Smart Spectrograph
SD1024 Series

High-Performance
SD1024D

General Purpose
SD1024DL
SD2048DL

Verity
INSTRUMENTS, INC.

Spectrograph SD1024D Series

Note that some feature sets for SD1024D Series spectrographs are currently under development, including embedded operation and application-specific multifiber capability.

Summary

SD1024D

- For demanding applications
- Single or multi-fiber input
- Scientific grade CCD

SD1024DL

- For general purpose applications

SD2048DL

- For high resolution applications
- Bright plasma required

Features and Benefits

- Provides robust endpoint determination
- SpectraView™ software provides:
  - Variety of algorithms
  - Open algorithms and sequences for flexibility
  - Tool integration via Ethernet, RS232, and DI/O
- Use for endpoint detection, fault detection, and process diagnostics
- 200–800nm range

Description

The SD1024D Series spectrographs are optical emission monitors that integrate sophisticated embedded processors and software designed to provide intelligent instrument control, data acquisition and endpoint interface capabilities. The SD1024D Series uses common electronics, application software and enclosures. The differences between the SD1024D, the SD1024DL, and the SD2048DL are the charge coupled device (CCD), optical platform and embedded software parameters.

The **SD1024D** was designed for demanding semiconductor process applications. Its optical system employs a 1024-element, scientific-grade CCD array specifically designed for multi-channel spectroscopy, offering high performance at a moderate cost. The advantages of the SD1024D include excellent ultraviolet (UV) response (down to 200nm), stability against degradation under UV exposure, high sensitivity, wide dynamic range and superior output linearity. The unique optical platform results in highly efficient imaging of spectral information at the element of the two-dimensional detector array.

The **SD1024DL** was designed for general purpose semiconductor process applications. It uses a 2048-element, one-dimensional CCD designed for cost effective operation. The CCD is phosphor coated for UV sensitivity. The SD1024DL uses a simple optical platform and the same 16-bit A/D electronics as the SD1024D.

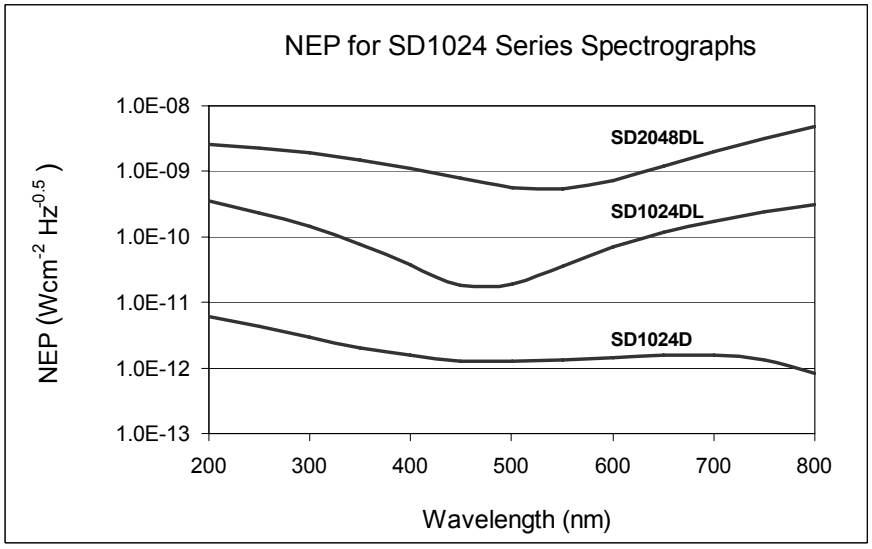
The **SD2048DL** is nearly identical to the SD1024DL, but reports spectral data in 0.25nm increments instead of 0.5nm readings as in the SD1024D and SD1024DL. This is done by using a narrower inlet slit and modified embedded software parameters. Although the SD2048DL has better resolution than the SD1024DL, its sensitivity is diminished by about one order of magnitude.

