SURFACE OPTICS CORPORATION

OPTICAL PROPERTY MEASUREMENT SERVICES

FAST ACCURATE OPTICAL PROPERTY MEASUREMENTS

Surface Optics Corporation is an engineering and manufacturing firm specializing in optical property characterization and associated technologies. Headquartered in San Diego, CA, company capabilities include coatings and pigments for thermal and signature control, precision optical measurement services, reflectometers, spectral imaging systems and custom engineering services.

ASTM STANDARDS TESTING

C1549

Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer.

E903

Standard Test Method for Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres.

E408

Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Technique.

E1980

Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

ASTM INTERNATIONAL

SURFACE OPTICS IS A LEADING SUPPLIER OF HEMISPHERICAL DIRECTIONAL REFLECTANCE, BRDF, TRANSMITTANCE, AND EMITTANCE TESTING SERVICES

Surface Optics's founders pioneered the design of analytical instrumentation for hemispherical and bidirectional reflectance measurements and established Surface Optics in 1977 to meet the optical properties testing needs of the aerospace and defense industries.

Today our lab has expanded to serve customers in commercial electronics, solar energy, biomedical technology, computer-generated imagery, cool roofing, construction, and many other applications requiring optical data for heat transfer modeling. Surface Optics customers receive the same high-quality testing and analysis we use for our own AS9100 certified coatings lab.

MEASUREMENT LAB SERVICES

Our mission is to provide accurate measurements with quick turnaround times, affordable costs, and superior customer support for our unique service offerings

Our instruments and procedures are traceable to National Institute of Standards & Technology. Surface Optics is an ASTM organizational member and we use testing methods consistent with applicable ASTM standards. We welcome both domestic and international customers.

AVAILABLE TESTING SERVICES

Hemispherical Directional Reflectance
Measures the fraction of the light incident on a sample at a given angle that is reflected back into the hemisphere. Measurements of HDR from 0.3 µm to 50 µm. Typical HDR measurements are made out to 25 µm. We measure HDR as a function of incident elevation, polarization, wavelength, temperature, and provide both the specular and diffuse components.

Transmittance
A transmissive material may transmit electromagnetic radiation in one of the following two ways. First, as a collimated beam of light propagates through the material it may be scattered into a hemisphere of 2 steradians upon exiting the material (Scattered Transmittance, Ts).

Secondly, if the transmitted beam is parallel to the incident beam across the width of the entire beam, the transmittance is referred to as Collimated Transmittance (Tc). Transmittance measurements can be made from the UV out to the very long IR.

Bidirectional Reflectance Distribution Function
The bidirectional reflectance (BRDF) of a surface is defined as the ratio of the luminous radiance reflected into a unit solid angle to the total incident radiance. Bidirectional reflectance measurement capabilities span from 0.35 µm to 14 µm with a full four degrees of angular freedom (incident elevation and azimuth, and reflected elevation and azimuth).

Emissivity / Emittance
From reflectance measurements (and transmittance where necessary), we generate emittance data as a function of polarization, wavelength, angle, and temperature.

Directional, near-normal emittance, when reflectance has been measured at near normal incidence (θ = 10°).

Directional angular emittance, when reflectance has been measured at any incidence angle other than near-normal.

Total hemispherical and spectral hemispherical emittance, when reflectance has been measured over a sufficiently wide range of incidence angles to permit integration over the hemisphere.

Solar Absorptance
As a function of polar incidence angle. Exo-atmospheric and endo-atmospheric.

Solar Reflectance
Solar Reflectance Index or Total Solar Reflectance testing.

INSTRUMENTATION

SOC-100 HDR
Reflectance for parallel, perpendicular & unpolarized beam at 12 user selected angles between 8° and 80°. Separation of reflectance into diffuse and specular components. Collimated and scattered transmittance at 0° incidence. Directional emittance as a function of wavelength, angle from 8° to 80°, and temperature to beyond 500°C. Total hemispherical emittance as a function of temperature.

Cary 5000 UV-Vis-NIR
Spectrophotometer with a DRA 2500 attachment. Measures 175 to 3300 nm using a PbSmart NIR detector for extended photometric range.

