

# HITACHI SPECTROPHOTOMETER Measurement Systems for Optical Parts / New Materials



## System configuration Catalog

- Micro sample reflectance measurement system
- Micro sample transmittance measurement system
- Detector attachment measurement system
- Wafer reflectance/transmittance measurement system
- Optical thin film reflection measurement system
- Lens transmittance measurement system
- Other accessories
- Examples of custom-designed system and optional software

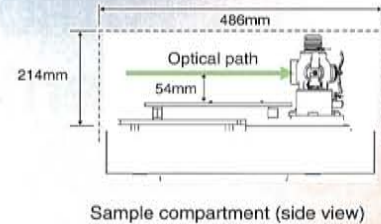
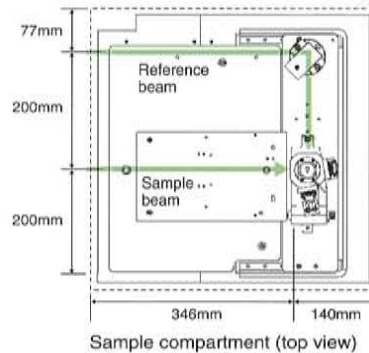


## Solid Sample Measurement System

This system is suitable for transmittance/reflectance measurement of solid samples. It is possible to construct a suitable system according to the purpose of measurement in combination with optional accessories.

### System Configuration

Monochromator: Prism-grating / Sample compartment: Standard sample compartment / Detector: Standard integrating sphere / Measuring wavelength range: 240 to 2,600nm / Sample size: 200 × 200mm max.

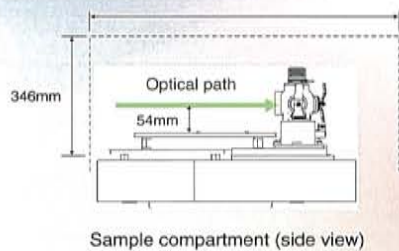
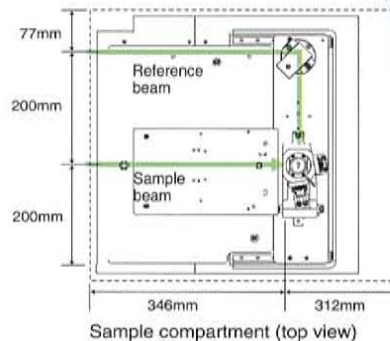


## Large Sample Measurement System

This system permits non-destructive transmittance/reflectance measurement of various optical and electronic materials including large-sized glass, silicon wafer and liquid crystal board.

### System Configuration

Monochromator: Prism-grating / Sample compartment: Large sample compartment / Detector: Standard integrating sphere / Measuring wavelength range: 240 to 2,600nm / Sample size: 430 × 430mm max.

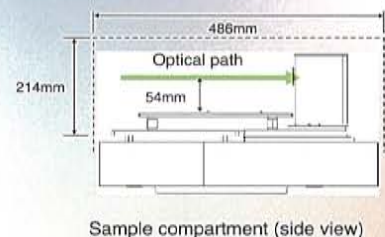
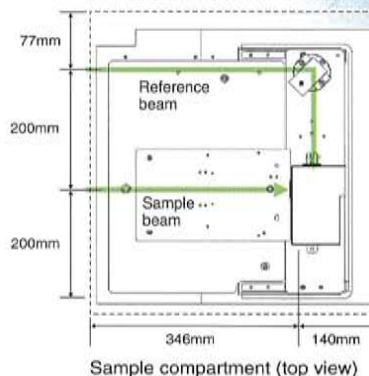


## Ultraviolet Region Measurement System

This system is suitable for sample measurement in the ultraviolet region. Optical parts including light source, monochromator and detector are specialized for use in the ultraviolet region. The system is useful for transmittance/reflectance measurement of optical parts used in the ultraviolet region, such as parts for the excimer laser.

### System Configuration

Monochromator: Grating-grating / Sample compartment: Standard sample compartment / Detector: High-sensitivity integrating sphere / Measuring wavelength range: 175 to 2,600nm / Sample size: 200 × 200mm max.





# Customization according to Target Sample or Application Purpose Allows User to Construct an Suitable System.

The Model U-4100 Spectrophotometer allows the user to combine a monochromator, detector and sample compartment according to the target sample and application purpose.

It is possible to construct a system which satisfies various analytical needs (ultraviolet region measurement system which permits measurement down to 175nm, very large sample compartment for non-destructive measurement of large samples, for example).

The Model U-4100 ensures high-sensitivity analysis in a wide variety of fields including semiconductor/new material development and biotechnology.

**P.03**

## Micro Sample Reflectance Measurement System

Small 5° specular reflectance accessory (absolute)  
for U-4100: P/N 134-0103

**P.05**

## Transmittance measurement system for micro samples

Transmittance measurement system  
for micro samples P/N: 1J0-0204

**P.07**

## Measurement system for liquid samples

Detector Attachment P/N: 134-0219

**P.09**

## Wafer Reflectance/Transmittance Measurement System

Top-mount transmittance/reflectance measurement unit (relative)  
for U-4100: P/N 134-0107

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## Optical Thin Film Reflection Measurement System

Variable angle absolute reflectance accessory: P/N 134-0116

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## Lens Transmittance Measurement System

Lens transmittance measurement accessory: P/N 134-0201  
ø60 full-sphere accessory: P/N 134-0205

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## Other Accessories

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## Examples of Custom-designed System and Optional Software



### For Liquid Sample Measurement

A system optimum for absorption/transmittance measurement of liquid samples is also available. The system is standard-equipped with a 10mm rectangular cell holder and adopts a photometric system which is based on direct irradiation of the detector. It covers a wide wavelength range and measuring range, thus enabling absorption/transmission measurement of various samples.

# Micro Sample Reflectance Measurement System

Optical materials such as mirror and film can be evaluated by measuring the reflectance with the light irradiated squarely or at a low incident angle onto the object.

The reflectance does not appreciably change in an incident angle range of  $0^\circ$  to  $5^\circ$ . So evaluation is generally made by measuring the absolute reflectance at an incident angle of  $5^\circ$  instead of  $0^\circ$ .

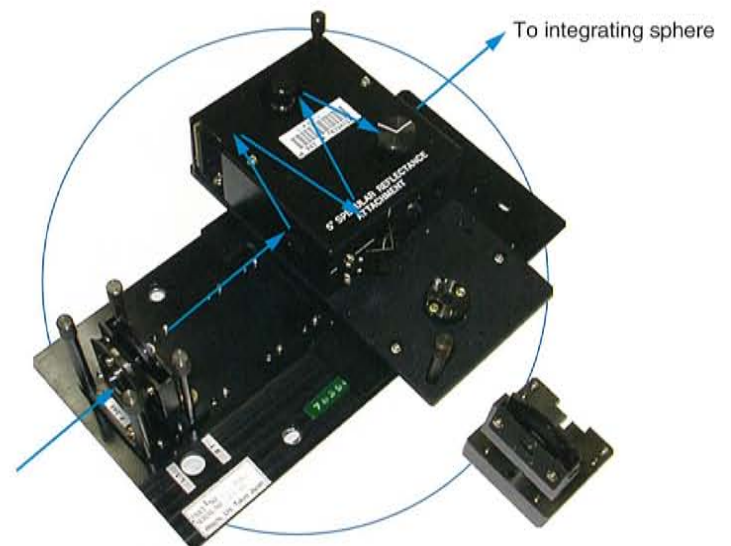
In addition, because the incident angle is as low as  $5^\circ$ , there is little influence of polarization characteristics of a sample (which is not true of special samples), whereby a polarizer need not be used.

