MV-2000 Series
Portable Multichannel Spectrophotometer

The MV-2000 is a complete spectrophotometer system integrating a light source, monochromator, and detector into a compact footprint. A true multi-wavelength photometer, the MV-2000 can provide simultaneous detection of the entire instrument wavelength range to perform instantaneous measurements. Available programs and sampling accessories are designed for numerous sample measurements including on-line quality control applications. The four models of the MV-2000 series Multichannel Spectrophotometers contain an analysis solution for your sample.

Specifications

Wavelength range	UV type 200 - 360 nm, VIS type 360 - 960 nm, UV/VIS type 200 - 800 nm, NIR type 900 - 1600 nm
Measurement time	1 sec to 100 sec
Measurement programs	Spectral measurement, multicomponent analysis, color analysis, film thickness, and time course software (Optional)
Sampling accessories	Square cell holder, fiber optic, immersible fiber optic probe, flow cell, etc.

VIR-9000 Series
Portable FT-IR Spectrometer

The VIR-9500 is a multipurpose FT-IR system offering sampling flexibility and instrument portability unmatched by any other FT-IR instrument, allowing infrared analysis for a broad spectrum of sample applications. Designed to be compact and lightweight, yet with a stable platform, the VIR-9500 can be set up almost anywhere. The flexible optical design can be used to build a measurement solution for chemical vapor deposition chambers or room air monitoring. The only limitation is your imagination.

Specifications

• VIR-9500	
Wavenumber range	7000 - 400 cm^{-1}
Max. resolution	0.5 cm^{-1}
SNR	10,000:1 peak-to-peak (1-minute acquisition, 4 cm^{-1} resolution)
Source	High-intensity ceramic
Detector	DLATGS
Interferometer	Sealed Michelson interferometer (using corner cube mirror) with auto-alignment feature
Measurement unit	Interchangeable fiber optic, ATR, transmission/reflection accessories, gas cell, etc.

RMP-210
Portable Laser Raman Spectrophotometer

The RMP-210 is a portable Raman instrument integrating a high-throughput singly dispersive monochromator; compact, air-cooled laser; thermoelectrically cooled CCD detector; and a fiber optic sampling probe in a compact size. Much smaller than conventional Raman systems, the RMP-210 makes telemetry and measurement of large or remote samples a simple, painless process.

Specifications

Wavenumber range	4,000 - 200 cm^{-1} Raman shift
Max. resolution	3 cm^{-1} (FWHM)
Excitation source	Green laser (532 nm) Optional lasers of 488, 514.5, 632.8, or 785 nm are available
Detector	Thermoelectrically cooled CCD detector
Sampling unit	Fiber probe head with focusing objective (CCD camera included)

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ISO 9001 Certified

Products described herein are designed and manufactured by ISO-9001-certified JASCO Corporation.

Serving the global marketplace with Analytical Instrumentation

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JASCO Semiconductor Solutions

- VUV Spectrophotometer
- Film-Thickness Measurement System
- UV/Vis/NIR Microspectrophotometer
- Absolute Reflectance Measurement System
- Near-Field Optical Microspectrometer
- Ellipsometer
- Raman Spectrometer
- VUV Birefringence Meter
- VUV Spectrofluorometer
- Quantum Efficiency Measurement System
- Near Infrared Spectrofluorometer
- Electric Field Modulation Spectrophotometer
- Confocal Fluorescence Detector
- FT-IR Full Vacuum Gas Measurement System
- PFPE Preparative SFE System
- Supercritical Fluid Wafer Cleaning System
- Portable Multichannel Spectrophotometer
- Portable FT-IR Spectrometer
- Portable Raman Spectrophotometer

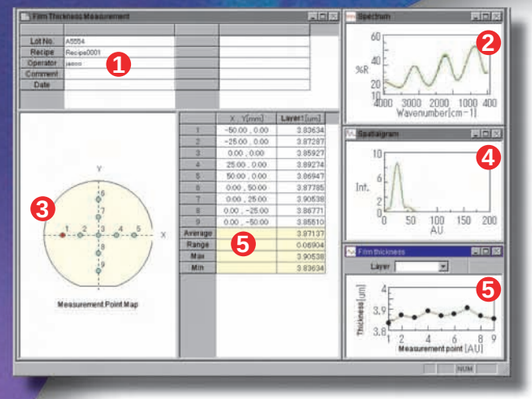
UTS-200
Film-Thickness Measurement System

The thickness of the epitaxial layer, substrate, etching (residual layer), liquid crystal cell gap, and other semiconductor layers dramatically impacts semiconductor device performance. Management of layer thickness during the manufacturing process is extremely crucial for production of large yields of stable devices.

JASCO's film-thickness measurement system is a nondestructive, non-contact analysis method using the latest interferometric technology to provide rapid film thickness measurements. Utilizing a proprietary frequency analysis method, the sample interference spectrum is converted to a spatialgram and the film thickness calculated with a high degree of accuracy. This integrated system offers the film thickness measurements required for the exacting standards of the semiconductor industry including high-speed sample mapping; a wide thickness measurement range; and a refined operating environment, supporting a wide range of analysis requirements from process use to R&D. JASCO offers near-infrared and mid-infrared models according to the thickness measurements desired.

System Features

- **Wide thickness measurement capability**
  Enables film thickness (substrate thickness) measurements from 0.25 to 750 µm.
- **Highly accurate thickness measurements**
  Acquisition of precision data using a high-accuracy interferometer and high-throughput optics.
- **Support for multi-wafer cassettes**
  Optional automated cassette sampling system, enabling fully automated measurement for wafer cassettes.
- **Simplified operating system**
  Various conditions for measurement, mapping, and film thickness calculations are configured as preset recipes and managed in a recipe table. Measurement of film thickness is initiated by simply selecting a required method from the recipe table and clicking the Measure button.



Intuitive Software for Film Thickness Measurements

1. **Measurement information**
   Input information for an analysis.
2. **Fringe spectrum**
   The cycle of the interference spectrum changes according to film thickness.
3. **Point map**
   Displays the measurement positions.
4. **Spatialgram**
   Calculates accurate film thickness from the peak position.
5. **Film thickness distribution graph**

High Measurement Reproducibility

The following table shows consecutive measurement results for a Silicon epitaxial layer.
The error of 10 consecutive measurements is less than ±0.001 µm. These figures demonstrate the extremely reproducible film thickness measurement capability.

Reproducibility of consecutive measurements

Measurement No.	Measured Value (µm)	Deviation (µm)
1	4.9001	-0.0013
2	4.9014	0.0000
3	4.9010	-0.0004
4	4.9019	0.0005
5	4.9015	0.0001
6	4.9018	0.0004
7	4.9011	-0.0003
8	4.9014	0.0000
9	4.9017	0.0003
10	4.9021	0.0007

Average value (µm): 4.9014
Standard deviation (µm): 0.0006

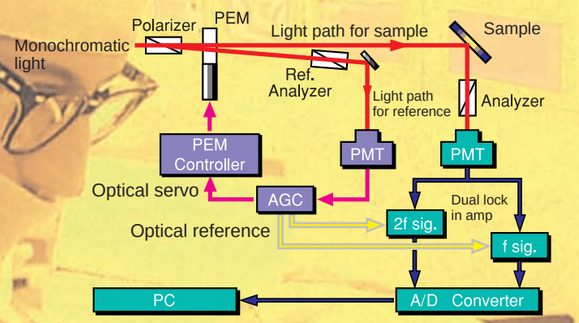
Specifications

Measurement method	FT-IR interference method for film thickness measurements
Measurement configuration	Reflection
Objectives	Near infrared: Lens objectives (4X, 12.5X) and Cassegrain objectives (15X, 30X) Mid-infrared: Cassegrain objectives (15X, 30X)
Focus mechanism	11 mm stroke
Sampling area	20 x 20 to 1200 x 1200 µm
Sample positioning	Verification of measurement area using an integrated CCD camera
Measurement range/accuracy	
Film thickness	0.25 to 750 µm (for Si)
Reproducibility	±0.005 µm or less (for Si with identical measurements)
XY stage	
Stage movement	200 x 200 mm (Other options available)
Minimum step size	2 µm
Data processing unit	
Operating System	Windows 98, NT, 2000 and XP
Monitor	15-inch LCD
UPS(Uninterruptible Power Supply)	Maintains PC and display power for 15 minutes after a power failure
System control	JASCO Spectra Manager software; Optics and X-Y stage control; Wafer cassette system control (option)
Table	
Type	Integrated vibration isolation table
Dimensions	1240 x 810 x 1550 mm (excluding protrusions or optional cassette loading system)
Power requirement	300 VA

