DUST MITIGATION METHOD FOR LUNAR EXPLORATION UTILIZING AN ELECTRON BEAM. X. Wang1,2, B. Farr1,2, J. Goree3, I. Hahn4, U. Israelsson5 and M. Horányi1,2, 1Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado 80303; 2NASA/SSERVI’s Institute for Modeling Plasma, Atmospheres and Cosmic Dust, Boulder, Colorado, 80303; 3Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa, 52242; 4Jet Propulsion Laboratory, Pasadena, California, 91109.

Introduction: Dust stirred up due to human activities on the lunar surface has been found to be a great engineering challenge during the Apollo missions. These dust fines can readily stick to almost all kinds of surfaces, such as spacesuits, solar panels and thermal blankets, causing damages or degradation of these equipment. If the lunar dust is inhaled by astronauts, it may cause serious health issues. Dust hazard is one of potential issues for human exploration on the lunar surface. Efficient mitigation technologies are needed in order to ensure the success of NASA’s Artemis program.

Several dust mitigation techniques have been studied and developed. During the Apollo missions, dust was removed utilizing brushes, but it was not efficient. Calle et al. [1] were the first to develop an Electrostatic Dust Shielding (EDS) technique to shed dust off surfaces. The principle of EDS is to release charged dust by oscillating high voltages on electrodes embedded underneath the surface of equipment. Though the EDS technique has a high efficiency for cleaning dust (~90%), the embedded electrodes may significantly increase the complexity and cost for equipment’s manufacturing. In addition to the above active methods, a passive method that modifies the surface properties by ion beam bombardment to reduce the surface adhesion was investigated [2].

Recently, it has been demonstrated that using a plasma jet (1-2 kV) is an efficient way to clean dust on a surface [3]. However, the jet diameter is generally small, and it requires a high voltage and a high current as well as a pressurized vessel. Here we present a simple technique utilizing an electron beam to create the high-level charge on dust particles which repel each other to be released from a surface.

Experiment: Our new technique was developed based on our recent studies on dust charging and lofting on the surfaces of the Moon and other airless bodies. Our new laboratory experiments [4] have successfully demonstrated dust jumping due to exposure to electron beam or UV. A new charging theory, called the “patched charge model” [4], was developed, which suggests that the emission and re-absorption of secondary electrons or photoelectrons inside microcavities between dust particles can result in large negative charges on the surrounding particles and the inter-particle repulsive force can be sufficiently large to eject dust off the surface.

Based on this new charging theory, we designed an experiment using an electron beam to charge and shed dust off a surface. The experiment was carried out in a 50 cm diameter and 28 cm tall vacuum chamber. JSC-A lunar simulant ($\rho \sim 2.9 \times 10^3$ kg/m$^3$) less than 25 µm in diameter was deposited on a sample surface attached to a substrate. The dust covered sample surface was then exposed to the electron beam emitted from a negatively biased, hot filament mounted on the top of the chamber. The dust shedding process was recorded by a video camera. The brightness of pixels was analyzed to calculate the surface cleanliness.

In this paper, we will show the dust shedding results tested with different energies and currents of the electron beam that impacted on the sample of spacesuit, glass plate or thermal blanket with different thicknesses of the dust layer. We show that the electron beam technique is efficient and easy to use in the lunar environment to clean dust off various surfaces. The cleanliness can reach as high as 80%.

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