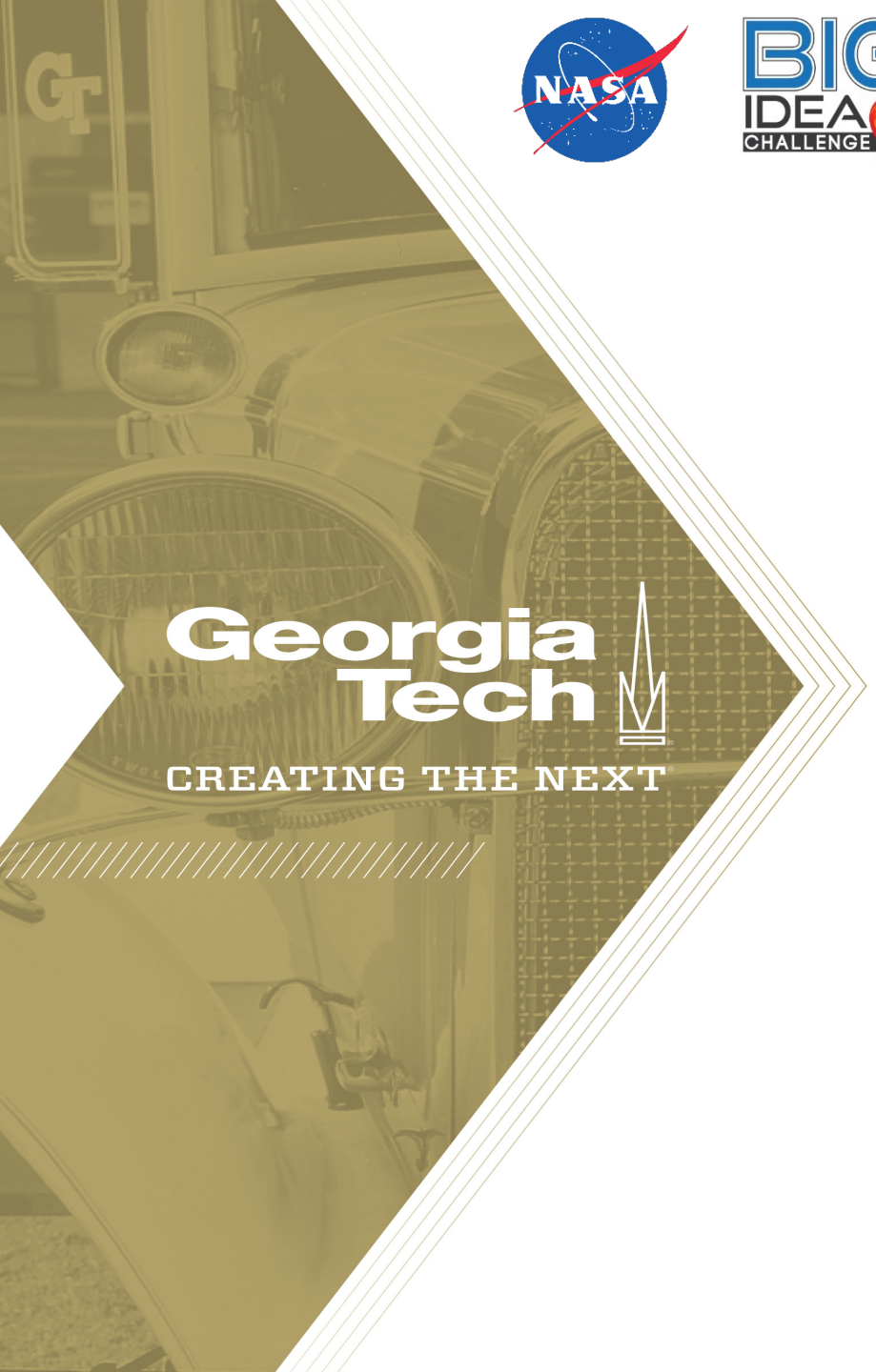

Hybrid Dust Mitigation Brush Utilizing EDS and UV Technologies

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Agenda

- Project Scope & Statement
- Proposed System
- Experimentation
- Findings & Conclusions