SOC-210 BDR
BRDF measurements are performed using our unique SOC-210 BDR gonioreflectomer. This system performs automated measurements at customer specified wavelengths from 0.35 µm to 14 µm, with a full four degrees of angular freedom: incident polar, incident azimuthal, reflected polar and reflected azimuthal angles. Data from the sample is measured against a known standard.

410 Series Reflectometers
The 410 Series Reflectometers are portable measurement tools for rapid solar reflectance, absorptance, and thermal emittance characterization. Designed for quality control and research and development applications, the SOC410 Series Reflectometers produce precision measurements comparable to complex benchtop instrumentation in an easy-to-use handheld package. A touchscreen interface provides guides calibration, sample identification, and measurement data display.

SOC-100 HEMISPHERICAL DIRECTIONAL REFLECTOMETER

Polarized, angular diffuse reflectance measurements from 8° to 80° incident angles in the 2.0 to 25.0 µm spectral range

Traditional techniques for measuring the diffuse reflectance of materials use an integrating sphere to capture the diffusely scattered energy. Because of energy considerations inherent to integrating spheres, useful measurement data is limited to about 14 µm. The SOC-100 uses a 2π imaging hemiellipsoid to illuminate the sample using a 700°C blackbody. A movable overhead mirror captures the energy reflected at angle and directs a collimated beam into the FTIR. Operates as an attachment to the Thermo Scientific™ Nicolet™ iS50 FTIR Spectrometer.

SPECIFICATIONS

Measurement Configuration
Automated reflectometer 18" electroformed hemiellipsoid.

Calibration
Comparison of scans of the specimen sample and calibrated specular gold standard at each angle polarization combination.

Source
A custom heated cavity provides uniform 2π steradian radiation into the subtended hemiellipsoid from a 0.75" opening centered at one ellipse focus. All cavity surfaces excepting the opening are insulated with high performance Min-K insulation and the unit is surrounded by a water cooled jacket.

Resolution
Depending on data requirement: 2, 4, 8, 16, or 32 cm-1 resolution may be employed.

Data format
ERAS, ASTM tabular formats. Graphical, linear and log scale, µm or cm-1, reflectance vs. wavelength, and reflectance vs. angle.

APPLICATIONS

Aerospace
Verification of paint and coatings | α/ε | Thermo-optical properties

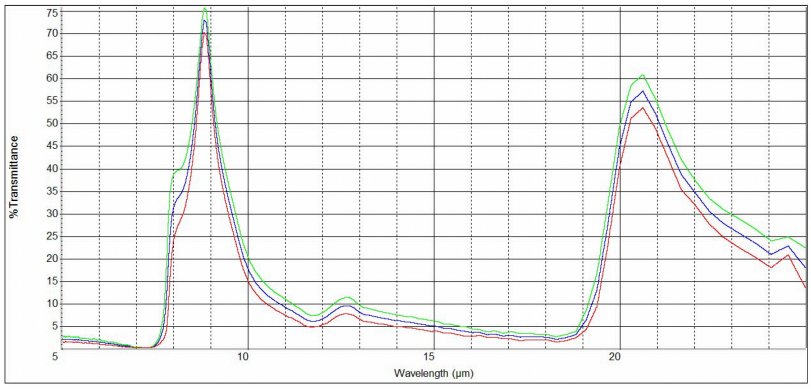
Energy and Solar Power
Mirror qualification | Determining the specularity of reflective components | Solar absorptance

Defense | Aerospace
IR Signature | Low observable paint & coatings

Radiative Heat Transfer
Emittance for thermal analysis heat transfer

Remote Sensing
Simulator scene generation | Ground truth | Material mapping

Material Science
Identification and measurement of surface contaminants | Optical constants (n, k) of bulk and powdered materials



DIRECTIONAL REFLECTANCE OF FUSED SILICA
Red curve - parallel; green curve - perpendicular; blue curve - averaged polarization.

SPECTRAL REFLECTANCE MEASUREMENTS

Spectral reflectance measurements from 0.3 to 50 microns

Surface Optics utilizes two instruments for the measurement of spectral reflectance: the Cary 5000 for the spectral range 0.3 - 2.0 and the SOC-100 HDR from 2.0 - 50 microns.

