Space Environmental testing at GSFC

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Solar Absorptance measurements (\( \alpha \))

- **AZ-Tek LPSR-300**
  - Total hemispherical reflectance
  - 250nm-2800nm
  - 1” dia samples

- **Perkin-Elmer Lambda-19**
  - Total hemispherical Reflectance
  - 250-2500nm
  - Center/side mount integrating sphere

\[
\alpha(\theta) = 1 - \frac{\int_0^\infty R(\lambda, \theta) S(\lambda) d\lambda}{\int_0^\infty S(\lambda) d\lambda}
\]
Solar Absorptance measurements ($\alpha$)

- New Instrumentation (coming soon)
- Cary 5000
  - 200-2500nm
  - Diffuse Reflectance Attachment
Emittance measurements ($\varepsilon_n$, $\varepsilon_H$)

- **Gier-Dunkel DB-100**
  - IR reflectance 4-40µm
  - 1” dia samples
  - Must be grey & Lambertian

- **Az-Tek Temp 2000A**
  - IR Reflectance 3-35µm
  - Normal & Hemispherical emittance
  - Must be grey & Lambertian
Emittance measurements \(( \varepsilon_n \varepsilon_H )\)

**Nicolet Magna 760 FTIR**
Transmittance 2-30µm
SOC-100 Hemispherical Directional Reflectometer

\[
\varepsilon_T(\theta, \phi, \lambda) = 1 - \frac{\int \int \int \rho(\theta, \phi, \lambda) \frac{8\pihc}{\lambda^5 (e^{hc/\lambdaTk} - 1)} d\lambda d\phi d\theta}{\int \int \int \frac{8\pihc}{\lambda^5 (e^{hc/\lambdaTk} - 1)} d\lambda d\phi d\theta}
\]

\[
\varepsilon_h = 2 \int_0^{\pi/2} \varepsilon_t(\theta, \phi, \lambda) \sin(\theta) \cos(\theta) d\theta
\]
Transient Calorimetric Technique $\epsilon_H$

- Total hemispherical emittance from $30^\circ K$ - $350^\circ K$
- Vacuum: $< 3 \times 10^{-7}$ torr
- Sample Size: 1.5” dia A1100 Aluminum with embedded Silicon Diode Sensor
Transient Calorimetric Technique

\[ \varepsilon_H = \frac{-mC_p \frac{\Delta T}{\Delta t} - m_c C_p_c \frac{\Delta T}{\Delta t} - Q_{lc} - Q_{gas} + Q_{sd} + a \varepsilon(T_s) \sigma T_s^4}{a \sigma T^4} \]

Where:
- \( \sigma \): Stefan-Boltzmann constant
- \( m \): mass of the Aluminum substrate
- \( \Delta T \): temperature increment
- \( m_c \): mass of coating
- \( C_p \): specific heat of substrate
- \( \Delta t \): time increment
- \( C_{p_c} \): specific heat of coating
- \( Q_{lc} \): manganin supports wires heat loss
- \( Q_{gas} \): residual gas heat loss
- \( Q_{sd} \): heat input from silicon diode
- \( a \): surface area of coating
- \( T_s \): temperature of shroud
- \( \varepsilon(T_s) \): coating emittance at the temperature of the shroud

![Graph showing hemispherical emittance of Aeroglide Z307 vs. Temperature (K)]
Electrostatic charge testing

- Simulates Space charge Environment
- Sample size: 6x6 inch
- Temperature Range: -150°C to +100°C
- Electron Energy: 500eV- 20KeV
- Kimball physics EFG-9
- Beam Current: 10nA/cm²
- Contactless Electrostatic probe
  - Trek 341B: 0-10Kv
- Coating Electrical Conductivity
UV degradation testing

- 14 samples 1” dia, plus one reference
- 0.5 – 2 equivalent suns (250-3000nm)
- Water cooled samples
- In-situ relative reflectance measurements
- Degradation as a function of UV exposure
  – 250-2400nm

Mulitsedes System

Spectrolab X25 Solar Simulator
UV degradation Testing

- Sample size: 8”x8” max
- UV grade quartz window
- Solar Simulation 0.5 – 2 suns
- Reflectance measured externally

Leybold Vacuum Chamber

Oriel 1600W

X25 Spectral Irradiance

Johnson Curve
Dec 2006 Vis
Dec 2006 UV
Solar Wind Facility

• Simulation of low energy p⁺, e⁻ & UV at the GEO environment

• Proton Beam
  – Kimball Physics IMG-31
  – 2KeV – 5 KeV
  – 1.0nA/cm² (6x10⁹p⁺/s-cm²)

• Electron Beam
  – Kimball Physics EFG-9
  – 500eV 20KeV
  – 10nA/cm²

• Full Spectrum Solar Simulation
  0.5 – 2.0 equivalent suns

• In-situ absolute reflectance measurements
  – 12 samples
  – Lambda 9 plus center mount vacuum integrating sphere
  – 250nm – 2200nm
Solar Wind Facility

Solar Wind Facility Conceptual

Solar Wind Facility Vac Chamber
Solar Wind testing

Solar Wind Sample Carousel
Solar Wind testing

White Paint

Hemispherical Reflectance vs Wavelength (nm)

- White Paint
- 4.4 E15 p+
- 1.1 E16 e-
- 211 ESH
Thermal Coatings Committee

- BOL & EOL for thermal control coatings properties
- Based on environmental testing and flight data
- Committee Members: Lon Kauder
   Jack Triolo
   Ted Michalek
   Mark Hasagawa
   Ray Levesque
   Wanda Peters