Electron-beam Lunar Dust Mitigation (ELDM) Tehcnology. X. Wang[1], B. Farr[1], J. Goree[2], I. Hahn[3], U. Israelsson[3], and M. Horányi[1]. [1]University of Colorado Boulder, [2]University of Iowa, and [3]Jet Propulsion Laboratory (xu.wang@colorado.edu).

Introduction: As learned from the Apollo missions, lunar dust causes a series of issues: damage to spacesuits, degradation of thermal radiators and solar panels, and interference with the hatch seals of Extravehicular Activity (EVA) systems, for example. As NASA prepares to send humans back to the Moon and stay, dust mitigation must be resolved for future long-term, sustainable lunar surface exploration in a timely manner, as identified by the Lunar Surface Innovation Consortium (LSIC). Though various methods have been under development, there is a lack of technologies to efficiently mitigate lunar dust hazards. Here we present a novel Electron-beam Lunar Dust Mitigation (ELDM) technology to fill this technology gap.

ELDM Technology: The ELDM technology is developed based on a novel dust charging theory – Patched Charge Model (PCM) [1]. As illustrated in **Fig. 1** [1, 2], secondary electrons are emitted when an electron beam hits dust particles, and a fraction of the secondaries are re-absorbed within microcavities between dust particles, resulting in buildups of negative charges on the surrounding particles. Due to the small cavity size that is on the order of the particle size, a small potential difference across microcavities will induce large electric fields and substantial charges on the surrounding particles. Subsequently, strong repulsive forces between these negatively charged dust particles cause their release and removal from the surface.

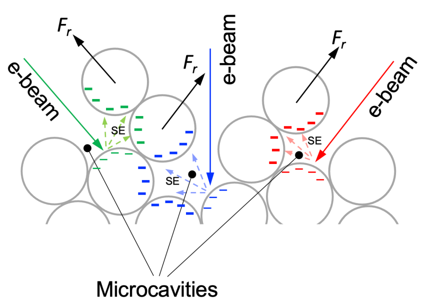

Fig. 1 Schematic of the Patched Charge Model (PCM) [1, 2].

As shown in **Fig. 1**, when the electron beam hits the surface at different angles, more microcavities are exposed and charged, causing more dust particles to be removed to optimize dust cleaning efficiency. **Fig. 2a** shows a cloud of dust partciels (JSC-1A) jump off a glass surface under exposure to a 120 eV electron beam [3]. **Fig. 2b** shows images of spacesuit and solar panel samples before and after beam exposure [2].

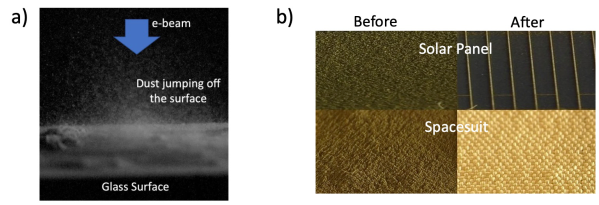

Fig. 2 a) Dust release due to exposure to a 120 eV low-energy electron beam [3]; b) Before & after images of cleaning of spacesuit and solar panel samples [2].

Dust Cleaning Results: ELDM utilizes a hot filament to generate a low-energy (100-300 eV) electron beam to aim at dust-covered surfaces to be cleaned. A series of tests with different beam setups show that the ELDM technology can achieve up to ~92% cleaning efficiency for most of insultaing surfaces, including spacesuits, optical surfaces, thermal blankets, and solar panels (**Fig. 3** [2, 4]). The ELDM technology is not suitable for conductive surfaces due to the image force of charged dust, which tends to attract the dust on the surface. Varying [4] or having multiple [2] beam angles, as shown in Fig. 1, results in maximum cleaning efficiency (**Fig. 3**).

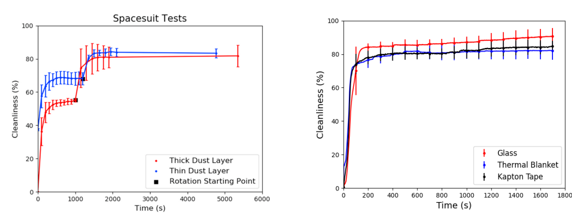

Fig. 3 Cleaning efficiency of various samples vs. beam exposure time with varying [4] or having multiple [2] beam angles.

It has been demonstrated that the optimum beam energy and flux are 100-230 eV and 1.5-3 μA/cm^2 [3]. In the current lab setup, power consumption is ~15-20W for several minutes to clean a surface area of 100 cm^2. No ESD events were observred in all above tests.

Conclusion and Future Work: The ELDM technology is demonstated to be potentially an efficient method to mitigate dust on sensitive engineered surfaces for lunar exploration. In the future, ELDM prototypes will be developed to demonstrate their performance on the lunar surface.

References: [1] Wang et al., (2016), GRL, 43, 6103–6110. [2] Farr et al., (2022), Acta Astronautica, 200, 42–47. [3] Farr et al., (2020), Acta Astronautica, 177, 405-409. [4] Farr et al., (2021), Acta Astronautica, 188, 362–366.