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THORLABS

IS236A - OCTOBER 19, 2021

Item # IS236A was discontinued on OCTOBER 19, 2021. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

GENERAL-PURPOSE INTEGRATING SPHERES

- **Made of Durable, Highly Reflective Bulk Material**
- **3 or 4 Input Ports and 1 Detector (Output) Port**
- **SM05 Threading and 30 mm Cage System Compatibility**
- **Post Mountable (Imperial and Metric Versions Available)**

IS200 Series
3 Input Ports, Available
With or Without Photodiode

2P4
4 Input Ports

Highly Reflective Interior
over 250 - 2500 nm

Hide Overview

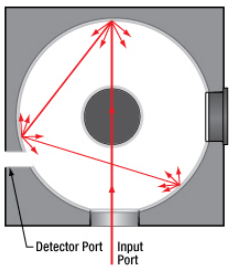
OVERVIEW

Features

- Integrating Spheres in Black Anodized Aluminum Housings
- Durable, White, High-Reflectance Sphere Material for 250 - 2500 nm
- Equipped with Three or Four Ø1/2" Input Ports for Easy Coupling of Light
- Recessed Ø3 mm Detector Port with SM05 (0.535"-40) Threading Allows Direct Connection of Any of Our SM05PD Series Photodiodes
- Directly Compatible with SM05 Lens Tubes and Our 30 mm Cage Systems
- Imperial and Metric Versions for Post Mounting

Compatible Mounted Photodiodes		
Sensor Type	**Wavelength Range**	**Photodiodes**
GaP	150 - 550 nm	SM05PD7A
Si	200 - 1100 nm	SM05PD2A SM05PD2B
Si	350 - 1100 nm	SM05PD1A SM05PD1B
InGaAs	800 - 1700 nm	SM05PD5A
	900 - 1700 nm	SM05PD4A
Ge	800 - 1800 nm	SM05PD6A

Thorlabs' Integrating Spheres are general-purpose devices for high sensitivity measurements of optical signals. An integrating sphere evenly spreads the incoming light by multiple reflections over the entire sphere surface. This makes it the ideal instrument for many applications such as laser power, flux, reflectance and radiance measurements. The input ports feature SM05 (0.535"-40) threading and can be equipped with reflective-coated port plugs, fiber adapters, or any SM05-threaded component. The detector port is also SM05 threaded for compatibility with our SM05PD series photodiodes; the port is recessed to avoid direct light exposure from the incidental light to the active area of the photodiode.



The sphere is manufactured from PTFE-based bulk material that has high reflectance in the 250 - 2500 nm wavelength range (see *Specs* tab for details) and is resistant to heat, humidity, and high levels of radiation. This reflective surface provides a specific roughness and diffusive reflection properties. It should not be cleaned using

solvents, as this could damage the inner surface. We only recommend using compressed air for cleaning the inner surface of the integrating spheres (Item #s CA4-US and CA6-EU).

Click to Enlarge
Integrating Sphere Design
(Side View)

These integrating spheres are compatible with Thorlabs' SM05 (0.535"-40) thread standard as well as our 30 mm cage systems, thereby enabling easy integration into existing setups. Each integrating sphere is also post mountable via the 8-32 (M4) tapped hole on the bottom of the unit.

Thorlabs can calibrate integrating spheres with user-selected sensors upon request and provide the pertinent NIST- and/or PTB-traceable certificates of calibration. Contact Tech Support for more information.

We also offer modular integrating spheres that can be configured with a variety of housing interfaces for compatibility with different optomechanical systems.