M-550 Ellipsometer

Ellipsometry is a method for determining the refractive index and extinction coefficients of a sample by measuring the change in polarization state of surface reflected light. Film thickness and optical constants of an adsorption layer or oxide film on a substrate surface can be determined with exceptional sensitivity. Conventional interference spectroscopy utilizes light passed through separate optical paths, while ellipsometry is a form of interferometry that uses two vibrational components with the same optical path, providing measurements with excellent accuracy and sensitivity.

Block Diagram of Signal Processing



JASCO's ellipsometer employs a proprietary polarization modulation technique (a PEM dual lock-in system) utilizing a photoelastic modulator, instead of the rotational drive mechanism of conventional ellipsometers. The PEM dual lockin system provides a stable measurement with additional capabilities including highspeed data sampling and wavelength scanning.

System Features

- **Automated wavelength scanning**
  The PEM dual lock-in system (JP Pat. # 2064627) automatically controls the PEM drive voltage for the current wavelength with an optical servo (JP Pat. #2081599) to increase ordinate accuracy during high speed scanning.
- **High-speed data sampling**
  Using high-speed electrical modulation, the PEM dual lock-in system enables high-speed data sampling in as little as 1 millisecond (optional 20 microseconds), far faster than systems that mechanically rotate a polarizer/analyzer combination.
- **High stability and reliability**
  The PEM dual lock-in system offers a static measurement free from mechanical error with high stability by using the optical servo and an optical reference.
- **Highly sensitive thin film analysis**
  The PEM dual lock-in system employs a proprietary polarizing configuration offering maximum sensitivity for extremely thin dielectric and semiconductor films.

PEM dual lock-in system

The PEM dual lock-in system exposes a sample to light that has undergone high-speed modulation (50 kHz) by a photo-elastic modulator (PEM) and then measures the change in polarization by simultaneously detecting the primary (50 kHz) signal and second harmonic (100kHz) signals with a dual lock-in amplifier.

Innovative optical servo and optical reference control

The PEM is sensitive to environmental changes such as temperature because it modulates the refractive index of the transmissive material. JASCO's spectroscopic ellipsometer employs a proprietary optical servo and optical reference in addition to a temperature control system, markedly improving instrument stability.

Multilayer Film Analysis

JASCO developed a special program for calculating the film thickness and optical constants for each layer of a multilayer film based on the ellipsometric dispersion parameters (Δ, ψ)λ for the material. A multilayer film model is developed for the sample, the film thickness and optical constants optimized to minimize the error for the measured values.

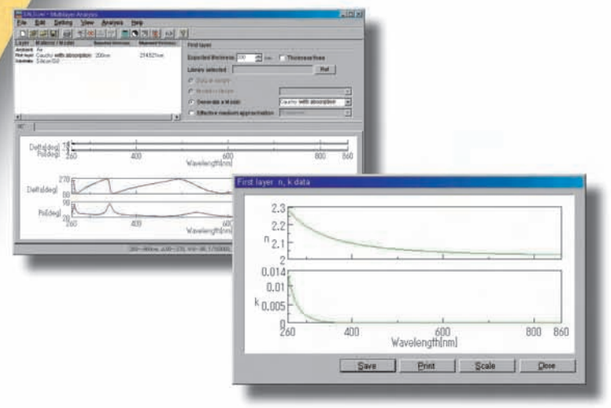
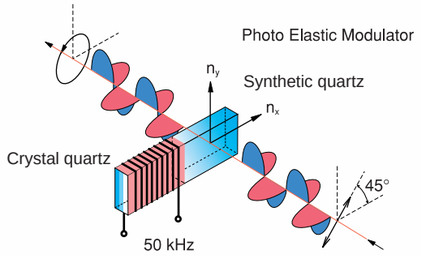
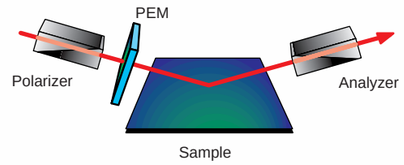


Diagram of PEM Principle

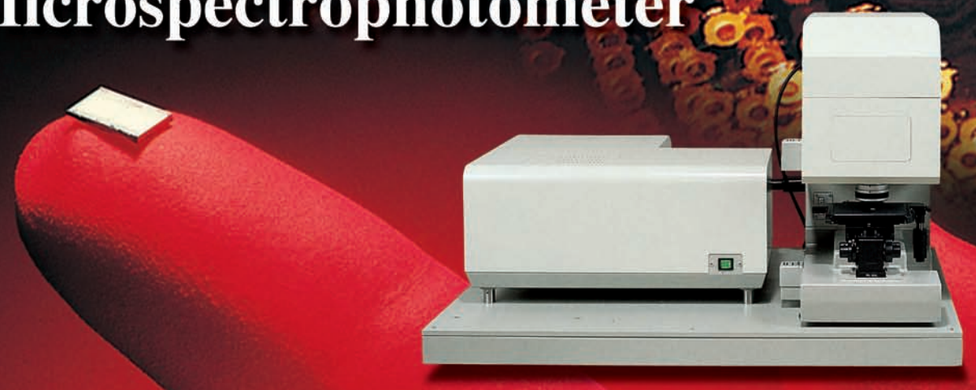




Specifications

Measurement system	PEM dual lock-in
Wavelength	650 nm utilizing LD light source Xe light source with a single monochromator to provide a range of 350 - 800 nm
Spectral bandwidth	1 nm
Incidence angle	Continuous automated settings from 45˚ to 90˚
Film thickness	1 - 99,999 Å
Measurement time	1 msec or greater (20 µsec optional)
Beam diameter	LD light: Approx. 1 mm^2 Monochromatic light: Approx. 2 mm^2
Measurement accuracy	Refractive index: ±0.01 Film thickness: ±1 Å (±0.1 nm) Extinction coefficient: ±0.01 Values are for measurements of 100 msec or more and vary according to surface state and film quality.
Sample stage	Standard sample size: 15 to 150 mm square or circular samples
Optical system	Optical path switching mechanism Polarizer (Rochon prism), photo-elastic modulator (PEM), and optical servo and reference optics (Glan-Taylor prism, plane mirror, and photomultiplier)
Sample chamber	Standard stage allows custom incidence angles and variable sample sizes.
Detector system	Analyzer (Glan-Taylor prism) and photomultiplier (R928)

MSV-350/370
Ultraviolet, Visible, and Near-Infrared Microspectrophotometer



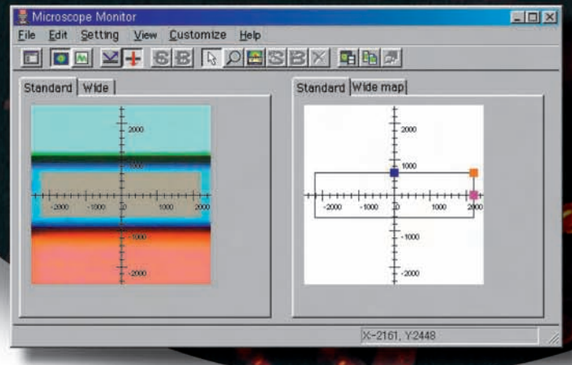
The MSV-300 series is a microspectroscopy system providing transmittance/reflectance measurements of microscopic sample sites for a wide range of wavelengths from ultraviolet to near infrared. Conventional measurements require samples with dimensions comparable to a mm sized optical beam. The MSV-300 series can measure color, film thickness, and other spectral properties of a microscopic area for either large or small samples. The optional automated X-Y-Z stage provides multi-point measurements and surface analysis mapping capabilities.

