INVESTIGATION AND DEVELOPMENT OF 2D AND 3D EDS TOWARDS THE CREATION OF A HYBRID DUST MITIGATION BRUSH. K. G. Sjolund¹, M. J. Schaible², M. E. Judson¹, E. A. Ryan¹, M. L. Shofner¹, T. M. Orlando¹, and J. S. Linsey¹. ¹George W. Woodruff School of Mechanical Engineering, ²School of Materials Science and Engineering, ³School of Chemistry and Biochemistry, Georgia Institute of Technology (julie.linsey@me.gatech.edu).

Introduction: For NASA’s Artemis missions to be successful, novel solutions to the lunar dust problem must be developed. Efforts of the SSERVI REVEALS team at Georgia Institute of Technology have focused on novel implementations of Electrodynamic Dust Shield (EDS) technology as an active mitigation solution for lunar dust. This development began as a part of NASA’s 2021 BIG Ideas Challenge where students proposed EDS technology in a brush structure combined with UV photoelectric charging of dust grains in a high vacuum environment to test the viability of creating a UV and EDS assisted handheld dust brush. This presentation will describe further development of EDS systems including: (1) an investigation and reproduction of known 2D-EDS effects using electrodes made from copper and a novel conductive polymer composite developed by the SSERVI REVEALS team [1, 2], (2) enhancement of 2D-EDS efficiency using UV radiation to induce photoelectric charging of dust grains, and (3) development of 3D-EDS brush systems using a flexible electrode array embedded in a bristle structure.

Investigation of 2D-EDS: Initial testing of 2D-EDS systems began with interdigitated electrodes of bare Cu on a PCB. The samples were held in vacuum at around 10⁻⁵ torr, and a neon-sign transformer provided a high voltage (0.5-10 kV) 2-phase, 180 degree offset sine-wave signal at 60 Hz. Although this signal is not an ideal as determined in previous EDS developmental work [3], it does allow for preliminary testing of the systems and a general sense of the relative efficiency for different electrode configurations and experimental conditions. Under this configuration with applied peak-to-peak voltage at or above 2.5kV, almost all but the smallest of dust grains were removed from the surface. This behavior matched that found in literature [3].

Chemically modified reduced graphene oxide (rGO-dd) EDS system. The SSERVI REVEALS teams has developed a conductive polymer composite construct for lunar environments, and this material system was tested as a potential EDS electrode material. The benefits of an EDS system made with rGO-dd are that this material could be easily laminated onto both flexible film and woven fiber thermoplastic substrates in a wide variety of patterns. Initial experiments have shown that rGO-dd based EDS performs in a similar capacity to Cu-based EDS under the conditions described previously. However, dust grains have been observed to collect on the CMrGO electrodes after EDS activation, which is the opposite of previously described behavior using Cu electrodes where the electrodes were the first to be cleared [3]. Further results of ongoing testing involving rGO-dd based 2D-EDS systems will be discussed.

UV enhancement to EDS functionality: To understand if EDS performance could be enhanced, a UV source was added to the experimental set-up. Specifically, a 172 nm excimer lamp UV source was positioned several centimeters above the bare Cu 2D-EDS system to test the added effect of photoelectric charging on the EDS efficiency. Experiments exposing dust to only UV showed no movement, but combined EDS and UV caused dust movement to begin at 750V, or about 50% the voltage required to cause movement without UV. In later experiments, it was observed that the UV had an immediate effect, and for EDS voltages initially below the threshold of grain movement, repulsion was seen immediately after the lamp was turned on. It is reasoned that the UV radiation charges the dust grains through photoelectric emission and that the charged particles are more affected by the traveling electric fields. Testing of the combined EDS and UV effects with the rGO-dd show similar results, suggesting that UV enhanced EDS may be applicable for a wide variety of applications.

Development of 3D-EDS: Low fidelity experiments of the 3D-EDS system involved a row of electrodes embedded in bristles at an angle. While these experiments demonstrated that EDS affects dust caught within bristles, it required significant refinement. Ongoing efforts are focused on aligning a matrix of electrodes among bristle clusters within a brush. It is expected that the 3D-EDS will be able to better repel dust grains out of the volume using this arrangement. Alternate bristle materials that tolerate high temperatures and have high dielectric permittivity are also being investigated.

Acknowledgements: This work was directly supported by the NASA Solar System Exploration Research Virtual Institute (SSERVI) under Cooperative Agreement #NNA17BF68A (REVEALS). It was also part of NASA’s 2021 BIG Idea Challenge with Shoot for the Moon from Georgia Institute of Technology.

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