A Triboelectric Sensor Array for Electrostatic Studies on the Lunar Surface

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The Dust Problem

• Dust from this equipment fell back onto the lower crewmember and into the cabin and seemed to bind the conveyor so as to require considerable force to operate it. – Apollo 11 Mission Report

• The cohesive properties of lunar dust in a vacuum, augmented by electrostatic properties, tend to make it adhere to anything it contacts. – Apollo 12 Mission Report

• After exposure to a dusty lunar environment, the both crewmen’s suit wrist-ring disconnects were hard to rotate to the locked and unlocked position. – Apollo 16 Mission Report
Harrison Schmitt – Apollo 17 (Photo Credit: NASA)
Triboelectric Sensor Array

• Dry lunar environment prime for electrostatic charging
• Monitors electrostatic charge build up due to tribocharging
• Uses heritage materials that span the triboelectric series
• Enables better selection of materials for future missions

MECA Electrometer
Wheel Electrostatic Spectrometer
ELSA
MECA Electrometer

• Designed as part of the 2001 Mars lander
• Fully developed as a flight instrument
• Cancelled due to Mars polar mission mishap
• Four sensors
  • Electric Field Sensor
  • Ion Gauge
  • Triboelectric Sensor Array
  • Temperature Sensor
MECA Electrometer

![Diagram of MECA Electrometer with a graph showing charge density over time for different materials (Fiberglass, Lexan, Teflon, Rulon J, Lucite) with annotations for lift, contact, rub, up, and down actions. The graph spans from 0 to 60 seconds on the x-axis and from -0.6 to 0.6 on the y-axis, showing variations in charge density. The diagram also includes a label for Mars Regolith.]
Wheel Electrostatic Spectrometer

• Dissimilar materials are tribocharged against planetary regolith
• Creates an electrostatic charge spectrum
• Difference in spectrum could be used to determine when a rover is driving over a new material
• Enables more tribocharging opportunities than scoop placement
Wheel Electrostatic Spectrometer

Average Peak Charge Density (pC/cm²)

- Bulk Mars-1
- JSC-1a ≥10um
- JSC-1a >200um
- JSC-2a/limerite Mix

Legend:
- G10
- Lexan
- Lucite
- Teflon
Electrostatic Sensor Array

- Placed over robotic arm contact sensors
- Collects electrostatic data whenever surface is contacted
- Unobtrusive measurements
- Backup to mechanical contact sensors
Electrostatic Sensor Array
Conclusions

• Lunar electrostatic environment is complex and must be studied for success of long duration missions
• Triboelectric charge data will provide key data for material selection of future missions
• Three use cases
  • Electrostatic sensor suite
  • Triboelectric sensors in wheels
  • Triboelectric/contact sensor

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References


