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Electrodynamic Dust Shield for Space Applications

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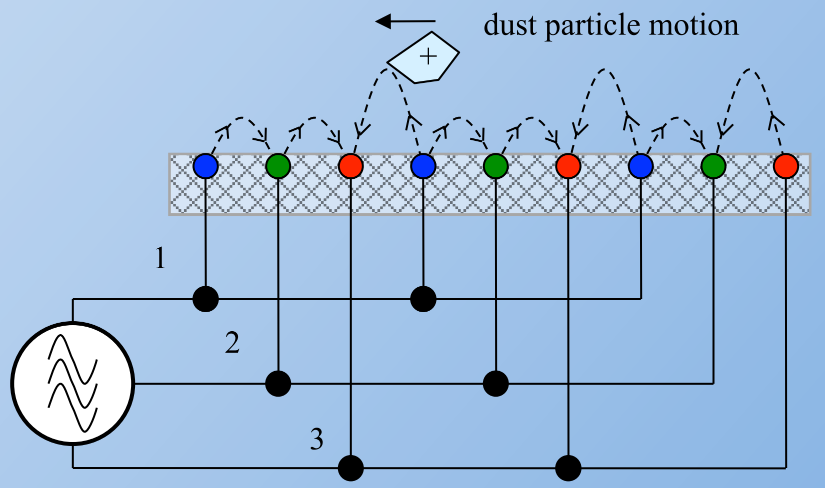
Dust Removal

- NASA KSC's Electrodynamic Dust Shield (EDS) technology removes dust from optical systems and prevents dust accumulation
- Dust Shield is based on the Electric Curtain concept developed at NASA in 1967*
- Masuda at U. Tokyo built first prototypes (1970s)
- NASA KSC and University of Arkansas developed EDS for Mars (NASA Science Mission Directorate NRA – 2003-2006)
- KSC currently developing technology for space applications

* Tatom, F.B., V. Srepel, R.D. Johnson, N.A. Contaxes, J.G. Adams, H. Seaman, and B.L. Cline, "Lunar Dust Degradation Effects and Removal/Prevention Concepts", *NASA Technical Report No. TR-792-7-207A*, p. 3-1 (1967)

Electrodynamic Dust Shield (EDS)

- EDS generates a non--uniform electric field using a varying high voltage on multiple electrodes.
- The non-uniform field generates a dielectrophoretic (DEP) force which moves the particles.
- Low Power, (mA)
  - High voltage (1kV to 4kV)
  - Low current (µA) signal



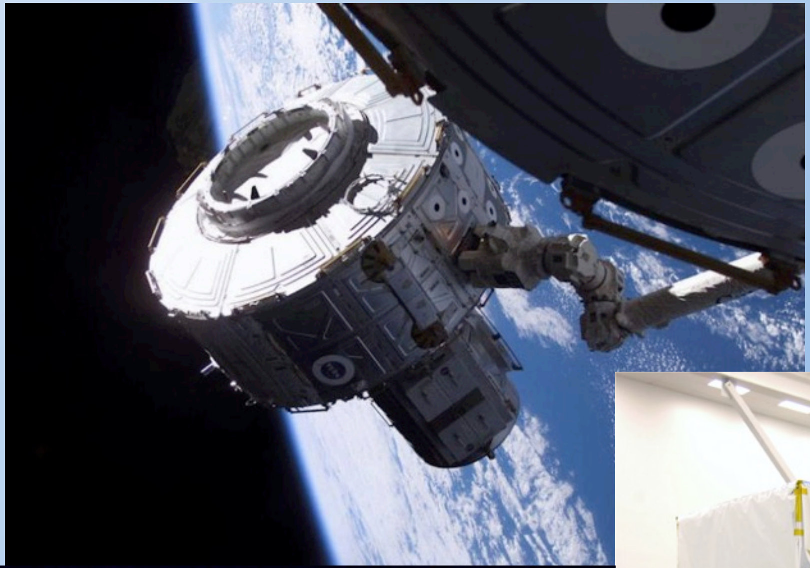
Three-phase electrode pattern with **phase 1** electrodes at V_1=-V, **phase 2** electrodes at V_2=+V, and **phase 3** electrodes at V_3= +V. Charged particles will move in a particular direction.

