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Potential Sputtering Experiments on Mineral Targets Relevant for the Lunar Surface

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Ion sputtering, micrometeorite impacts, and desorption processes severely affect the surfaces of celestial bodies in the absence of a protecting atmosphere. These processes cause changes of optical properties and lead to the emission of surface atoms to form a thin exosphere [1]. Both aspects are frequently investigated to get more insight into remote bodies in the solar system [2]. For example, ESA's recently launched BepiColombo mission will begin investigating Mercury's exosphere in 2025.

For refractory elements, sputtering by solar wind ions represent an important release process [3]. Due to limited availability of experimental results, most exosphere models use SRIM simulations to derive sputtering yields [4]. However, we recently found significant discrepancies between measured sputtering yields and SRIM predictions for a wollastonite ($CaSiO_3$) target [5]. The program SDTrimSP on the other hand [6], was able to reproduce measured kinetic sputtering yields accurately.

We now expand our experiments on thin wollastonite films deposited on a Quartz Crystal Microbalance (QCM) to investigate the effects of potential sputtering in more detail. Potential sputtering is caused by multiply charged ions hitting insulating targets [7]. There we have previously found that multiply charged ions relevant for the solar wind significantly increase the total sputtering of minerals [5]. We present new results for the sputtering of multiply charged Ar and He ions with a focus on the dependence on fluence and angle of incidence. Potential sputtering causes an additional depletion of oxygen and therefore prolonged irradiation will lead to a metallization of the surface with a corresponding change in surface reflectivity. The metallization in turn results in strongly decreasing potential sputtering yields, which reaches a steady state after sputtering of the first few monolayers. For the first time, we investigate the angular dependence of potential sputtering experimentally. These results are essential to quantify the sputtering of realistic rough or grain-like surfaces, where ions will hit under several angles of incidence simultaneously. Therefore, our experiments play an important role in assessing the significance of multiply charged ions and potential sputtering for space weathering and the formation of exospheres.

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