Evaluation of Radiation Hardness for optical glasses in Space Applications

Patrick Dern[1], Andreas Pohl[1], Martin Pertenais[1], Simone del Togno[1], Gisbert Peter[1]

***Abstract*— We present gamma irradiation and Atomic Oxygen (ATOX) tests on optical glasses planned to be used as protective cover of the Venus Emissivity Mapper (VEM) instrument on the VERITAS (NASA) and EnVision (ESA) spacecrafts. These covers protect the Infra-Red spectrometer optics during the aerobraking phases in Venus atmosphere.**

I. Introduction

Within the Venus missions EnVision as well as VERITAS, aerobraking phases will be used to decelerate the spacecraft inside the Venus atmosphere. To ensure full science capabilities without degradation of the valuable optics inside the instrument, a Turn Window Unit (TWU) is used to shield the optics from outer influences until end of aerobraking. As science shall be conducted pre Venus aerobraking and possibly without deployment of the Turn Window Unit during orbit around Venus post aerobraking, the window within the TWU needs to be optically transparent in VEM science spectrum pre- as well as post aerobraking.

Among other tests, the evaluation of possible optical glasses thereby includes specific gamma irradiation as well as ATOX bombardment tests.

II. Gamma irradiation test

The qualification TID was calculated as 568 krad (mission EOL, FoS=2). The irradiation test has been performed at the HZB using a Co60 γ-ray source [2], with a dose rate of 2 krad/h. 37 fused silica glasses (Corning 7979, Corning 7980, Corning 8655 and BK7) with and/or without antireflection coating were placed equidistantly around the cylindrical γ-ray source (Figure II-1).

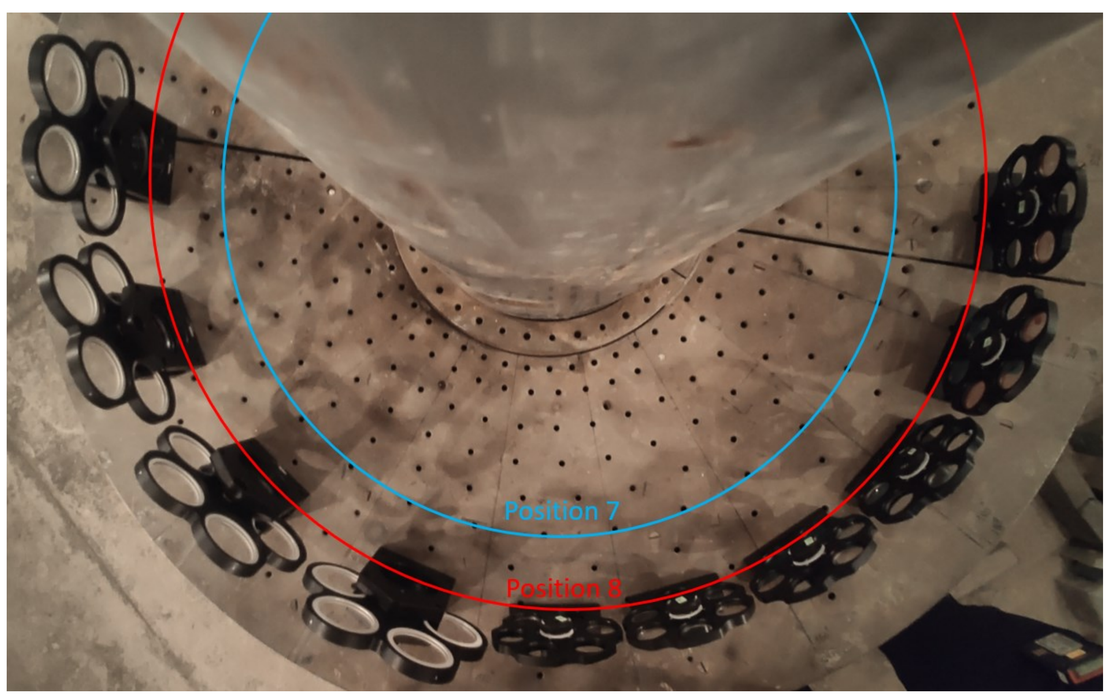

Figure II-1: Windows placed next to cobalt source

Transmittance spectra were measured pre- and post-irradiation and additionally after the environmental tests with a Bruker VERTEX 80v spectrometer, evaluated as shown in Figure II-1. Throughout the tests the silica glass transmittance shows no signs of opacity with maximum deviations of ≦0.5%. Those marginal changes can be attributed to the measurement error of the utilized spectrometer. The spectrometer was used with an NIR filament source, a CaF2 UV-to-NIR beam splitter and an InGaAs detector. The spectral resolution was set to 1 cm^{-1}.

