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Micrometeoroid from MISSE Examined to Understand the Effects of the Space Environment on Space Suit

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Overview of SUSpECS on MISSE-6

MISSE-6 is just one part of the MISSE project that aims to subject various materials to the space environment and document the effects in a controlled setting. In order to do this the MISSE-6 samples were coated, launched into space, suspended off of the International Space Station, and then returned to Earth in pristine condition for analysis. The Utah State University SUSpECS project was a unique student experiment on MISSE-6.

Abstract

Samples that were part of the Materials International Space Station Experiment (MISSE) experienced varying effects whilst exposed to the space environment; perhaps the most intriguing effect was the crater created by a micrometeoroid impact into a thin film of Vapor Deposited Aluminum (VDA) coated Mylar. Approximately 160 samples of various materials used in space-component design were flown on MISSE-6 and spent 18 months suspended off the side of the International Space Station. The Utah State University SUSpECS project was a unique student experiment that allowed for pre- and post-flight analysis of these material samples which were returned in pristine condition after exposure to the space environment. Despite micrometeoroids being a common occurrence, there is a significant lack of data pertaining to the effects of micrometeoroids on space components. Further examination of the micrometeoroid impact sample will allow us to determine the impact velocity, mass, and composition of the micrometeoroid and its influence on materials in space. Micrometeoroids pose a serious threat to space operations and in turn require constant observation. It is of particular interest to note that Mylar is a major component in the construction of astronaut suits; the knowledge gained from our evaluation of this meteoroid will allow us to determine the mass required to penetrate through a space suit.

SUSpECS Objective

The purpose of SUSpECS is to characterize the performance of prospective spacecraft materials when exposed to the space environment, enabling more durable spacecraft assemblies.

Pre- and Post- Flight Comparisons

• Optical microscopy and normal specular reflectance of pre- and post-flight samples are compared to assess on-flight degradation.

Future Work

Work on analysis of the effects of space environment exposure on the 168 samples has only begun. The elements of optical analysis, material metrology, FTIR, emissivity, mass loss, electron, ion- and photon-induced electron emission, photodissolution, AES, photomission, and variable angle UV/VIS/RIR reflectivity will continue. Work will also progress in collaboration with the AEDC space simulation facility to understand the origins of these effects and quantify their impacts.

References/Acknowledgements


Space Environment Exposure

The ISS environment ranges in temperatures from approximately 40 K to 300 K. It is also a high plasma environment that causes the gas density to become ionized that leads to charging of surfaces in space. The direct UV light exposure combined with the atomic oxygen makes the ISS environment highly reactive leading to chemical erosion and oxidation of the materials.

SUSpECS Impact on Mylar

Mylar with Micrometeoroid Impact

The VDA coated Mylar samples underwent vast changes in composition whilst in the ISS environment, beyond just the impact of the micrometeoroid. The most obvious would be the removal of VDA by Atomic Oxygen, exposing the underlying Mylar. Another is the UV yellowing of the initially white Mylar due to extended UV exposure. Also evident is the degradation of the Mylar, again, due to Atomic Oxygen.

The estimated size of the micrometeoroid is found by matching the kinetic energy of the energy required to vaporize a hole of the observed size.

Penetrating a Spacesuit

Mylar with Micrometeoroid Impact

Sample and Impact Specifications:

- Diameter of Exposed Mylar: 5mm
- Diameter of Vaporized Region: 1.0mm
- Diameter of Spall Volume: 1.5mm
- Diameter of Micrometeoroid: 3.5 x 10^-4 mm
- Thickness of Mylar Sample: 1.3 x 10^-4 mm
- Volume of Micrometeoroid: 7.7 x 10^-4 cm^3
- Density of Micrometeoroid: 3.5 gm/cm^3
- Mass of Micrometeoroid: 2.7 x 10^-7 gm

Cummulative Impact Probability Flux

Modern astronaut spacesuits are designed with a dual-layer system containing bumer plates to protect the wearer from supervelocity impact by foreign objects. This additional space allows for the compression of the space suits to lessen the force of the impact.

SUSpECS Test Samples

This large communication satellite incorporates materials which are contained in SUSpECS.

- Graphite Composite
- Al/Mylar
- Kapton
- Black Kapton
- Aquadag
- White Paint
- ITO
- RTV
- FFR
- Overcoat

SUSpECS Sample Sources

- Wide array of common spacecraft materials (see above).
- Basic materials and key components of ISS solar array and structure.
- Materials from CRES satellite designed to study environment-induced charging.
- Materials used in Floating Potential Measurement Unit plasma probe for ISS.
- Critical thermal control and optical materials for LDEF, GPTS, and OTE.
- Composite and ceramic materials of the ATK Thermal Protection and Lightweight Structure Systems.
- James Web Space Telescope Insulator Sample Charging Tests.
- Solar Probe Mission Heat Shield Insulator Samples tests.