Introduced here is an example of measurement in the system employing "Small  $5^\circ$  specular reflectance accessory (absolute) for U-4100 (P/N 134-0103)".

This accessory permits absolute reflectance measurement at an incident angle of  $5^\circ$  for micro samples ( $\phi 7$  to  $\phi 17\text{mm}$ , 0.2 to 2mm thick) by use of the micro sample holder.

The accessory also permits measurement of a sample in the same size as with  $5^\circ$  specular reflectance accessory (absolute) for U-4100 (P/N 134-0102) ( $\phi 25$  to  $\phi 50\text{mm}$ ) if the micro sample holder is not used.

\* In addition to the  $5^\circ$  specular reflectance accessory (absolute) for U-4100 (P/N 134-0102), the  $5^\circ$  specular reflectance accessory (relative) for U-4100 (P/N 134-0100) is available for relative reflectance measurement of standard samples. The Reflectance accessories whose respective incident angles are  $12^\circ$ ,  $30^\circ$  and  $45^\circ$  are also available.



Appearance of Small  $5^\circ$  specular reflectance accessory (absolute) for U-4100 (P/N 134-0103)



## Specifications

Wavelength range	240 to 2,600nm
Incident angle	$5 \pm 1^\circ$
Measuring method	Absolute/relative reflectance
Beam size	Approx. 2.2 (W) × 2.2 (H)mm
Sample mounting section	ø20mm
Sample size	Refer to the table at right.

	Measurable Sample Size
In standard system	ø25 to ø50mm 25 (W) × 25 (H)mm to 150 (W) × 100 (H)mm
When using micro sample holder (refer to Fig. 1)	ø7 to ø17mm 5 × 5mm to 12 × 12mm

The following optional holders are available for measurement of even smaller samples.

Micro sample holder 2 (P/N 132-7401)	Measuring section: ø2mm Sample size: ø3mm to ø18mm (12mm sq. or less)
Micro sample holder 4 (P/N 132-7403)	Measuring section: ø4mm Sample size: ø5mm to ø18mm (12mm sq. or less)



Fig. 1 Micro Sample Holder (standard-equipped)

## Applicable System

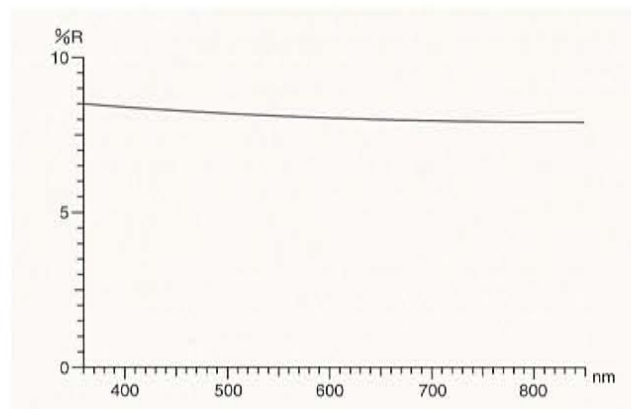
Solid Sample Measurement System	Large Sample Measurement System	Ultraviolet Region Measurement System	Liquid Sample Measurement System
○	○	○	×

## Example of System Configuration

	U-4100 Spectrophotometer
134-0103	Small 5° specular reflectance accessory (absolute) for U-4100 (P/N 134-0103)

## Example of Measurement

Measurement of reflectance  
(sample: optical material BK7, measured with micro sample holder)



# Transmittance measurement system for micro samples

Transmittance measurements are taken to evaluate optical components such as micro lenses and micro filters.

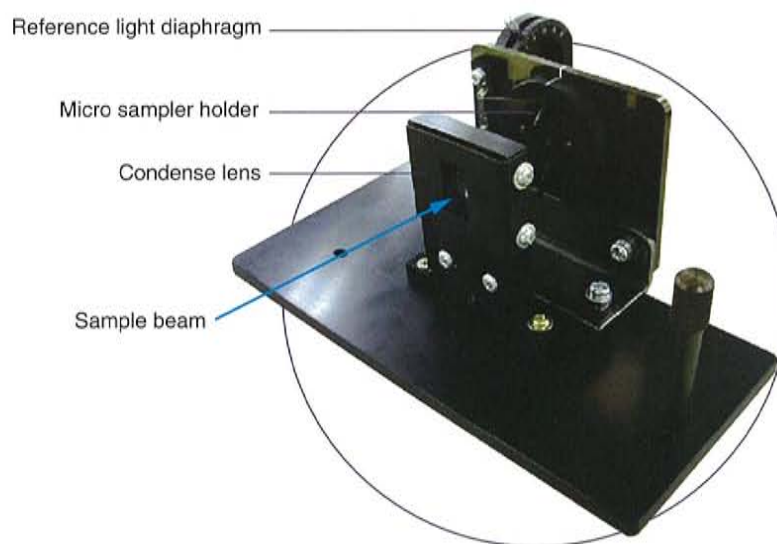
For micro lenses such as endoscopic lenses and micro glasses and filters, etc., that are  $\phi 25\text{mm}$  or smaller, it can be difficult to focus the sample beam (light irradiated onto the sample) to a size smaller than the sample for irradiation at the center of the sample.

Below, we introduce a system using the "Accessory unit for transmittance measurement of micro samples P/N:1J0-0204".

This accessory unit allows for easy setting and the measurement of even micro samples by using a condenser lens, reference light aperture, and a micro sample holder.

Transmittance measurement can be performed by using a micro sample holder ( $\phi 3$  mask) on micro samples ( $\phi 5$  to  $20$  and  $0.2$  to  $3$  mm thickness).

\* The other micro sample holder is also optional line upped that fits even smaller micro samples ( $\phi 3$  to  $20$ ,  $0.2$  to  $3$  mm thickness).



Appearance of accessory unit for transmission measurement of micro samples

## Specifications of Accessory Unit

Mask type	Measurable sample size
ø3 mm mask (Standard accessory)	ø5 to 20, 3 mm or less thickness
ø1 mm mask (Optional) P/N 1J0-1860	ø3 to 20, 3 mm or less thickness



Micro sample holder (standard -equipped)

\* The light-source mask should be replaced with the attached ø4 mm light-source mask.

Item	Specification
Baseline flatness (100% line) 240 to 850 nm 850 to 2,000 nm	±1.0%T or below (slit 6 nm, 300 nm/min) ±1.5%T or below (slit : Auto change, Pbs Gain: 2, 750 nm/min)
Noise level ( 100%T, peak to peak) 500 nm 1,500 nm	The specification of ø1 mm mask is shown in parentheses. ±1.0%T or below [ ±1.5%T or below] (slit 6 nm, measurement time 60 sec) ±1.0%T or below [ ±1.5%T or below] (slit : Auto change, Pbs Gain: 2, 60 sec)

## Applicable System

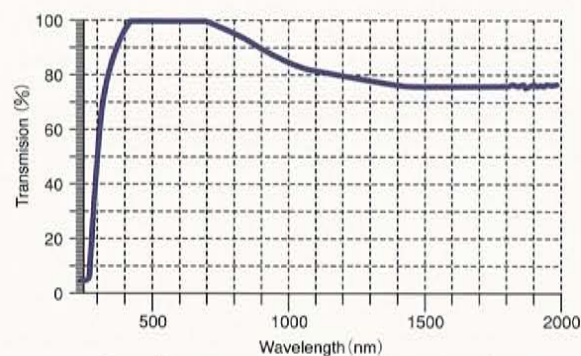
Solid Sample Measurement System	Large Sample Measurement System	Ultraviolet Region Measurement System	Liquid Sample Measurement System
○	○	○	×

## Example of System Configuration

	U-4100 Spectrophotometer
1J0-0204	Accessory unit for transmission measurement of micro samples (ø3 mm mask standard accessory)
1J0-1860	Micro sample holder (ø1 mm mask)

## Example of Measurement

Example of transmittance measurement  
(anti-reflection coating substrate)



Transmittance spectrum of anti-reflection coating substrate  
(Sample: 5 mm×5 mm (1 mm thickness), ø3 mm mask is used.)



