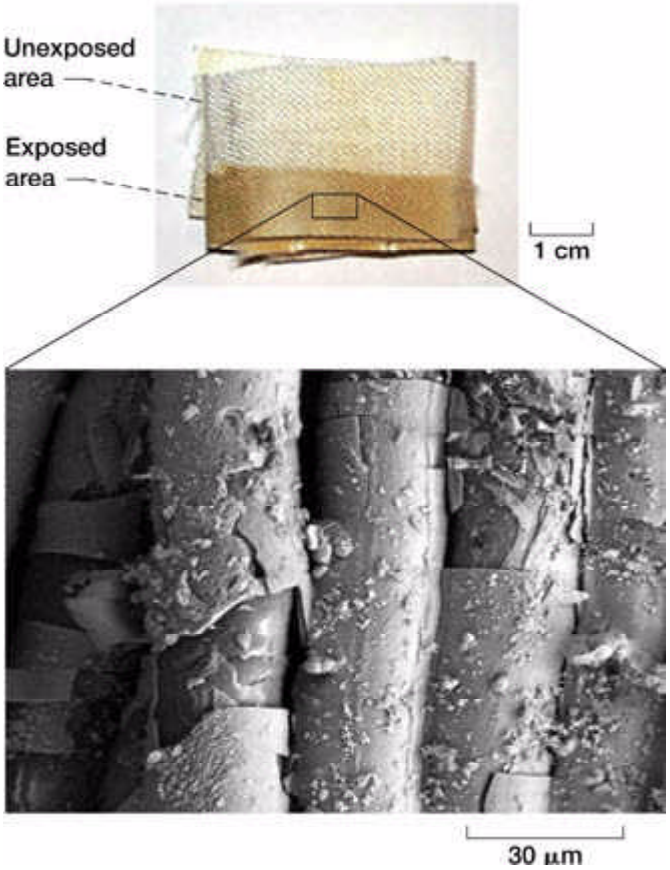
Contaminated Solar Array Handrail Samples Retrieved From Mir Analyzed

In January 1998 during the shuttle STS–89 mission, an eight-section Russian solar array panel was retrieved after more than 10 years of exposure to the orbital space environment on Mir. The array was deployed June 16, 1987, and removed on November 3, 1997. It had been actively used as a source of electrical power for 8 years. This operational array had been located on the Mir core module, located directly above the Kvant-2 module. Its retrieval provided a unique opportunity to study the effects of the low-Earth-orbit environment on a functional solar array.

The intact solar array underwent scientific inspections and preliminary tests by a joint team of U.S. and Russian investigators to evaluate the effects of long-term space exposure. Upon initial examination, significant contamination was observed over most components of the array. One panel, panel 8, was provided to the U.S. scientists for further evaluation.

As part of the U.S. investigations, two solar array handrail samples from panel 8 were evaluated for contamination at the NASA Glenn Research Center at Lewis Field. One is a section of a rigid handrail, and the other is a section of woven fabric tape that was overwrapped around a flexible handhold. Both the flexible handhold woven fabric and the rigid handrail were significantly darkened after 10 years of space exposure. They were evaluated with optical microscopy, field emission scanning electron microscopy (FESEM), and energy-dispersive spectroscopy. Solar absorptance and room-temperature emittance values also were obtained. The returned contaminated solar array segment is very similar in design to the solar arrays being supplied by the Russians for the International Space Station. Therefore, it was desirable to determine what the contaminants on various surfaces are and what the sources of the contamination were.



Flexible handhold fabric tape from the Russian solar array retrieved after 10 years of exposure to the low-Earth-orbit space environment on Mir. A very thick (»1.6-㎜) brown oxidized silicon contaminant layer developed during the 10-yr space exposure.

Optical microscopy and FESEM imaging showed that the brown stained areas have thick layers of contamination that have crazed and spalled-off the surfaces in some regions. An area where the cross section of the contaminant is visible in FESEM imaging shows the film to be approximately 1.6-µm thick. The figure shows contaminated (space-exposed) and uncontaminated (protected) areas of the flexible handhold fabric along with a high-magnification FESEM image showing the thick contaminant layer coating the fabric fibers. The contaminant caused a 41-percent increase in the solar absorptance of the flexible handhold fabric. Energy-dispersive spectroscopy revealed that the brown contaminant on both samples is composed of oxidized silicon with very little carbon content. There is no silicon present on the unexposed fabric overwrap, and very small amounts in the white paint. Therefore, the contaminant layer on both handrail samples is attributed to silicone contamination from other spacecraft materials that were oxidized by atomic oxygen while in orbit. A significant source of the silicone contamination has been determined to be from the solar array itself, specifically from the silicone compounds used to laminate the solar array panel. FESEM images of the handhold fabric show areas where the contaminant layer has spalled off the organic fibers and atomic oxygen erosion has occurred. This implies that flakes of the thick contaminant coating spalled off while in space and became

a source of particulate contamination.

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