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A novel setup to examine sputtering characteristics of mineral samples

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The surface of bodies without a thick atmosphere in outer space is exposed to the harsh space environment [1]. Space weathering alters its properties and leads to the formation of a tenuous exosphere. This elevated density of particles is coupled to the surface and therefore carries information about the latter. The BepiColombo mission aims to probe the composition of Mercury’s exosphere for the purpose of extracting this information [2]. However, this task requires precise models of exosphere formation [3]. Sputtering by solar wind ions is expected to be one of the main drivers for exosphere formation and models are therefore sensitive to sputtering inputs. So far, mainly simulation data are used, as experimental sputtering data for relevant materials are rare. Furthermore, available measurements have been typically performed with amorphous thin films due to use of the Quartz Crystal Microbalance (QCM) technique for sputtering measurements [4, 5]. Such a QCM is very sensitive to mass changes with resolutions in the sub mono-layer regime and is therefore an ideal tool for quantitative measurements of sputtering yields [6].

We introduce a new method for determining sputtering yields of more realistic samples, which allows to overcome the limitations of thin films while making use of the high sensitivity of QCMs. For this purpose, pellets pressed from minerals that are relevant for Mercury are used. The primary sample holder is placed on a xyzφ -manipulator, which enables switching between different samples and varying the irradiation angle α. A secondary quartz (C-QCM) is placed on an independently rotatable manipulator. This setup allows probing the angular distribution of sputtered particles by determining the mass change $\Delta m\ ion^{-1}$ in dependence on the angle α_C between the sample and the C-QCM, which can lead to further improvement of exosphere models. Furthermore, mass changes of the irradiated sample due to ion implantation [7], can be untangled as only deposition of ejected particles contributes to the C-QCM signal. The use of pressed pellets enables a variation in sample parameters not accessible with thin films like crystal structure, surface roughness and porosity. Nonetheless, a QCM coated with the same material is installed on the primary sample holder in addition to the pellet for calibration.
First results with the Ca-pyroxenoid wollastonite ($CaSiO_3$) and 2 keV Ar^+ ions are very promising. They indicate no difference in sputtering of the amorphous thin film and the pressed wollastonite pellet for Ar^+ irradiations. In a next step, solar wind ions will be used, which will improve the understanding of sputtering of realistic samples by solar wind ions.

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