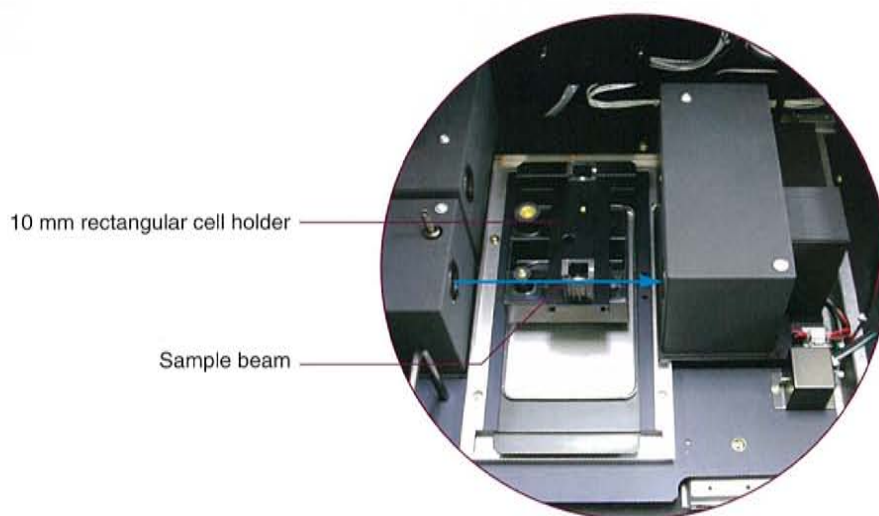
# Measurement system for liquid samples

A U-4100 solid sample measurement system or a large sample measurement system is used; thus, when a liquid sample with a narrow bandpass and less noise needs to be measured, use of an integrating sphere has limitations.

Here, we introduce the "**Detector attachment P/N:134-0219**".

This accessory unit provides a large wavelength range (185 to 3,300 nm) and a large measurement range by changing the integrating sphere into optical measurement through use of the detector's normal incidence, which can measure the absorption/transmission of a wide range of samples.

\* For use of cells other than 10 mm rectangular cells, please use a another cell holder.



Appearance of detector attachment



## Specifications of Accessory Unit

Item	Specification	
Wavelength range	185 to 3,300 nm	
Corresponding cell	10 mm square cell (prepared separately)	
Stray light		
NaI 220 nm		≤0.00008%
NaNO <sub>2</sub> 340 nm		≤0.00005%
Chloroform 1,690 nm		≤0.025%
Baseline flatness (0Abs line)	<Measuring conditions>	
185 to 200 nm	±0.05Abs or below	Slit: 2 nm (UV-VIS), auto change (NIR), sampling interval: auto, Scan speed: 300 nm/min (UV-VIS), 750 nm/min (NIR) Measurement is conducted after user baseline correction (at 2 hours or more after power-on). Absorption wavelength of water, detector switching wavelength, and light-source switching wavelength are excluded.
200 to 850 nm	±0.001Abs or below	
850 to 2,500 nm	±0.002Abs or below	
2,500 to 3,300 nm	±0.004Abs or below	
Noise level (0Abs,RMS)	<Measuring conditions>	
500 nm	0.00004Abs or below	Slit: 2 nm (UV-VIS), auto change (NIR), scan time: 60 s, sampling interval: 1s (excluding drift).
2,000 nm	0.00003Abs or below	

\*Additional installation to the existing U-4100 type is made at additional expense.

## Applicable System

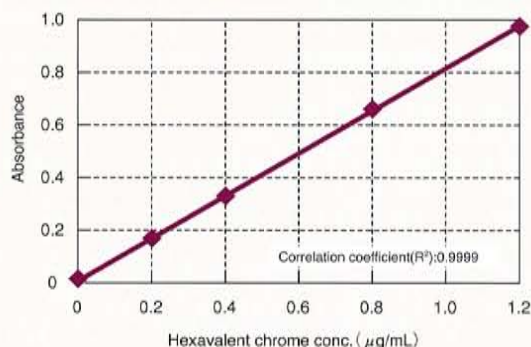
Solid Sample Measurement System	Large Sample Measurement System	Ultraviolet Region Measurement System	Liquid Sample Measurement System
○	○	○	×

## Example of System Configuration

	U-4100 spectrophotometer
134-0219	Detector attachment

## Example of Measurement

Measurement of a liquid sample (hexavalent chrome)



Example of a quantitative assay of hexavalent chrome using the diphenylcarbazide / absorption spectroscopy method

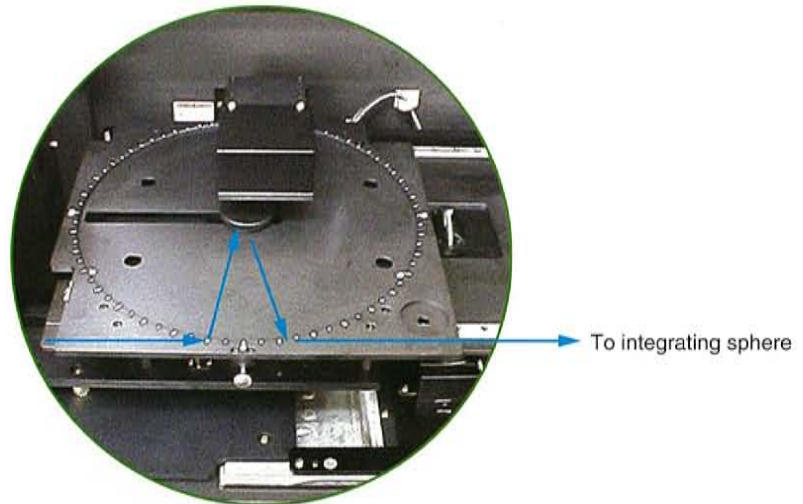
# Wafer Reflectance /Transmittance Measurement System

The U-4100 Spectrophotometer (large sample measurement system) is available for non-destructive transmittance/reflectance measurement of various optical and electronic materials including large-sized glass, silicon wafer and liquid crystal board.

Introduced here is an example of measurement in the system employing "Top-mount transmittance/reflectance measurement unit (relative) for U-4100 (P/N 134-0107)".

This accessory permits measurement of the relative reflectance to the reference sample at an incident angle of  $5^\circ$  and measurement of the transmittance at an incident angle of  $0^\circ$  (the absolute reflectance cannot be measured with this accessory). The accessory also permits reflectance/transmittance measurement at a desired angle on a sample with the moving/rotating stage.

\* The top-mount transmittance/reflectance measurement unit (absolute) (P/N 134-0108) is available for absolute reflectance measurement.



