Development of a Low-Power Electrostatic Dust-Repulsion System for Lunar Surface Solar Panels

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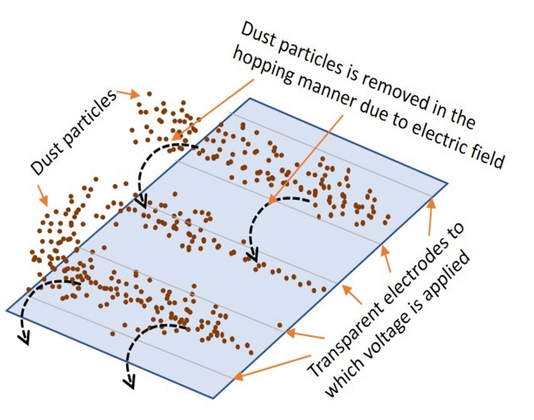
Can We Clean Dust Without Wasting Power, How can a flexible, low-power electrostatic surface be engineered to remove lunar dust efficiently while operating under a one-watt power limit?

Introduction

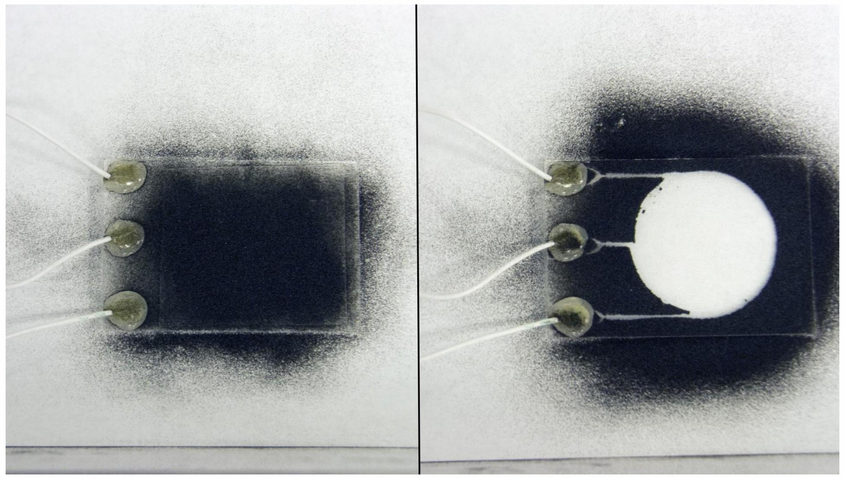
Future lunar missions will rely heavily on solar panels to power habitats, rovers, instruments, and communication systems. However, lunar dust is one of the biggest obstacles to long-term surface operations. These particles are sharp, highly adhesive, and electrostatically active, allowing them to cling to exposed surfaces and reduce solar efficiency. This project investigates a low-power electrostatic dust-repulsion system designed to protect lunar solar panels and improve the reliability of future surface power systems. Lunar dust is far more than a housekeeping issue. When it accumulates on solar panels, it blocks light, lowers power generation, and threatens the performance of critical systems. Since future Artemis-era missions will depend on stable and sustainable energy, dust mitigation is essential for mission success. A lightweight and low-power cleaning system could make lunar exploration more reliable, efficient, and practical.



Traditional electrodynamic dust shield systems have shown promising results, but many rely on fragile glass-based materials, continuous operation, and relatively high power demands. This project explores a more practical alternative by combining pulsed-voltage control with lightweight conductive materials. By using intermittent operation instead of constant power, the system aims to reduce energy use while still producing effective dust-removal performance.

What makes this project different?

- Low-power pulsed operation
- Flexible, lightweight material approach
- Designed for future lunar surface systems



Results

The prototype demonstrated successful electrostatic removal of lunar dust analog from the test surface using a pulsed low-power system. Dust displacement was clearly observed after activation, with the strongest performance occurring between 300–500 V and 20–50 Hz, where the electric field was sufficient to overcome particle adhesion. Under optimized conditions, the system removed approximately 90–95% of the deposited dust from the active region while remaining designed to operate under 1 W of power. After thermal exposure testing, the prototype remained electrically functional and continued to show measurable dust-repulsion behavior, supporting the feasibility of flexible, low-cost electrostatic dust mitigation for future lunar surface systems.

Key Research Behind This Idea

1. Calle, C. I., et al.
Electrodynamic Shield to Remove Dust from Solar Panels and Optical Systems.
NASA Technical Report, NASA Kennedy Space Center, 2021.
2. Gaier, J. R.
The Effects of Lunar Dust on Photovoltaic Cells.
NASA Glenn Research Center Technical Paper, 2010.
3. Calle, C. I., Buhler, C. R., and McFall, J. L.
Electrodynamic Dust Shield Technology Development for Lunar Surface Systems.
Journal of Aerospace Engineering, 2017.

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