UNPOLARIZED SPECTRAL REFLECTANCE

PRODUCT CODE	REGION	TYPE	DESCRIPTION
8888-1111	Full	HDR	0.3 - 25 microns, UnPol, 8° AoI, α and ε
8888-1112	Full	DDR	0.3 - 25 microns, UnPol, 8° AoI
8888-1113	Full	SDR	0.3 - 25 microns, UnPol, 8° AoI, α and ε
8888-1121	Vis	HDR	0.3 - 2.0 microns, UnPol, 8° AoI, α
8888-1122	Vis	DDR	0.3 - 2.0 microns, UnPol, 8° AoI
8888-1123	Vis	SDR	0.3 - 2.0 microns, UnPol, 8° AoI, α
8888-1131	IR	HDR	2.0 - 25 microns, UnPol, 8° AoI, ε
8888-1132	IR	DDR	2.0 - 25 microns, UnPol, 8° AoI
8888-1133	IR	SDR	2.0 - 25 microns, UnPol, 8° AoI, ε
8888-1141	Full Extended	HDR	0.3 - 50 microns, UnPol, 8° AoI, α and ε
8888-1142	Full Extended	DDR	0.3 - 50 microns, UnPol, 8° AoI
8888-1143	Full Extended	SDR	0.3 - 50 microns, UnPol, 8° AoI, α and ε
8888-1151	IR Extended	HDR	2.0 - 50 microns, UnPol, 8° AoI, ε
8888-1152	IR Extended	DDR	2.0 - 50 microns, UnPol, 8° AoI
8888-1153	IR Extended	SDR	2.0 - 50 microns, UnPol, 8° AoI, ε
8888-1161	Far IR	HDR	20.0 - 50 microns, UnPol, 8° AoI
8888-1162	Far IR	DDR	20.0 - 50 microns, UnPol, 8° AoI
8888-1163	Far IR	SDR	20.0 - 50 microns, UnPol, 8° AoI
8888-1171	IR - ET	HDR	2.0 - 25 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1172	IR - ET	DDR	2.0 - 25 microns, UnPol, 8° AoI, Elevated Temperature (Max 500°C)
8888-1173	IR - ET	SDR	2.0 - 25 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1181	IR Extended - ET	HDR	2.0 - 50 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1182	IR Extended - ET	DDR	2.0 - 50 microns, UnPol, 8° AoI, Elevated Temperature (Max 500°C)
8888-1183	IR Extended - ET	SDR	2.0 - 50 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1191	Far IR - ET	HDR	20.0 - 50 microns, UnPol, 8° AoI, Elevated Temperature (Max 500°C)
8888-1192	Far IR - ET	DDR	20.0 - 50 microns, UnPol, 8° AoI, Elevated Temperature (Max 500°C)
8888-1193	Far IR - ET	SDR	20.0 - 50 microns, UnPol, 8° AoI, Elevated Temperature (Max 500°C)

SPECTRAL REFLECTANCE MEASUREMENTS

SINGLE ANGLE POLARIZED SPECTRAL REFLECTANCE

PRODUCT CODE	REGION	TYPE	DESCRIPTION
8888-1211	Full	HDR	0.3 - 25 microns, Polarized, 1 angle, α and ε
8888-1212	Full	DDR	0.3 - 25 microns, Polarized, 1 angle
8888-1213	Full	HDR, DDR, SDR	0.3 - 25 microns, Polarized, 1 angle, α and ε
8888-1221	Vis	HDR	0.3 - 2.0 microns, Polarized, 1 angle, α
8888-1222	Vis	DDR	0.3 - 2.0 microns, Polarized, 1 angle
8888-1223	Vis	HDR, DDR, SDR	0.3 - 2.0 microns, Polarized, 1 angle, α
8888-1231	IR	HDR	2.0 - 25 microns, Polarized, 1 angle, ε
8888-1232	IR	DDR	2.0 - 25 microns, Polarized, 1 angle
8888-1233	IR	HDR, DDR, SDR	2.0 - 25 microns, Polarized, 1 angle, ε
8888-1241	IR - ET	HDR	2.0 - 25 microns, Polarized, 1 angle, ε, Elevated Temperature (Max 500°C)
8888-1242	IR - ET	DDR	2.0 - 25 microns, Polarized, 1 angle, Elevated Temperature (Max 500°C)
8888-1243	IR - ET	HDR, DDR, SDR	2.0 - 25 microns, Polarized, 1 angle, ε, Elevated Temperature (Max 500°C)

