View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

372 755

THE PASSIVE OPTICAL SAMPLE ASSEMBLY (POSA) - I EXPERIMENT: FIRST FLIGHT RESULTS AND CONCLUSIONS

P4

James M. Zwiener
Chief, Physical Sciences and Environmental Effects Branch
EH12
Marshall Space Flight Center, AL 35812
Phone (256) 544-2528
Fax (256) 544-0212
jim.zwiener@msfc.nasa.gov

Rachel R. Kamenetzky
Mechanical Engineer
EH12
Marshall Space Flight Center, AL 35812
Phone (256) 544-1089
Fax (256) 544-0212
rachel.kamenetzky@msfc.nasa.gov

Jason A. Vaughn
Physicist
EH12
Marshall Space Flight Center, AL 35812
Phone (256) 544-9347
Fax (256) 544-0212
jason.vaughn@msfc.nasa.gov

Miria M. Finckenor
Materials Engineer
Senior Member AIAA
EH12
Marshall Space Flight Center, AL 35812
Phone (256) 544-9244
Fax (256) 544-0212
miria.finckenor@msfc.nasa.gov

ABSTRACT

The Passive Optical Sample Assembly-I (POSA-I), part of the Mir Environmental Effects Payload (MEEP), was designed to study the combined effects of contamination, atomic oxygen, ultraviolet radiation, vacuum, thermal cycling, and other constituents of the space environment on spacecraft materials. The MEEP program is a Phase 1 International Space Station Risk Mitigation Experiment.

SSP 30258 "Thermal Control Architectural Control Document", section 3.1.2 requires that International Space Station (ISS) external materials meet performance requirements when exposed to the external environment as defined in SSP 30426, "Space Station External Contamination Control Requirements." Contamination control documents call for less than 3 x 10^{-7} gm/cm^2/yr of molecular contamination on a surface at 300 K at the Prime Measurement Points during quiescent periods and less than 1 x 10^{-6} gm/cm^2/yr during non-quiescent periods. Assuming a density of 1.0 g/cm^3 for the contaminant, this is roughly equivalent to 30-100 Å per year. A previous Mir flight experiment (Guillaumon et al. 1991) measured 321 - 716 Å per year. Were this to happen on ISS, the radiators would reach end-of-life properties much sooner than the planned 10 years. Therefore, POSA was proposed to expose ISS-baselined materials (such as Z93 white thermal control paint and chromic acid anodized aluminum) to the Mir environment and determine not only the level of contamination from an orbiting, active space station but also the effect of contamination on thermal optical properties.

POSA-I consisted of nearly 400 samples of various candidate materials for ISS. Paint samples flown included Z-93 and YB-71 white thermal control paints and a new inorganic bright

yellow paint that can be utilized for astronaut visual aids. Chemical conversion coatings flown on POSA-I included both chromic and boric/sulfuric acid anodize. A variety of mirrors and optics were flown in vacuum ultraviolet (VUV) customized carousels, making post-flight measurements easier without disturbing the samples. POSA-I also flew state-of-the-art materials, such as electrically conductive thermal control coatings developed under contract by IITRI and AZ Technology, colored anodizes developed by Aachrom, and atomic oxygen-resistant polymer films and threads developed under SBIR contract by Triton Systems, Inc. POSA-I also carried passive instruments for monitoring the atomic oxygen and ultraviolet radiation total dose to the experiment.

POSA-I samples were placed in a Passive Experiment Carrier "suitcase" with o-ring seals (Figure 1) so that the samples were protected until deployment on the Mir docking module by EVA during the Space Shuttle mission STS-76. The Passive Experiment Carrier (PEC) was designed by Langley Research Center for all of the MEEP experiments. After being attached to the docking module, the astronaut unfolded the suitcase, so that half of the samples faced the Mir core (Figure 2) and the other half faced space. The PEC used a unique 360 degree double hinge which functioned smoothly on orbit in microgravity. The PEC was removed during STS-86 after exposure to the Mir environment for 18 months.

After POSA-I was returned to MSFC, extensive normal and black light photography was performed. On the side facing space ($-Z_B$ direction using the Mir coordinate system), visible contamination was observed. The contamination was uniform as would occur from a slow photodeposition process. A very definite film was deposited on the optical samples. The deposition appears to have directionality with definite shadowing effects. On the side facing the Mir core ($+Z_B$ direction using the Mir coordinate system), contamination was present but was less obvious than that on the space-facing side. Fourier Transform Infrared Analysis indicated the presence of silicate, likely outgassed silicone deposits converted by atomic oxygen and ultraviolet radiation interactions. Electron spectroscopy for chemical analysis (ESCA) with depth profiling confirmed the presence of 26 - 31 nm silicate on the Mir-facing side and 500 - 1000 nm silicate on the space-facing side.