System Features

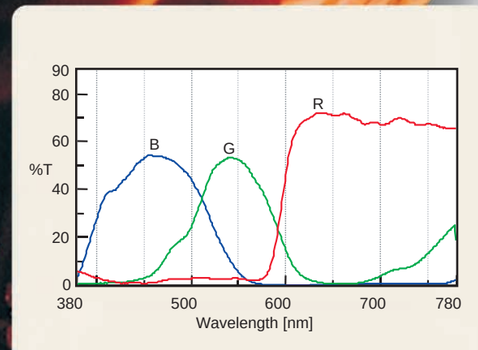
- **Wide spectral measurement range**
  Continuous measurements between 250 and 2,000 nm (MSV-370) using a spectrometer with a wide band, Cassegrain objective.
- **Simple operation**
  The integrated CCD camera allows verification of the analysis site and sample position while defining the sample aperture on the software system.
- **Double-beam system**
  Superior measurement stability using a double-beam spectrophotometer.
- **Automated X-Y-Z stage**
  With the optional automated stage, discrete measurement areas can be selected using the mouse while simultaneously viewing the sample area on the CCD monitor.

Microscope image monitor

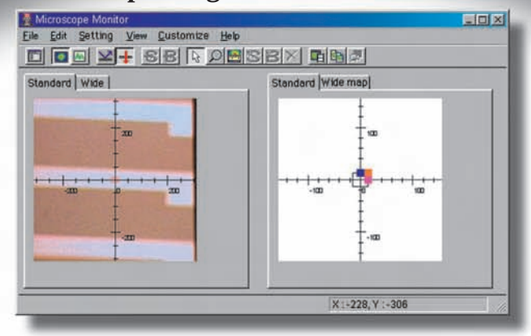
70 x 240 µm aperture set for a blue filter on an LCD panel



RGB filter on an LCD panel

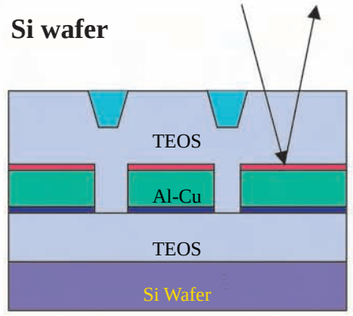


Microscope image monitor



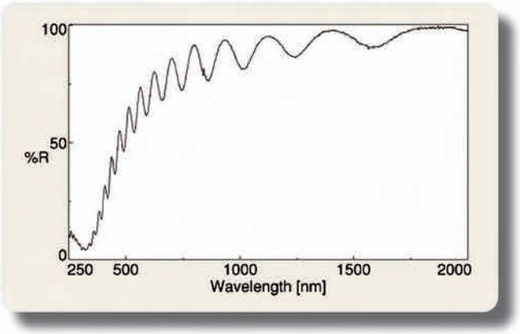
Measurement of SiO_2 on Si wafer (Sampling area : 30 x 30 µm)

Si wafer



SiN

SiO_2 layer thickness measurement



Film thickness was calculated as 1.98 µm.)

Specifications

System name	MSV-350 UV/Vis Microspectrophotometer	MSV-370 UV/Vis/NIR Microspectrophotometer
Measurement system	Double-beam, single monochromator system	
Spectrophotometer	Czerny-Turner optical system	
Light source	Deuterium and halogen lamps (automated switching)	
Wavelength range	250 - 800 nm	250 - 2000 nm
Spectral bandwidth	1, 2, 5 and 10 nm	1, 2, 5 and 10 nm (NIR: 2, 4, 8, 20 and 40 nm)
Wavelength accuracy	±0.3 nm	±0.3 nm
Wavelength reproducibility	±0.1 nm	±0.1 nm (NIR: ±0.4 nm)
Detector	Photomultiplier	Photomultiplier and PbS detector (automated switching)
Sample observation	CCD video camera Binocular eye piece and optional sample observation polarizer	
Objective	Cassegrainian objective (10X, 16X, and 32X magnification: 16X or 32X is standard. Other magnifications are available.)	
Sampling area	From 30 µm x 30 µm (with 32X objective spectral bandwidth of 10 nm (NIR - 40 nm))	
Data collection	Spectral measurement, time course, and fixed wavelength measurement	
Polarizer/analyzer	Glan-Taylor polarizer (option)	
Control/data processing	32-bit compatible (Spectra Manager)	
Sample stage	Manual (Optional automated X-Y-Z stage)	
Optional software	Mapping measurements, film thickness calculations, and color analysis	
Power requirement	210 VA	
Dimensions/weight	750 mm (W) x 700 mm (D) x 650 mm (H); 130 kg	

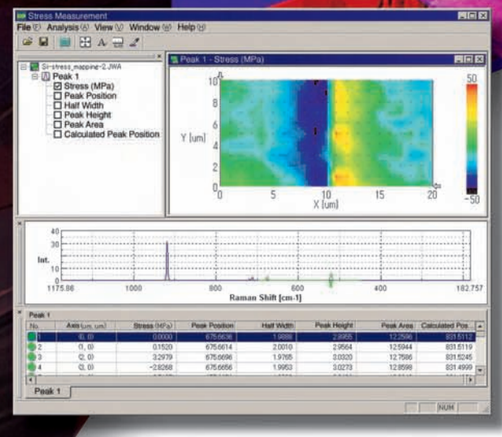
NRS-3000 Series
Raman Spectrometers

The NRS-3000 Series Raman spectrometer is an integrated instrument system utilizing laser excitation to produce Raman scattering unique to the sample. A non-destructive, non-contact technique without requirements for special preprocessing or sample handling, Raman spectra can also be collected while varying sample temperature and/or pressure. The NRS-3000 Series can provide information about molecular species, types of atomic groups, and molecular crystal structures based on analysis of the Raman spectra. In addition, information about crystal axes, crystallinity, and molecular orientations can be easily obtained using laser polarization methods. Measurements on the micron scale are easily accomplished by utilizing the various available microscope objectives, further focusing the laser excitation source. In the semiconductor field, the system can be used for applications such as evaluating the stress of Si device components at the microscopic level, managing DLC film quality, and analyzing contaminants on semiconductor wafer material.

System Features

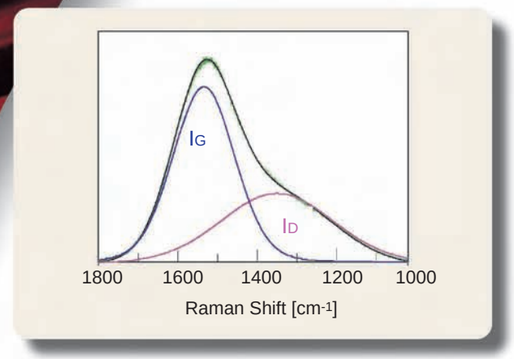
- High throughput aberration-corrected single monochromator
- One to three holographic gratings on an automated turret
- High quality on-screen sample view and image capture
- Automated mapping stage with auto-focusing option

- **Molecular and crystallinity data**
  Elemental analysis techniques only offer data about the sample's form and elemental composition. Raman spectroscopy, however, can be used to characterize and identify molecular species, offer functional group information, and provide evidence of sample crystal structure. Using laser polarization, it can also provide insight into the crystal structure, sample crystallinity, and molecular orientation of solid samples.
- **Non-destructive, non-contact analysis**
  No elaborate sample preparation is required, simply expose a specific area of the sample to the laser beam and collect the Raman data. Analysis of liquid or solid samples can often be conducted in a clear glass sample vial, then the sample used for other analysis techniques. Raman spectra can also be collected in-situ while varying sample conditions such as temperature, pressure or chemical composition, etc.
- **Microscopic analysis**
  Inherently a micro technique, the macro sampling option provides a laser spot size of ~50 microns, analyzing a small portion of a larger sample. The various microscope objectives can provide micro-Raman measurements for a sample area as small as 1 micron while CCD video observation provides for precise positioning of the smallest sample.



