Characterization of Integrating Spheres for Ultraviolet Radiometry

Ping-Shine Shaw, Zhigang Li, Uwe Arp, Howard W. Yoon, Robert D. Saunders, and Keith R. Lykke

National Institute of Standards and Technology, Gaithersburg, MD, USA
Integrating Sphere for UV Application
- irradiance calibration of deuterium lamps using synchrotron radiation at NIST

Facility for Irradiance Calibration Using Synchrotrons (FICUS)
Why integrating sphere?

- Output light with near Lambertian distribution independent of input light distribution.
- Unpolarized output light.
Measured irradiance of deuterium lamps at FICUS with combined uncertainty ~ 1.2% (k=2)
Problem with integrating sphere - instability

Raw data from two days of measuring a deuterium lamp
Problem with integrating sphere - fluorescence

Relative throughput of an integrating sphere measured with monochromatic and polychromatic light

Relative throughput

Wavelength (nm)

- with monochromatic light
- with polychromatic light from deuterium lamp
Questions:
What is the cause for the instability and fluorescence in UV? Are instability and fluorescence correlated?
“It has been suggested that these differences could have been caused by the accumulation of tobacco smoke on the surface of the sphere.”
UV Characterization of integrating spheres

(1) Laser Induced Fluorescence (LIF)

SIRCUS - Spectral Irradiance and Radiance Responsivity Calibrations Using Uniform Sources
Response of a sintered PTFE integrating sphere/monochromator system from incident laser beam
UV induced fluorescence from typical PTFE integrating spheres excited by 220 nm laser
UV Characterization of integrating spheres

(2) Throughput measurement
Throughput measurements using a deuterium lamp

Recently brought commercial sintered PTFE integrating spheres

NIST pressed PTFE integrating spheres
Effect of baking a sintered integrating spheres in vacuum at 90° C for 2 days

Laser induced fluorescence

Throughput

Polycyclic Aromatic Hydrocarbons?
Typical structures of Polycyclic Aromatic Hydrocarbon (PAH)

1-ring (Benzene)
2-ring (Naphthalene)
3-ring (Anthracene)

A common source for PAHs is the gasoline and diesel fuel.
Sintered PTFE integrating spheres exposed to gas exhaust

With 220nm excitation laser
Sintered PTFE integrating spheres exposed to diesel gas exhaust

With 220nm excitation laser
Throughput of a Sintered PTFE integrating spheres exposed to gas and diesel exhaust

![Graph showing throughput vs. wavelength for Sintered PTFE integrating spheres before and after exposure to gas and diesel exhaust.](image-url)
Raw data from two days of measuring a deuterium lamp

Absorption

Fluorescence

Wavelength (nm)

Signal (V)

Day 1

Day 2
Effect of baking integrating spheres in vacuum at 95°C for 2 days

NIST pressed PTFE integrating sphere

![Graph showing absorption and fluorescence signal changes before and after baking.]
• Fluorescence from laser excitation and measurement of the UV throughput of an integrating sphere are very useful in characterizing the condition of an integrating sphere.

• Fluorescence and instability in the UV are mainly caused by contamination of the wall coating.

• Baking in vacuum can remove some but not all contaminants.

• PTFE integrating sphere can be contaminated from environment by air pollution such as PAHs.