MULTIANGLE POLARIZED SPECTRAL REFLECTANCE

PRODUCT CODE	REGION	TYPE	DESCRIPTION
8888-1311	Full	HDR	0.3 - 25 microns, Polarized, 8 angles, α and ε
8888-1312	Full	DDR	0.3 - 25 microns, Polarized, 8 angles
8888-1313	Full	SDR	0.3 - 25 microns, Polarized, 8 angles, α and ε
8888-1321	Vis	HDR	0.3 - 2.0 microns, Polarized, 8 angles, α
8888-1322	Vis	DDR	0.3 - 2.0 microns, Polarized, 8 angles
8888-1323	Vis	SDR	0.3 - 2.0 microns, Polarized, 8 angles, α
8888-1331	IR	HDR	2.0 - 25 microns, Polarized, 8 angles, ε
8888-1332	IR	DDR	2.0 - 25 microns, Polarized, 8 angles
8888-1333	IR	SDR	2.0 - 25 microns, Polarized, 8 angles, ε
8888-1341	IR - ET	HDR	2.0 - 25 microns, Polarized, 8 angles, ε, Elevated Temperature (Max 500°C)
8888-1342	IR - ET	DDR	2.0 - 25 microns, Polarized, 8 angles, Elevated Temperature (Max 500°C)
8888-1343	IR - ET	SDR	2.0 - 25 microns, Polarized, 8 angles, ε, Elevated Temperature (Max 500°C)

SPECTRAL TRANSMITTANCE MEASUREMENTS

UNPOLARIZED SPECTRAL TRANSMITTANCE

PRODUCT CODE	REGION	TYPE	DESCRIPTION
8888-2111	Full	Scattered (Ts)	0.3 - 25 microns, UnPol, 0° AoI
8888-2112	Full	Collimated (Tc)	0.3 - 25 microns, UnPol, 0° AoI
8888-2121	Vis	Scattered (Ts)	0.3 - 2.0 microns, UnPol, 0° AoI
8888-2122	Vis	Collimated (Tc)	0.3 - 2.0 microns, UnPol, 0° AoI
8888-2131	IR	Scattered (Ts)	2.0 - 25 microns, UnPol, 0° AoI
8888-2132	IR	Collimated (Tc)	2.0 - 25 microns, UnPol, 0° AoI
8888-2141	Full Extended	Scattered (Ts)	0.3 - 50 microns, UnPol, 0° AoI
8888-2142	Full Extended	Collimated (Tc)	0.3 - 50 microns, UnPol, 0° AoI
8888-2151	IR Extended	Scattered (Ts)	2.0 - 50 microns, UnPol, 0° AoI
8888-2152	IR Extended	Collimated (Tc)	2.0 - 50 microns, UnPol, 0° AoI
8888-2161	Far IR	Scattered (Ts)	20.0 - 50 microns, UnPol, 0° AoI
8888-2162	Far IR	Collimated (Tc)	20.0 - 50 microns, UnPol, 0° AoI
8888-2171	IR - ET	Scattered (Ts)	2.0 - 25 microns, UnPol, 0° AoI, Elevated Temperature (Max 500°C)
8888-2172	IR - ET	Collimated (Tc)	2.0 - 25 microns, UnPol, 0° AoI, Elevated Temperature (Max 500°C)
8888-2181	IR Extended - ET	Scattered (Ts)	2.0 - 50 microns, UnPol, 0° AoI, Elevated Temperature (Max 500°C)
8888-2182	IR Extended - ET	Collimated (Tc)	2.0 - 50 microns, UnPol, 0° AoI, Elevated Temperature (Max 500°C)
8888-2191	Far IR - ET	Scattered (Ts)	20.0 - 50 microns, UnPol, 0° AoI, Elevated Temperature (Max 500°C)
8888-2192	Far IR - ET	Collimated (Tc)	20.0 - 50 microns, UnPol, 0° AoI, Elevated Temperature (Max 500°C)

