Space Environmental Effects (SEE) Testing Capability

NASA / Marshall Space Flight Center

H. DeWitt Burns

June 2012
• Understanding the effects of the space environment on materials and systems is fundamental and essential for mission success.
• If not properly understood and designed for, the space environment can lead to materials degradation, reduction of functional lifetime, and system failure.
• Ground based testing is critical in predicting performance.
• NASA/MSFC’s expertise and capabilities make up the most complete SEE testing capability available.
Capabilities Summary

• Ionizing Radiation –
  – Combined Space Environmental Effects
  – Solar Wind Facility
• Ultraviolet Radiation
• Atomic Oxygen (AO)
• Space Plasma Interaction – charging/arcing
• Hypervelocity Impact
• High Temperature Emissivity Measurement System (HiTEMS)
• Lunar Environments
• Analytical Capabilities
• Flight Experiments
Ionizing Radiation - Combined Space Environmental Effects

Pelletron Particle Accelerator System
- Low Energy Electrons
  - 1 keV – 100 keV
- High Energy Electrons
  - 100 keV – 2.5 MeV
- Protons
  - 40 keV – 700 keV
- Vacuum Ultraviolet Radiation (VUV)
  - 110nm – 160 nm
  - Deuterium Lamp
- In-Vacuum Reflectance Measurement
- 4-inch Diameter Exposure Area
Ionizing Radiation – Solar Wind Facility

- Low Energy Electrons
  - 1 keV – 100 keV
- Low Energy Protons
  - 1 keV – 30 keV
- Ultraviolet Radiation
  - Vacuum UV & Near UV
- 12-inch Diameter Exposure Area

Other systems are available with low-energy electrons and UV only

Test chambers and exposure parameters can be customized to meet a wide range of customer requirements
Ultraviolet (UV) Radiation
Combined Test Systems
  Near UV (NUV) and/or Vacuum UV (VUV)
System with NUV only
Variable Intensity Range
  (1-5 Suns)
Thermally Controlled Sample Holder

Atomic Oxygen (AO)
Atomic Oxygen Beam Facility (AOBF)
  • 5 eV Neutral Beam
  • $10^{16}$ AO atoms/cm$^2$sec
  • Concurrent VUV Radiation (130 nm)
AO Drift Tube System (AOTDS)
  • Thermal Energy
  • Neutral AO Atoms
  • NUV can be added
Space Plasma Interactions

- **LEO plasma** simulated using a magnetic filtered source
  - Electron Temperature Range (0.1 eV to 0.5 eV)
  - Plasma Density Range \((10^4 \text{ - } 10^6)/\text{cm}^3\)
  - Monitored by Langmuir and emissive probes
- **GEO plasma** simulated using electron flood guns
  - Two flood guns exist to simulate high energy but low density environment.
  - Electron energies range from 1 to 100 keV.
- **Polar orbit conditions** are simulated using a combination of both the LEO and GEO sources discussed above
- Plasma Simulators are used to study:
  - Material conductivity
  - Arc characterization in both GEO and LEO
  - High voltage system interactions with plasma
- Test for Flight programs such as:
  - International Space Station Plasma Contactor Unit
  - ProSEDS tether and plasma contactor
  - Floating Potential Measurement Unit (FPMU)
  - National Polar Orbiting Environmental Satellite System (NPOESS)
Conducted a series of tests on the Wide Langmuir Probe (WLP), which is one of three plasma probes on the FPMU, to determine effects of contamination on measured plasma properties.

Placed WLP probe from FPMU qualification test article in MSFC plasma chamber, operated probe similar to on-orbit operation and measured plasma properties in the chamber.

Found WLP was susceptible to contamination, helping produce contamination control requirements for FPMU.
Hypervelocity Impact Range

- Capability for testing to support materials, component, and subsystem development and performance characterization
- Model validation testing

Micro-light Gas Gun (MLGG)

- Bore size up to 3 mm (0.1 in.) diameter
- Velocity Range: 0.3 – 7.5 km/s
- Target chamber approx 1 m (3 ft.) dia. X 2 m (6 ft.) long
- Shot Frequency: 5-7 per day

Shuttle Flight 7 – window impact
High Temperature Emissivity Measurement System (HiTEMS)

- Emissivity is a measure of a material’s ability to transfer heat to the space vacuum.
- HiTEMS offers a unique capability for measuring material emissivity from 300 K (27°C) to 3000 K (2700°C).
- Capability consists of 2 test systems:
  - HiTEMS provides emissivity from 330K to 1600 K.
  - Ultra-HiTEMS provides emissivity from 1600K to 3000K.
Materials and Processes Supporting Capabilities

Analytical Capabilities
- Reflectance Measurements (AZ Tek LPSR)
- Transmission Measurements (PE UV/VIS/NIR Spectrometer)
- Infrared Reflectance Measurements (AZ Tek LPIR)
- Emittance Measurements (AZ Tek TEMP 2000)
- VUV Reflectance
- Fourier Transfer Infrared Spectroscopy (FTIR)
- Thin Films Tensile Testing

Other Materials and Processes Lab capabilities available:
- Materials and Processes Technical Information System (MAPTIS)
- Failure Analysis Laboratory
  - SEM, TEM, ESCA, Auger
- Mechanical Properties Testing
  - Metals and Non-Metals
- Chemistry
- Non-Destructive Evaluation (NDE)
- White Light Scanning
- Digital Manufacturing
- Composites development and manufacturing
Flight Materials Data

- MISSE data on MAPTIS
- Sample lists, presentations, papers, raw data, photos
- Searchable by material name, experiment, flight
- MISSE investigators are welcome to add their own data
Flight Materials Data

• For access to MAPTIS

  • http://maptis.nasa.gov/Request.aspx
    – and fill out the form.

• To add MISSE data to MAPTIS
  – Contact ben.henrie@nasa.gov or miria.finckenor@nasa.gov
  – Miria – 256-544-9244
  – Be sure to specify whether your information is unlimited access or ITAR-restricted