THE ROLE OF ACCELERATION FACTOR IN PROTON IRRADIATION TESTS

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\textbf{ABSTRACT}

Terrestrial electromagnetic and corpuscular radiation tests of satellite components shall confirm their suitability for application in space. Irradiation experiments can be performed with radiation intensities varied from low to high values, which are significantly exceeding those present in space. Frequently, the choice is dictated by economic reasons, i.e. the costs of laboratory time usage.

Our main objective is to emphasise potential risks, which may occur upon performing irradiation tests of satellite components with an acceleration factor higher than one. As the reference irradiation test we have used thin metallic surfaces exposed to a flux of incident protons.

Acceleration factor is defined as “ratio of the intensity of a degrading factor applied to a material at the laboratory during a space simulation versus the intensity of the same degrading factor in space”.

Irradiation tests were performed with the help of the Complex Irradiation Facility (CIF) at DLR, Bremen. It is an Ultra High Vacuum (UHV) facility equipped with two linear accelerators and three light sources. All working simultaneously are meant to simulate space environment. Corpuscular sources are proton and electron accelerators. The kinetic energy of the particles can be set from 1keV to 100keV while the particle currents can be varied from 1nA to 100 µA. Electromagnetic sources are an Argon-VUV-source, a Deuterium lamp and the so-called Solar Simulator equipped with an arc-Xenon lamp. All working together cover a wide wavelength range from 40 nm to 2150 nm. The samples can be tempered from IN\textsubscript{2} level to almost 400°C.

To generate scientific results presented in this work, we have used monoenergetic 2.5 keV protons and thin polyimide films covered at both sides with 100 nm aluminium layers as a target material. The samples were mounted onto a sample holder and then inserted into the irradiation chamber. The sample holder was kept during the experiment at constant temperature of 33°C ±0.22°C and pressure of ≈10\textsuperscript{-8} mbar range.

Here, we present a degradation process which turned out to be very sensitive to the amplitude of incident radiation. It is the so-called Hydrogen blistering process. It refers to formation of tiny surface blisters filled with Hydrogen molecular gas. The gas is formed by recombination processes of the incident protons bombarding aluminium surface and the electrons of the sample. It has been proven that the process takes place in space under specific sets of environmental conditions.

We present the sensitivity of the process with respect to the proton flux. The chosen fluxes are compared to those present in space. This gives an impression of how the process evolves with different acceleration factors.

The blistering process was studied by analysing the surface morphology parameters after receiving different proton fluxes and fluences. Both the average blister radius and the number of blisters as a function of the exposure time to proton flux was analysed.

In view of the results presented in this work, which were primarily focused on the hydrogen blistering phenomenon and its sensitivity to process parameters, i.e. flux of incident protons, we have proven that even a small change of the incident radiation flux magnitude can have a big impact on the outcome of laboratory tests. Too high proton fluxes may lead to an accelerated material degradation that does not reflect the true nature of aging processes as present in the environment under study.