 1.55 nm <1.87 nm limit (200-900 nm)	1.8 nm	1.33 nm <1.6 nm limit (200 - 800 nm) 1.55 nm <1.87 nm limit (200-900 nm)	0.9 nm (200-800 nm) 1.0 nm (200-900 nm)	1.70 nm <2.0 nm limit	0.80 nm <1.0 nm limit	1.70 nm <2.0 nm limit	0.80 nm <1.0 nm limit
Wavelength Position Accuracy[1] (nominal)	< 0.1 nm 0.15 nm limit (200 - 800 nm) <0.12 nm 0.175 nm limit (200 – 900 nm)	< 0.1 nm 0.15nm limit (200 - 800 nm) <0.12 nm 0.175 nm limit (200 - 900 nm)	pending	< 0.1 nm 0.15 nm limit (200 - 800 nm) <0.12 nm 0.175 nm limit (200 - 900 nm)	< 0.1 nm 0.15 nm limit (200 - 800 nm) <0.12 nm 0.175 nm limit (200 - 900 nm)	<0.1 nm 0.15 nm limit	<0.1 nm 0.15 nm limit	<0.1 nm 0.15 nm limit	<0.1 nm 0.15 nm limit
Saturation (counts)[2]	pending	50,000[4] to 65,536	pending	≥ 65,000	≥ 65,000	≥ 65,000	≥ 65,000	≥ 65,000	≥ 65,000
Sensitivity Variation Outside the Calibrated Wavelength	pending	+/- 25% +/- 3% with broadband calibration[6]	pending	pending	pending	pending	pending	pending	pending
Readout Noise, counts (nominal, 2 nm band)[8]	0.4	1 - SD1024G 0.3 – SD1024GH	1.4	1.5	1.5	8	9	8	7
Readout Noise, electrons[13, 14] (nominal, 2nm band)[8]	**7**	**27 (SD1024G) 13 (SD1024GH)**	**43**	**17**	**9**	**87**	**53**	**28**	**13**
Sensitivity, electrons[13]/uW/cm^2/ms (nominal, at 530 nm)	**53,000**	**37,000 (SD1024G) 54,000 (SD1024GH)**	**68,000[15]**	**19,000**	**8900**	**4400**	**500**	**3900**	**500**
Dynamic Range[12]	27,400	23,000 (SD1024G) 47,000 (SD1024GH)	33,000	12,000	5700	1600	1400	1800	1600
Maximum Signal to Noise (2nm band) (nominal)[9]	200 - 800 nm: 3100 200 - 900 nm: 2900	200 - 800 nm: 3200 200 - 900 nm: 2960	1800	1150	1150	1000	1000	600	600
Order Sorting Filter		Higher Order Suppression Filter Included							
Minimum Integration Time and Minimum Data Interval (standard A/D)	7 ms	13 ms	13ms	2 ms	2ms	6 ms	6 ms	2 ms	2ms
Minimum Integration Time and Minimum Data Interval (fast A/D)	2 ms	2 ms (SD1024G) 7 ms (SD1024GH)	2ms			2 ms	2 ms		

Specifications – 2nd Page

Model	SD2048GH	SD1024G/ SD1024GH	SD1024GS	SD1024GM	SD2048GM	SD1024GL	SD2048GL	SE1024GL-CMOS[11]	SE2048GL-CMOS[11]
Mechanical & Integration									
Dimensions - inches (mm)	5.4" (137 mm) W x 10.2" (259 mm) L x 5.6" (142 mm) H							5.4" (137 mm) W x 7.5" (191 mm) L x 4.0" (102 mm) H	
Weight	6.2 lbs. (2.8 kg)					5.5 lbs. (2.5 kg)		3.5 lbs. (1.6 kg)	
Fiber Optic Connection	Custom Design					SMA			
Power	20-28VDC, 45W max. User accessible 2.5A fuse							20-28 VDC, 45W max.	
Standards									
Compliance	EN 55022 RoHS		EN 55024 SEMI S8-0308		IEC 61010-1 SEMI S2-0310	Semi S10-0307			
Environmental									
Operating Temperature Range	32°F (0°C) to 104°F (40°C)							68°F(20°C)-104°F(40°C)[10]	
Storage Temperature Range	-4°F (-20°C) to 140°F (60°C)								
Maximum Humidity (Operation and Storage)	85% Non-condensing								