Appearance of Top-mount transmittance  
/reflectance measurement unit (relative) for U-4100  
Optical system for  
relative reflectance measurement at  $5^\circ$   
(arranged in U-4100 large sample compartment)



## Specifications

Wavelength range	240 to 2,600nm
Incident angle	0 ±1° (transmission) 5 ±1° (reflection)
Measuring method	Transmittance and relative reflectance
Beam size	Approx. 8.2 (W) × 6.2 (H)mm (transmission) Approx. 9.5 (W) × 9.1 (H) mm (reflection)
Sample size	Refer to the table at right.
Measurable range	Sample center to position of 15mm from sample edge

	Measurable Sample Size
When using ø6-inch sample holder	ø6-inch
When using ø8-inch sample holder	ø8-inch

\* The accessory is standard-equipped with the ø6-inch sample holder, ø8-inch sample holder and flat sample holder.

## Applicable System

Solid Sample Measurement System	Large Sample Measurement System	Ultraviolet Region Measurement System	Liquid Sample Measurement System
×	○	×	×

## Optical System

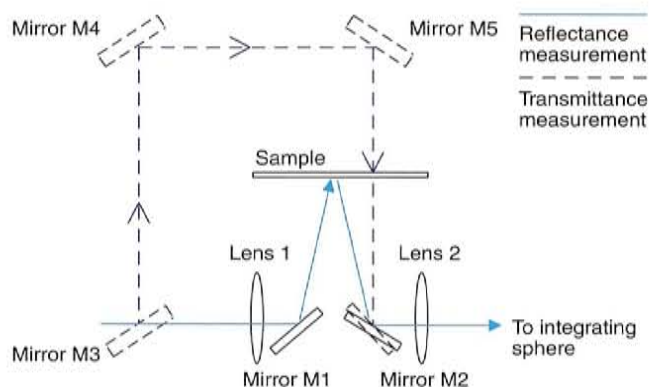
Transmittance measurement or reflectance measurement is selected by putting in/pulling out the mirror M3 and switching over the mirror M2.

## 1. Transmittance measurement

The optical path in transmittance measurement is indicated by dashed line in the figure below. The transmittance is measured with the mirror M3 inserted and the mirror M2 switched to the transmission side.

## 2. Reflectance measurement

The optical path in reflectance measurement is indicated by solid line in the figure below. The reflectance is measured with the mirror M3 pulled out and the mirror M2 switched to the reflection side.

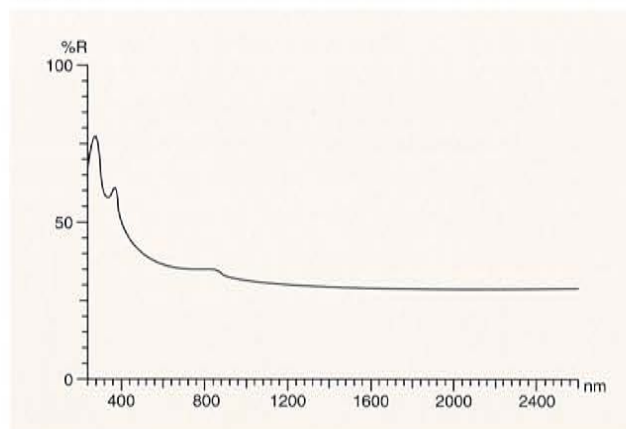


## Example of System Configuration

134-0006	U-4100 Spectrophotometer (large)
134-0107	Top-mount transmittance/reflectance measurement unit (relative) for U-4100

## Example of Measurement

Measurement of reflectance  
(sample: ø6-inch silicon wafer, reference material: evaporized Aluminum)



# Optical Thin Film Reflection Measurement System

Analysis of reflection/transmission characteristics and their angular dependence is indispensable in the field of optical materials such as film and thin film.

Introduced here is an example of reflection spectrum measurement at variable incident angles with “Variable angle absolute reflectance accessory (10° to 60°) (P/N 134-0116)”.

When the incident angle is 12° or higher, the polarization characteristics of a sample increase. When this accessory is used, therefore, it is necessary to measure the S and P polarized components by use of a polarizer for accurate measurement.

\* The following variable angle reflectance accessories are also available.

Variable angle absolute reflectance accessory (15° to 65°) (P/N 134-0117):

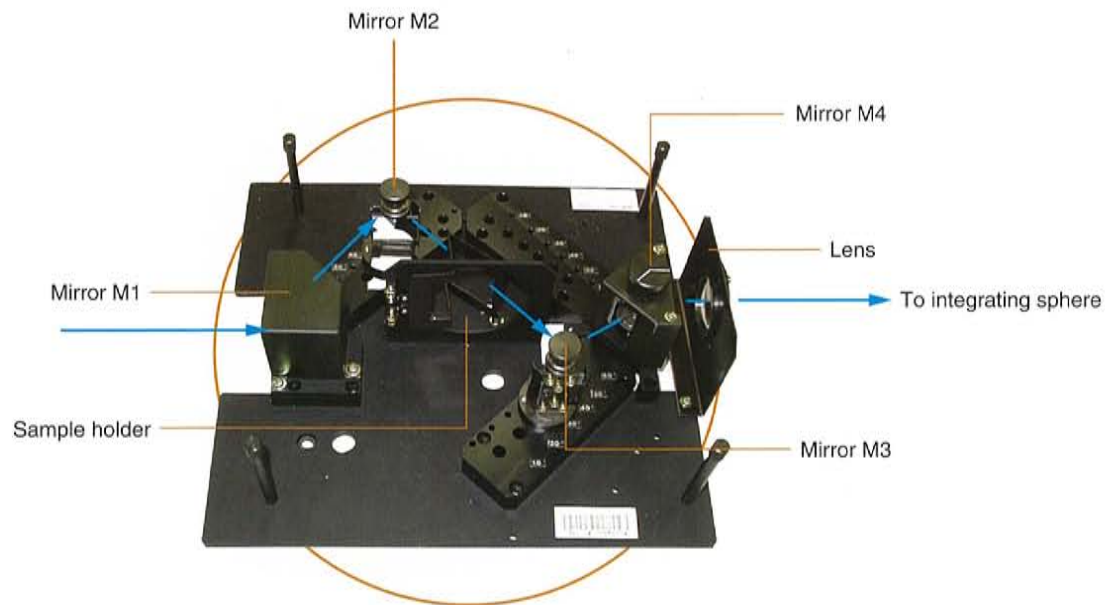
This accessory has a different incident angle range.

Variable angle absolute reflectance accessory (20° to 60°) (P/N 134-0115):

This accessory measures the absolute reflectance and transmittance at a desired angle by rotating the detector (integrating sphere) and sample stage independently of each other.

Variable angle reflectance accessory (relative) (20° to 60°) (P/N 134-0118):

This accessory measures the relative reflectance to the standard reflecting plate by utilizing the specular reflection of a sample.



Appearance of Variable angle absolute reflectance accessory (10° to 60°)



## Specifications

Wavelength range	240 to 2,600nm
Incident angle	10°, 20°, 30°, 40°, 50°, 60°
Measuring method	Absolute reflectance
Beam size	Approx. 10.7 (H) × 6.4 (W)mm (at an incident angle of 10°)
Sample holder	ø8 mm when using ø8–ø21
Sample size	Refer to the table at right.