Noise Equivalent Power Comparison

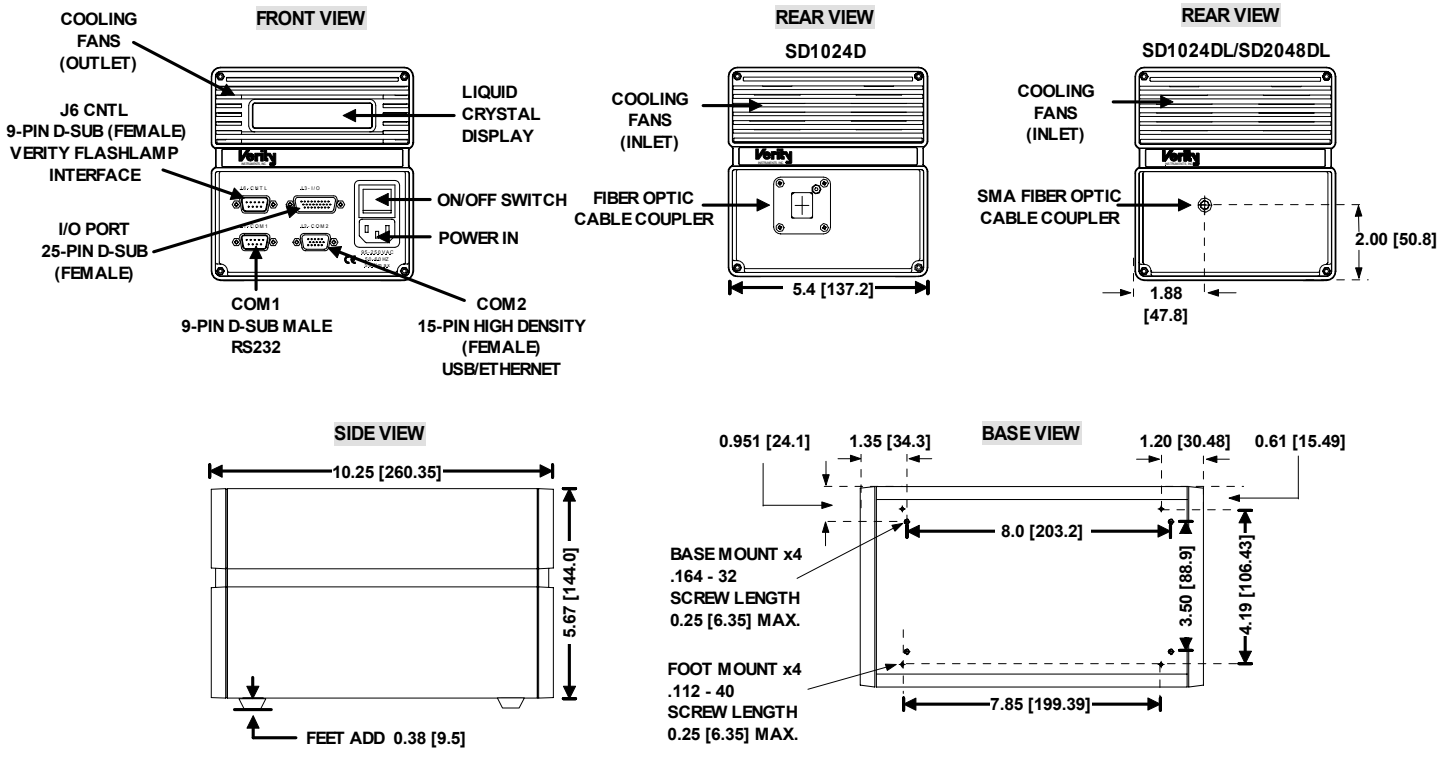
Verity has quantified the spectrograph's Noise Equivalent Power (NEP). NEP, the amount of power that equals the noise, was determined by dividing the noise by the responsivity. The noise is the standard deviation of the signal. The responsivity is determined by dividing the signal by the power incident on the detector.

All integration times were set to 200ms resulting in a 5Hz temporal bandwidth. All measurements were further corrected for the effective spectral bandwidth of each instrument.

The resultant NEP characterizations are plotted in the figure at the right. Of course, a lower NEP is indicative of a superior instrument.