[1] Based on the average of several measurements taken across the spectrum at time of shipment.
[2] Saturation – based on using standard calibration method, consult factory for alternate calibration methods.
[3] Spectral Range - consult factory for range to 1100 nm.
[4] 50,000 is the minimum saturation for generic SD1024Gs, non-generic SD1024G's have different saturation values. 65,000 is the minimum saturation value for all SD1024GHs.
[5] Optionally, 170-770 nm is available
[6] This specification is for the SD1024G, the specification for the SD1024GH is pending.
[7] For the SD2048GH models resolution is based on using SpectraView 7.2.02F08 or later
[8] The system readout noise (standard deviation) is determined before any software scaling factor is applied at standard A/D speed and 25ms integration time.
[9] Maximum signal to noise (S/N) is based on: SD1024G/GH and SD2048GH- the point at which the CCD output becomes non-linear; "high gain" calibrations will reduce the maximum S/N. With the SD1024GL and SD2048GL the maximum S/N is based on using our standard low gain calibration. For the SE1024GL-CMOS the maximum S/N is based on using our standard calibration. The maximum S/N for the SD1024GM/SD2048GM is an estimate based on a typical calibration.
[10] The SE1024GL-CMOS and SE2048GL-CMOS can be used from 32°F (0°C). However, at lower temperatures and longer integration times it is possible for the baseline to be negatively shifted.
[11] For more information on the SE1024GL-CMOS see the SE1024GL-CMOS brochure.
[12] Dynamic Range calculated by 65,536/(Readout Noise x Typical calibration factor), where Readout Noise is in counts per pixel.
[13] Counts are converted to electrons using the photon transfer curve method.
Specifications are subject to change without notice.
[14] For 2048 pixel CCDs readout noise expressed in electrons is approximately 2x higher in "1024" models versus "2048" models due to the effective doubling of the conversion factor of counts to electrons.
[15] The SD1024GS shows the highest sensitivity at 530 nm due to the grating selection to support the 250-1100 nm wavelength range.
Specifications may change without notice.

Application Computer Software

Application Software	SpectraView™
Operating System	SpectraView 6.0.xx: Win 7® Pro 32BIT With SP1 SpectraView 6.1.xx to 6.5.XX: Win XP SP2 / SP3 or Win 7 Pro 32BIT With SP1 or Win 2003 Server 64 Bit SpectraView 6.5.01 to 7.X.XX: Win 7 Pro 32Bit / 64 Bit With SP1 SpectraView 8.0.00+ Win XP SP2 / SP3 , Win 7 Pro, for production (Win 8.1 Pro, Win 10 for R&D)
Comm. from Application to Spectrometer	Ethernet TCP/IP or TCP/IP over USB (RNDIS Driver) (Ethernet is recommended)
Comm. from Tool to Application Software	ASCII or Proprietary Serial (RS232) and/or DI/O, Proprietary Ethernet TCP/IP and/or DI/O

Minimum Application Computer Requirements (SpectraView Only)

Attribute	Specification
Platform	Intel X86 architecture
Processor	Minimum Pentium 4 class CPU, 2.0+ GHz (some advanced algorithms or multi-instance needs may require more processing power)
Memory	1GB or greater, 1333Mhz DDR RAM (Per SpectraView Instance) (some advanced algorithms or multi-instance needs may require more memory)
Hard Drive	80+ GB Per SpectraView Instance
Graphics	XGA (1024x768, 256Colors)
COM Port(s) to SD1024 **COM Port (s) to Tool** **Com Port to LAN Optional**	USB or 100/1000 Ethernet (Ethernet preferred) RS232, Digital I/O, or 100/1000 Ethernet Additional 100/1000 Ethernet recommended (for data uploading) PCI card slot(s) for DIO and/or analog output card installation

Recommended Application Computer Requirements (SpectraView Only)

Attribute	Specification
Processor	Typical PC industry standard minimum (e.g. Intel i3 Dual Core) class CPU, 2.0+ GHz (typical, some advanced algorithms or multi-instance needs may require more processing power)
Memory	Current PC industry standard minimum (e.g. 2GB 800MhzDDR3) (typical, some advanced algorithms or multi-instance needs may require more memory)
Hard Drive	Current PC industry standard minimum storage available (e.g. 250+ GB) For single Spectrograph 100GB for storage is adequate
COM Port(s) to SD1024	10/100/1000 Ethernet (Ethernet is preferred) or, USB 2.0
COM Port (s) to Tool	RS232, Digital I/O, or 10/100/1000 Ethernet
Com Port to LAN Optional	Additional 100/1000 Ethernet recommended (for data transfer) PCI or PCIe card slot(s) for DIO and/or analog output card installation

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