Using Indium Tin Oxide To Mitigate Dust on Viewing Ports

2007 Center Director's Discretionary Fund Project

Contamination Control

NASA plans to use a number of onboard viewing ports to measure lunar regolith *in situ* and to monitor robotic and human activities on the lunar or Martian surface. Because of the size and abundance of dust particles on these bodies, the potential for dust to occlude viewing ports and windows is high enough to threaten system lifetime and reliability, especially when activities rely on relaying video to either a habitat module or controllers on Earth.

This project uses a technology being developed by KSC's Electrostatics and Surface Physics Laboratory to remove dust from windowlike surfaces. The technology applies an alternating electric potential to interlaced electrodes. In this application, we use indium tin oxide (ITO) to create various electrode patterns in order to determine the most reliable pattern for dust removal. This technology has application to systems where optical clarity is important. Specifically, this project considers the *in situ* resource utilization (ISRU) application of a viewing port for Raman spectroscopy, where the electrode pattern on glass would be coated with a scratch-resistant sapphire film (Al_2O_3).

Electrode patterns were tested in ambient and dry air. These patterns included a single-phase square, single-phase circle, single-phase comb, three-phase square, three-phase circle, and three-phase comb. The voltage, frequency, and waveform applied to each screen were varied in search of the best way to remove dust.

Of the patterns tested, the three-phase circular spiral was the most efficient at removing dust. The circular pattern minimizes the number of abrupt endings to the electrodes, thereby minimizing the points where high electric fields could lead to breakdown and sparking. The screen was tested with JSC-1 lunar simulant particles of less than 25 µm in diameter. A majority of the dust was removed within 10 s under ambient conditions and within 5 min under dry-air conditions (near 0 percent relative humidity).

We continued screen testing under vacuum conditions to demonstrate proof of concept in a more relevant environment. Test parameters were varied in a manner similar to the tests performed under ambient and dry-air conditions on a glass screen with a spiral ITO pattern coated with a thin film of sapphire. The clearing of the dust was similar to the clearing demonstrated under dry-air conditions.

An additional test successfully demonstrated the use of the screen on and near metal surfaces. The proximity of the metal surface did not appear to affect how well the screen removed dust. Applications for using the technology on metals range from dust transport mechanisms to clearing dust from seals and mechanical joints.

Key accomplishments were

- developing a technique to apply electrode patterns to ITO-coated glass slides up to 0.7 mm thick,
- developing a processing technique to remove the uncoated ITO from the glass slides and coat the slides with an insulating material to prevent sparking, and
- optimizing test parameters (voltage, waveform, frequency).

Key milestones were

- determining an efficient pattern for dust removal,
- demonstrating the capability of ITO screens to remove dust under high-vacuum conditions, and
- demonstrating the capability of ITO screens to remove dust when backed with grounded and ungrounded metal plates.

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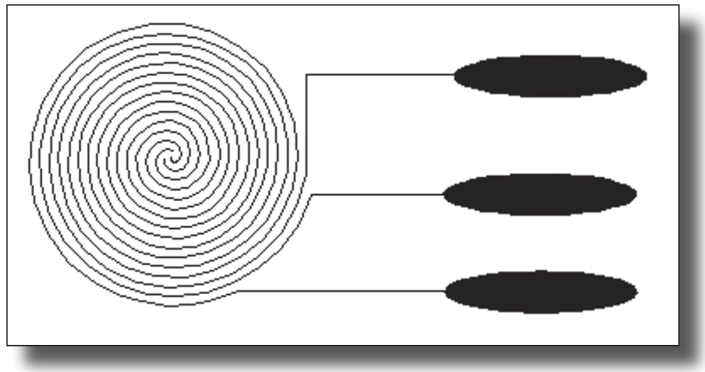
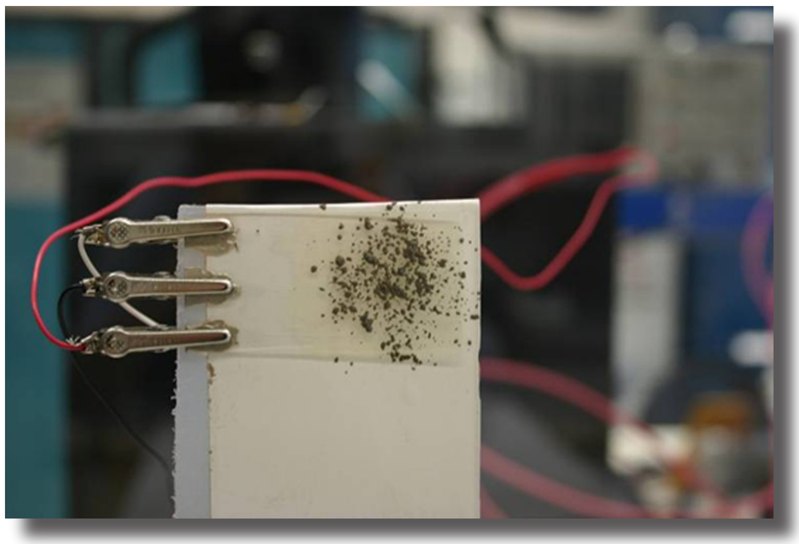
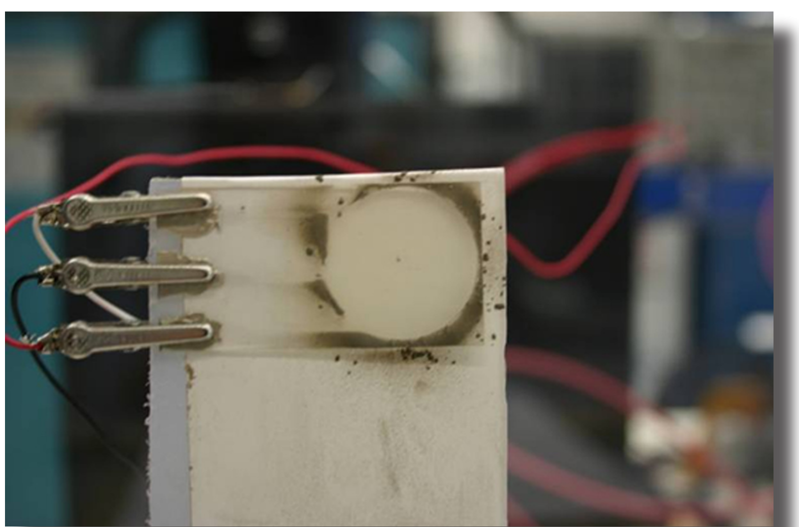


Screen pattern design.



A 2.3-cm circular spiral on ITO-coated glass at T = 0 s under dry/ambient conditions.



A 2.3-cm circular spiral on ITO-coated glass at T = 8 s under dry/ambient conditions.