POLARIZED SPECTRAL TRANSMITTANCE

PRODUCT CODE	REGION	TYPE	DESCRIPTION
8888-2231	IR	Scattered (Ts)	2.0 - 25 microns, Polarized, 1 angle(Max 0f 60°)
8888-2241	IR - ET	Scattered (Ts)	2.0 - 25 microns, Polarized, 1 angle, Elevated Temperature (Max 500°C)
8888-2331	IR	Scattered (Ts)	2.0 - 25 microns, Polarized, 6 angles
8888-2341	IR - ET	Scattered (Ts)	2.0 - 25 microns, Polarized, 6 angles, Elevated Temperature (Max 500°C)

SOC-210 BDR BIDIRECTIONAL REFLECTOMETER

Measures BRDF from .35 to 14 µm

The SOC-210 Bidirectional Reflectometer is a precision laboratory instrument designed for mapping bidirectional reflectance distribution functions (BRDF) of surfaces, paints, coatings, liquids, and particles. Broad band source for continuous BRDF spectral coverage from .35 to 14µm. Horizontal sample mounting for measurement of samples, including powders and liquids. Repeatability to within 5% of the noise floor. Complete automation for all four goniometric coordinates (θ and ϕ, incident and reflected angles); automatically switching between the calibration reference and the sample.

SPECIFICATIONS

Spectral Range
.35 to 14 microns.

Angular Coverage
Incident polar angles from 0° to 85°.
Incident azimuthal angles, 0° to 350°.
Reflected polar angles, 0° to 85°.
Reflected azimuthal angles, 0° to 345°.

Accuracy
New or custom functions can be added to the default options including AM 0, 1.5.

Noise Floor
Less than 10-3 ster-1 or better (bandpass filter dependent).

Detectors
Si (.35-1.1µm), InGaAs (1.0-1.7 µm), InSb (1.5-5.0 µm), MCT (5.0-14.0 µm).

Mapping Techniques
In-plane only, In-plane and cross-plane, or Full Hemispherical Mapping (Full Mapping).

APPLICATIONS

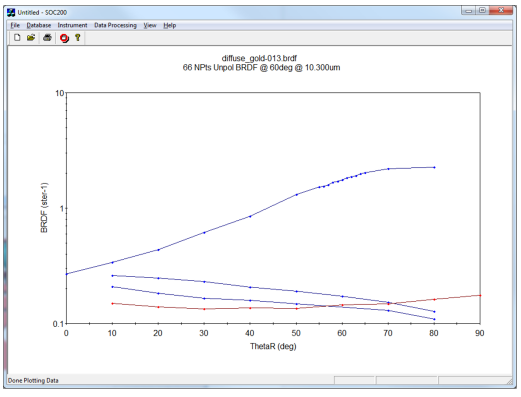
Aerospace and Defense
Stray light analysis | IR signature | Low observable paint & coatings

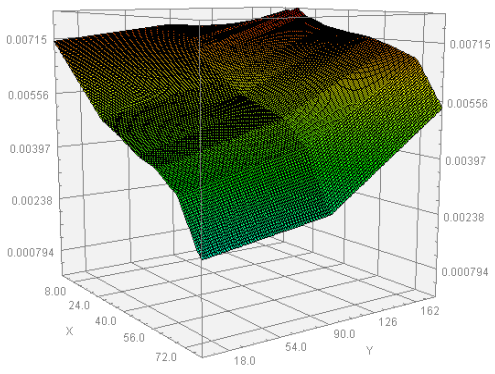
CGI
Photorealistic rendering | Inputs for POVRay, Renderman and Blender

Illumination Design
LCD back lighting | optical sensors | reflector material characterization

