Dusty Spacesuit Charging/Discharge and Its Effects on Spacesuit Material Property 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 where the potential of the surface in the shadow can be hundreds to thousands of volts negative. This raises concerns for astronaut safety on lunar surface.

Previous studies of spacecraft charging have mostly focused on the charging of clean conducting or dielectric surfaces whereas a study of spacesuit charging on lunar surface must take into account of the effects of dust coverage. Our previous laboratory experiments have shown that dust accumulation on spacesuit material can enhance differential charging and induce electrostatic discharge and arcing. However, there is very limited knowledge on both the physics of spacesuit discharge and the effects of discharge on spacesuit material properties.

Approach: This paper presents a modeling study of electrostatic discharge and breakdown on dusty spacesuit. The simulation study utilizes a set of 4 simulation codes: 1) an Immersed-Finite-Element Particle-in-Cell (IFE-PIC) code to simulate plasma-surface interactions and macro-scale spacesuit charging; 2) a Direct Simulation Monte Carlo (DSMC) code to simulate neutral desorption from electron simulated desorption (ESD) in the discharge process; 3) a PIC with Monte-Carlo Collision (PIC-MCC) code to simulate micro-scale discharge; and 4) a Molecular Dynamics (MD) simulation code to simulate material properties changes from the molecular level.

Results and Discussions: Simulations show that, under most space plasma conditions at the lunar terminator, strong differential charging can develop at dusty spacesuit surface and strong micro-scale electric field ($>10^6$ V/m) can develop at the plasma-dust-spacesuit "triple-junction" points. Depending on the local neutral density, electrostatic discharge or arcing can occur around the "triple-junction" points. In addition to the surface charging potential dust coverage: material outgassing property, seal/suit leakage, water sublimation, leakage at the hatch, etc are important factors influencing discharge/arcing onset

Both the strong micro-scale electric field and the transient current during discharge can cause spacesuit material property changes. The micro-scale electric field can affect the material in two ways. First, it can change the electric conductivity of the material by generating electron holes. The change of conductivity will further generate more 'triple junction' points on the surface, enhancing discharge or arcing onset. Second, an electric field $>10^6$ V/m can cause direct breakdown of the molecules of the material. Depending on the strength of the discharge, the heat generated by the transient current may also lead to damage of the material. Because of these effects on spacesuit material property, we find the combination of high surface potential and dust deposition will significantly increase the safety risks for astronauts at lunar terminator and far-side.