Project Scope & Statement

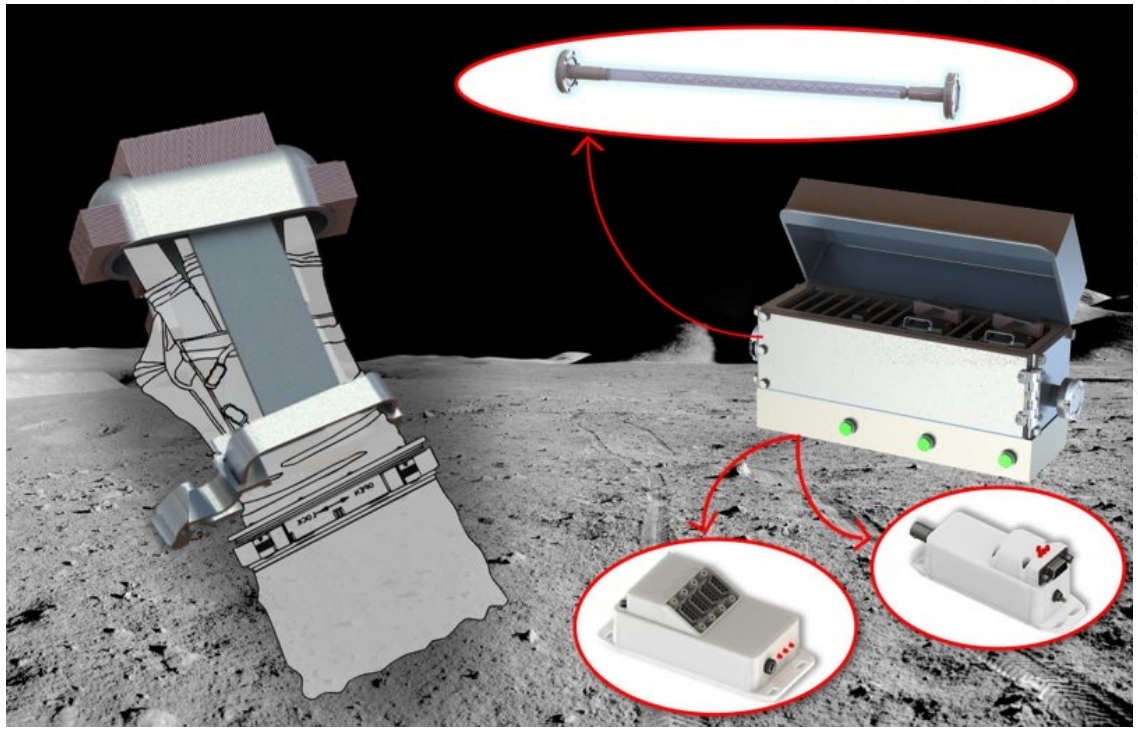
- Lunar dust accumulation poses an operational obstacle and health hazard to astronauts.
- Prior solutions for dust mitigation were marred by dust accumulation due to electrostatic adhesion
- **Focus**: mitigate lunar dust accumulation on astronaut suits

Astronaut James Irwin uses scoop during Apollo 15 EVA, NASA. 1971.