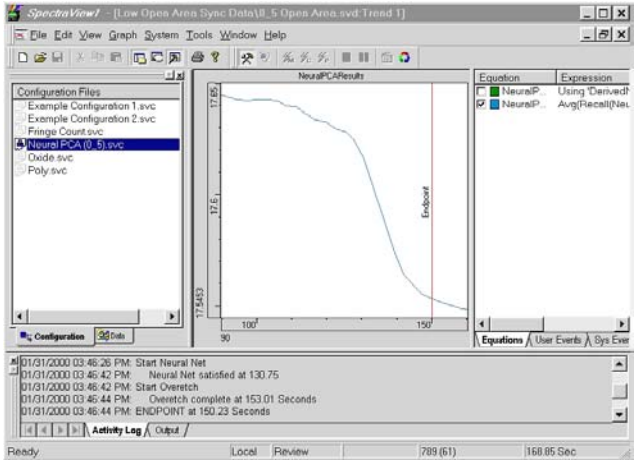


Dimensions



Algorithms for Endpoint Detection

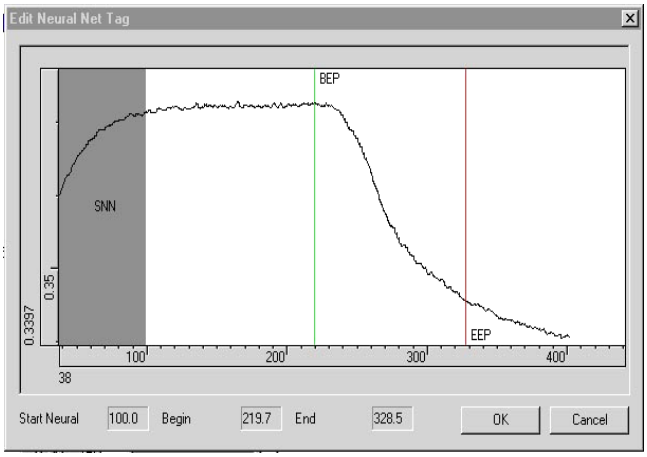
Verity Instruments provides a powerful suite of endpoint algorithms, including the multivariate Neural PCA algorithm, which can be processed with Verity's proprietary Neural Network pattern recognition software.



Neural PCA Multi-Wavelength Algorithm

Verity's endpoint-detection computations can employ robust algorithms such as the patent pending Neural PCA for multivariate, full-spectrum analysis.

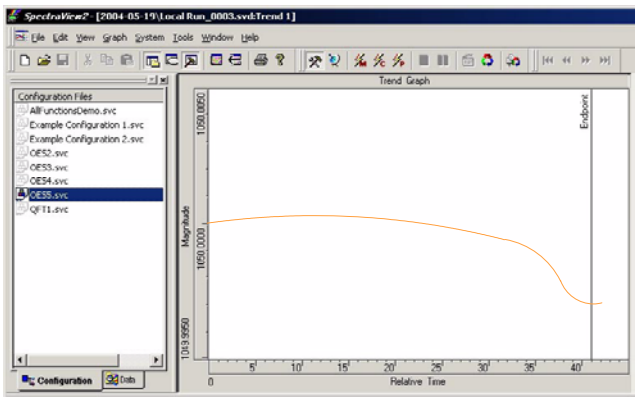
Data represented at left apply to a 0.5% exposed area contact etch using Verity's Neural PCA algorithm. Within the SpectraView™ endpoint software application, the Neural PCA endpoint trace can be processed using Neural Network or threshold-based methods.



Neural Network Algorithm

The Neural Network algorithm is used to analyze endpoint traces. The Neural Network uses proprietary techniques to recognize characteristic endpoint shapes in the trend line. This is performed in real time and the pattern recognition algorithm adapts to expected amplitude and duration changes in the endpoint trace during successive runs.

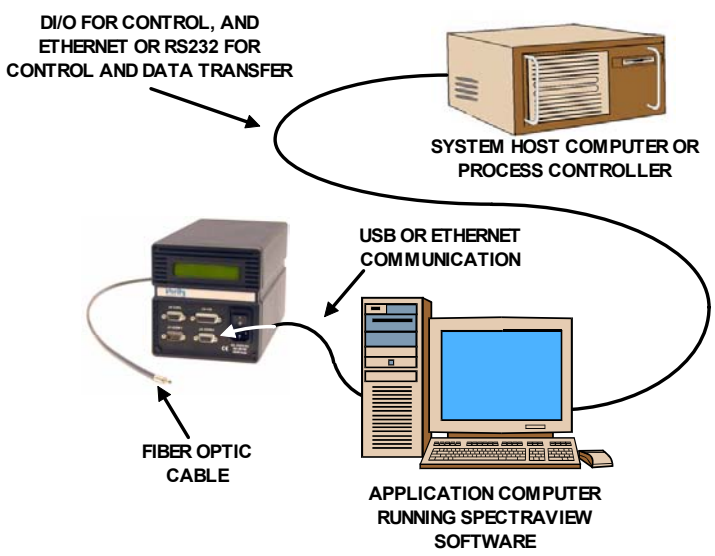
Unlike other types of neural networks, Verity's algorithm can be set up with only a few training runs. If a false positive or negative is found, it can easily be added to the training set for improved robustness. Process engineers using Verity's Neural Net software are freed from the burden associated with developing and testing threshold-based algorithms. In addition, data can be analyzed "on-the-fly" or replayed, reviewed, or reprocessed with SpectraView™.



Threshold-Based Algorithm

Using threshold-based algorithms, endpoint recognition is based upon the output rising above or below a preset level for a predetermined length of time. However, for demanding applications, the Neural Network algorithm is commonly selected over the threshold-based algorithm.

