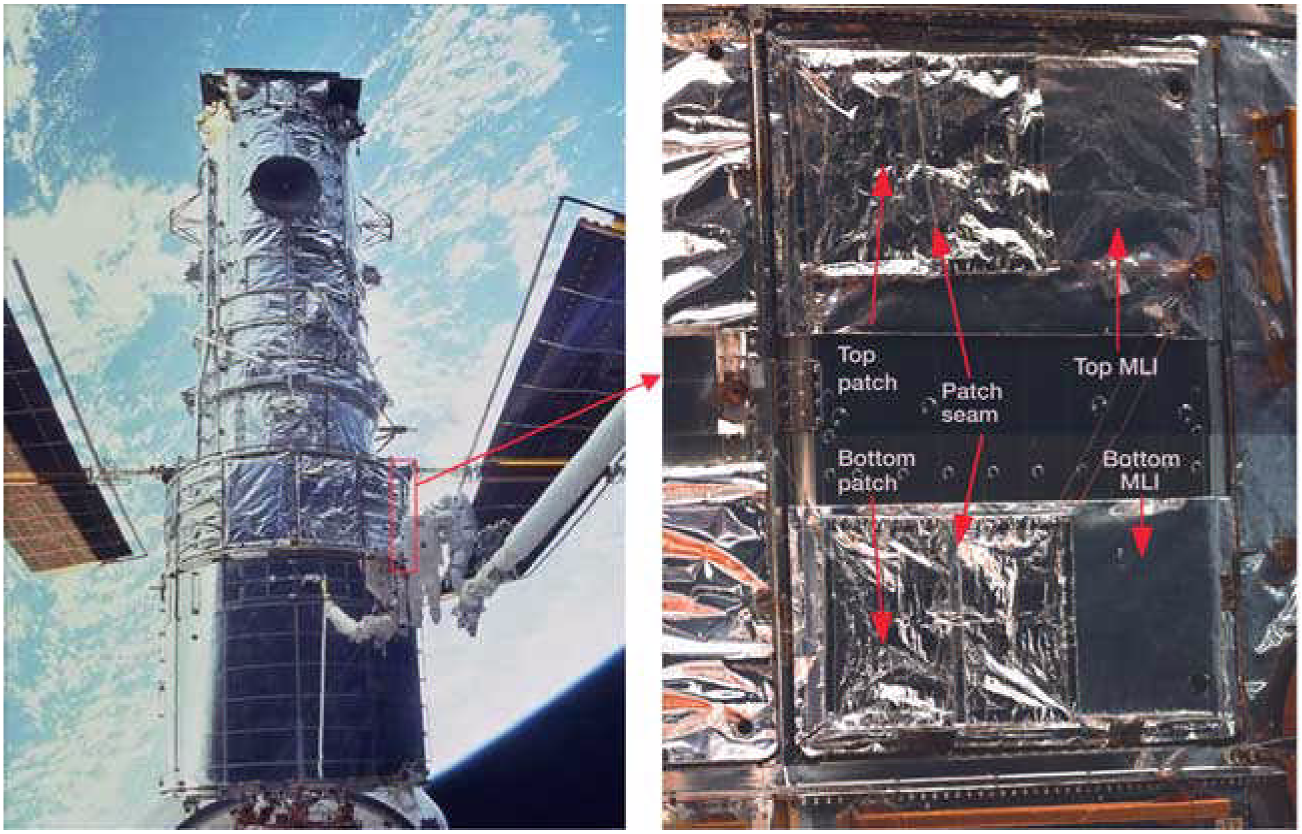
Physical and Thermal Properties Evaluated of Teflon FEP Retrieved From the Hubble Space Telescope During Three Servicing Missions

Mechanical properties of aluminized Teflon fluorinated ethylene propylene (FEP) thermal control materials on the Hubble Space Telescope (HST) exposed to low Earth orbit for up to 9.7 years have significantly degraded, with extensive cracking occurring on orbit. The NASA Glenn Research Center and the NASA Goddard Space Flight Center have collaborated on analyzing the physical and thermal properties of aluminized FEP (FEP-Al, DuPont) materials retrieved in December 1999 during HST's third servicing mission (SM3A). Comparisons have been made to properties of FEP-Al retrieved during the first and second HST servicing missions, SM1 and SM2, in order to determine degradation processes for FEP on HST.

Both 127-μm-thick aluminized FEP (FEP-Al) from the top multilayer insulation (MLI) layer retrieved during SM3A (exposed for 9.7 years), and 50.8-μm-thick FEP-Al patches installed during SM2 and retrieved during SM3A (exposed for 2.8 years), have numerous through-the-thickness cracks and show significant decreases in tensile properties. Various areas of 50.8-μm-thick FEP-Al patch material exposed to space for 2.8 years underwent degradation of mechanical properties similar to, or worse than, 127-μm-thick FEP-Al exposed for 9.7 years, indicating an increased rate of degradation for the thinner FEP material. The SM3A FEP-Al was not as degraded as an FEP-Al sample retrieved during SM2, which had 2.8-yr less space exposure. Ground tests conducted at Glenn and Goddard using retrieved Hubble materials have shown that the reason for the more severe embrittlement of the SM2 sample is that it experienced a significantly higher on-orbit temperature of 200 °C in comparison to the maximum of 50 °C for the SM3A FEP-Al. It was, therefore, concluded that the degradation in mechanical properties of space-exposed FEP-Al is strongly influenced by temperature.

Many through-the-thickness cracks were found in the as-retrieved SM3A FEP-Al samples, and examination of crack surface morphology led to the conclusion that all through-the-thickness cracks in the SM3A FEP-Al surfaces were produced on orbit via slow crack growth processes. A gradient in the embrittlement of both the SM3A MLI and patch materials from a top highly embrittled layer to a backside ductile layer is indicative of a significantly greater radiation dose absorbed in the surface layer and a gradually decreasing dose through the FEP thickness. Cyclic growth patterns in the cracks appear to be the result of on-orbit cyclic processes, such as temperature cycling from Sun/shadow cycles, causing cracks to propagate through the thickness of on-orbit embrittled FEP. The tests conducted indicate that irradiation (solar, x-ray, and particle radiation) of Teflon FEP in space causes chain scission, resulting in FEP embrittlement, and that excessive heating, such as that experienced by the retrieved curled SM2 sample, allows increased mobility of the space-environment-induced scissioned short chains, with resulting increased crystallinity, density, and embrittlement.



Left: Astronauts working at Bay 10 on Hubble Space Telescope (HST) during SM3A. Right: Close up of the Bay 10 multilayer insulation (MLI) and patches showing the designations of the retrieved materials, Top MLI, Top Patch, Bottom MLI, and Bottom Patch.

Find out more about this research:
Hubble Space Telescope http://hubble.nasa.gov/index.php
Glenn's Electro-Physics Branch http://www.grc.nasa.gov/WWW/epbranch/ephome.htm

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