The DLR Complex Irradiation Facility (CIF)

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ABSTRACT

The DLR Institute of Space Systems in Bremen is commissioning a new facility to study the behavior of materials under complex irradiation and to estimate their degradation in a space environment. It is named Complex Irradiation Facility (CIF). With CIF it is possible to irradiate samples simultaneously with three light sources for the simulation of the spectrum of solar electromagnetic radiation. The light sources are a solar simulator with a Xe-lamp (wavelength range 250-2500 nm), a deuterium-UV-source (112-400 nm), and an argon-gas-jet-VUV-simulator. The latter enables the irradiation of samples with shorter wavelengths below the limitation of any window material. The VUV-simulator has been validated in the wavelength range between 40 and 400 nm at the PTB (Physikalisch Technische Bundesanstalt) in Berlin by calibration which uses synchrotron radiation. In addition to the different light sources CIF provides also electron and proton sources. The charged particles are generated in a low energy range from 1 to 10 keV with currents from 1 to 100 nA and in a higher range from 10 to 100 keV with 0.1 to 100 µA. Both particle sources can be operated simultaneously. In order to model temperature variations as appear in space, the sample can be cooled down to liquid nitrogen level and heated up to about 450 K by halogen lamps behind the target during irradiation. The complete facility has been manufactured in UHV-technology with metal sealing. It is free of organic compounds to avoid self-contamination. The different pumping systems achieve a final pressure in the 10⁻⁹ mbar range (empty sample chamber).

Besides the installed radiation sensors, which control the stability of the various radiation sources, and an attached mass spectrometer for analysing the outgassing processes in the chamber, the construction of CIF allows adding other in-situ measurement systems to measure parameters that are of the user’s interest. We are currently planning to develop an in-situ measurement system in order to determine changes in the optical properties of the samples caused by irradiation.

Configuration and geometry of the CIF (Figure 1)

The vacuum test chamber is connected to a bulk chamber. The sample is mounted in a holder and will be transformed by a magnetically manipulator into the sample station in the center of the test chamber after vacuuming the lock chamber.

The beamline of protons and electrons, the optical path of the solar simulator and the light cone of the VUV-source are arranged in the same level and directed the target with an angle of 30° to the solar simulator which is located in the middle. The Deuterium-UV-source is mounted above the solar simulator with an angle of 60° to the plane of the other sources.

The target mounting (Figure 2) allows a rotation of 30° in two directions to get an orthogonal relation in between the surface of the sample and the VUV-radiation respectively the beamline of particles.

The argon-gas-jet-VUV-simulator

Principle of operation [Vorbeis/Becker et al., 1999]

The radiation is produced by excited gas atoms which come to the ground state. The excitation occurs by electron bombardment (beam energy of a gas jet (50 eV) Ar: 0.5 A, He: 1 A, Ne: 1 A, Ni: 1 A), which is stopped by a nozzle from top of the VUV-chamber into the vacuum (Figure 3 and 4). The main part of the gas lead is pumped out through an intake port at the bottom of the chamber by a cove pump. The rest of the gas cloud is flown out by two baffles, which are connected to both stages of the cold lead from a commercial cove pump. The alignment of the electron beam is approx. horizontal (+15°). The electron which pass through the gas jet are caught by the collector on the opposite side of the gas. The intensity can be adjusted by changing the emission current of the electron source and the gas flow. Figure 5 illustrates the size and intensity of the spot qualitatively with different settings for the emission current in amperes and for the gas flow in cc/sec.

The spectra of electromagnetic radiation in comparison to zero air mass solar spectral irradiance

Figure 6: Spectral irradiance of the argon VUV-source, the deuterium lamp and the solar simulator in comparison to [ASTM E 490] and [Gaseous (1)]

Present state and outlook

- Still commissioning after transfer to DLR Bremen
- Procurement of a not ozone free Xenon lamp is in progress to compensate the low intensity in the wavelength range between 180 and 250 nm
- First results with ex-situ measurements of thermo optical properties, in-situ will follow

References