General-Purpose Integrating Spheres				
Item #	**IS200**	**IS236A**	**IS210C**	**2P4(/M)**
Input Ports	Three			Four
Included Detector	None	Si Detector for 350 - 1100 nm (SM05PD1B)	InGaAs Detector for 900 - 1700 nm (Anode-Grounded SM05PD4A)	None

Hide Specs

SPECS

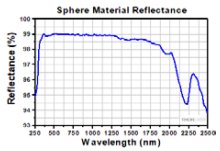
Integrating Spheres with 3 Ports

Item #	IS200	IS236A	IS210C
Detector Type	No Detector	Si	InGaAs
Detector	-	SM05PD1B	Anode-Grounded SM05PD4A
Detector Wavelength	-	350 - 1100 nm	900 - 1700 nm
Sphere Reflectance	~99% @ 350 to 1500 nm; >95% @ 250 to 2500 nm		
Sphere Diameter	2"		
Port Diameter	0.5"		
Ports	3 at 0°, 90°,and Top		
Photodiode Port	Ø3 mm for SM05PD		
Thermal Stability	Up to 250 °C		
Laser Damage Threshold	2 kW/cm^2, 7 J/cm^2		
Dimensions	61 mm x 61 mm x 65 mm (2.4" x 2.4" x 2.56")		
Weight	0.35 kg (0.77 lb)		
Reflective Plug	SM05CP2C		
FC/PC Adapter	SM05FC		
SMA Adapter	SM05SMA		

Integrating Spheres with 4 Ports

Item #	2P4(/M)
Input Ports	Four at 0°, 90°, 180°, and Top
Sphere Diameter	50 mm
Input Port Diameter	11.5 mm (0.45")
Detector Port	Ø3 mm with SM05 (0.535"-40) Thread
Typical Reflectance	>94% at 250 nm - 2500 nm >99% at 350 nm - 1500 nm
Wavelength Range	250 nm - 2500 nm

Operating Temperature	-20 °C to 60 °C
Operating Humidity	5% to 95%
Laser Damage Threshold	Pulsed: 7 J/cm^2 CW: 2 kW/cm^2
Weight	350 g
Dimensions	63.0 mm x 63.0 mm x 77.0 mm (2.48" x 2.48" x 3.03")
Reflective Plug	2P10
FC/PC Adapter	2P-FC
SMA Adapter	2P-SMA



Click to Enlarge
Integrating Sphere Material Reflectance

Hide Insights

INSIGHTS

Insights into Best Lab Practices

Scroll down to read about things to consider when building integrating spheres into setups and analyzing data results.

- Ultraviolet and Blue Fluorescence Emitted by Integrating Spheres
- Sample Substitution Errors

Click here for more insights into lab practices and equipment.

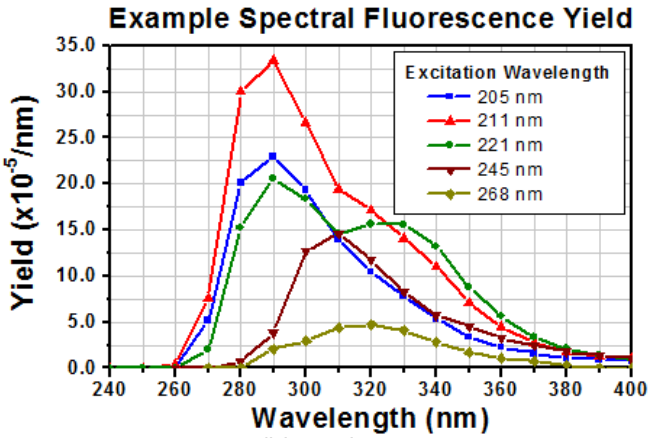
Ultraviolet and Blue Fluorescence Emitted by Integrating Spheres

A material of choice for coating the light-diffusing cavities of integrating spheres is polytetrafluoroethylene (PTFE). This material, which is white in appearance, is favored for reasons including its high, flat reflectance over a wide range of wavelengths (see the Specs tab for details) and chemical inertness.

However, it should be noted that integrating spheres coated with both PTFE and barium sulfate, which is an alternative coating with lower reflectance, emit low levels of ultraviolet (UV) and blue fluorescence when irradiated by UV light. [1-3]

Hydrocarbons in the PTFE Fluoresce

It is not the PTFE that fluoresces. The sources of the UV and blue fluorescence are hydrocarbons in the PTFE. Low levels of hydrocarbon impurities are present in the raw coating material, and pollution sources deposit additional hydrocarbon contaminants in the PTFE material of the integrating sphere during its use and storage. [1]



Click to Enlarge

Figure 1: Typical yields at each wavelength are around four orders of magnitude lower than the excitation wavelength. [4]

The spectral fluorescence yield relates the intensity of the fluorescence emitted within the integrating sphere with the intensity of the excitation wavelength. The yield is calculated by dividing the wavelength-dependent, total fluorescence excited over the entire interior surface of the sphere by the intensity of the light excitation.

