Electrostatic Characterization of Lunar Dust

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Lunar Launch/ Landing Site Ejecta Mitigation

To ensure the safety and success of future lunar exploration missions, it is important to measure the toxicity of the lunar dust and its electrostatic properties. The electrostatic properties of lunar dust govern its behavior, from how the dust is deposited in an astronaut's lungs to how it contaminates equipment surfaces. Astronaut Harry Schmidt said, "Dust is going to be the environmental problem for future missions, both inside and outside the habitats." NASA has identified the threat caused by lunar dust as one of the top two problems that need to be solved before returning to the Moon.

The main reason lunar dust adheres to surfaces is its electrical charge, and the dry conditions on the Moon increase those adhesive properties. The Apollo 12 Mission Briefing report stated that "the cohesive properties of the lunar dust in vacuum, augmented by electrostatic properties, tend to make it adhere to anything it contacts."

To understand the electrostatic nature of lunar dust, NASA must answer the following questions: (1) how much charge can accumulate on the dust? (2) how long will the charge remain? and (3) can the dust be removed? These questions can be answered by measuring the electrostatic properties of the dust: its volume resistivity, charge decay, charge-to-mass ratio or chargeability, and dielectric properties. The volume resistivity of a material indicates the likelihood that the particles will acquire a charge and their ability to dissipate the charge. Charge decay measurements give the time it takes for samples to dissipate the applied charge. The charge-to-mass ratio (chargeability) measurements indicate the amount of charge the dust is likely to acquire during specific processes. The dielectric properties of the dust give a measure of the dust's ability to polarize.

All lunar dust samples that were returned to Earth have been contaminated by air. This contamination most likely affected the electrostatic properties of the material through oxidation. The addition of oxygen atoms to the surface changes the surface chemistry, lowers the surface free energy, and changes the work function of the material. In many cases, these properties influence the magnitude and sign of the charges exchanged between materials, which in turn influences the electrostatic properties. These relationships illustrate the importance of measuring the electrostatic

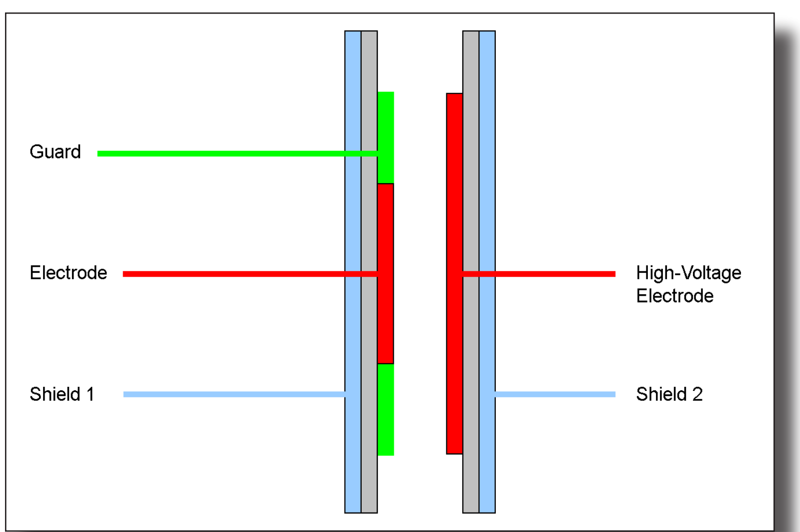

Figure 1. Schematic of the side profile of the design of the test cell used throughout the experiments.

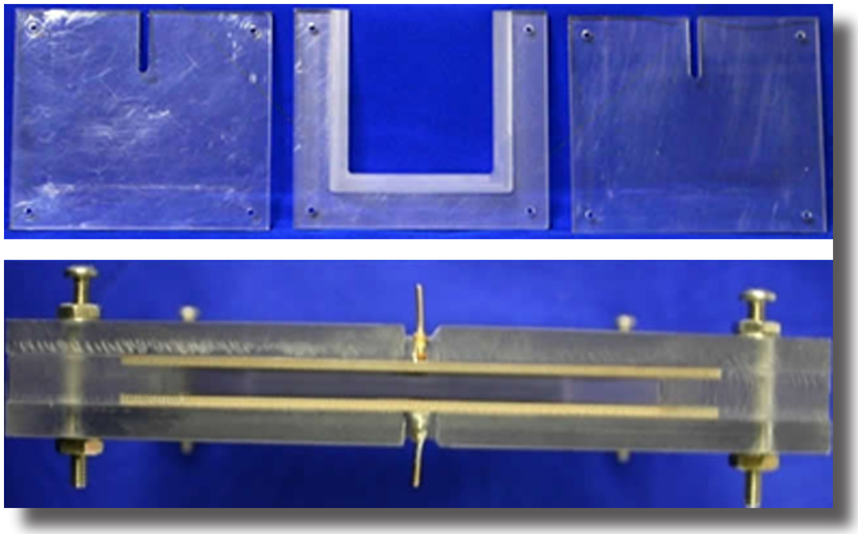

Figure 2. Top images show how the electrodes are sandwiched between a polycarbonate spacer and two backsides to form the cell. Bottom image is a top view of the test cell.

properties of lunar regolith *in situ*. Research performed in the Electrostatics and Surface Physics Laboratory at KSC has led to the development of a device that can be incorporated onto a lander or a rover for measuring all four electrostatic properties during future lunar missions.

A test cell was developed for experimentation with this device before using it on a lander or rover. This test cell compiled with standards in ASTM D 150 as well as British Standard (BS) 5958 in measuring the volume resistivity of powders. Figures 1 and 2 shows the test cell construction: a guard, a guarded electrode, and a shield on one plate; and a high-voltage electrode and a shield on the other plate. All tests with this test cell were performed in vacuum with Minnesota Lunar Simulant (MLS)-1. Because of its mineralogical composition, MLS-1 is believed to be a good lunar soil simulant, even though it does not contain glass or agglutinates. Once the material was delivered to the test cell, it was not disturbed. To measure the four different electrostatic properties, we only needed to change the electrical connections in test setup. This was done outside the test cell without disturbing the regolith.

The experiment mimicked how soils on the lunar surface may one day be handled. They would most likely be collected with a metal scoop or container and poured onto or into a sensitive device that could be damaged by the electrostatic fields produced by highly charged dust. Results of the chargeability test showed relatively high charge-to-mass ratios when the dust was poured onto the test cell. The results were not unexpected in the high-vacuum conditions used during the test. Dielectric measurements of the soil showed no fluctuation of the dielectric constant with frequency, which suggested the absence of moisture, and gave a dielectric constant of about 4. Volume resistivity measurements were made after the soil stabilized for several minutes. The values fell within the appropriate range for highly insulating silicate materials and were consistent with the literature on lunar fines. The charge decay measurements, made by induction-charging the soil, were also consistent with the literature and the previously measured electrostatic properties.

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