[1]*DLR Institute of Optical Sensor Systems, Rutherfordstr. 2, 12489 Berlin*

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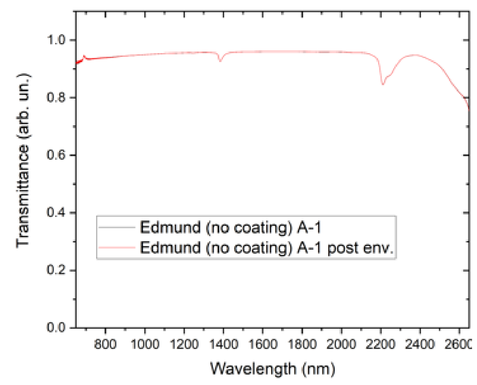

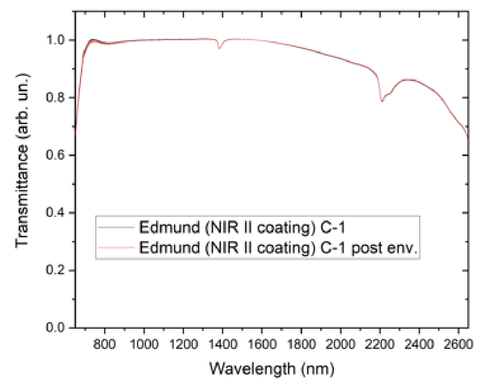

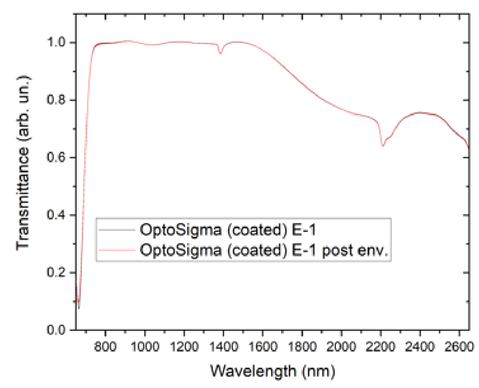

Figure *II-2: Transmission Evaluation pre-/post environmental testing*

III. ATOX testing

Atomic Oxygen (ATOX) also plays an important role on possible optical degradation during aerobraking in Venus atmosphere and therefore was tested by and at ESA's expense in their Low Earth Orbit Facility, LEOX, based at ESA's technical center in the Netherlands. With the ability of specific temperature settings, the windows were tested at room temperature as well as at 100°C with ATOX fluences of 1.3e20 to 3.4e20 atoms/cm².

Transmittance spectra were recorded by ESA prior to ATOX testing, after thermal vacuum testing and after ATOX testing. Figure III-1 shows the change in transmission of AR coated Corning 7980.

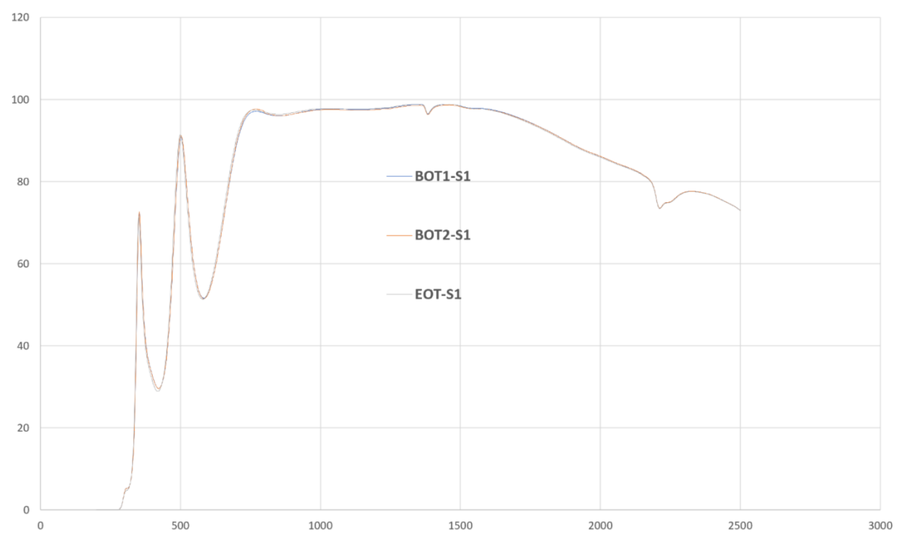

Figure III-1: Transmission Evaluation pre-/post ATOX radiation test of coated Corning 7980 [1]

No significant changes were observed from Beginning of Test (BOT1) to End of Test (EOT).

IV. Conclusion

Neither gamma irradiation nor ATOX bombardment seem to have detrimental effects on neither the silica glasses nor their coatings used as candidates for the protective windows for VEM on the VERITAS/EnVision missions. Thereby the radiation tests contribute to the qualification of the protective windows for use in space.

References

[1]Abel Brieva, ESA, "ATOX Testing of optical materials for Envision"

[2]https://www.helmholtz-berlin.de/industrie/mehr-erfahren-ueber-industriekooperationen/techniken/bestrahlung_de.html