Proposed System

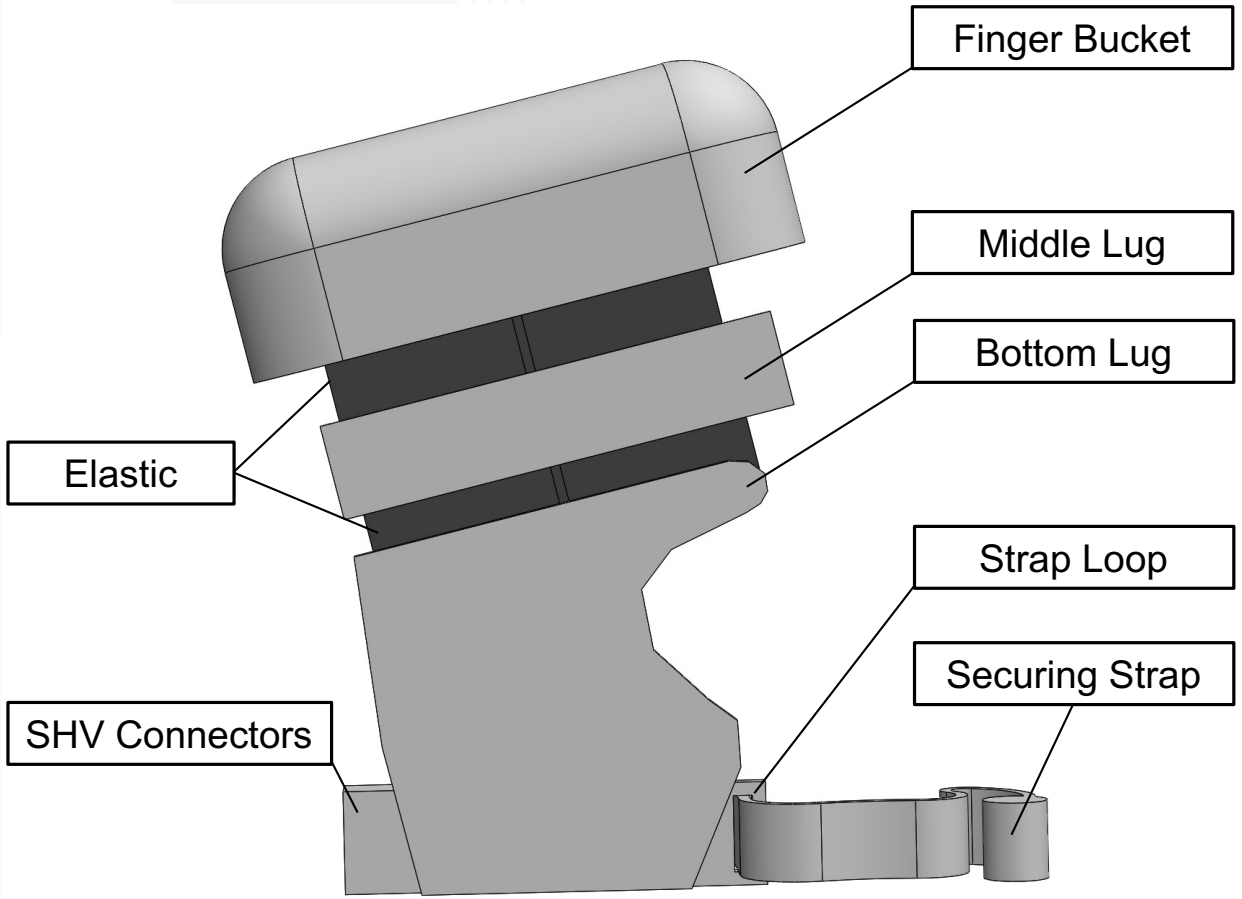
- Proposed solution:
  - Astronaut-centric ergonomic brush system that electrostatically charges and repels lunar dust with UV and 3D-EDS technology

- Multi-stage dust mitigation
  - Brush dust from astronaut suit
  - UV to charge present dust particles
  - EDS to repelled charged lunar dust



- Verification testing successfully shows dust mitigation
  - Effective EDS & UV implementation
  - Improvement: simultaneous implementation

Final Design



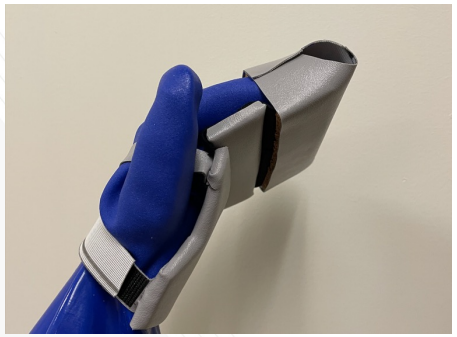
Flexible brush which secures over the xEMU glove. Bristles would be present on the palm and fingers of glove-brush

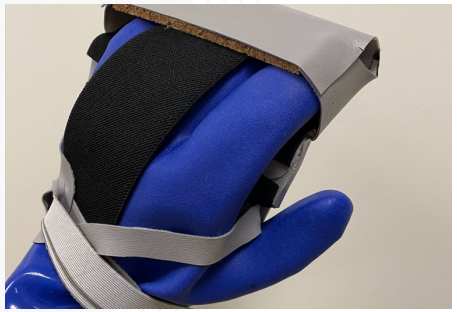
Advantages:

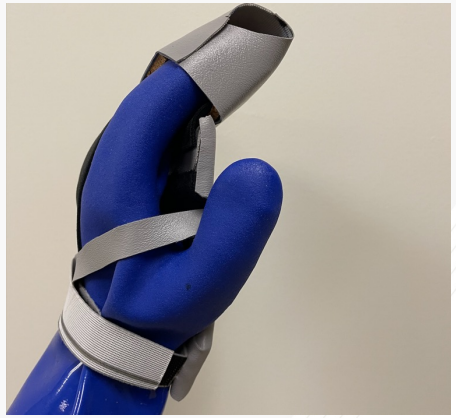
- Increased cleaning area on curved surfaces
- Reduced muscle fatigue
- Low mechanical complexity
- Intuitive design

Mechanically simple, flexible brush design optimized for astronaut use

Prototype





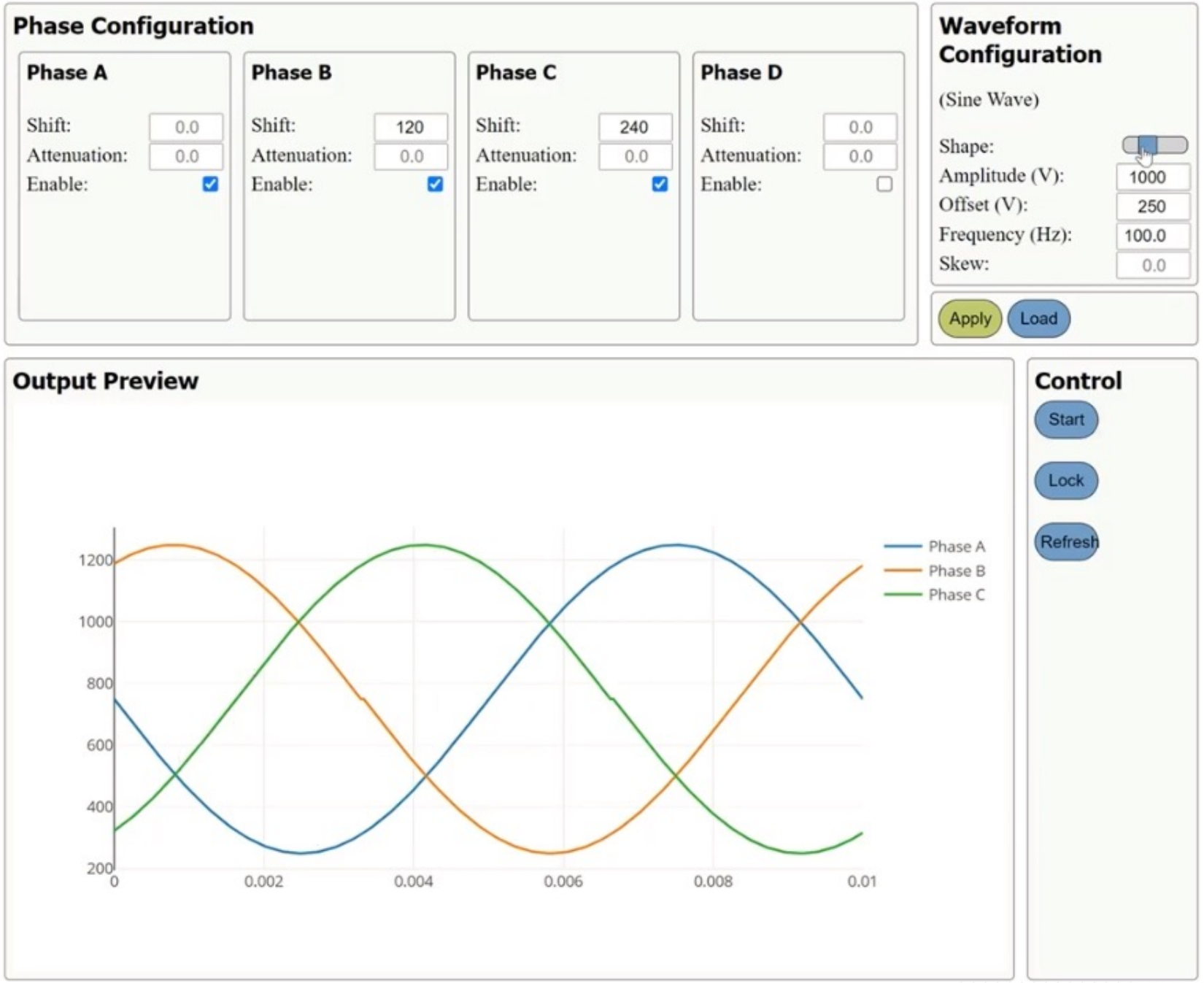


Verify:

- Functionality
  - Curving
- Ergonomics
  - Security without muscle actuation
  - Ease to don/doff
- Approximate Dimensions
- Identify Improvements

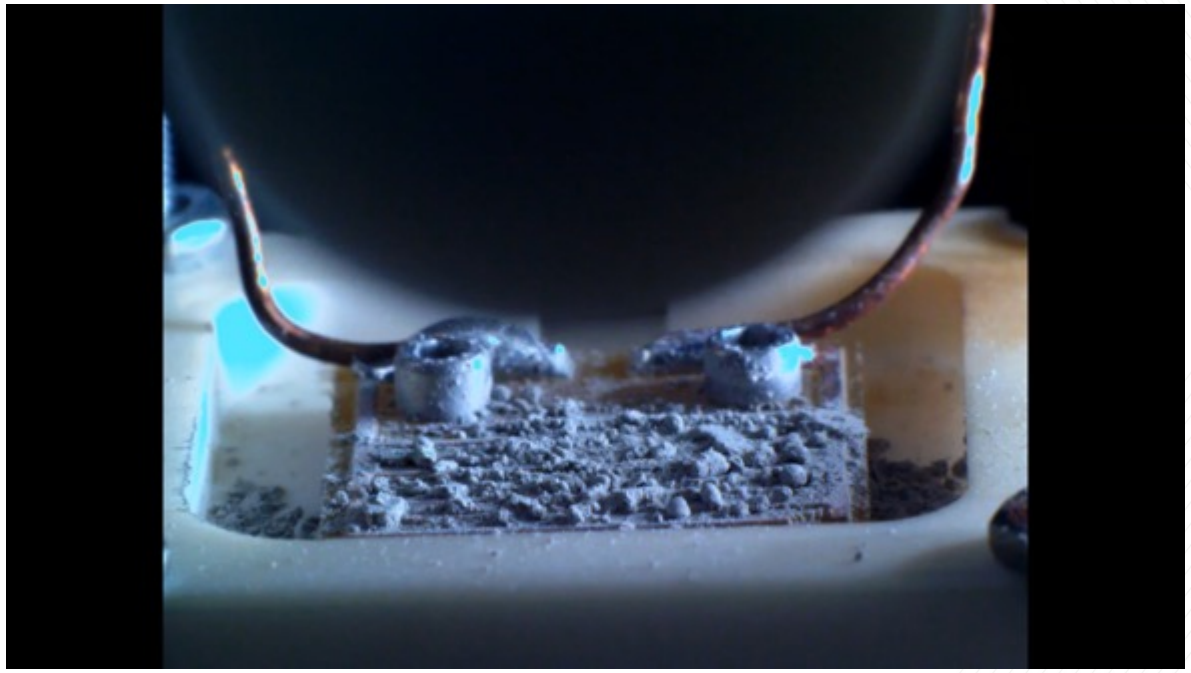
Web Based Control GUI

- Multi-Phase arbitrary waveform control
- Permit wide range of experiments



2D EDS Chip Experiments

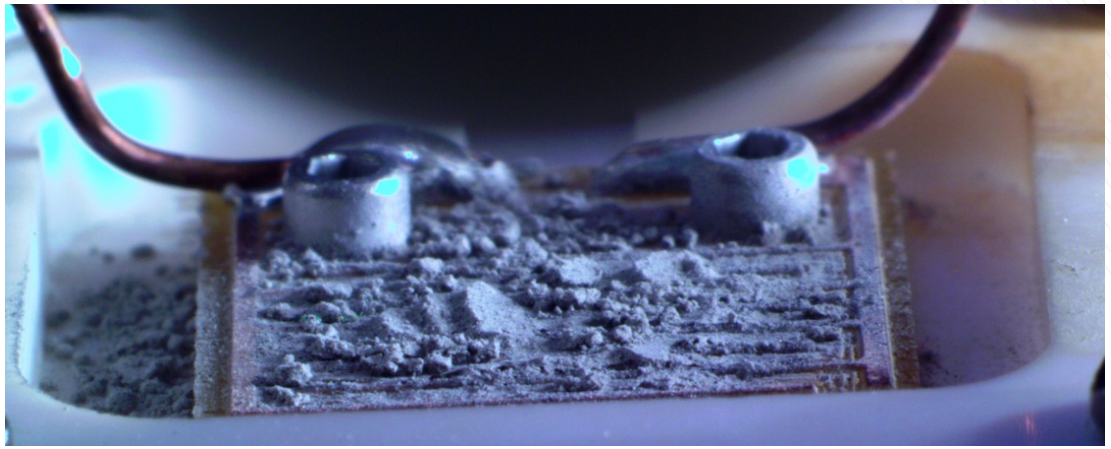
- Interdigitated chip
- First used variac and neon sign transformer
  - 60 Hz sine wave with 2-phase potential and 180° offset