Semiconductor stress measurement

The evaluation of stress in silicon devices is extremely important in the development of next generation, high-precision, highly integrated devices. Since the Raman spectrum reflects the degree of pressure dependence on the sample's lattice vibration, it can detect stress in silicon and other semiconductors. The amount of stress is calculated from the Raman peak shift of Si. Stress free Si has a sharp peak at around 520 cm^{-1}. If compression stress is exerted on the crystal lattice, the lattice constant decreases and the coupling strength increases. Accordingly, the lattice vibration energy increases and the peak will shift towards higher wavenumbers. When the compression is released, the peak will shift in the oppsite direction to lower wavenumbers.



Evaluation of DLC film

Diamond like carbon (DLC) forms an amorphous (non-crystalline) carbon with about twice the hardness of ceramics, and is widely used as a protective film for hard disks and magnetic read heads. Raman spectra are sensitive to disorder changes in crystalline formation and structural modifications in a DLC film. The Raman spectrum of a DLC film consists of two peaks around 1335 cm^{-1} (D band) and 1550 cm^{-1} (G band). D band intensity is related to crystalline size, and the intensity ratio, I_D/I_G, is related to the grain size. The NRS-3000 Series enables rapid DLC measurement with a high signal-to-noise ratio. The optional carbon analysis program simplifies the calculation of peak separation and peak ratio.

Specifications

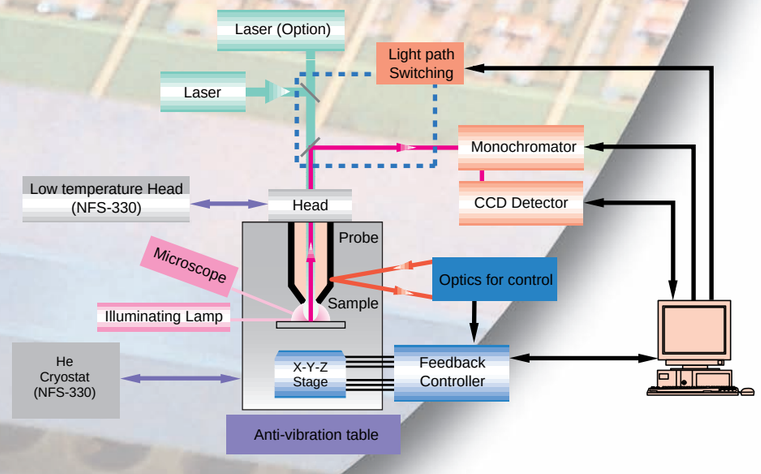
Optical system	
Monochromator	Single monochromator
Max. resolution	1 cm^{-1} with 532 nm excitation
Spectral range	50 to 8,000 cm^{-1} (Raman shift) with 532 nm excitation
Standard laser	532 nm
Detector	CCD detector (thermoelectric cooling)
Diffraction grating	1800 grooves/mm standard; optional 600, 1200 and 2400 grooves/mm gratings available
Monochromator drive	High precision direct drive
Sample chamber	
Sample observation	Integrated CCD camera and video capture
Raman imaging	Optional
Accessory	Automated X-Y-Z stage with auto focus (optional)
Software and data processing	
Computer system	PC with Windows 2000 or XP
Data processing	Spectral search, cosmic ray elimination, derivatives, smoothing, baseline correction, spectral arithmetic, spectral subtraction and peak analysis functions
Optional programs	Curve fitting, carbon analysis, stress analysis, H_2 gas quantitation, sample mapping, interval measurement, and instrument validation
Dimensions, weight, and power requirements	
Dimension	860(W) x 820(D) x 635(H) mm
Weight	200 kg
Power requirement	500 VA

NFS Series
Scanning Near-Field Optical Microspect rometer

The NFS Series of scanning near-field optical microspectrometers have been optimized as a new solution for nanotechnology applications. Traditionally, characterization methods on the nanometer scale consist of topography observation using an electron or scanning probe microscope or elemental analysis using an x-ray microanalyzer. These methods deliver images with high spatial resolution but they cannot obtain chemical information from a sample surface. On the other hand, traditional FT-IR, photoluminescence, or Raman microspectroscopy instruments can provide chemical data for a sample, but the spatial resolution is determined by the diffraction limit of light, limited to the wavelength of the light used. Scanning near-field microspectrometers allows characterization at the extreme nano level range exceeding the diffraction limit of light. Introducing light into a fiber probe with an aperture of a hundred to several hundred nm produces near-field light of the same size as the probe aperture. Bringing the sample close to the probe aperture (within 100 nm) allows spectroscopic observations with a spatial resolution of several hundred nm as a result of the interaction of the near-field light with the sample surface.

System Features

- Integrated scanning near-field microspectrometer systems.
- Spectroscopic measurements with spatial resolutions between a hundred to several hundred nm.
- JASCO near-field probes provide reproducible spectral measurements and are available with specified dimensions.
- Topographical measurement of sample features with simultaneous spectral measurements.
- Can support illumination-collection, collection, and illumination (transmission) modes.



Nanometer scale characterization

Sample characterization with submicron spatial resolution is critical because impurities on the nanometer scale can have a major impact on electrical properties of semiconductors. For instance, the compositional ratio of GaAs and GaP in a GaAsP material can be estimated from the emission spectra of the sample surface. Conventional near-field microscopes that do not provide spectroscopic data cannot produce the compositional information. With the NFS series, however, observation of minute peak shifts from the emission spectra can easily be performed for multiple sample sites. Figure 1 is the topographical image of a sample surface for a 6 x 6 μm area. Figure 2 illustrates the peak shift distribution of the GaAsP substrate, the green portions denoting a long wavelength shift, indicating that the GaP concentration is slightly higher than the surrounding area.

Figure 1 Topography of GaAsP

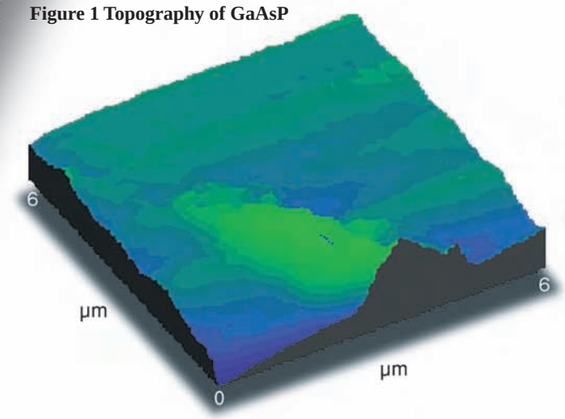
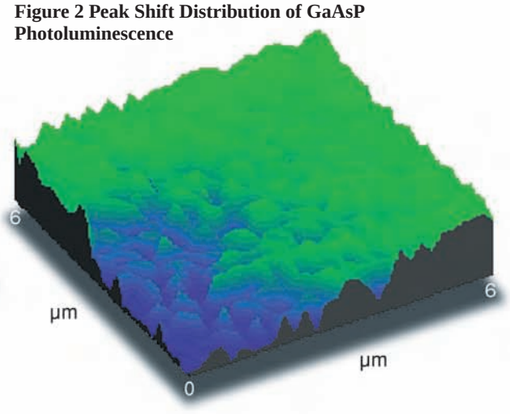


Figure 2 Peak Shift Distribution of GaAsP Photoluminescence



Specifications

Model	NFS-330/230	NFS-300FT/200FT
Measurement modes	Illumination-collection, collection, and illumination (transmission)	Illumination-collection, collection, and illumination (transmission)
Integrated laser	Green laser (532 nm)	Green laser (532 nm)
Spectrometer	Czerny-Turner aberration-corrected spectrograph	Fourier Transform spectrometer
Wavelength range	500 - 1000 nm	850 - 1500 nm
Detector	CCD	InGaAs

- For low temperature experiments, the NFS-330 and NFS-300FT include a He gas-flow cryostat for cooling to 20K or less.