Radiative Heat Transfer
Absorptance for thermal modeling

Semiconductors
Quality control

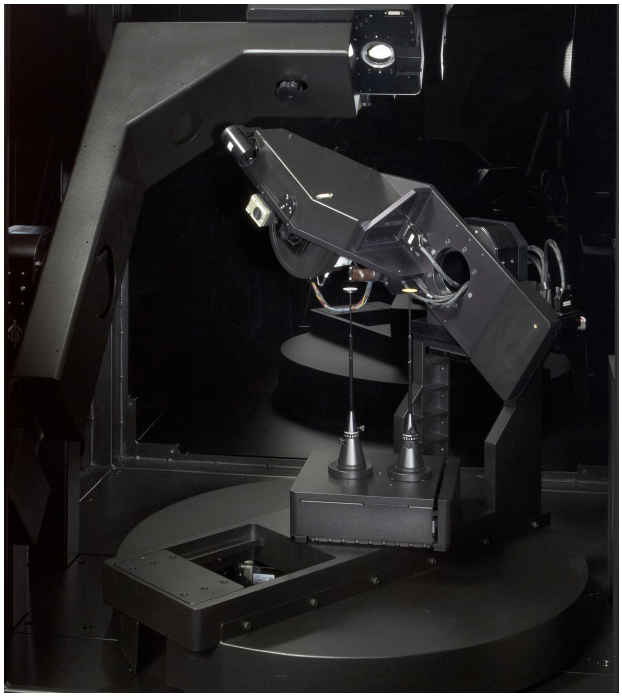




EXAMPLE BRDF OUTPUTS
In-Plane/Cross BRDF measurements.

BRDF MEASUREMENTS

PRODUCT CODE	REGION	TYPE	DESCRIPTION
8888-3111	In-Plane	One	BRDF at (1) Wavelength, 1 Incident Angle, In-Plane data only (-80 to 80°)
8888-3112	In-Plane	Three	BRDF at (1) Wavelength, 3 Incident Angles, In-Plane data only (-80 to 80°)
8888-3113	In-Plane	Four	BRDF at (1) Wavelength, 4 Incident Angles, In-Plane data only (-80 to 80°)
8888-3114	In-Plane	Eight	BRDF at (1) Wavelength, 8 Incident Angles, In-Plane data only (-80 to 80°)
8888-3121	In-Plane / Cross Plane	One	BRDF at (1) Wavelength, 1 Incident Angle, In-Plane, Cross-Plane
8888-3122	In-Plane / Cross Plane	Three	BRDF at (1) Wavelength, 3 Incident Angles, In-Plane, Cross-Plane
8888-3123	In-Plane / Cross Plane	Four	BRDF at (1) Wavelength, 4 Incident Angles, In-Plane, Cross-Plane
8888-3124	In-Plane / Cross Plane	Eight	BRDF at (1) Wavelength, 8 Incident Angle, In-Planes, Cross-Plane
8888-3131	Full Mapping	One	BRDF at (1) Wavelength, 1 Incident Angle, Full Mapping
8888-3132	Full Mapping	Three	BRDF at (1) Wavelength, 3 Incident Angles, Full Mapping
8888-3133	Full Mapping	Four	BRDF at (1) Wavelength, 4 Incident Angles, Full Mapping
8888-3134	Full Mapping	Eight	BRDF at (1) Wavelength, 8 Incident Angles, Full Mapping
8888-3141	Ring	One	BRDF at (1) Wavelength, 1 Incident Angle, Ring
8888-3142	Ring	Three	BRDF at (1) Wavelength, 3 Incident Angles, Ring
8888-3143	Ring	Four	BRDF at (1) Wavelength, 4 Incident Angles, Ring
8888-3144	Ring	Eight	BRDF at (1) Wavelength, 8 Incident Angles, Ring



SOC-210 BDR INTERIOR
Sample and calibration coupon stages.

Thermal emittance derived from directional reflectance measurements

Emittance data as a function of polarization, wavelength, angle, and temperature, including: directional near-normal emittance, when reflectance has been measured at near normal incidence (θ = 10°). Directional angular emittance, when reflectance has been measured at any incidence angle other than near-normal. Total hemispherical and spectral hemispherical emittance, when reflectance has been measured over a sufficiently wide range of incidence angles to permit integration over the hemisphere.