Sample Size	Stand	Sample Holder Used
8 to 21mm sq., 5mm or less thick	Stand (1)	Sample holder ø8–ø21
21 to 45mm sq., 5mm or less thick	Stand (1)	Sample holder ø21–ø45
30mm cube to 90 (W) × 100 (H)mm, 5 mm or less thick	Stand (2)	—



Stand (1)



Stand (2)



Sample holder ø8–ø21



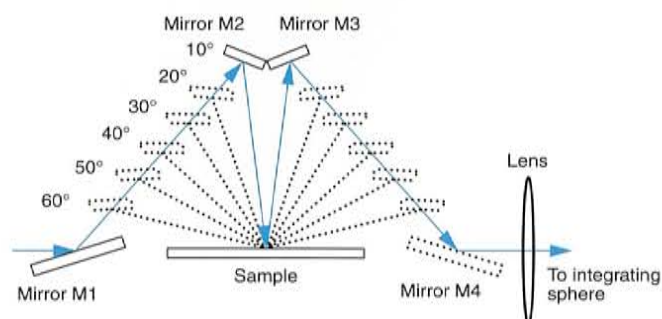
Sample holder ø21–ø45

## Applicable System

Solid Sample Measurement System	Large Sample Measurement System	Ultraviolet Region Measurement System	Liquid Sample Measurement System
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## Optical System

This system permits measuring the absolute reflectance of a sample by displacing the mirror M3 and switching over the mirror M4. In addition, the incident angle can be changed in steps of 10° in a range of 10 to 60° by changing the respective insertion points of mirrors M2 and M3.

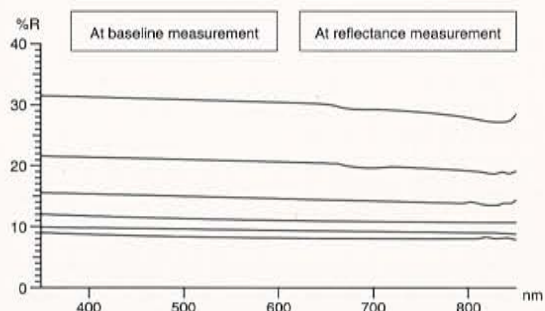


## Example of System Configuration

	U-4100 Spectrophotometer
134-0116	Variable angle absolute reflectance accessory (10° to 60°)
132-0325	Polarizer holder (Separately prepare a polarizer.)

## Example of Measurement

Measurement of reflectance  
(sample: optical material BK7, S polarized component measured by polarizer)



# Lens Transmittance Measurement System

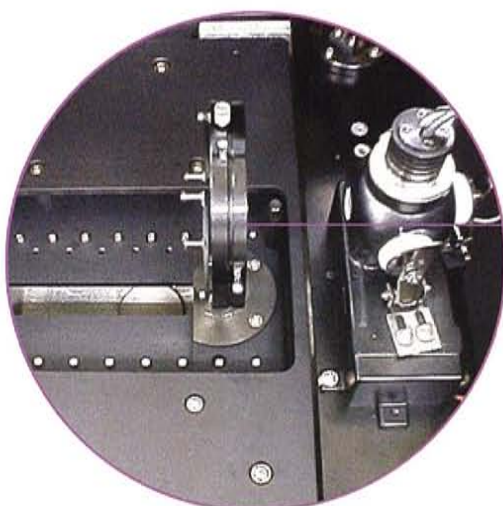
Integrating sphere is indispensable for measuring the transmittance and reflection characteristics of solid samples including optical materials such as glass, lens and prism.

For measurement of the lens transmittance, use “**Lens transmittance measurement accessory (P/N 134-0201)**”.

The light beam which has passed through the lens may overflow on the white plate of the standard integrating sphere. It is therefore advisable to use this accessory in combination with “**ø60 full-sphere accessory (P/N 134-0205)**”.

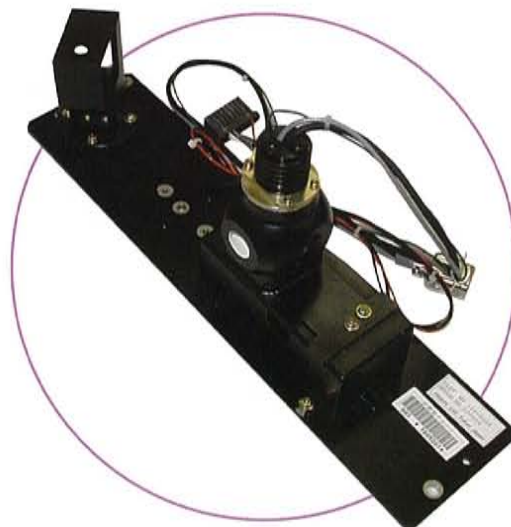
\* The large lens measurement unit (P/N 134-0203) is also available for transmittance measurement of a large lens (ø50 to ø200mm (300mm or less in length))

\* The U-4100 (ultraviolet region measurement system) is standard-equipped with the high-sensitivity integrating sphere accessory (full-sphere). So the ø60 full-sphere accessory need not be used.



Lens holder (25 to 80)

Appearance of Lens transmittance measurement unit  
(arranged in U-4100 sample compartment)



Appearance of  
ø60 full-sphere accessory



## Specifications

### [Lens transmittance measurement accessory]

This accessory permits measuring the transmittance of a lens whose diameter is 25 to 110mm by replacing two kinds of lens holders. The distance from sample to integrating sphere can be changed in steps of 25mm.

Incident angle	0°	
Measuring method	Transmittance	
Sample size	When using (25 to 80)	ø25 to ø80mm (6mm or less in fringe thickness)
Lens Holder	When using (40 to 110)	ø40 to ø110mm (6mm or less in fringe thickness)

### [ø60 mm full integrating sphere accessory]

This accessory is not provided with a photometric window, which is arranged at the sub-standard white plate position of the U-4100 standard integrating sphere, and its inner wall is coated with barium sulfate ( $\text{BaSO}_4$ ). If the light beam which has passed through a sample is diffused (in lens transmittance measurement for example), correct photometric values may not be obtained due to a difference in reflectance between the inner wall ( $\text{BaSO}_4$ ) and sub-standard white plate ( $\text{Al}_2\text{O}_3$ ) of the standard integrating sphere. This accessory is useful in such a case.

Wavelength range	240 to 2,600nm
Diameter of integrating sphere (inside)	60mm

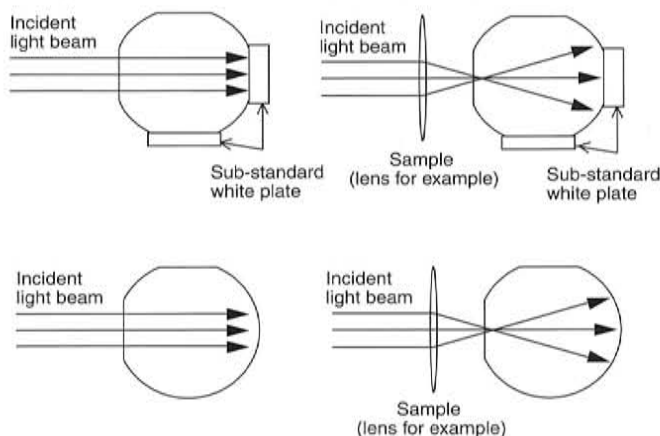
## Applicable System

Solid Sample Measurement System	Large Sample Measurement System	Ultraviolet Region Measurement System	Liquid Sample Measurement System
○	○	○	×

## Principle

With the U-4100 standard integrating sphere, the light beam which has been led into it may be reflected on both the sub-standard white plate and inner wall of the integrating sphere in measurement of a sample through which the light beam changes. In such a case, correct photometric values cannot be obtained because baseline measurement and sample measurement are not conducted under the same conditions due to a difference in reflectance between the sub-standard white plate and inner wall.

With the ø60mm integrating sphere, its inner wall is coated with  $\text{BaSO}_4$ , which enables correct measurement even when the light beam is diffused after passing through the lens.

