In-Situ Artificial Substrate Witness Plates: A Passive Tool to Assess Materials for Long-term Exposure L. Morrissey[1,2], P. Saxena[2], J. McClain[2], N. Curran[2], and R. M. Killen[2], [1]Memorial University, NL, Canada, Washington, DC 20005, USA, [2]NASA GSFC, Greenbelt, Maryland 20771, USA

Introduction: Given the stark increase in lunar orbital and surface efforts by several countries, there is a pressing need to better understand several scientific and operational relevant surface processes. A NASA led effort to return astronauts to the Moon, Artemis, is an initial step to long-term sustainable human presence at the Moon. However, key Lunar processes relevant to material performance are known to vary spatially and temporally [1]. Thus, the goal of establishing a sustained presence on the Moon relies on understanding how such processes can modify exposed operationally significant materials. In particular, the solar wind (SW) is a stream of high-energy charged particles originating from the sun consisting of electrons, protons, and trace amounts of heavy ions. Because the Moon does not possess an atmosphere or intrinsic magnetic field to shield it from the SW; its surface is constantly impacted. As SW ions impact the surface, they deposit energy, leading to the emission of surface atoms, erosion, and damage [2]. Understanding the effects of SW impacts on materials placed on the lunar surface is therefore critical to designing long-term lunar structures.

Artificial Witness Plates for the Future: In this study, we discuss the potential value of a tool complementary to these techniques: in-situ artificial substrate witness plates (termed 'Biscuits') for material assessment. Witness plates can potentially simultaneously assess the performance of several different materials as a function of time and location. These plates are low cost, low mass, and produce a low environmental footprint. Exposed plates would be fully characterized pre and post exposure, allowing for comparison of identical structures.

To demonstrate the unique ability of biscuits to capture valuable solar activity related effects we have conducted a case study using the binary collision approximation (BCA) simulation tool, SDTrimSP. For this case study we simulate SW impacts onto a pure aluminum target, a commonly used operational material that could be exposed on the Lunar surface for extended durations. Following recommended best practices, we approximate the SW as 96% 1 keV H^+ and 4% 4 keV He^{++} impacting an aluminum target with an energy of 1 keV/amu. Using a SW flux of $4\text{x}10^8$ cm^2/s, a total fluence corresponding to 10 Earth years of dynamic SW exposure was simulated. The average aluminum sputtering yield was ~ $5\text{x}10^{-2}$ Al atoms/ impact. Extending this over 10 earth years, this corresponds to ~$6.3\text{x}10^{15}$ Al atoms/cm^2. For a 20 cm^2 biscuit this would correspond to a total mass loss of 0.056 mg and 0.11 mg for 5- and 10-years exposure respectively. This total mass loss from the biscuit is well above detection limits for changes in total mass and demonstrates the applicability for biscuits to be used to quantify SW processes while also assessing the performance of different operational materials. In addition, SDTrimSP can be used to study the depth and damage produced during exposure. After 10 years of exposure to the SW significant damage has accumulated in the sample due to incident SW. As incoming energetic SW ions make their way through the target they deposit energy along the way, eventually reaching a 'final' depth. Therefore, the depth of SW induced damage, peaks at 150 A within the sample, shallower than the peak in number of implantations, 50 A. As such, thin biscuit samples can capture the entire deposition and damage profile during exposure.

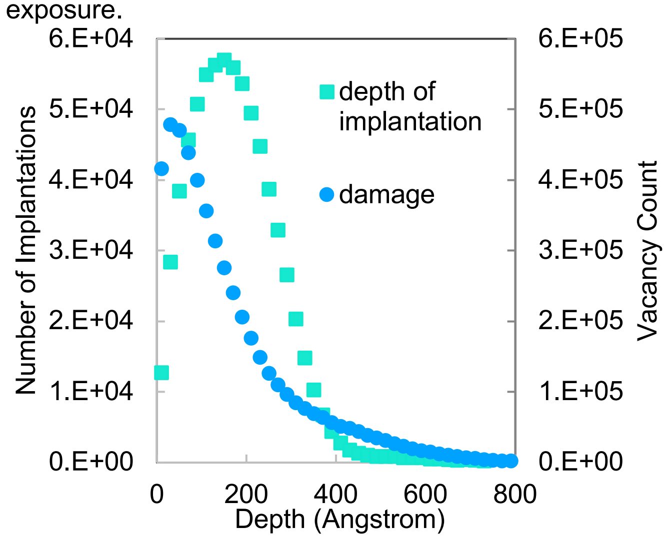

Fig. 1 SW implantations and damage as a function of target depth

References: [1] W. M. Farrell et al. (2017) JGR. [2] R. Behrisch and W. Eckstein (2007)