The source of this contamination is not exactly defined, but it is improbable that it came from the experiment itself. First, there is the directionality of the deposition which indicates it may have come from the Russian Solar Array Carrier, which was attached to the docking module in line-of-sight of POSA-I. Second, all materials, including samples, were selected on the basis of the most stringent contamination/outgassing criteria, eliminating any silicone or adhesive materials. Those ISS baseline material samples with silicone content or other likely source of contaminant were flown on POSA-II, with Dr. Gary Pippin of Boeing Space and Defense, Seattle, WA, as principal experimenter. POSA-II was also contaminated on only one side, but this has been identified as the result of a waste dump/s (Pippin 1998). Both POSA experiments were positioned on the Mir Docking Module to avoid line-of-sight, and any possible perception of cross contamination. Mounting criteria for the POSA experiments was also based on the desire to expose POSA-II to more atomic oxygen and obtain data from a different location on Mir. The locations chosen proved to be very advantageous since the type of contamination detected by the both experiments were radically different.

By measuring the mass loss of polymer films such as Kapton™, the atomic oxygen fluence to the Mir-facing side was determined to be approximately 7×10^{19} atoms/cm^2. Because of the extensive contamination, the atomic oxygen fluence to the space-facing side could not be determined. However, the mass gain of the polymer films agrees with the ESCA sputtering results. Assuming a density of 1.0 g/cm^3, contaminant deposition on the space-facing side ranged from 508 to 896 nm. Pinhole cameras designed to measure atomic oxygen fluence showed no sign of oxidation, likely due to the high angle off the ram direction.

VUV diodes were included in the POSA-I experiment to passively monitor the solar exposure received. The diodes indicated 413 equivalent sun-hours (ESH) for the Mir-facing side and 571 ESH for the space-facing side.

Measurements of total hemispherical spectral reflectance and infrared emittance before and after flight show the degrading effect contamination has on optical properties. Slight to negligible effects on optical properties were noted on the Mir-facing samples. The space-facing samples of Z-93 paint and boric/sulfuric anodize were degraded, increasing solar absorptance by as much as 33%. Infrared emittance of the space-facing boric/sulfuric and chromic acid anodizes degraded by 18% or more. Pre- and post-flight characterization of other candidate spacecraft materials is discussed, along with measurements of the bi-directional reflectance distribution function (BRDF) and vacuum ultraviolet (120 - 200 nm) spectral reflectance.

References

1. Guillaumon, J.C., Marco, J., Paillous, A.: "Flight and Laboratory Testing of Materials in Low Earth Orbit," Proceedings of the Fifth International Symposium of Materials in a Space Environment, Mandelieu, France; Sept. 1991, pp. 27-42.
2. Pippin, H.G.: "Results of Recent Materials Flight Experiments; POSA-I and II and ESEM," Proceedings of the 1998 SEE Flight Experiments Workshop, June 1998.

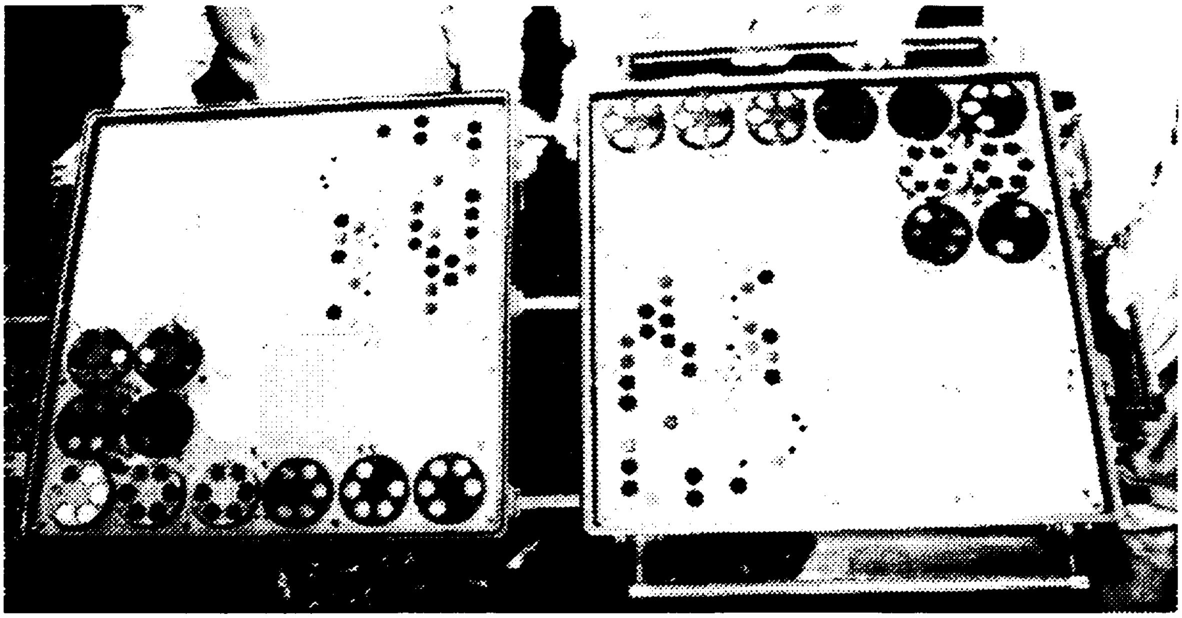

Figure 1 POSA-I Flight Hardware

Figure 2 POSA-I Attached to Mir Docking Module