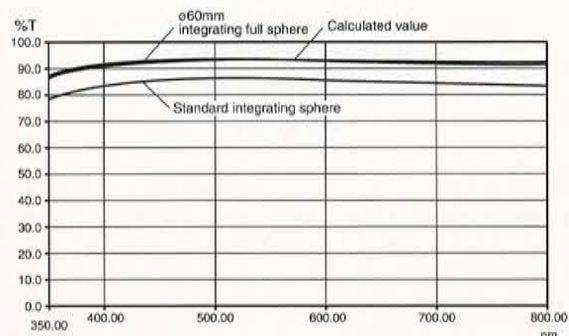


## Example of System Configuration

	U-4100 Spectrophotometer
134-0201	Lens transmittance measurement accessory
132-0205	ø60 full-sphere accessory

## Example of Measurement

Measurement of concave lens (2 pcs) with ø60mm integrating sphere and standard integrating sphere (same sample)  
For a combination of two lenses, its transmittance has been measured to compare the calculated values and actually measured values. With the ø60mm integrating sphere, the calculated values approximately coincide with the actually measured ones.



# A Full Array of Other Optional Accessories to Support the Diversified Measurement Needs



5° specular reflectance accessory  
(absolute)

134-0102



12° specular reflectance accessory  
(absolute)

134-0104



45° specular reflectance accessory  
(absolute)

134-0106



30° specular reflectance accessory  
(absolute)

134-0105

These accessories measure the absolute reflectance of a sample by the V-N method. They are used for obtaining the reflection characteristics of metallic film and glass surfaces according to the incident angle. Be sure to use them in combination with a polarizer. They are designed to set a sample on the side.

## Common Specifications

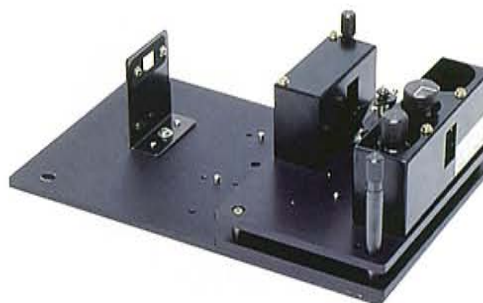
Sample size	Absolute reflectance measurement: 25 × 25mm to 100 × 150mm
Wavelength range	240 to 2,600nm



5° specular reflectance accessory  
(relative) for U-4100

134-0100

Sample size	Relative reflectance measurement: 25 × 25mm to 100 × 15mm
Wavelength range	240 to 2,600nm



Small prism measurement unit

134-0111

This unit measures the transmittance/reflectance of a microprism.

Incident angle	45°
Sample size	5 to 6mm cube, 7 to 20mm cube
Wavelength range	240 to 2,600nm





Polarizer holder for U-4100  
(polarizer not included)

132-0325

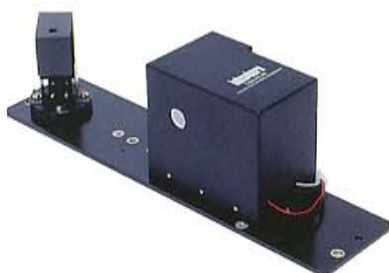


Variable angle transmittance  
measurement accessory

134-0200

This accessory permits transmittance at a desired incident angle (0 to 60°) by use of the rotating stage.

Incident angle	0° to 60°
Beam size	Approx. 12.3 (H) × 8.5 (W)mm
Wavelength range	240 to 2,600nm
Sample size	40 × 40mm to 140 × 140mm, 3mm or less thick

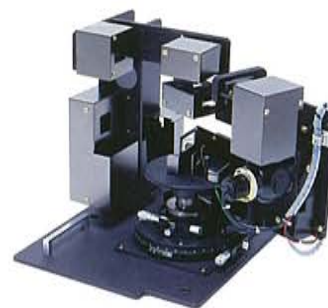


High-sensitivity integrating sphere accessory

134-0206

This accessory is sensitive in the ultraviolet region. It is useful for transmittance/reflectance evaluation of optical parts used in the ultraviolet region, such as parts for the excimer laser.

Wavelength range	190 to 2,600nm
Detector	Full sphere (with R955 photomultiplier)
100%T line flatness	±0.5%T (195 to 850nm) ±2.0%T (190 to 195nm)

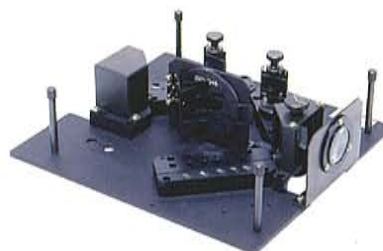


Variable angle absolute reflectance accessory

134-0115

This accessory measures the absolute reflectance and transmittance at a desired angle by rotating the detector (integrating sphere) and sample stage independently of each other.

Incident angle	20° to 60°
Sample size	Plane board: 30 × 30mm to 40 × 140mm Prism: 85mm cube or less
Wavelength range	340 to 2,000nm



Variable angle absolute reflectance  
accessory (10° to 60°)

134-0116

Variable angle absolute reflectance  
accessory (15° to 65°)

Refer to  
pages 7 and 8.

134-0117

These accessories measure the absolute reflectance of a sample by the V-N method with the mirror inserted at a specified position.

Incident angle	134-0116: 10° to 60° (in 10° steps) 134-0117: 15° to 65° (in 10° steps)
Sample size	8 × 8mm to 90 × 100mm
Wavelength range	240 to 2,600nm

# Examples of Custom-designed System

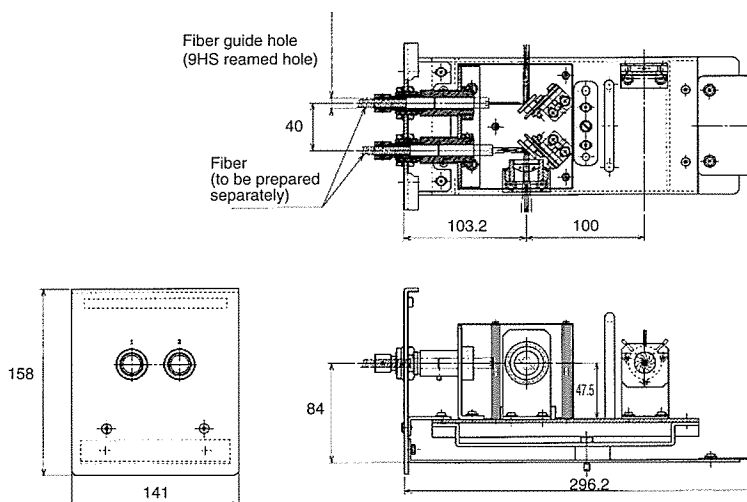
As exemplified below, the system can be customized according to the measuring object and application purpose.

For Measurement of Various Samples	
CD-R transmission/integrating sphere reflection system	Very large sample compartment
Full glass plate transmittance measurement (auto/manual) system	Movable glass filter measurement system
Strip fluorescent light measurement system	Optical pickup lens measurement system
Circular fluorescent light measurement system	Special glass filter measurement system
Plastic measurement system	Custom-designed polarizing sample measurement accessory
Lens transmittance measurement system	Micro sample transmission measurement system
Microprism measurement system	Microlens reflection/transmission measurement system

Upon Request for Various Measurements	
35° absolute reflectance measurement system	Mobile ø60mm integrating sphere system
57° absolute reflectance measurement system	Sample changer
Large sample compartment + 73° relative reflectance measurement system	Automatic X-Y stage
Cryostat system for large sample compartment	Heating stage
20° to 60° reflection/transmission measurement system (position measurement possible)	Optical fiber system for reflected color measurement
Large sample compartment + 4-opening high sensitivity integrating sphere system	Band gap measurement system
ø200mm integrating sphere system	Multi-wavelength measurement program for remote measuring system

## Schematic Diagram of Optical Fiber Connecting Sample Compartment in Optical Fiber System

Shown below is the optical fiber connecting sample compartment for the liquid sample measurement system of the U-4100 Spectrophotometer. The sample beam is taken out through the optical fiber and returned to the detector in the sample compartment via the external sample compartment.