Materials and Uses

- Conductive electrodes can be embedded in different materials for specific applications
  - Thermal Radiators
  - Space Suit Fabric
  - Visors
  - Camera Lenses
  - Solar Panels

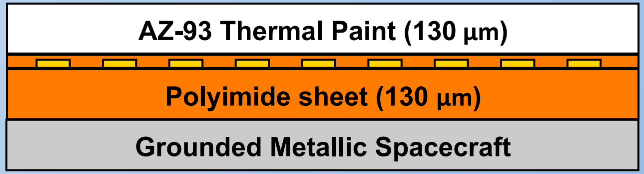
Thermal Radiators

- Two kinds of radiators
  - – Coated metallic surfaces
    - AZ-93 white paint on aluminum
  - – Second Surface Mirrors
    - Silver on FEP film
    - Aluminum on FEP film



Thermal Radiators

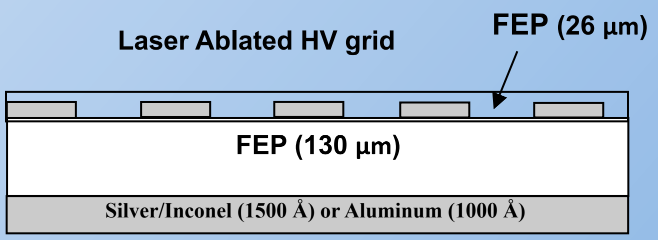
- Coated Metallic Surfaces
  - 130 µm polyimide coating on aluminum surface
  - Copper electrode grid
  - 130 µm coating of AZ-93 inorganic thermal paint (AZ Technology)
    - AZ-93 absorbs 14-16% solar radiation
    - Emits 89-93% internal heat
    - In use on ISS



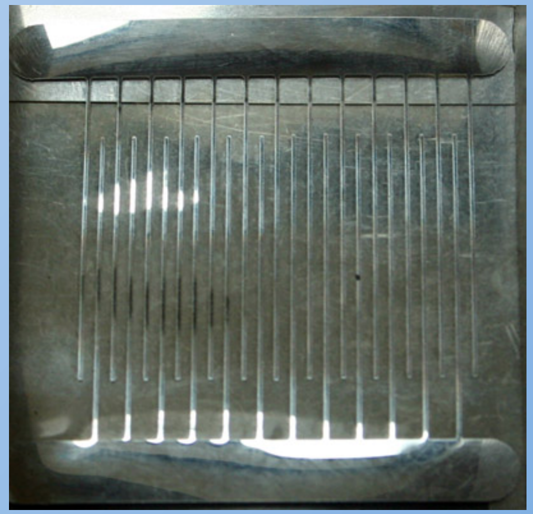
Schematic of the cross-section of a surface with the Electrodynamic Dust Shield embedded into a substrate coated with AZ-93 thermal paint.

Second Surface Mirrors

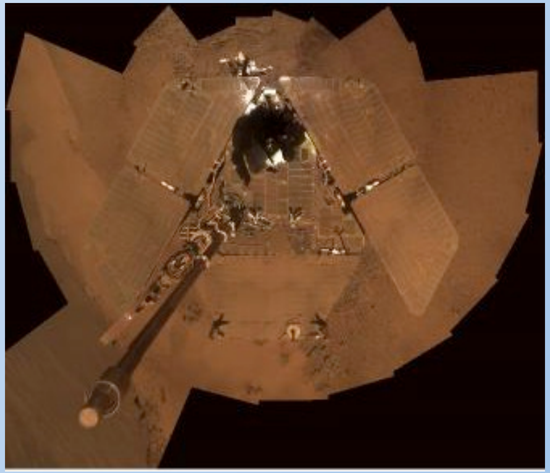
- Flexible, Reflective Materials
  - Fluoroethylene Polypropylene (FEP)
  - Transparent polymer
  - Resists oxygen attack
  - Substrate for vapor-deposited metallic layer
- Structure
  - 1000 Å-1500 Å silver or aluminum layer
  - 130 µm FEP
  - Silver or aluminum electrode grid
  - 26 µm FEP protective layer



