Sputter removal of adsorbed H_2O from Lunar Highland Soil

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Abstract. In 2009, several spacecraft reported that infrared absorption bands at 2.8μm and 3.0 μm, attributed to O-H stretch vibrations in OH and H_2O molecules, were present on the lunar surface.[1,2] Since, there has been much speculation[3] about their source and what could be the cause of reported diurnal variations in the depth of the absorption bands.**Error! Bookmark not defined.** To measure the contribution of solar irradiation (ions and photons) to these variations, we have measured the sputtering cross-section for adsorbed water from lunar highland soil and calculated the expected lifetime of a water molecule on the lunar surface. In addition, we measured the desorption cross section of water ice from a smooth carbon surface by 193nm photons.

All experiments were performed under ultra high vacuum (base pressure ≤ $5x10^{-9}$ Torr) conditions. Lunar soil sample 65901 was cooled with LN2 then dosed with water to an exposure of 5-10L. The presence of ice was confirmed by taking X-ray photoelectron spectroscopy (XPS) measurements before and after deposition and comparing the percent atomic concentration of oxygen on the surface. After deposition, a low energy ion gun was used to irradiate the sample with 4keV He^+ up to a fluence of $1x10^{17}$ He^+ cm^{-2}. During irradiation, the desorbed species were monitored with secondary ion mass spectrometry (SIMS), and XPS spectra were taken at several intermediate fluences. From the change in the oxygen concentration on the surface, we determined the cross section σ = $3.3x10^{-15}$ cm^2 for water adsorbed on the lunar soil (fig. 1.a), giving a lifetime of ~200 days. Subsistence of water at high fluences is due to the sample topography that prevents ions from reaching all the grains analyzed by XPS. The photodesorption experiments were similar except that a carbon-coated quartz crystal microbalance (QCM) was used to monitor the evolution of the mass of water on the substrate. The measured desorption cross section was 7.4 x 10^{-19} cm^2 (fig. 1.b). While this is much lower than for ions, the photon flux at the lunar surface is much higher, thus giving a lifetime of only 135s.

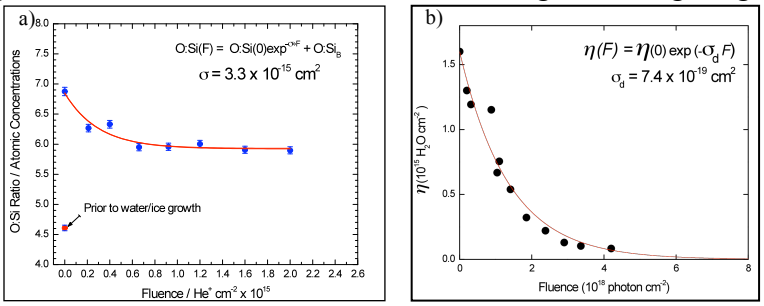

Figure 1: (a) Exponential decay of the Oxygen on lunar soil under 4keV He^+ irradiation. (b) Desorption of water ice from carbon substrate by 193nm photon irradiation.

[1] Clark, R. N., Science 326, 562 (2009); C. Pieters, J. Goswami, et al., Science 326, 568 (2009)
[2] Sunshine, J. M., T. L. Farnham, et al., Science 326, 565 (2009);
[3] D. Burke, C. Dukes et al., Icarus, 211, 1082 (2011)