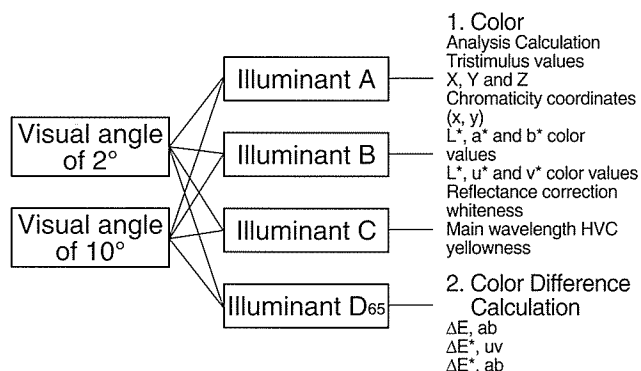
# Color Analysis/Applied Measurement Program Package (134-0321)

## Color Analysis

To specify the color of light or an object, it is convenient to pre-assign the illuminant, object and eyes and represent the results. The standard illuminant for measurement is prescribed by JIS Z8720, and the color specification in the XYZ color system by JIS Z8701. The color analysis program permits accurate color analysis through diffuse reflectance measurement of a solid sample surface. The measurement system conforms to JIS Z8722.

Using photometric values at 780 to 380 nm, this program figures out tristimulus values (X, Y, Z), lightness indices ( $L^*$ ,  $L$ ), chromaticness indices ( $a^*$ ,  $b^*$ ,  $a$ ,  $b$ ,  $u^*$ ,  $v^*$ ), and chromaticity coordinates ( $x$ ,  $y$ ).

Moreover, with the tristimulus values (X, Y, Z) of standard sample, the program is capable of working out color differences ( $\Delta E^*_{ab}$ ,  $\Delta E^*_{uv}$ ,  $\Delta E_{ab}$ ).



## Applied Measurement

This program conforms to the test procedure for the transmittance and reflectance of plate glass which is prescribed by JIS.

### ■ Daylight Transmittance (Reflectance) Measurement Program

This program measures the spectral transmittance and reflectance of plate glass in the visible region, and automatically calculates, from the measured values, the daylight transmittance  $\tau_v$  and daylight reflectance  $\rho_v$  with the CIE (International Commission on Illumination) spectral luminous efficiency for photopic vision against the CIE standard illuminant D65.

$$\tau_v = \frac{\sum_{\lambda=380}^{780} D_{\lambda} \cdot V_{\lambda} \cdot \tau(\lambda)}{\sum_{\lambda=380}^{780} D_{\lambda} \cdot V_{\lambda}} \quad \rho_v = \frac{\sum_{\lambda=380}^{780} D_{\lambda} \cdot V_{\lambda} \cdot \rho(\lambda)}{\sum_{\lambda=380}^{780} D_{\lambda} \cdot V_{\lambda}}$$

$D_{\lambda}$  : Spectral distribution of standard illuminant D65  
 $V_{\lambda}$  : CIE spectral luminous efficiency for photopic vision

### ■ Solar Transmittance (Reflectance) Measurement Program

This program measures the spectral transmittance and spectral reflectance of plate glass, and automatically calculates the solar transmittance  $\tau_e$  and solar reflectance  $\rho_e$ .

$$\tau_e = \frac{\sum_{\lambda=300}^{2100} D_{\lambda} \cdot \Delta\lambda \cdot \tau(\lambda)}{300} \quad \rho_e = \frac{\sum_{\lambda=300}^{2100} E_{\lambda} \cdot \Delta\lambda \cdot \rho(\lambda)}{300}$$

$\tau(\lambda)$  : Spectral transmittance (measured value)  
 $\rho(\lambda)$  : Spectral reflectance (measured value)  
 $E_{\lambda}$  : Standard spectral distribution of direct sunlight relative value

### ■ Summation Program

The above two programs conform to JIS (R3106), while this program is their general form. It multiplies the photometric value at each wavelength by factor  $\tau(\lambda)$  and sums up the results thus obtained for normalization.

The program can cope with optional setting of factor  $\alpha(\lambda)$ , wavelength range and normalization factor.

$$S = \frac{\sum_{\lambda_1}^{\lambda_2} \alpha(\lambda) \cdot \tau(\lambda)}{\sum_{\lambda_1}^{\lambda_2} \alpha(\lambda)} = \frac{1}{K} \sum_{\lambda_1}^{\lambda_2} \alpha(\lambda) \cdot \tau(\lambda)$$

$$K = \sum_{\lambda_1}^{\lambda_2} \alpha(\lambda)$$

### ■ Factor Input Program

This program is used to input a correction value (factor) at every wavelength interval  $\Delta\lambda$  in a wavelength range of  $\lambda_1$  to  $\lambda_2$ . The summation program is executed by use of these input values. The wavelength interval can be specified individually for a maximum of 5 ranges. Up to 500 data values can be specified.

### ■ Spectrum Correction Program

This program functions to graphically display and record the product of photometric value at each wavelength multiplied by correction factor  $R_o(\lambda)$ . The correction factor can be optionally set by the user. The program is useful for measuring an absolute reflectance spectrum, etc.

$$R(\lambda) = r(\lambda) \cdot R_o(\lambda)$$

$R(\lambda)$  : Corrected data  
 $r(\lambda)$  : Measured data (%)  
 $R_o(\lambda)$  : Correction factor data

### ■ Correction Factor Input Program

This program is used to input correction factor data. Up to 500 data values can be specified.

### ■ Film Thickness Measurement Program

This program has the following functions:

- To calculate the thickness of a film sample from the measured interference spectrum, and present it on the CRT and printer.
- To automatically output onto the printer photometric values at the wavelengths corresponding to peaks and valleys of the measured interference spectrum.
- To calculate the difference between a reference film thickness and actually measured film thickness, and present it on the CRT and printer.

$$d = \frac{N-1}{2\sqrt{n^2 - \sin^2\theta}} \times \frac{1}{\frac{1}{\lambda_1} - \frac{1}{\lambda_2}} \times 10^{-3}$$

$d$  : Film thickness ( $\mu\text{m}$ ) (calculated value)  
 $N$  : Number of interference peaks (automatically counted value)  
 $n$  : Refractive index (manually input value)  
 $\theta$  : Incident angle (manually input value)  
 $\lambda_1$  : Wavelength of first peak on spectrum (nm)  
 $\lambda_2$  : Wavelength of last peak on spectrum (nm)