V-1000
Vacuum-Ultraviolet Spectrophotometer

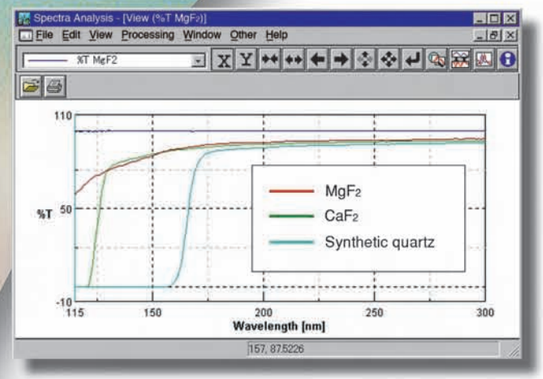
Miniaturization of wafer manufacturing processes has promoted the shift towards shorter photolithography wavelengths. Currently, ArF lasers (193 nm) are most currently used. Research on the practical implementation of F_2 (157 nm) has reduced the imprinting node to 0.07 μm.

The V-1000 was designed to evaluate optical properties in the wavelength range between 115 and 300 nm. Typically, instrument optical paths for analyses in this range are evacuated due to the strong absorption of oxygen, thus, the 'vacuum' ultraviolet range. The V-1000 provides rapid sample measurements without evacuation of the entire instrument by using a nitrogen purge and dual sample exchange cabinets to enhance purge efficiency. Superior photometric reproducibility is achieved by using a double monochromator for elimination of stray light and a reference stabilized double-beam system to maintain baseline stability.

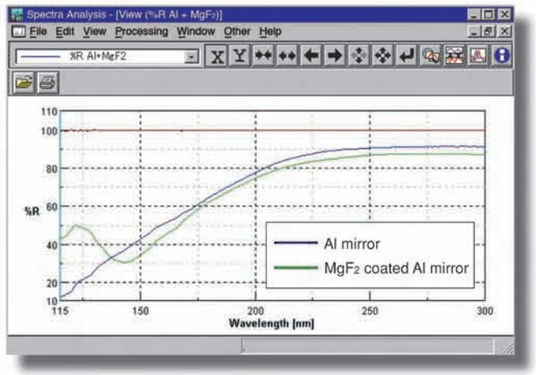
System Features

- **Highly accurate measurements in the vacuum UV range**
  Double monochromator and reference stabilized double-beam system achieves a photometric reproducibility of 0.03% .
- **Rapid switchover between transmission/reflection measurement**
  Samples are easily loaded for either reflection measurements at 5° or 45° or transmission measurements without replacing sampling accessories. Please contact us if you require a special configuration.
- **Quick measurements**
  By increasing purge efficiency and eliminating dead space in the optical path, measurements are completed within minutes.

%T Transmission measurement



%R Reflection measurement



Superb Photometric Reproducibility

- This example uses a calcium fluoride window 30 mm in diameter and 2 mm thick.
- One hundred consecutive measurements were taken on five separate occasions using a wavelength of 157.6 nm.

Measurement	Average Transmittance	Standard Deviation (Num. of samples: 100)
1	86.07 %	0.025 %
2	86.03 %	0.023 %
3	86.02 %	0.023 %
4	86.04 %	0.024 %
5	86.05 %	0.025 %

Specifications

Wavelength range	115 to 300 nm
Photometric reproducibility	Standard deviation at 157 nm: ±0.03 % or less for material with 70 %T or greater
Spectrophotometer	Double monochromator with dual concave gratings and reference stabilized double-beam system
Instrument resolution	3 nm (Optional: 1 nm)
Light source	Deuterium lamp
Detector	Photomultiplier tube (PMT)
Purge	Nitrogen purge (Sample chamber purged separately)
Measurement configuration	Transmission and 5° or 45° incidence reflection (standard)
Optional accessories	Absolute reflection and polarization dependence
Sample size	Maximum sample size 50.8 mm diameter and 10 mm thickness
Data collection and analysis software	Spectral scanning, fixed wavelength, baseline correction, smoothing, spectral arithmetic, peak area, peak height, peak half width, and data conversion routines
Supplied support equipment	Support bench, oxygen monitor, vacuum gauge and vacuum pump
Size	1300(W) x 700(D) x 1200(H)
Weight	Approx. 450 kg
Power requirement	130 VA

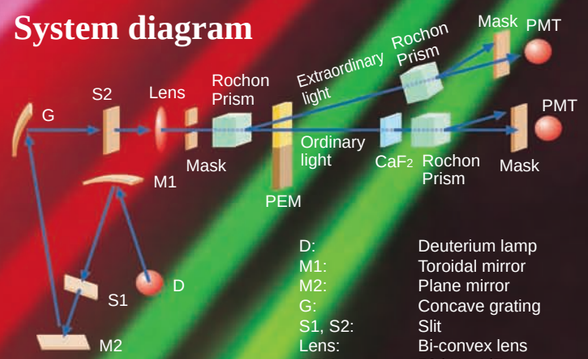
BRV-100
Vacuum Ultraviolet Birefringence Meter

CaF_2 is the most suitable material to be used for lenses in 157 nm optical lithography applications. However, CaF_2 is an anisotropic material subject to birefringence, distorting the focal point of the laser light used in optical lithography. Although the birefringence errors can be corrected, the CaF_2 lenses and optical systems require accurate characterization to ensure a proper focal point of the illuminating laser. Characterization of the CaF_2 birefringence requires a metrological measurement with extremely high accuracy. Based on years of experience in polarization measurements, the BRV-100 was developed by JASCO to measure the birefringence of optical materials. A highly sensitive birefringence instrument using a PEM (photoelastic modulator) for polarization modulation, the transmission wavelength is extended to the vacuum ultraviolet region by purging the optical path with nitrogen to reduce absorption by oxygen and water vapor.

System Features

- **High sensitivity**
  The phase difference angle is calculated from an arc-sine function providing a highly sensitive measurement of birefringence below 1 nm/cm. The birefringence (F-signal) is calculated as f = -sin(D), with accurate detection of signals around zero.
- **High stability**
  The LiF PEM is controlled by an optical servo loop, providing measurements with highly stable ordinate values. A reference beam monitors the retardation amplitude of the PEM to observe an achromatic modulation even in the vacuum ultraviolet region. The optical servo provides a stable measurement of below 0.1% in the purged instrument environment.

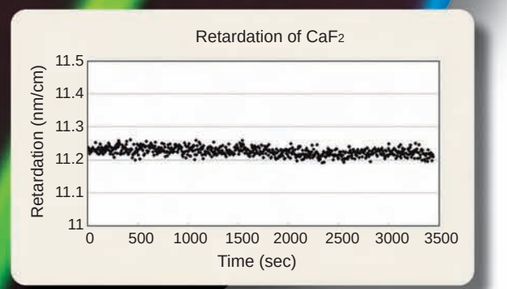
System diagram



D:	Deuterium lamp
M1:	Toroidal mirror
M2:	Plane mirror
G:	Concave grating
S1, S2:	Slit
Lens:	Bi-convex lens
PEM:	50 kHz, LiF
Rochon Prism:	MgF_2
PMT:	Photomultiplier tube
CaF_2:	Sample

CaF_2 retardation

The measured values agree with the value of 11.2 nm for the NIST standard. The precision of 0.05 nm/cm is much less than the acceptable birefringence value of 1 nm/cm for 157 nm optical lithography required by the ITRS.