- Effectively removed dust from chip surface
  - ~1.5 kV for initial movement
  - ~2.5 kV to remove most of dust
- Dust size distribution and thickness affect performance



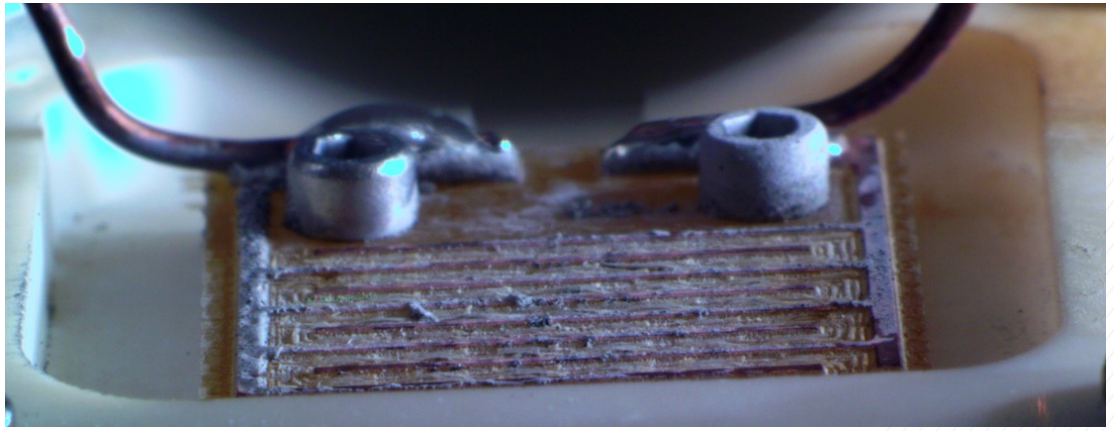
Effective dust repulsion accomplished with 2D EDS

UV Experiments

- 172 nm excimer lamp
- Minimum dust movement with UV-only
- Reduced EDS voltage requirement with photoelectric charging
  - Observed initial dust movement with 50% of voltage
- No latency for effectiveness