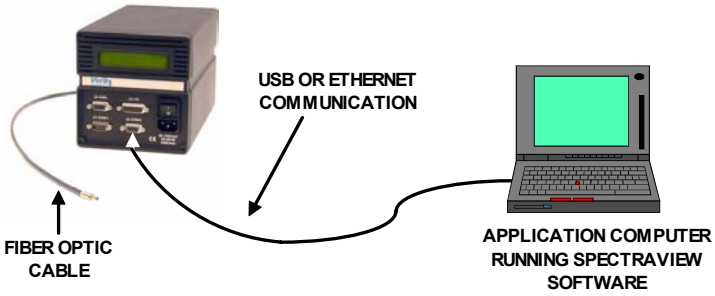
System Schematic



Partially Integrated Within a System

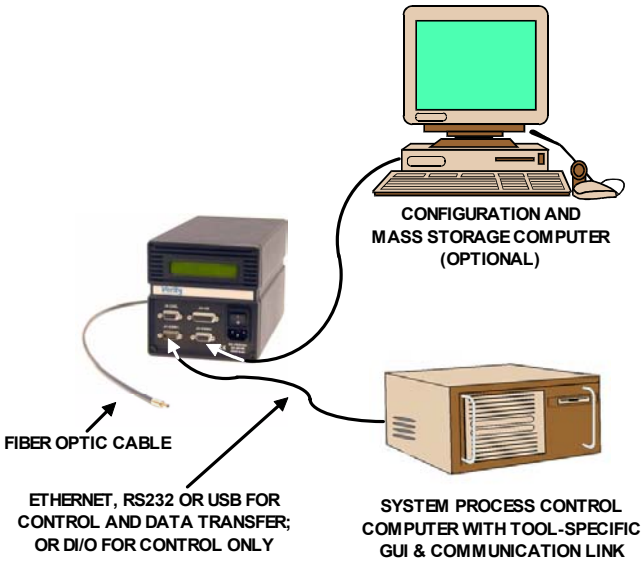
In a partially integrated configuration, an application computer is used to provide the user interface and data storage. Communication from the spectrograph to the application computer includes Ethernet or USB

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 spectrograph is frequently not integrated with the process tool. Communication to the application computer includes Ethernet or USB.



Fully Integrated Within a System

The following functionality is currently under development and the description below and at left is preliminary.

In a fully integrated configuration, the need for an application computer is eliminated. While this cost-effective configuration removes the need for the application computer, monitor and keyboard, it does require the development of a communication link to the spectrograph and a tool-specific graphical user interface (GUI). Alternatively, Verity's SpectraView™ software can be run as an instance within Windows 2000-based host computers to monitor the process. All endpoint algorithms reside on the spectrograph, thus avoiding overburdening the system host computer.

If full-spectrum data transfer to the system host computer is desired, data can be transferred via Ethernet or USB. Serial (RS232) should not be used if full spectra are needed. If required for control purposes, DI/O can be used in addition to the other protocols. A provision for data storage should be made if data from past runs are to be saved.

Specifications

Model Number	SD1024D	SD1024DL	SD2048DL
Type	High Performance	General Purpose	High Resolution
Performance/Optics			
Range	200–800nm	200–800nm	200–800nm
Resolution [1]	<2.0nm	<2.0nm	<1.0nm
CCD	1024 x 128 pixels, TE cooled Backthinned (for enhanced UV sensitivity)	2048 pixels Phosphor coated for UV sensitivity	2048 pixels Phosphor coated for UV sensitivity
Mechanical			
Slit Width	25 microns	25 microns	5 microns
Dimensions - inches (mm)	10.25 (260.0) x 5.4 (137.2) x 6.05 (153.5)	10.25 (260.0) x 5.4 (137.2) x 6.05 (153.5)	10.25 (260.0) x 5.4 (137.2) x 6.05 (153.5)
Weight	7 lbs (3.2 kg)	6 lbs (2.7 kg)	6 lbs (2.7 kg)
Integration			
Fiber Optic Connection	Custom Design	SMA905	SMA905
Power	95–250VAC, 50/60Hz 35W typical – 50W Max. 20-28VDC@2A Optional	95–250VAC, 50/60Hz 35W typical – 50W Max. 20-28VDC@2A Optional	95–250VAC, 50/60Hz 35W typical – 50W Max. 20-28VDC@2A Optional
Standards			
Compliance	CE	CE	CE
Environmental			
Operating Temperature Range	32 (0°C) — 104 (40°C)		
Storage Temperature Range	-4 (-20°C) — 140 (60°C)		
Max. Humidity (Operation and Storage)	85% Non condensing		

[1] Resolution — full width at half of maximum peak height, the maximum average of several measurements taken across the spectrum.