Specifications

Wavelength range	140 to 320 nm
Sensitivity at 157 nm	0.05 nm
Stability at 157 nm	1/1000 per hour
Baseline at 157 nm	0.17 nm

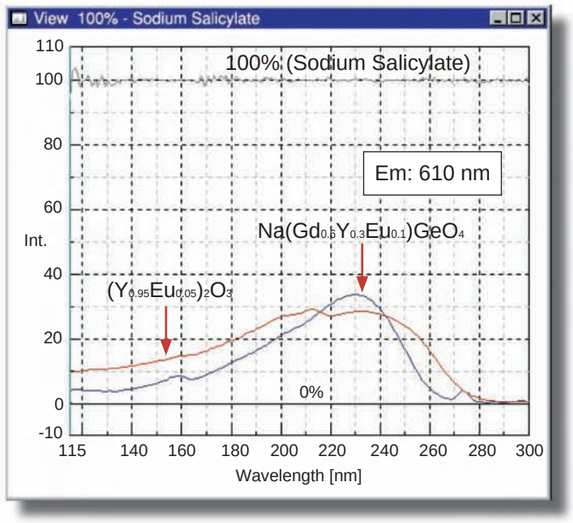
FLV-1000
Vacuum-Ultraviolet Spectrofluorometer

The plasma display panel (PDP) is expected to dominate the flat panel display market due to an improved viewing angle, faster update speeds, and a crisper picture quality. Gas discharge excitation of RGB photoluminescent phosphors is used by the plasma display panels to produce the displayed picture. However, there is still a need for improvement in display performance; the high power requirements and relatively high cost of manufacture restricting the viability of the PDP compared to other display alternatives. The JASCO FLV-1000 VUV Spectrofluorometer can be used for the development and characterization of new PDP phosphors or the inspection and control of PDP manufacturing processes.

System Features

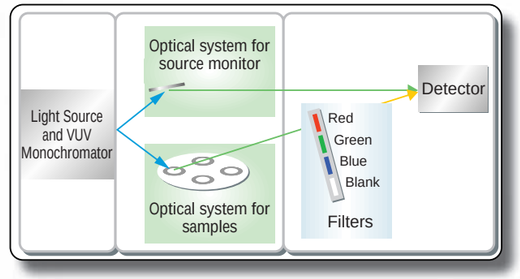
- Zero dispersion double monochromator for low stray light and high-throughput
- Dual-beam optical system using sodium salicylate as a reference monitor for excellent repeatability
- Stand-alone system includes a nitrogen purge system
- Automated cell changer for up to three samples
- Filter program for optimum fluorescence wavelengths
- Optional transmittance mode measurements

Excellent repeatability (Sodium Salicylate)



Results demonstrate relative intensity compared to Sodium Salicylate at 100.
Note: Samples supplied by Professor Toda of Niigata Univ.; Faculty of Engineering.

System Diagram



Specifications

Spectral range	130 to 300 nm
Resolution	3 nm
Repeatability	1%
Data point resolution	0.1 to 2 nm
Wavelength accuracy	±0.5 nm
Wavelength repeatability	±0.1 nm

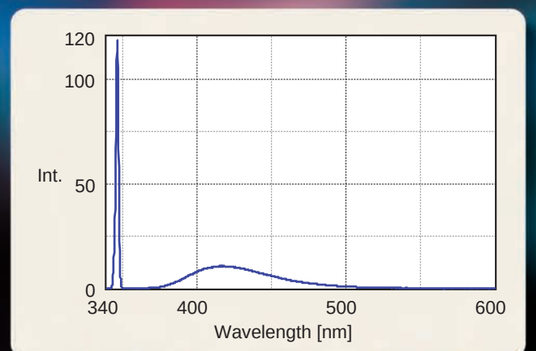
FP-6000 Series
Solid-state quantum efficiency measurement system

A quantum efficiency measurement system for solid samples integrates the FP-6500/6600 spectrofluorometer with an integrating sphere for fluorescence emission and a quantum efficiency calculation program. This system permits measurement of powdered fluorescent materials and calculates the external quantum efficiency, internal quantum efficiency and absorbance of the sample. The instrument can be used to measure fluorescent materials such as those being evaluated for "next generation" plasma display panels.

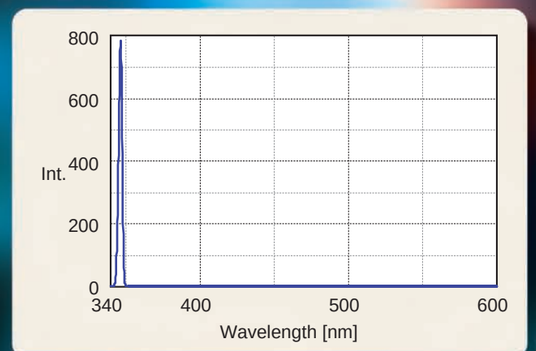
System Features

- Simple sample handling using the powdered sample holder
- Precise correction by referenced light source

Diffuse scattering spectrum of the Spectralon reference standard



Diffuse scattering and emission spectrum of Sodium Salicylate



Excitation Intensity	Diffuse Scattering	Sample Emission	Absorption	Internal quantum Efficiency	External quantum Efficiency
2227.2	278.7	714.6	87.5%	36.7%	32.1%

Specifications

Powdered sample holder	16 mm diameter with quartz window
Wavelength range	340 - 800 nm
Emission correction	Referenced light source
Detection	Integrating sphere, 60 mm diameter
Incident angle	5 degree
Reference standard	Spectralon

Near Infrared Spectrofluorometer

JASCO offers a Near Infrared (NIR) spectrofluorometer with the capability to measure materials with strong fluorescence in the NIR region, such as rare-earth elements or carbon nanotubes. Carbon nanotube characteristics change drastically according to the tube diameter or the chiral angle. A NIR spectrofluorometer is a very powerful tool for evaluation of these and other samples including 3-dimensional measurements that simultaneously scan both excitation and emission wavelengths.

System Features

- Precise correction by a calibrated, reference light source
- Quantum efficiency measurements in the NIR range

Applications

- Identification of single walled carbon nanotubes
- Characterization of organic compounds
- Emission spectra of rare earth complexes
- Analysis of semiconductor band structures

Specifications

Detectors	Thermoelectrically Cooled NIR Photomultiplier tube, Nitrogen Cooled NIR Photomultiplier tube
Detection	Lock-in amplifier using optical chopping
EX wavelength range	220 - 850 nm
EM wavelength range	950 - 1700 nm (Thermoelectrically Cooled) 600 - 1700 nm (Nitrogen Cooled)

EMV-100
Electric Field Modulation Spectrophotometer

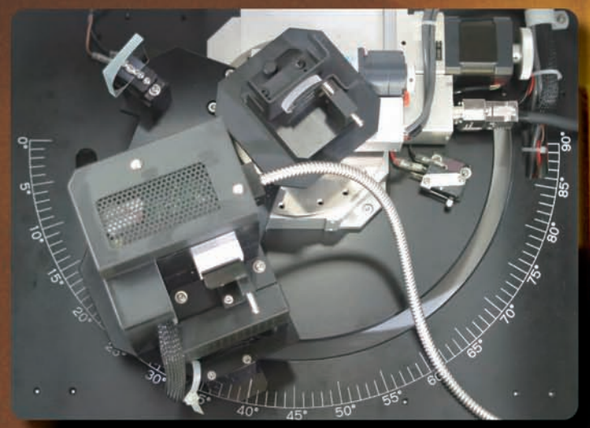
The EMV-100 electric field modulation spectrophotometer is capable of measuring changes in absorbance in the ultraviolet, visible and near-infrared region caused by application of an electrical field (several 100 V/μm) to film samples of optical performance materials. This system can perform quantitative measurement of changes in the dipole moment or polarizability and other characteristic sample parameters as a result of electronic excitation. This instrument is expected to extend the application to the evaluation of organic electro-luminescent (EL) materials, organic optical conversion molecules, and other molecular electronics elements. Furthermore, it will contribute to the elucidation of structures and functions related to optical excitation.