Dust on Interdigitated Chip **“before”** EDS and UV

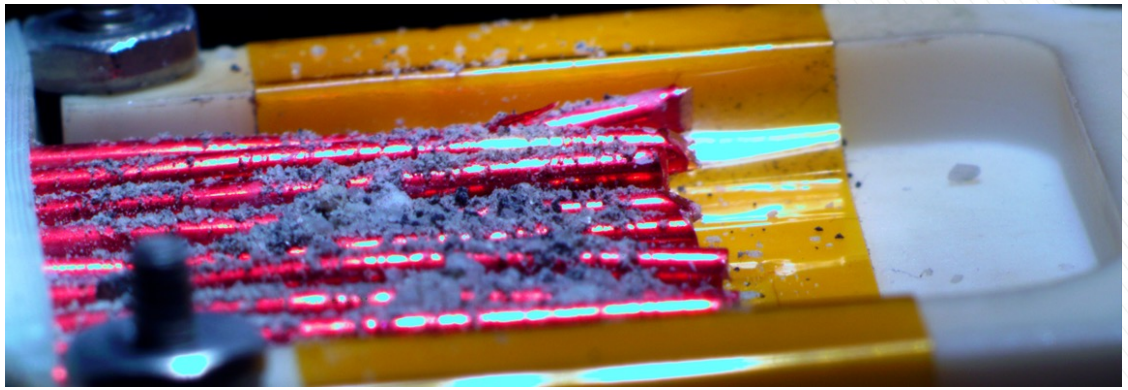


Dust on Interdigitated Chip **“after”** EDS and UV

Using UV enhances EDS effectiveness

3D Electrodes Experiments

- Linear pattern electrodes with alternating potential
- Impacting factors:
  - Diameter
  - Spacing
  - Coating
- Repelled smaller grain off electrode surfaces
- Dust propagated towards tip of electrodes
- UV enhanced effectiveness



3D Electrodes **“before”** EDS and UV

3D Electrodes **“after”** EDS and UV

Successful dust repulsion in desired direction from 3D electrodes

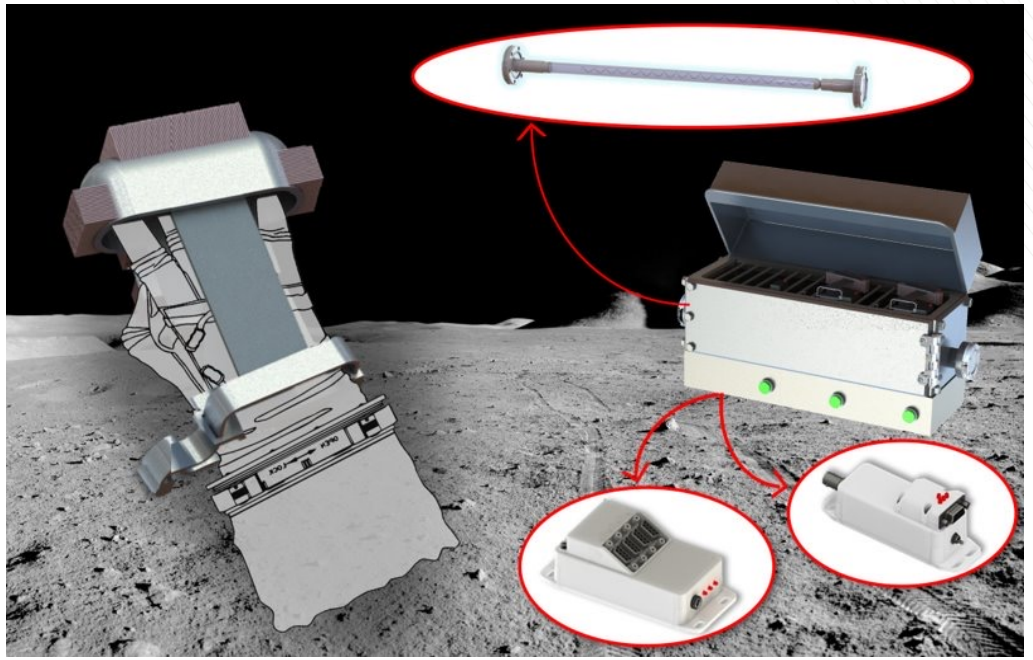
Integrated Bristles-Electrodes Experiments

- Inserted coated electrodes into bristle clusters
- EDS triggered bristle vibration and repel dust out of bristles
- UV effective but caused Thunderon bristles to deform
- Tested alternative bristle material (nylon)
- Ideal bristle material
  - High dielectric permittivity
  - Low conductivity

Successful dust repulsion, need to improve bristle material due to UV

Strategic Knowledge Gaps Addressed

- SKG III-D-1: Lunar dust remediation
  - Demonstrated benefits of UV and EDS mitigation in unison
- SKG III-D-2: Regolith adhesion to human systems
  - Development of dust mitigation tools for astronaut use



BIG Ideas Challenge project coupled with REVEALS and SSERVI provided a path to connect science and technology, delivering solutions for implementation by STMD

Future Work

- Investigate alternate bristle and electrode material
  - Significant interest in Carbon Nano Tubes
- Quantify dust mitigation capabilities of hybrid EDS & UV technologies
  - Effects in 2D and 3D EDS
  - Possibilities of alternate emitter forms
- Develop functional prototype of 3D EDS brush
  - Multiple form factors for different applications

Thank you!