Changes in the Optical Properties of Materials Are Observed After 18 Months in Low Earth Orbit

Opening the Passive Optical Sample Assembly (POSA) experiment after 18 months in low Earth orbit.

Materials located on the exterior of spacecraft in low Earth orbit are subjected to a number of environmental threats, including atomic oxygen, ultraviolet radiation, thermal cycling, and micrometeroid and debris impact. Atomic oxygen attacks materials vulnerable to oxidation. Ultraviolet radiation can break chemical bonds and cause undesirable changes in optical properties. Thermal cycling can cause cracking, and micrometeroid and debris impacts can damage protective coatings. Another threat is contamination. The outgassing of volatile chemicals can contaminate nearby surfaces, changing their thermal control properties. Contaminated surfaces may undergo further change as a result of atomic oxygen and ultraviolet radiation exposure.

The Passive Optical Sample Assembly (POSA) experiment was designed as a risk mitigation experiment for the International Space Station. Samples were characterized

before launch, exposed for 18 months on the exterior of Mir, and characterized upon their return. Lessons learned from POSA about the durability of material properties can be applied to the space station and other long-duration missions.

Thirty-two Lewis samples were on POSA-2. The suitcase-sized mounting hardware, which was attached to the shuttle docking module, allowed half of the samples to face Mir and the other half of the samples to face space. Those samples facing space also faced the shuttle when it was docked to Mir.

Postflight evaluation of the samples revealed atomic oxygen erosion, changes in the optical properties of solar absorptance and infrared emittance, and contamination from at least two different sources. Dehydrated Kapton mass loss measurements identified an atomic oxygen fluence of 8.2×10^{19} atoms/cm^2 for the Mir-facing side and 2.1×10^{20} atoms/cm^2 for the space-facing side. The mass of contamination was found to be negligible.

Contamination changed some optical properties. For example, the solar absorptance of aluminum mirror samples increased in all cases, with the increase being greater for the Mir-facing samples. Such increases are undesirable because they cause unwanted heating of spacecraft surfaces. It was also observed that the infrared emittance of thermal control paint samples decreased, with the amount of decrease essentially the same for both the Mir-facing and space-facing samples. Such decreases are undesirable because they diminish the heat-rejection capability of the thermal control paint.

Chemical evaluation of several samples identified a silicon signature. The origin of the silicon is thought to be the outgassing of a silicone paint during one or more zero-eclipse orbits. The source for the other contaminant(s) is still under investigation.

Lewis contact: Dr. Donald A. Jaworske, (216) 433-2312,
Donald.A.Jaworske@grc.nasa.gov
Authors: Dr. Donald A. Jaworske
Headquarters program office: OSS (ATMS)
Programs/Projects: ISS, POSA