Dust Effects on Spacesuit Charging/Arcing: Implications for Astronaut Safety on Lunar Surface J. Wang[1] and Z. Huang[1], [1]Department of Astronautical Engineering, University of Southern California, Los Angeles, CA 90089 (josephjw@usc.edu).

Introduction: Lacking a global magnetic field and an atmosphere, the lunar surface is directly exposed to space plasma and solar radiation, and is electrically charged by the impingement of electrons and ions and the emission of photoelectrons. Charging was not considered a serious risk during the Apollo mission because astronauts always stayed under sunlit where there is no significant charging due to photoelectron emission. However, future lunar missions will explore the lunar terminator and far-side. Observations have found that, while the potential of the sunlit surface is typically a few tens of volts positive with respect to ambient due to photoelectron emission, the potential of the surface in the shadow can be hundreds to thousands of volts negative because of the hot electron flux from the ambient plasma. This raises concerns for astronaut safety on lunar surface.

While spacecraft charging has been studied extensively, there is very limited knowledge of astronaut charging on the lunar surface. This is because previous studies have mostly focused on the charging of clean conducting or dielectric surfaces whereas a study of astronaut charging on lunar surface must take into account of the effects of dust coverage due to the lunar dust environment. Dust accumulation on spacesuit will enhance differential charging on spacesuit surface and thus increase the probability of electrostatic discharge and arcing.

This paper presents both numerical simulations and laboratory experiments to investigate dust effects on spacesuit charging and arcing.

Laboratory Experiments: Laboratory experiments were carried out in a cylindrical, stainless steel vacuum chamber (0.9m in diameter, 1.2m in length) with a pressure of 10^{-7} to 10^{-6} torr. A 4-cm diameter grid ion thruster with a hot filament neutralizer was used to generate a mesothermal argon plasma flow with parameters similar to that of the average solar wind plasma condition. The target samples considered include Gore-Tex and Gore-Tex with exposed aluminum strips. Plasma charging was measured for both clean samples and samples covered by lunar simulant JSC-1A.

We find that a clean Gore-Tex surface is generally discharge resistant. However, once dust grains are presented, substantial discharge will occur if the surface voltage is sufficiently high. Fig.1 shows a photo of arcing occurring on a dusty sample surface. Experiments clearly show that larger surface potential and more dust coverage will lead to higher discharge rates.

Numerical Simulations: A numerical simulation model is developed for spacesuit charging and arcing. This simulation model utilizes Particle-in-Cell (PIC) to simulate plasma interactions, Direct Simulation Monte Carlo (DSMC) to simulate neutrals from electron simulated desorption (ESD), and PIC with Monte Carlo Collision (MCC) to simulate arcing onset. Fig. 2 shows a typical PIC simulation of a dust grain (size: ~5μm) on spacesuit surface. In this case, the local electric field at the dust-spacesuit interface point is more than 10^6 V/m, which exceeds the semi-vacuum breakdown condition and arcing onset condition proposed in previous study [1].

Preliminary simulation results show that, when dust grains deposit on a surface, a large electric field may be established between jagged dust grains and the surface, creating the necessary condition for arcing. Arcing may be initiated at the "triple-junction" between dust grain, spacesuit, and plasma, and follow a similar a similar process as vacuum surface flashover.

Conclusions: Dust coverage on a surface creates a nonuniform surface conductivity leading to differential charging. Large differential charging is a necessary condition for electrostatic discharge and arcing. Dust coverage also significantly increases the "triple junction" locations on spacesuit surface and thus can trigger more frequent discharge and arcing. The results indicate that charging/arcing may pose a serious safety risk to astronauts at the lunar terminator and far-side due to the combined condition of dust coverage and high-voltage plasma charging.

Reference:

[1] M. Cho and D. E. Hastings, "Dielectric charging processes and arcing rates of high voltage solararrays," *J. Spacecr. Rockets*, vol. 28, no. 6, pp. 698–706, 1991.

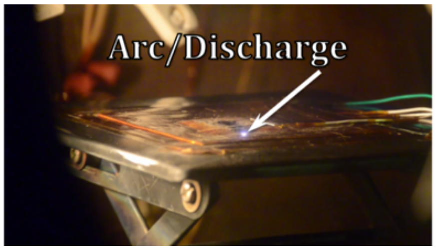

Fig.1: Arcing on dusty Gore-Tex sample.

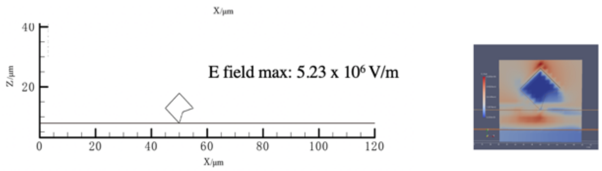

Fig.2: PIC simulation of dust grin on spacesuit.