Data were kindly provided by Dr. Ping-Shine Shaw, Physics Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899, USA.

Fluorescence Wavelength Bands and Strength

Researchers at the National Institute of Standards and Technology (NIST) have investigated the fluorescence excited by illuminating PTFE-coated integrating spheres. The total fluorescence output by the integrating sphere was measured with respect to fluorescence

wavelength and excitation wavelength. The maximum fluorescence was approximately four orders of magnitude lower than the intensity of the exciting radiation.

The UV and blue fluorescence from PTFE is primarily excited by incident wavelengths in a 200 nm to 300 nm absorption band. The fluorescence is emitted in the 250 nm to 400 nm wavelength range, as shown by Figure 1. These data indicate that increasing the excitation wavelength decreases the fluorescence emitted at lower wavelengths and changes the shape of the fluorescence spectrum.

As the levels of hydrocarbon contaminants in the PFTE increase, fluorescence increases. A related effect is a decrease of the light output by the integrating sphere over the absorption band wavelengths, due to more light from this spectral region being absorbed. [1, 3]

Impact on Applications

The UV and blue fluorescence from the PTFE has negligible effect on many applications, since the intensity of the fluorescence is low and primarily excited by incident wavelengths <300 nm. Applications sensitive to this fluorescence include long-term measurements of UV radiation throughput, UV source calibration, establishing UV reflectance standards, and performing some UV remote sensing tasks. [1]

Minimizing Fluorescence Effects

Minimizing and stabilizing the fluorescence levels requires isolating the integrating sphere from all sources of hydrocarbons, including gasoline- and diesel-burning engine exhaust and organic solvents, such as naphthalene and toluene. It should be noted that, while hydrocarbon contamination can be minimized and reduced, it cannot be eliminated. [1]

Since the history of each integrating sphere's exposure to hydrocarbon contaminants is unique, it is not possible to predict the response of a particular sphere to incident radiation. When an application is negatively impacted by the fluorescence, calibration of the integrating sphere is recommended. A calibration procedure described in [4] requires a light source with a well-known spectrum that extends across the wavelength region of interest, such as a deuterium lamp or synchrotron radiation, a monochromator, a detector, and the integrating sphere.

References

[1] Ping-Shine Shaw, Zhigang Li, Uwe Arp, and Keith R. Lykke, "Ultraviolet characterization of integrating spheres," *Appl.Opt.* **46**, 5119-5128 (2007).
[2] Jan Valenta, "Photoluminescence of the integrating sphere walls, its influence on the absolute quantum yield measurements and correction methods," *AIP Advances* **8**, 102123 (2018).
[3] Robert D. Saunders and William R. Ott, "Spectral irradiance measurements: effect of UV-produced fluorescence in integrating spheres," *Appl. Opt.* **15**, 827-828 (1976).
[4] Ping-Shine Shaw, Uwe Arp, and Keith R. Lykke, "Measurement of the ultraviolet-induced fluorescence yield from integrating spheres," *Metrologia* **46**, S191 - S196 (2009).

Date of Last Edit: Dec. 4, 2019

Sample Substitution Errors

Absolute transmittance and absolute diffuse reflectance spectra of optical samples can be found using integrating spheres. These spectra are found by performing spectral measurements of both the sample of interest and a reference.

Measurement of a reference is needed since this provides the spectrum of the illuminating light source. Obtaining the reference scan allows the spectrum of the light source to be subtracted from the sample measurement.

The light source reference measurement is made with no sample in place for transmittance data and with a highly reflective white standard reference sample in place for reflectance measurements.

Sample substitution errors incurred while acquiring the sample and reference measurement sets can negatively effect the accuracy of the corrected sample spectrum, unless the chosen experimental technique is immune to these errors.