PRODUCT CODE	REGION	TYPE	DESCRIPTION
8888-1111	Full	HDR	0.3 - 25 microns, UnPol, 8° AoI, α and ε
8888-1113	Full	SDR	0.3 - 25 microns, UnPol, 8° AoI, α and ε
8888-1121	Vis	HDR	0.3 - 2.0 microns, UnPol, 8° AoI, α
8888-1123	Vis	SDR	0.3 - 2.0 microns, UnPol, 8° AoI, α
8888-1131	IR	HDR	2.0 - 25 microns, UnPol, 8° AoI, ε
8888-1133	IR	SDR	2.0 - 25 microns, UnPol, 8° AoI, ε
8888-1141	Full Extended	HDR	0.3 - 50 microns, UnPol, 8° AoI, α and ε
8888-1143	Full Extended	SDR	0.3 - 50 microns, UnPol, 8° AoI, α and ε
8888-1151	IR Extended	HDR	2.0 - 50 microns, UnPol, 8° AoI, ε
8888-1153	IR Extended	SDR	2.0 - 50 microns, UnPol, 8° AoI, ε
8888-1171	IR - ET	HDR	2.0 - 25 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1173	IR - ET	SDR	2.0 - 25 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1181	IR Extended - ET	HDR	2.0 - 50 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1183	IR Extended - ET	SDR	2.0 - 50 microns, UnPol, 8° AoI, ε, Elevated Temperature (Max 500°C)
8888-1211	Full	HDR	0.3 - 25 microns, Polarized, 1 angle, α and ε
8888-1213	Full	HDR, DDR, SDR	0.3 - 25 microns, Polarized, 1 angle, α and ε
8888-1231	IR	HDR	2.0 - 25 microns, Polarized, 1 angle, ε
8888-1233	IR	HDR, DDR, SDR	2.0 - 25 microns, Polarized, 1 angle, ε
8888-1241	IR - ET	HDR	2.0 - 25 microns, Polarized, 1 angle, ε, Elevated Temperature (Max 500°C)
8888-1243	IR - ET	HDR, DDR, SDR	2.0 - 25 microns, Polarized, 1 angle, ε, Elevated Temperature (Max 500°C)
8888-1311	Full	HDR	0.3 - 25 microns, Polarized, 8 angles, α and ε
8888-1313	Full	SDR	0.3 - 25 microns, Polarized, 8 angles, α and ε
8888-1331	IR	HDR	2.0 - 25 microns, Polarized, 8 angles, ε
8888-1333	IR	SDR	2.0 - 25 microns, Polarized, 8 angles, ε
8888-1341	IR - ET	HDR	2.0 - 25 microns, Polarized, 8 angles, ε, Elevated Temperature (Max 500°C)
8888-1343	IR - ET	SDR	2.0 - 25 microns, Polarized, 8 angles, ε, Elevated Temperature (Max 500°C)

HANDHELD REFLECTOMETER MEASUREMENTS

Solar reflectance and thermal emittance from in-band measurements

The SOC410 Series Reflectometers are portable measurement tools for rapid solar reflectance, absorptance, and thermal emittance characterization. Designed for quality control and research and development applications, the SOC410 Series Reflectometers produce precision measurements comparable to complex benchtop instrumentation in an easy-to-use handheld package. Our lab uses the ET100 and 410-Solar models for in-band reflectance measurements and data collection for SRI.

SPECIFICATIONS

- **Emittance spectral range**
  1.5-2.0, 2.0-3.5, 3.0-4.0, 4.0-5.0, 5.0-10.5, 10.5-21.
- **Solar reflectance spectral range**
  335-380, 400-540, 480-600, 590-720, 700-1100, 1000-1700, 1700-2500.
- **Measured parameter**
  Directional hemispherical reflectance (DHR).
- **Angle of incidence**
  20° & 60° from normal incidence for ET100 and 20° from normal for 410-Solar.
- **Accuracy**
  +/- .03 units.
- **Room temperature samples**
  Calculate emissivity without heating sample.

