SPARKLED: DUST REMOVAL TOOL AND IMPLICATIONS FOR SOLAR SYSTEM FORMATION.

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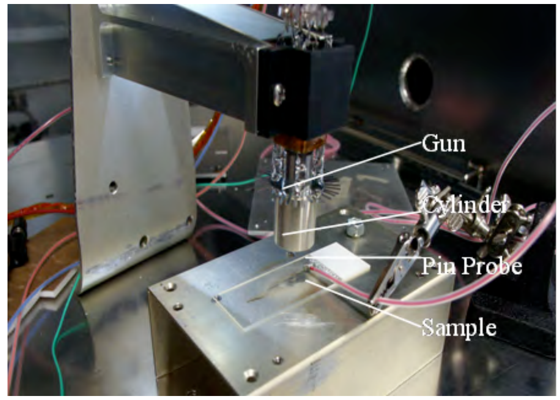
Abstract: We have had the first successful tests for a low power, lightweight NASA patent protected electrostatically-based tool (SPARCLED, Space Plasma Alleviation of Regolith Concentrations in Lunar Environment by Discharge) to remove dust in the airlock environment [1,2] and, in the process, demonstrated plasma/dust interactions with implications for solar system formation [3].

Electrostatic Basis for Dust Tool: The SPARCLED concept involves controlling the charge transported to the dust covered surface, to induce dust flow (through repulsion) away from a surface and toward another surface with lower potential acting as a collector.

The spontaneous linear aggregation behavior of small grains in a randomly charged, weak gravity environment, such as the early solar nebula or planetary regolith, has been documented, as has the disaggregation of grains when the environment develops a sufficient net charge [4]. This effect occurs regardless of particle composition, shape, or size and is correlated with particle density. Linear aggregates imply irregular charge distribution and dipole formation.

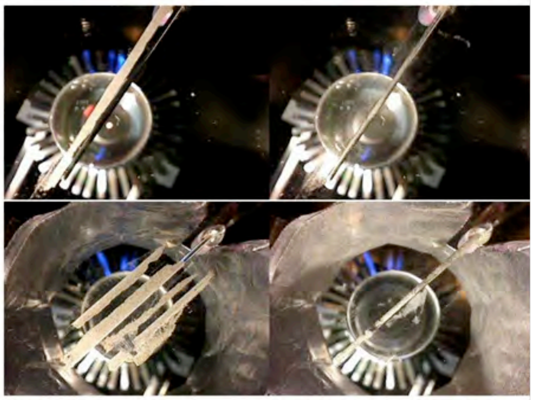
Experiment and Observations: We designed an experiment to test the interaction between a weak electron beam and dust particles (<20 micron JSC-1AF simulant) in the presence of a weak electric field created with the use of a small conducting object just above the non-conducting dust-covered surface in an environmental chamber with intermediate vacuum simulating the airlock [1]. We have now run successful experiments that successfully focused the relatively weak electron beam using a -900 volt VDC grid and a +1000 volt pin probe 2 mm above the surface to control the electrostatic potential of the surface in the presence of an electric field of 500 to 1000 volts through the onset of a discharge. The electron gun generated a weak electron beam in the milliamp range. The introduction of a relatively weak electric field of 500-1000 volts initiated a cascade of electrons in the beam by ionizing surrounding low density gas, greatly increasing the effective flux and luminosity of the beam. The negative charge to mass ratio of the dust grains rapidly increased, repulsion creating Delta-V and rapidly accelerating grains away from the negatively charged surface, diverging toward surrounding lower potential cylinder, acting as a collection surface. A second step involved introduction of a positively charged coil, resulting in disruption of grains 'stuck' to the cylinder, and the falling of grains onto a removal collection surface below.



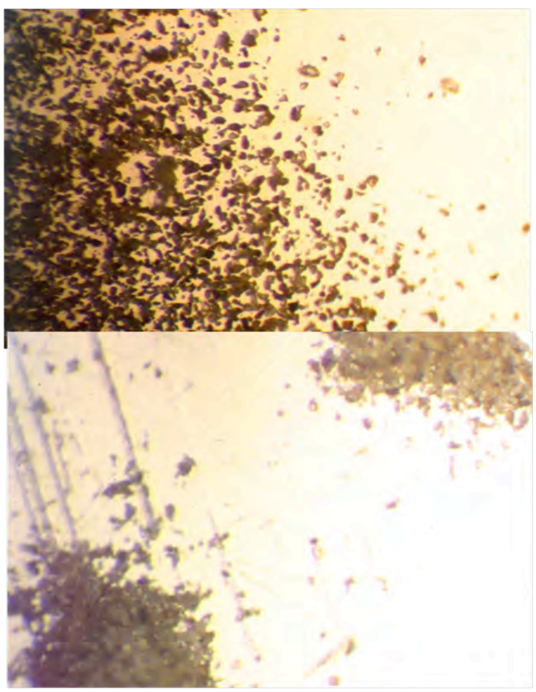
Experimental Set up

Implications: Grain accretion is an essential step in the formation of planets from the early solar nebula. This process links the temperature-dependent condensation of gases following proto-sun and proto-nebular disk gravitational collapse to the coalescence of kilometer-size planetesimals into protoplanets. Bypassing planetesimal formation issues, the process of protoplanet formation has been credibly dynamically modeled in recent years [5]. Yet, the net 'sticking' of grains to form planetesimals is the most poorly understood process in the Nebular Accretion Model. As grain aggregates grow in size, mean collision velocity also increases, increasing the probability of fragmentation. How do 1 cm sized particles coalesce into 1 km planetesimals? A number of mechanisms have been proposed [e.g., 6,7,8]. Electrostatic forces have been demonstrated to be 100 times more effective than van der Waals forces in the 'sticking' of silicate grains [9]. Here, we consider ongoing weak electrostatic discharge, a mechanism that hasn't been considered to a great extent in the past.

Our experiment allows us to examine the potential for these behaviors to contribute to the growth of planetesimals under simulated nebular conditions by observing the behavior of grains on a surface in a low discharge environment with a net overall charge. The resulting grains were charged, repelled from an underlying surface, accelerated, reaggregated on surrounding surfaces, disrupted once again by the introduction of an oppositely charged source, and finally collected on a 'neutral' surface. Accelerated monocharged grains could potentially provide ballistic mechanical energy to induce triboelectric dipole formation on less charged surrounding grains and thus accretion via inelastic collisions wherein the grains stick together post collision. The presence or lack of such a mechanism may ac-



Dust on initial non-conducting surface before (left) and after (right) charging introduced by the electron beam in the presence of a weak electric field.



SEM photos of dust on collection cylinder wall (top) and extracted from collection cylinder wall (bottom).

count for the presence or lack of stars with solar systems. We demonstrate this behavior through a series of experiments undertaken in a space simulating laboratory environment.

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