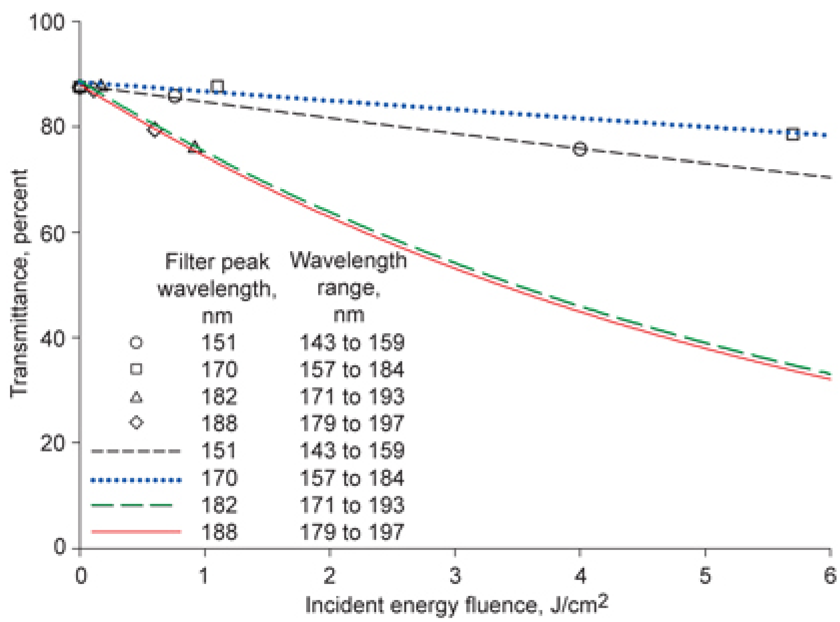
Vacuum Ultraviolet Radiation Effects on DC93-500 Silicone Film Studied

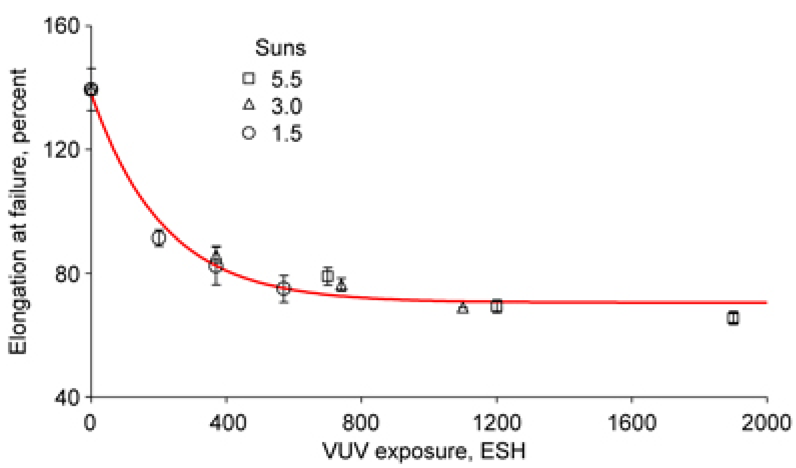
A space-qualified silicone polymer, DC93-500 (Dow Corning, Midland, MI), has been used as a spacecraft solar cell adhesive and has been proposed for use in a Fresnel lens solar concentrator for space power applications. Applications of DC93-500 for exterior space system surfaces require an understanding of its overall space environmental durability. Vacuum ultraviolet (VUV) radiation is among the space environment elements that can be hazardous to the properties of DC93-500, causing degradation in optical and mechanical properties. For materials or components that have not been tested previously for long-duration performance in space, such as DC93-500 in freestanding film form, ground laboratory testing is an important tool for assuring durability. However, differences between the space environment and ground laboratory testing environments lead to complexities in interpreting the ground test results. Two important differences between space and laboratory vacuum ultraviolet exposure conditions are irradiance spectra and light intensity. These important differences were the basis for laboratory experiments conducted to examine VUV wavelength dependence and VUV intensity dependence of DC93-500 degradation. Testing conducted at the NASA Glenn Research Center along with additional data provided through a grant with the University of Nebraska-Lincoln, has advanced the understanding of VUV effects on DC93-500 and has provided important conclusions regarding the use of ground laboratory VUV testing to predict the space environment performance of DC93-500.



Transmittance of 152-µm DC93–500 silicone film at 250 nm as a function of incident VUV energy fluence provided by exposure to various wavelength ranges through narrow bandpass filters.

In one set of experiments, transmittance degradation of DC93-500 was examined as a function of exposure to narrow wavelength bands (~20-nm bandwidth) of VUV in the 140- to 200-nm-wavelength range. The preceding graph plots the transmittance of DC93-500 at 250 nm, a wavelength where significant degradation was evident, versus the incident VUV energy fluence. It is evident from this figure that VUV exposure through filters that transmit longer wavelengths caused a higher rate of transmittance degradation than VUV exposure through filters that transmit shorter wavelengths. The most likely explanation for this is that the longer wavelengths penetrate more deeply into DC93-500 and, therefore, affect more of the bulk of the material. This theory was validated through ellipsometric measurements, which determined VUV penetration into DC93-500 as a function of wavelength.

In another set of experiments, broad-spectrum VUV exposures (to wavelengths greater than 115 nm) were used to examine the effects of VUV intensity on the degradation rates of optical and mechanical properties. The following graph shows elongation at failure for 152-µm-thick DC93-500 silicone films as a function of exposure given in equivalent space solar exposure hours (ESH) for intensities of 1.5, 3.0, and 5.5 times the solar VUV intensity (i.e., number of "suns"). Ultimate tensile strength, elongation at failure, and transmittance were found to decrease with increasing exposure, and the rate of degradation was found to be independent of intensity. Mechanical properties and optical properties decreased, approaching asymptotic values near the 2000-ESH exposure level. This work is part of ongoing research to support the development of long-duration, durable space power system materials and surfaces.



Elongation at failure for 152-µm DC93–500 silicone as a function of VUV exposure equivalent sun hours.

Find out more about this research at:

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