Specifications

Optics	Double beam
Wavelength range	190 - 3200 nm
Band width	0.1 - 10 nm (0.4 - 40 nm in NIR)
Measurement mode	Abs., %T, Single beam, Electro-absorption ($I\omega/I_{DC}$, $I2\omega/I_{DC}$)
Frequency	10 - 50 kHz
Modulation voltage	0 - 300 V
Detector	PMT, Cooled InSb
Sample holder	Variable angle incidence (40˚ - 90˚)

V-7000 Series
Automated Absolute Reflectance Measurement System

The absolute reflectance measurement system automates the measurement of the spectral properties, film thickness, angle variation or other characteristics of solid samples such as semiconductors, thin films and various optical elements. Coupled with the JASCO V-7000 UV/Vis/NIR Spectrophotometers, the instrument system provides measurements of challenging samples with dramatically reduced noise and excellent photometric stability. The incidence and collection angles can also be set in a synchronous mode, simultaneously rotating the sample stage and integrating sphere. Alternatively, the incidence and collection angles can be individually declared in an asynchronous mode. The polarization properties of a sample can also be examined using P or S polarization or by setting the desired polarization angles.



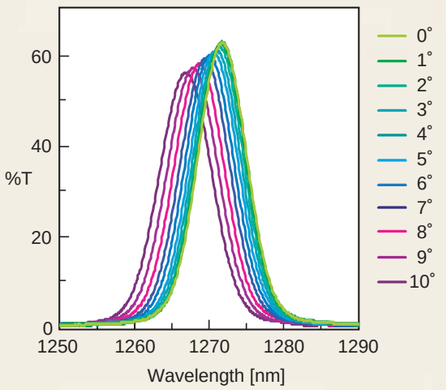
System Features

- PC control of instrument conditions such as incidence and collection angles and spectrum measurement parameters.
- Wide range of instrument wavelengths, from the ultraviolet to near infrared region.
- Superior photometric stability using a double-beam optical configuration.
- Individual control of incidence and collection angles.
- Standard polarization measurement capability.
- Purpose-built sample holder simplifies loading/removal of samples.

Specifications

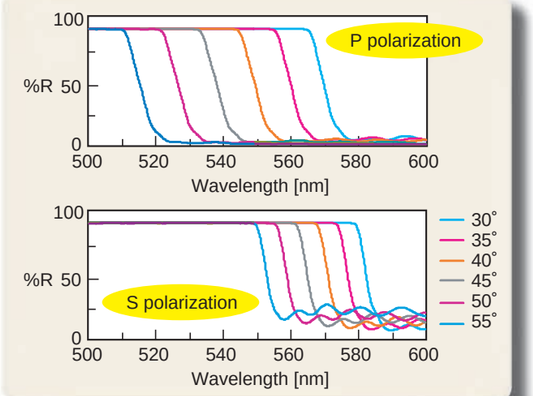
Wavelength range	250 nm to 850 nm (ARV-701) 250 nm to 2000 nm (ARV-702) 250 nm to 1800 nm (ARV-703)
Incidence angle	5˚ to 60˚(Reflectance mode) 0˚ to 60˚(Transmittance mode)
Sample dimensions	Minimum 20(H) x 20(W) x 0.5(T) mm Maximum 70(H) x 100(W) x 10(T) mm
Detectors	PMT (all models) PbS (ARV-702) InGaAs (ARV-703)

Transmittance profile of band pass filter



Varying the incidence angle, the transmittance characteristics of a band pass filter are measured. As shown above, the transmittance peak of the band pass filter is shifted about 8 nm to a shorter wavelength range as the incident angle is changed from 0 to 10 degrees.

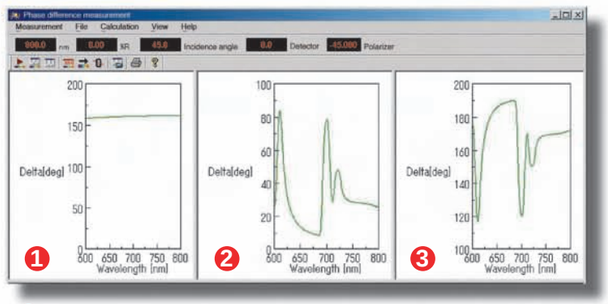
Reflectance profile of dichroic mirror



Varying the incidence angle, the reflectance characteristics of a dichroic mirror using P and S polarization are measured.

Phase difference measurement

By using an angle selective polarizer, measurements of the phase difference of metal films can be provided. Quarter wave plates for evaluation of optical disks can also be inspected.



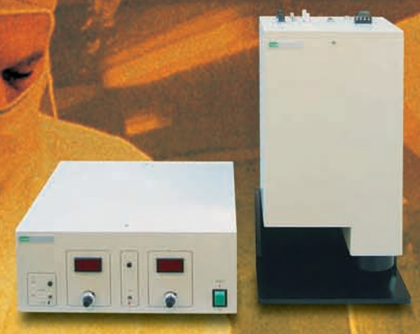
1. **Phase difference (Δ) of Al mirror**
2. **Phase difference (Δ) of a sample and Al mirror**
3. **Phase difference (Δ) of a sample**

CDF-102
Confocal Fluorescence Detector

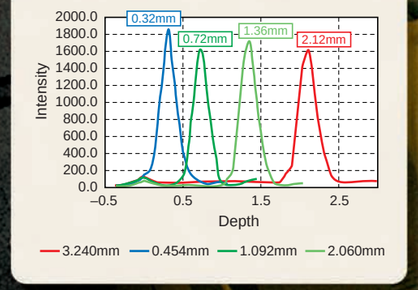
Fluorescent compounds in quartz crucibles used for silicon crystallization can contaminant the semiconductor material. These contaminants migrate through the quartz during the heating and cooling cycles, eventually bringing the fluorophores to the surface and contaminating the molten silicon. Traditionally, a representative crucible is destroyed to determine the depth of the fluorescent material. Confocal fluorescence detection can be used to determine the depth of the fluorescent contaminant without destroying the crucible. By gradually altering the source focal point and simultaneously recording the fluorescence response and source scattering, a fluorescence depth profile can be created, indicating the precise depth of the fluorescent contaminants.

System Features

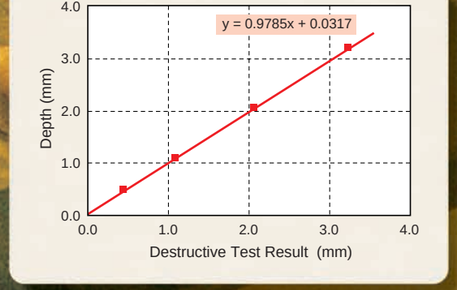
- A non-destructive, non-contact method for the detection of fluorescent contaminants in quartz or glass.
- Simultaneous measurement of the fluorescence and light scattering for calculation of the fluorescence depth profile. The distance of the fluorescent contaminant from the surface can be readily calculated.



Fluorescent Depth Profiles of Quartz Plates



Excellent Correlation to the destructive test results



Measurement results for detection of fluorescent contaminants in several quartz samples. Fluorescence impurities in the quartz plates were found at depths of 0.454, 1.092, 2.060 and 3.240 mm by the destructive test method. Measurements by the CFD-102 produce the fluorescence depth profiles indicating the presence of fluorescent contaminants at depths of 0.32, 0.72, 1.36 and 2.12 mm, respectively. The confocal fluorescence measurement demonstrates excellent correlation to the destructive test results.