# U-4100

## Specifications

	Solid sample/large sample /ultravioletregion measurement system	Liquid sample measurement system
Monochromator	Prism-grating or grating-grating type monochromator, Pre-monochromator: Littrow type monochromator employing a diffraction grating or prism, Main monochromator: Diffraction grating (switchover between 2 gratings), Czerny-Turner type monochromator	Prism-grating double monochromator, Pre-monochromator: Littrow type monochromator employing a prism, Main monochromator: Diffraction grating (switchover between 2 gratings), Czerny-Turner type monochromator
Detector	Photomultiplier (UV-VIS)/cooled type Pbs (NIR) ø60mm integrating sphere whose inside wall is coated with BaSO <sub>4</sub> , or Spectralon Incident angle for reflective sample: 10° at both standard side and reference side	Photomultiplier (UV-VIS) /cooled typePbs (NIR)
Sample compartment	Table-top sample compartment adaptable to very large samples Compartment size: 480 (W) × 470 (D) × 200 (H)mm (standard) 680 (W) × 470 (D) × 300 (H)mm (large) Beam spacing: 200mm	Compartment size: 120 (W) × 300 (D) × 140 (H)mm Beam spacing: 100mm
Wavelength indication	In 0.01nm steps	
Slit width indication	Ultraviolet-visible region: Automatic control and selection in 0.01nm steps in a range of 0.07 to 8.0nm, Near infrared region: Automatic control and selection in 0.1nm steps in a range of 0.18 to 20.0nm	
Wavelength accuracy	Ultraviolet-visible region: ±0.2nm, Near infrared region: ±1.0nm Automatic wavelength calibration function incorporated	
Wavelength reproducibility	Ultraviolet-visible region: ±0.1nm Near infrared region: ±0.5nm	
Wavelength scan speed	Automatic control and selection from among 0.3 (0.75), 3 (7.5), 15 (37.5), 30 (75), 60 (150), 120 (300), 300 (750), 600 (1,500), 1200 (3,000) and 2400 (6,000)nm/min * Wavelength scan speed in near infrared region is given in parentheses. Go To λ: 3600 (9000)nm/min	
Light source	Ultraviolet region: Deuterium lamp (quickly mountable type) Visible-near infrared region: 50W halogen lamp (lifetime 1,000hr)	
Switchover of light source	Automatic switchover linked with wavelength Wavelength for switchover optionally settable in a range of 325 to 370nm	
Stray light	— 0.00008% (at 220nm, using 10g/L NaI and 10mm cell) 0.00005% (at 340nm, using 50g/L NaNO <sub>2</sub> and 10mm cell) 0.025% (at 1690nm, using chloroform and 10mm cell)	
Photometric system	Double beam direct ratio photometry (negative absorbance or transmittance/reflectance of 100% or more measurable by Hitachi's unique differential feedback system) Ultraviolet-visible region: Negative voltage control system and slit control system Near infrared region: Slit control system and fixed slit system	
Photometric mode	Absorbance (Abs), transmittance (%T), reflectance (%R), reference-side energy (L(R))/sample-side energy (L(S))	
Photometric range	Absorbance: -2 to +5.0 Abs (in 0.001 Abs steps) Transmittance/reflectance: 0 to 999.99 (in 0.01% steps)	
Photometric accuracy	±0.002 Abs (0 to 0.5 Abs), ±0.004 Abs (0.5 to 1.0 Abs), ±0.3%T, Checked with NIST SRM 930	
Photometric reproducibility	±0.001 Abs (0 to 0.5 Abs), ±0.002 Abs (0.5 to 1.0 Abs), ±0.1%T, Checked with NIST SRM 930	
Response	Optimum value automatically set in linkage with slit width and wavelength scan speed	
Baseline correction	3 channels (1 channel for system baseline, 2 channels for user baseline)	
Baseline flatness	< ±0.002 Abs (240 to 850nm, slit 6nm) < ±0.004 Abs (850 to 2,200nm, slit automatically controlled) < ±0.008 Abs (2,200 to 2,600nm, slit automatically controlled)	< ±0.004 Abs (187 to 220nm, slit 2nm) < ±0.001 Abs (220 to 850nm, slit 2nm) < ±0.002 Abs (850 to 2,500nm, slit automatically controlled) < ±0.004 Abs (2,500 to 3,300nm, slit automatically controlled)
Baseline stability	Within 0.0004 Abs/hr (at 340nm) 2 hours after power on Within 0.0002 Abs/hr (at 500nm) 2 hours after power on	
Data processing unit	PC OS: Windows® XP Professional	
Operating temperature	15 to 35°C	
Operating humidity	45 to 80% (non-condensing; within 70% at 30°C or higher)	
Power consumption	100/115/220/240 V AC, 50/60Hz, 500VA	
Dimensions (spectrophotometer main unit)	730 (W) × 800 (D) × 880 (H)mm (standard sample compartment type) 930 (W) × 800 (D) × 980 (H)mm (large sample compartment type)	730 (W) × 700 (D) × 790 (H)mm
Weight	120kg	

## Functions

	Wavelength /Time Scan and Data Processing	Quantitative Calculation
Spectrophotometer control	<ul style="list-style-type: none"> <li>Wavelength shift (Go To λ)</li> <li>100%T adjustment (auto zero)</li> <li>Automatic wavelength calibration</li> </ul>	
Measuring conditions	<ul style="list-style-type: none"> <li>Measuring conditions</li> <li>Condition loading</li> <li>Condition saving (desired number of files, file rewriting/deletion possible)</li> <li>Automatic start function (measuring conditions automatically set upon turning on power)</li> </ul>	<ul style="list-style-type: none"> <li>Condition setting for calibration curve (1st to 3rd order, segmented line)</li> <li>Standard data setting (20 standards, average of 20 data values)</li> </ul>
Execution of measurement	<ul style="list-style-type: none"> <li>Spectrum/spectral change with time</li> <li>Repetitive spectrum measurement</li> <li>S/N selectable by user (setting of sampling interval)</li> <li>Baseline measurement (3 channels) (1 channel for system baseline, 2 channels for user baseline)</li> </ul>	<ul style="list-style-type: none"> <li>Remeasurement of calibration curve</li> </ul>
Recording /display	<ul style="list-style-type: none"> <li>Sample name</li> <li>Comment input</li> <li>Recorded line recording ON/OFF</li> <li>Measuring condition recording ON/OFF</li> <li>Recording/display of spectrum /spectral change with time</li> <li>Spectrum loading</li> <li>Spectrum saving</li> </ul>	<ul style="list-style-type: none"> <li>Calibration curve recording/display</li> <li>Data deletion</li> <li>Data loading</li> <li>Data saving</li> <li>Data list printout</li> </ul>
Data processing	<ul style="list-style-type: none"> <li>Rescaling (numerical value input, cursor input)</li> <li>Spectrum trace</li> <li>Smoothing</li> <li>Data printout</li> <li>Graph axis conversion</li> <li>X axis: nm, kcm-1, eV, THz</li> <li>Y axis: Abs, %T, %R, E(S), E(R), ε, loge</li> <li>Spectral calculation (arithmetic calculation/coefficient calculation)</li> <li>Differentiation (1st to 4th order)</li> <li>Area calculation</li> <li>Data reset</li> <li>Rate calculation (only in time scan mode)</li> <li>Spectrum selection</li> </ul>	<ul style="list-style-type: none"> <li>Calibration curve trace</li> <li>Data printout</li> <li>Sample data erasure</li> <li>Statistic calculation</li> <li>Decision coefficient calculation</li> </ul>
Miscellaneous	<ul style="list-style-type: none"> <li>File conversion (ASCII/JCAMP)</li> <li>Lamp ON time management</li> <li>Display format setting</li> <li>Cell length conversion</li> <li>Data transfer to Microsoft® Excel</li> <li>Graph copy</li> <li>Graph saving in meta-file</li> <li>Print preview</li> </ul>	

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NOTICE: For proper operation, follow the instruction manual when using the instrument.

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