Application Computer Software

Algorithms	Algebraic, trigonometric, Boolean logic functions Threshold-based Multi-Wavelength Algorithm (Neural PCA) Neural Network Pattern Recognition		
Application Software	SpectraView™		
Application Software Platform	Windows 2000®		
Communication from Application to Spectrograph	USB or Ethernet (Ethernet preferred)		
Communication from Tool to Application Software	RS232 and/or DI/O, Ethernet and/or DI/O	RS232 and/or DI/O, Ethernet and/or DI/O	RS232 and/or DI/O, Ethernet and/or DI/O

Recommended Application Computer Requirements

Attribute	Specification
Platform	Windows 2000®
Processor	Pentium 4 class CPU, 700Mhz or faster (minimum, some advanced algorithms may require more processing power)
Memory	256MB or greater, 133Mhz BUS or faster (minimum, some advanced algorithms may require more memory)
Hard Drive	20GB minimum
Graphics	XGA (1024x768, 256Colors)
COM Port(s) to SD1024	USB or 10/100Ethernet
COM Port(s) to Tool	RS232, Digital I/O or 10/100Ethernet

Ordering Information – SD1024DL and SD2048DL

Spectrograph Description	Model	Part Number
General Purpose	SD1024DL	1005379
High Resolution	SD2048DL	1005368

Fiber Optic Cables

Fiber Optic Cables — SMA905 on instrument end to standard Verity spot on chamber end (0.157" / 4.7mm)

Standard Temperature Rating (for usage to 100 C)

Description	Model Number	Part Number
50 cm plastic jacket	SMP-DUV04-020	1003139-020
100 cm plastic jacket	SMP-DUV04-040	1003139-040
200 cm plastic jacket	SMP-DUV04-079	1003139-079
250 cm plastic jacket	SMP-DUV04-099	1003139-099
300 cm plastic jacket	SMP-DUV04-119	1003139-119

High Temperature Rating (for usage to 250 C)

Description	Model Number	Part Number
50 cm stainless steel jacket	SMPXHT-DUV04-020	1005656-020
100 cm stainless steel jacket	SMPXHT-DUV04-040	1005656-040
200 cm stainless steel jacket	SMPXHT-DUV04-079	1005656-079

Ordering Information – SD1024D

Description	Model No.	Part Number
High Performance	SD1024D	1005109

Fiber Optic Cables

Fiber Optic Cables

Description	Model Number	Part Number
50 cm stainless steel jacket[1]	SGXHT-DUV02-020	1002727-020
100 cm stainless steel jacket[1]	SGXHT-DUV02-040	1002727-040
200 cm stainless steel jacket[1]	SGXHT-DUV02-079	1002727-079
300 cm stainless steel jacket[1]	SGXHT-DUV02-119	1002727-119

[1] These fiber optic cables are designed for use to 250C.

Hardware for Partially Integrated Application

Digital I/O Card for Use in Application Computer

Description	Model Number	Part Number
Digital I/O Card (ISA bus type, 8 inputs/8 outputs)	DAS-725	1000964
Digital I/O Breakout Box and Cable for use with DAS-725	N/A	1002881
Digital I/O Card (PCI type, 16 inputs/16 outputs)	DAS-7230	1005418

Communication Options

CABLES

For Single Spectrograph to Computer	Length	Part Number
Ethernet Cable[1]	14’ (4.5m) 20’ (6m) 50’ (15m)	1004358-168 1004358-240 1004358-600
USB Cable	9’ (2.6m) 16’ 5” (5m)	1003275-108 1003275-197

For Multiple Spectrographs to Computer	Length	Part Number
Ethernet Cable – PC to Hub: *Select only one*	1’ (0.3m) 7’ (2m) 14’ (4m)	1004442-012 1004442-084 1004442-168
Ethernet Cable(s) – Hub to Spectrograph: *Select one per spectrograph*	6’ (1.8m) 14’ (4m) 20’ (6m) 25’ (7.5m) 30’ (9m)	1004351-072 1004351-168 1004351-240 1004351-300 1004351-360
Ethernet Hub, including: 8 ports 10 Base-T 12VDC Adapter to 120VAC	Not applicable	TBD

[1] Ethernet Cable — each Spectrograph is shipped with a 9’ (2.6m) Ethernet crossover cable (1004358-108) for updating of the embedded software. This same cable can be used for Spectrograph to Host PC communications, if desired.

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