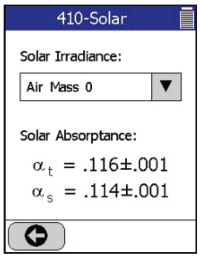
APPLICATIONS

- **Space Coatings**
  Thermal control | α/ε | Thermo-optical properties
- **Defense | Aerospace**
  IR Signature | Low observable paint & coatings
- **Cool Building Materials**
  TSR | SRI | ASTM | LEED | CRRC
- **Concentrated Solar**
  Mirror evaluation | Selective absorber coatings
- **Radiative Heat Transfer**
  Absorptance for thermal modeling
- **Semiconductors**
  Wafer fab hardware emissivity
- **Astronomy**
  Mirror evaluation

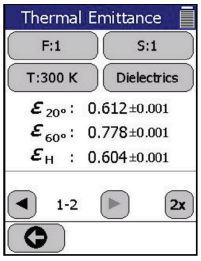
EXAMPLE MENU SCREENS

Measurement screen. Results are displayed on the liquid crystal display touchscreen, and stored on a SecureDigital (SD) card.

Solar absorptance calculation for the selected solar irradiance function.



Directional and hemispherical emittance measurement data screen.



HANDHELD REFLECTOMETER MEASUREMENTS

PRODUCT CODE	INSTRUMENT	TYPE	DESCRIPTION
8888-4111	410-Solar & ET100	SRI	SRI calculation per ASTM E - 1980, utilizing Handheld Devices
8888-4211	410-Solar	In-Band Reflectance	In-Band Reflectance, Visible, α
8888-4311	ET100	In-Band Reflectance	In-Band Reflectance, IR, ε

MEASUREMENT SERVICES GUIDE

AVAILABLE TESTING SERVICES

Hemispherical Directional Reflectance
Measures the fraction of the light incident on a sample at a given angle that is reflected back into the hemisphere. Measurements of HDR from 0.3 µm to 50 µm. Typical HDR measurements are made out to 25 µm. We measure HDR as a function of incident elevation, polarization, wavelength, temperature, and provide both the specular and diffuse components.

Transmittance
A transmissive material may transmit electromagnetic radiation in one of the following two ways. First, as a collimated beam of light propagates through the material it may be scattered into a hemisphere of 2 steradians upon exiting the material (Scattered Transmittance, Ts).

Secondly, if the transmitted beam is parallel to the incident beam across the width of the entire beam, the transmittance is referred to as Collimated Transmittance (Tc). Transmittance measurements can be made from the UV out to the very long IR.

Bidirectional Reflectance Distribution Function
The bidirectional reflectance (BRDF) of a surface is defined as the ratio of the luminous radiance reflected into a unit solid angle to the total incident radiance. Bidirectional reflectance measurement capabilities span from 0.35 µm to 14 µm with a full four degrees of angular freedom (incident elevation and azimuth, and reflected elevation and azimuth).

Emissivity / Emittance
From reflectance measurements (and transmittance where necessary), we generate emittance data as a function of polarization, wavelength, angle, and temperature.

Directional near-normal emittance, when reflectance has been measured at near normal incidence (θ = 10°).

Directional angular emittance, when reflectance has been measured at any incidence angle other than near-normal.

Total hemispherical and spectral hemispherical emittance, when reflectance has been measured over a sufficiently wide range of incidence angles to permit integration over the hemisphere.

Solar Absorptance
As a function of polar incidence angle. Exo-atmospheric and endo-atmospheric.

Solar Reflectance
Solar Reflectance Index or Total Solar Reflectance testing.

MEASUREMENT TYPE	Average Lead Time	Sample Size
Unpolarized spectral reflectance measurements	2 weeks	< 4” square, flat
Polarized single angle spectral reflectance - 0.3 to 25 microns	2 weeks	1 x 1.5”, flat
Polarized single angle spectral reflectance - 2.0 to 25 microns	2 weeks	< 4” square, flat
Polarized multi angle spectral reflectance - 0.3 to 25 microns	3 weeks	1 x 1.5”, flat
Polarized multi angle spectral reflectance - 2.0 to 25 microns	3 weeks	< 4” square, flat
Unpolarized collimated transmittance	2 weeks	< 4” square, flat
Unpolarized scattered transmittance	2 weeks	< 4” square, flat
BRDF at 1 wavelength, 1 incident angle, In-plane data only	3 weeks	< 4” square, flat
All other BRDF	4 weeks	< 4” square, flat
Handheld reflectometer solar absorptance and emittance	2 weeks	< 12”, flat

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