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A detailed look on the interaction of solar wind helium with Mercury's surface in the laboratory

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Bodies in space without a dense atmosphere are affected by several erosive space weathering processes [1, 2]. These processes are responsible for modifications of surface properties as well as for the formation of an exosphere. During the BepiColombo mission, an on-board mass spectrometer will probe this exosphere on Mercury. Knowledge the different processes causing its formation is crucial for the interpretation of the obtained mass spectrometry data [3, 4]. Sputtering by solar wind ions is expected to be one of the key drivers of the particle release that leads to the formation of the exosphere. In addition, these ions can modify the regolith, become implanted and are released into the exosphere [5, 6].

We emulate solar wind precipitating onto the surface of Mercury by irradiating analogue material with mass over charge selective ion sources. For this study in particular, a magnesium rich augite (Ca,Fe)(Mg,Fe)[Si_2O_6] sample was used as analogue. The material is deposited onto a Quartz Crystal Microbalance (QCM) as thin film. Chemical composition and thickness of these films was investigated by means of ion-beam analysis [7]. The QCM-technique allows for real time measurements of mass changes during the experiments. This approach enables us to determine sputter yields due to ion impact, as well as projectile implantation and rerelease. Furthermore, the target is heatable and desorbed atoms can be analyzed with a quadrupole mass spectrometer. The setup thus allows for Thermal Desorption Spectroscopy (TDS) measurements. Together with the QCM, temperature dependence of the projectile rerelease and the total mass change during heating cycles can be determined.

Irradiation of the targets with He^+ at solar wind energies of 4keV were performed and simulated using the program SDTrimSP [8, 9]. A significant amount of helium is implanted upon irradiation, leading to a fluence-dependent mass change rate. When an equilibrium of implantation and rerelease is reached the mass loss due to sputtering of target material is observed. This saturation happens after a fluence of about 10^{21} ions per m^2, which corresponds to an irradiation by the solar wind of several hundred years on the surface of Mercury [3]. The study shows that helium is mobile during ion irradiation, and released thermally from the sample at about 400K. Combining TDS results and measurements of the mass change, the helium volume abundance after saturation was estimated to about 10-15%. The results of this study therefore provide a more detailed understanding of the interaction between helium from solar wind and Mercury analogues.

References:

[1] Hapke B.: J. Geophys. Res. Planet., 106, 10039, 2001.
[2] Noble S.K., et al.: Sol. Syst. Res. 37, 31, 2003.
[3] Wurz P., et al.: Planet. Space Sci., 58, 1599, 2010.
[4] Benkhoff J., et al.: Planet. Space Sci. 58, 2, 2010.
[5] Sasaki S., et al.: Adv. Space Res., 33, 2152, 2004.
[6] Hartle R., et al.: J. Geophys. Res., 80, 3689, 1975.
[7] Moro M.V., et al.: Thin Solid Films, 686, 137416, 2019.
[8] Mutzke A., et al.: IPP Report, 2019.
[9] Szabo P.S., et al.: Icarus, 314, 98, 2018.