Schematic of the Electrodynamic Dust Shield FEP Thermal Radiators

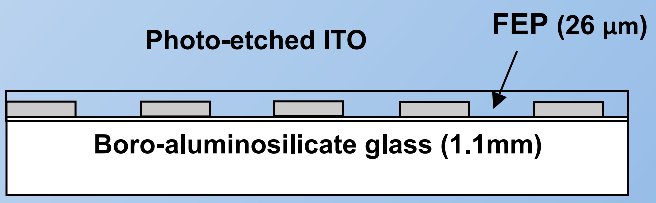


Solar Panels, Cameras, Visors



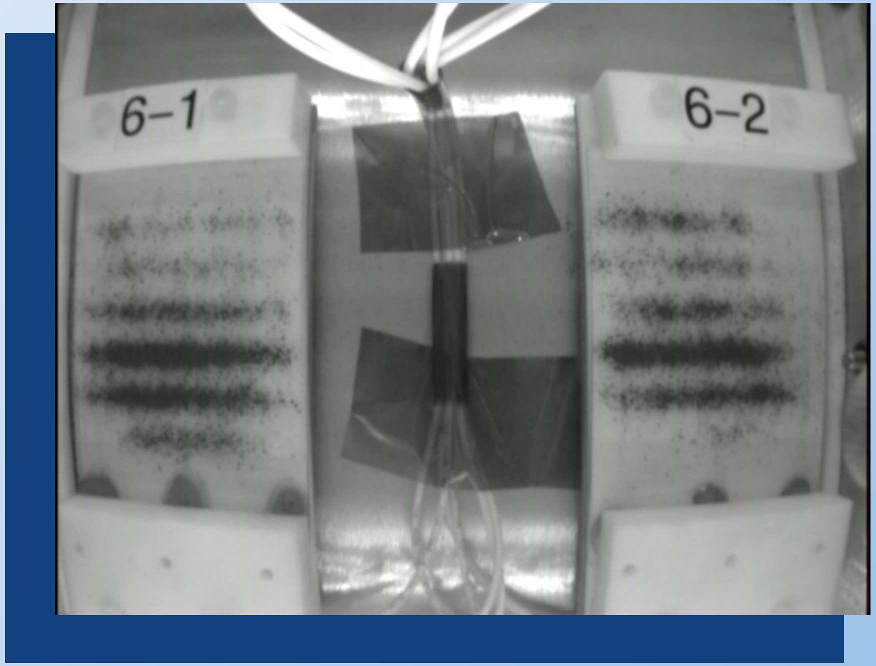
Transparent Substrates

- ITO on Glass
  - Three-phase dust shield
  - Indium tin oxide (ITO) transparent electrodes
  - Spiral pattern configuration on a glass substrate



Schematic of the Electrodynamic Dust Shield Transparent ITO on glass

Video Clip: Apollo Sample



- Real time video clip showing Apollo sample removal in vacuum chamber during RGF 2 at lunar gravity. An initial polarization phase removes some dust.
- The video cuts to the dust shield activation phase, which removes dust in less than one second