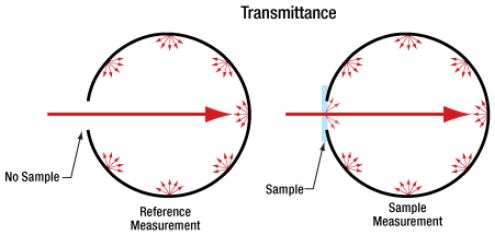


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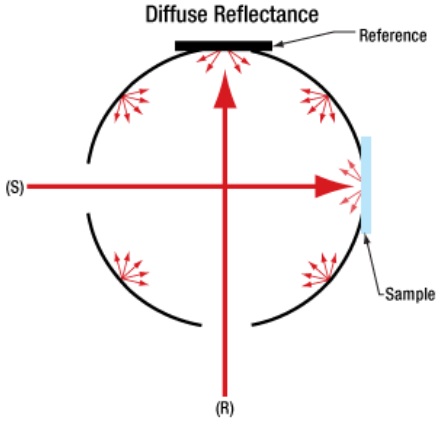
Figure 2: Measuring diffuse sample transmittance and reflectance as shown above can result in a distorted sample spectrum due to sample substitution error. The problem is that the reflectivity over the sample area is different during the reference and sample measurements.

Conditions Leading to Sample Substitution Errors
An integrating sphere's optical performance depends on the reflectance at each point on its entire inner surface. Often, a section of the sphere's inner wall is replaced by the sample when its transmittance and diffuse reflectance spectra are measured (Figure 2). However, modifying a section of the inner wall alters the performance of the integrating sphere.

Sample substitution errors are a concern when the measurement procedure involves physically changing one sample installed within the sphere for another. For example, when measuring diffuse reflectance (Figure 2, bottom), a first measurement might be made with the standard reference sample mounted inside the sphere. Next, this sample would be removed and replaced by the sample of interest, and a second measurement would be acquired. Both data sets would then be used to calculate the corrected absolute diffuse reflectance spectrum of the sample.

This procedure would result in a distorted absolute sample spectrum. Since the sample of interest and the standard reference have different absorption and scattering properties, exchanging them alters the reflectivity of the integrating sphere over the samples' surface areas. Due to the average reflectivity of the integrating sphere being different for the two measurements, they are not perfectly compatible.



Click to Enlarge
Figure 3: The above configuration is not susceptible to sample substitution error, since the interior of the sphere is the same for reference and sample measurements. During the reference measurement the light travels along (R), and no light is incident along (S). The opposite is true when a sample measurement is made.

Solution Option: Install Sample and Reference Together
One experimental technique that avoids sample substitution errors acquires measurement data when both sample and reference are installed inside the integrating sphere at the same time. This approach requires an integrating sphere large enough to accomodate the two, as additional ports.

The light source is located external to the integrating sphere, and measurements of the sample and standard reference are acquired sequentially. The specular reflection from the sample, or the transmitted beam, is often routed out of the sphere, so that only the diffuse light is detected. Since the inner surface of the sphere is identical for both measurements, sample substitution errors are not a concern.

Alternate Solution Option: Make Measurements from Sample and Reference Ports
If it is not possible to install both sample and standard references in the integrating sphere at the same time, it is necessary to exchange the installed sample. If this must be done, sample substitution errors can be removed by following the procedure detailed in [1].

This procedure requires a total of four measurements. When the standard sample is installed, measurements are made from two different ports. One has a field of view that includes the sample and the other does not. The sample of interest is then subsituted in and the measurements are repeated. Performing the calculations described in [1] using these measurements removes the sample substitution errors.

References
[1] Luka Vidovic and Boris Majaron, "Elimination of single-beam substitution error in diffuse reflectance measurements using an integrating sphere," *J. Biomed.Opt.* **19**, 027006 (2014).

