Design and Performance of a Spectrometer for Deployment on MISSE 7

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A spectrometer for reflectance and transmission measurements of samples exposed to the space environment has been developed for deployment on the Materials on the International Space Station Experiment (MISSE) 7. The instrument incorporates a miniature commercial fiber optic coupled spectrometer with a computer control system for detector operation, sample motion and illumination. A set of three spectrometers were recently integrated on the MISSE7 platform with launch and deployment on the International Space Station scheduled for summer of this year. The instrument is one of many active experiments on the platform.

The performance of the instrument prior to launch will be discussed. Data from samples measured in the laboratory will be compared to those from the instrument prior to launch. These comparisons will illustrate the capabilities of the current design.

The space environment challenges many materials. When in operation on the MISSE 7 platform, the new spectrometer will provide real time data on the how the space environment affects the optical properties of thermal control paints and optical coatings. Data obtained from comparison of pre and post flight measurements on hundreds of samples exposed on previous MISSE platforms have been reported at these meetings. With the new spectrometer and the ability to correlate measured changes with time on orbit and the occurrence of both natural events and human activities, a better understanding of the processes responsible for degradation of materials in space will be possible.
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Outline

Evolution

Design

Samples

Performance

Summary
Factors in the Space Environment Lead to Change

Atomic oxygen
Contaminants
  particulates
  surface coatings/obscurcation
  chemical reactions
Solar UV
Charged particles
Spectrometers in Space?

Optical Properties Monitor (OPM)
AZ Technology and NASA MSFC
Russian MIR Space Station - 1997
8 months on exterior surface

Science Package included:
Reflectometer
VUV Spectrometer
Total Integrated scatter
Molecular contamination monitor
Atomic oxygen monitor
Irradiance Monitor

*Figure used with permission from AzTechnology
MISSE PEC

~2 ft x 2 ft
Exposure area
On each side
The MISSE 7 PEC Layout

PEC baseplate is the integration platform
- System Integration, test in one phase
- Commercial computer boards used for control
  - Low power
  - Flash memory
- USB or RS-485 to all instrument packages
- System activated for measurement cycle each day
- Telemetry to ground through ISS link

≈ 48 experiments on the 7B platform
  11 active (3 spectrometers)
PEC Layout

Ram side, exposed surface with all except one experiment installed.
Spectrophotometer Design

Commercial spectrometers used
  Stellarnet BlueWave
Fiber coupled input
LED light engine
Carousel to hold samples
  motor drive for rotation
  positioning from Hall sensors
Reflectance and transmission configurations
Rapid measurement sequence
Stellarnet BlueWave

Commercial spectrometers
200-1050nm range, 1.6nm resolution
2000:1 dynamic range
Design uses
  holographic grating
  2048 CCD detector
Powered from USB
Single strand 400 micron core fiber input
  2 x UV 100micron bifurcated fibers coupled together
  SMA 905 connector
Convenient software
  detector integration time
  spectra manipulation

(25x75x125mm)
Integration is Always the Challenge

Most experiments were assembled onto both top/bottom sides of PEC baseplate
  Limited space envelope
  Experiment is separated from power/data management
  Point-to-point for all data/control lines, fibers, power

Spectrometers were assembled on both surfaces of the PEC baseplate
  Motors and the Bluewave spectrometer were located below the baseplate
  Optics were both above and below the baseplate
View underneath baseplate with motor, spindle, and optics installed
View underneath baseplate with everything installed.
Motor, spindle, and optics installed
Positioner electronics installed
Andy Robb installing the Hall sensor boards
Gary and Jim install a Carousel
Carousel installed
Light bar installed
Final configuration with passive exposure samples mounted on top surface of light bar
Cross Section view of Carousel and Light Bar

Transmission

LED engine

Fiber pick-up

Motor drive

Reflection

LED engine

Reflection Transmission
Wake Spectrometer – Boeing 2

Inner row for Transmission Samples

Outer row for Reflection Samples

Inner row and outer row are offset
The Light Engine is fabricated from smd devices for discrete wavelengths. UV array is a TO-100 package with sources at 255, 265, 280, 298, 315, 330, 345, and 365 nm.
Sample Description

Sample format
- 0.5” diameter
- 0.001” to 0.125” thick

Samples types
- bare fused silica
- magnesium fluoride
- AR coatings on fused Silica
- Al\textsubscript{2}O\textsubscript{3} on fused Silica, ZrO\textsubscript{2}
- SiO\textsubscript{2} on ZrO\textsubscript{2}
- ZnSe/ThF\textsubscript{4} high reflector
- AZ Technology White
- AZ Technology Black
- …numerous other customer samples
Spectra of High Reflectance Coatings

ZnSe/ThF4 HR Coatings on Silica

Transmission vs Wavelength (nm)

- MISSE 7 Spectro Data
- MSFC Data normalized by MISSE Light Engine Spectra
- MSFC Data
Spectra of Al2O3 on ZrO2 Samples

Signal vs. Wavelength (nm)
Reflection Spectra of AZ Technology White
Summary

- The MISSE 7 spectrometers are a significant step forward
  - Miniaturization
  - Low power consumption
  - Speed
  - Capability appears to be very good
- Data on the ground matches predictions fairly well
  - Some variation in amplitudes
    - Nonuniform illumination probably responsible
    - Data is reproducible
  - Measurement of shielded control samples in sequence may provide adequate baseline
- Specific sample designs chosen which may enhance sensitivity to low level contamination
- Launch is later this year!

MISSE 7 is the right platform on which to try a new instrument design and some customized samples