Advances

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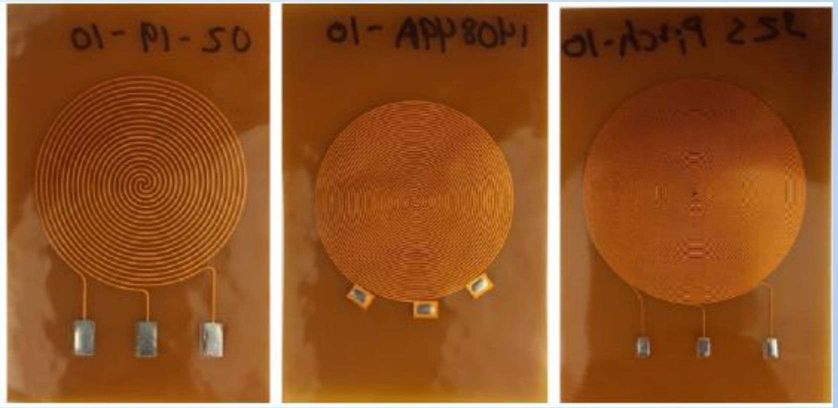
- Power Supply
  - Decreased mass and volume
  - Completed unit expected to be less than 500g

Advances

- Photo-lithography
  - used in copper on polyimide film panels of increasing density (electrode spacing left to right: 530µm, 215µm, 160µm)

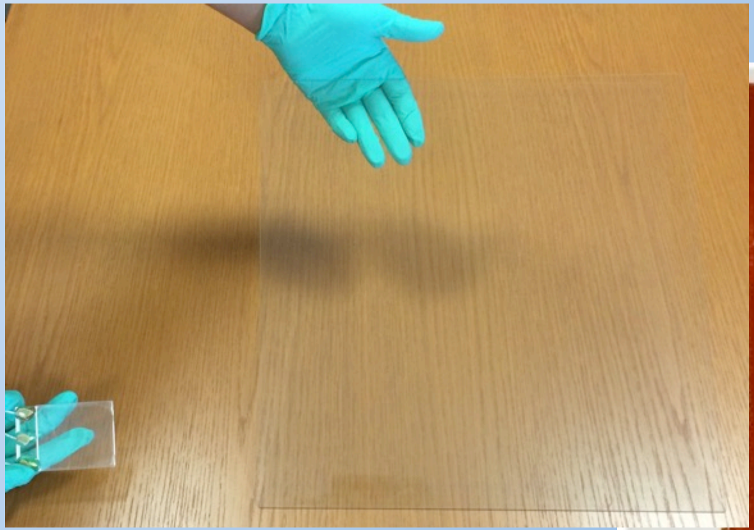


  - Electrode spacing is one factor in DEP generated by non-uniform, varying E-field.

Advances

- Shields
  - Increase in available size
  - Same power supply

    40 cm^2 glass panel to
    1200 cm^2 glass panel

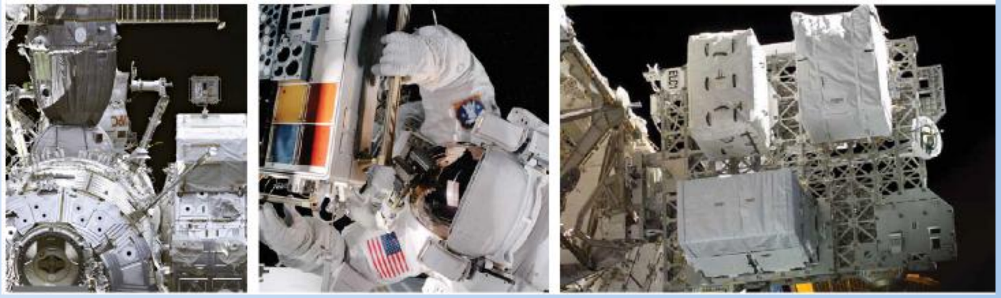


  - Decrease in reflection

    8% incident reflection to
    1% incident reflection

Future Testing

- Materials on International Space Station Experiment (MISSE)



- Test technology to prove it on platform that mimics aspects of the lunar environment
- Raise TRL to enable use in future landers, rovers and equipment