Date of Last Edit: Dec. 4, 2019

Hide Ø2" Integrating Spheres with 3 Input Ports

Ø2" Integrating Spheres with 3 Input Ports

- 3 Input Ports, 1 Output Port
- Available With or Without SM05PD Series Detector
- 8-32 and M4 Tapped Holes for Post Mounting
- Included Accessories
  - FC/PC Fiber Adapter
  - SMA Fiber Adapter
  - SM05 Lens Tube for Mounting SM05PD Series Photodiodes
  - Reflective-Coated Port Plugs (One per Port)

Click to Enlarge
Accessories for 3-Port Integrating Spheres

These integrating spheres have three input ports and one detector (output) port. The input ports are SM05 (0.535"-40) threaded to accept the included accessories: the SM05FC adapter for FC/PC fiber, the SM05SMA adapter for SMA fiber, the SM05L05 Ø1/2" lens tube, and the SM05CP2C reflective-coated port plug. Three port plugs and one of each other accessory is included with each integrating sphere; replacement items are also available separately.

The IS200 integrating sphere does not ship with a photodiode included. The IS236A includes a silicon mounted photodiode for 350 - 1100 nm, while the IS210C includes a germanium mounted photodiode for 900 - 1700nm. Any SM05PD series photodiode can be mounted to the output port of these integrating spheres by using the included SM05L05 lens tube.

Part Number	Description	Price	Availability
IS200	Ø2" Integrating Sphere, No Sensor, 3 Ports	$1,101.60	Lead Time
IS236A	Ø2" Integrating Sphere, Si Sensor, 3 Ports	$1,151.38	Today
IS210C	Ø2" Integrating Sphere, InGaAs Sensor, 3 Ports	$1,327.76	Today
SM05SMA	SMA Fiber Adapter Plate with External SM05 (0.535"-40) Threads	$30.30	Today
SM05L05	SM05 Lens Tube, 0.50" Thread Depth, One Retaining Ring Included	$14.52	Today
SM05FC	FC/PC Fiber Adapter Plate with External SM05 (0.535"-40) Threads, Wide Key (2.2 mm)	$26.52	Today
SM05CP2C	Customer Inspired! End Cap Coated with 1 mm Thick Reflective Sphere Material	$30.30	Today

Hide Ø50 mm Integrating Spheres with 4 Input Ports

Ø50 mm Integrating Spheres with 4 Input Ports

- 4 Input Ports, 1 Output Port
- Housing Opens Easily using Release Knob
- 8-32 (M4) Tapped Hole for Post Mounting
- Reflective-Coated Input Port Plugs Included (One per Port - Item # 2P10)

Click to Enlarge
Accessories for 3-Port Integrating Spheres

The 2P4(/M) integrating sphere has four input ports and one detector (output) port. The input ports feature SM05 (0.535"-40) threading and can be equipped with coated port plugs (included) or threaded fiber adapters (sold separately). The detector port is also SM05 threaded and directly accepts our SM05PD series photodiodes; the port is recessed to avoid direct light exposure from the incidental light to the active area of the photodiode.

The 2P-FC and 2P-SMA are adapters to connect FC/PC (2.2 mm wide key) or SMA fiber patch cables to an input port, respectively. The 2P10 is an input port plug with a reflective surface to block an input port of the integrating sphere; four 2P10 plugs are included with the 2P4(/M). All three of these items feature a curved surface that matches the radius of curvature of the integrating sphere's inner surface.

Part Number	Description	Price	Availability
2P4/M	NEW! Ø50 mm Integrating Sphere, 4 Input Ports, M4 Tapped Mounting Hole	$1,130.00	Today
2P-FC	NEW! SM05-Threaded FC/PC Adapter for Ø50 mm Integrating Sphere	$65.00	Today
2P-SMA	NEW! SM05-Threaded SMA Fiber Adapter for Ø50 mm Integrating Sphere	$65.00	Today
2P10	NEW! Reflective-Coated Input Port Plug for Ø50 mm Integrating Sphere	$50.00	Today
2P4	NEW! Ø50 mm Integrating Sphere, 4 Input Ports, 8-32 Tapped Mounting Hole	$1,130.00	Today

Visit the *General-Purpose Integrating Spheres* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=1658