Specifications

Spatial resolution	0.01 mm
Signals	Scattering and fluorescence
Objective travel	10 mm
Step size	0.002 mm
Aperture	1.0 mmØ
Light source	3 W low pressure Hg Lamp
Ex wavelength	254.7 nm
Em wavelength	400.0 nm
Size	460 x 280 x 180 mm (HxWxD)

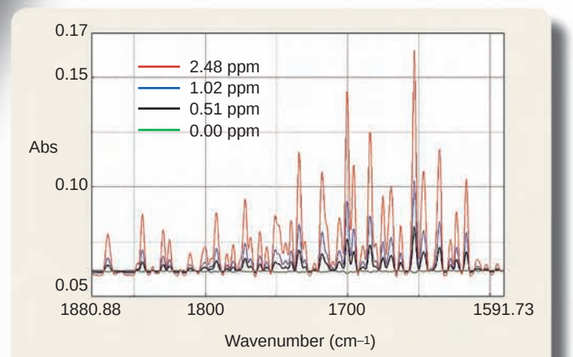
FT-IR full vacuum gas measurement system

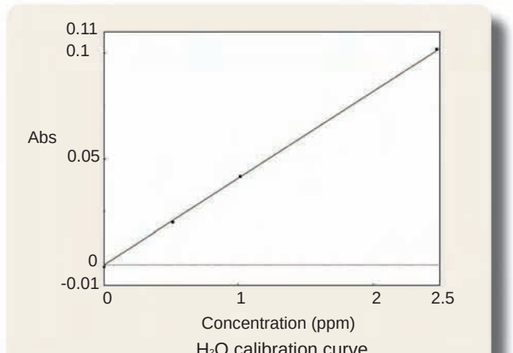
To measure low-concentrations of gases with high sensitivity using FT-IR, it can be necessary to remove CO_2 and H_2O from the instrument and sample compartment as well as use a long path gas cell. JASCO offers a high sensitivity full-vacuum gas measurement system with a wide spectral range DLATGS detector and/or a selection of high sensitivity MCT detectors for rapid measurement applications.

System Features

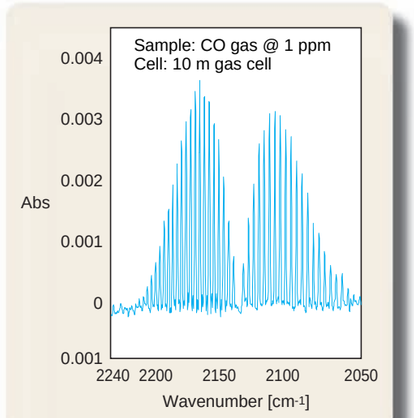
- Eliminates the effects of water vapor and CO_2
- Stable long-term measurements using sealed optics and an evacuated light path
- Detects very low concentrations of gases
- Integrated detectors to cover various application requirements

Quantitative analysis of H_2O in N_2





FT-IR spectrum of CO gas @ 1 ppm



Specifications

Gas cell path length	10 meters
Cell body	stainless steel
Mirrors	Gold-coated
Windows	KBr
Cell volume	2 Liters
Operational temperature range	ambient to 200˚C
Operational pressure range	ambient to 45 psi

Supercritical Fluid Technology

Photo Resist Stripping and Wafer Cleaning System using Supercritical CO_2

The complexity of integrated circuits has been increasing as lithography technology improves. In order to achieve pattern widths in the sub-micrometer range, the method of photoresist stripping and cleaning of silicon wafers is critical. Supercritical CO_2 offers excellent performance as a cleaning solvent in the photoresist stripping/cleaning/drying processes due to unique properties such as low viscosity, high diffusivity, high permeability, no surface tension, among other reasons.

In addition, the fluid becomes a gas when reducing the pressure to atmospheric at ambient temperature. A liquid solvent can often collapse microstructures with a high aspect ratio due to its high surface tension. On the other hand, supercritical CO_2 has no liquid-gas phase boundary and no surface tension occurs, therefore, the fluid can penetrate into microstructures without damaging the lithography pattern.

View Cells

Observation of conditions in the supercritical state by CCD camera

Three window supercritical CO_2 observation cell

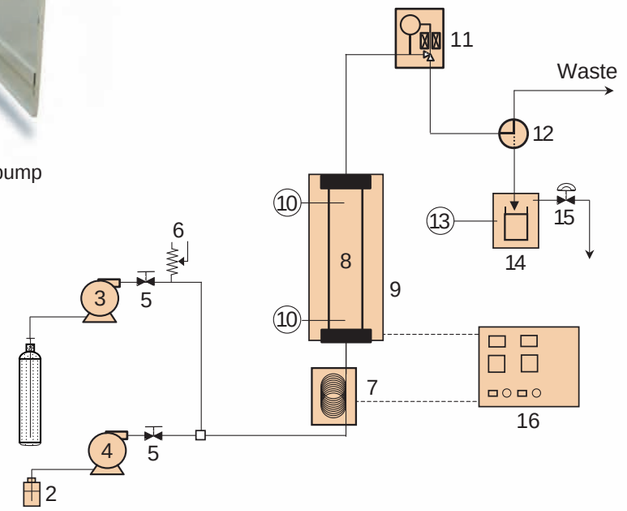
Two window supercritical CO_2 observation cell

Various high pressure vessels

Perfluoropolyether lubricant preparative refinery system using the supercritical fluid extraction method

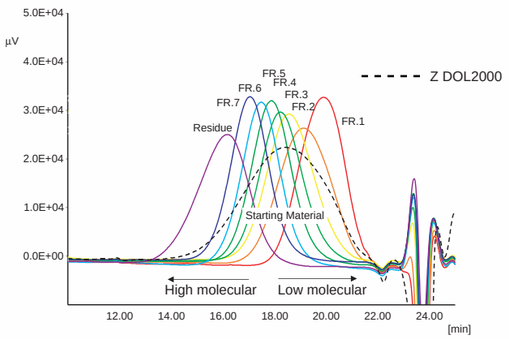
This preparative scale supercritical fluid extraction (SFE) system using carbon dioxide is equipped with a pump and back-pressure regulator to enable delivery of up to 150 ml/min of CO_2, and is also equipped with a 1 liter extraction vessel.

1. CO_2
2. Modifier or washing solution
3. CO_2 Large volume solvent delivery pump (PU-2150; Max.150 mL/min)
4. Modifier delivery pump
5. Stop valve
6. Safety valve
7. Pre-heating coil
8. Extraction vessel (1000 mL)
9. Temperature control jacket
10. Temperature meter
11. Back pressure valve
12. 6-way switching valve
13. Pressure meter
14. Fraction vessel
15. Back pressure valve
16. Temperature controller



Perfluoropolyether (PFPE) is a lubricant widely used in many aerospace, vacuum, electronic and semiconductor applications due to its excellent chemical and tribological properties. It is typically used for friction reducing films on hard disks. In order to obtain a greater amount of functional PFPE, supercritical carbon dioxide extraction systems can refine and separate wide molecular weight distribution PFPE mixtures into a higher performance PFPE with a narrower molecular weight distribution.

GPC chromatograms of PFPE fractions (Z DOL-2000, Polydispersity: 1.78) extracted by this system



Average molecular weight and polydispersity (Mw/Mn) of PFPE fractions extracted by this system.

Fractions	Pressure (MPa)	Extaction Time(min)	Mw	Mn	d=Mw/Mn	weight (g)	%
Z DOL 2000	Starting Material	-	2128	1192	1.7844	203.95	-
1	11.0MPa	90	767	638	1.2030	25.49	12.5
2	12.0MPa	90	1141	888	1.2848	51.93	25.46
3	12.5MPa	40	1502	1194	1.2573	21.61	10.59
4	12.7MPa	40	1790	1459	1.2268	20.47	10.03
5	13.0MPa	40	2191	1832	1.1960	18.25	8.94
6	13.5MPa	40	2755	2321	1.1870	18.17	8.90
7	14.0MPa	40	3469	2914	1.1904	17.14	8.40
Residue		-	6714	5039	1.3324	27.48	12.47
Total						200.54	98.32

The table outlines various PFPE fractions with narrow molecular weight distributions based on items such as polydispersity, 1.18 to 1.28.