Conductivity Measurements for Lunar Orbital Platform-Gateway (LOP-G) Materials

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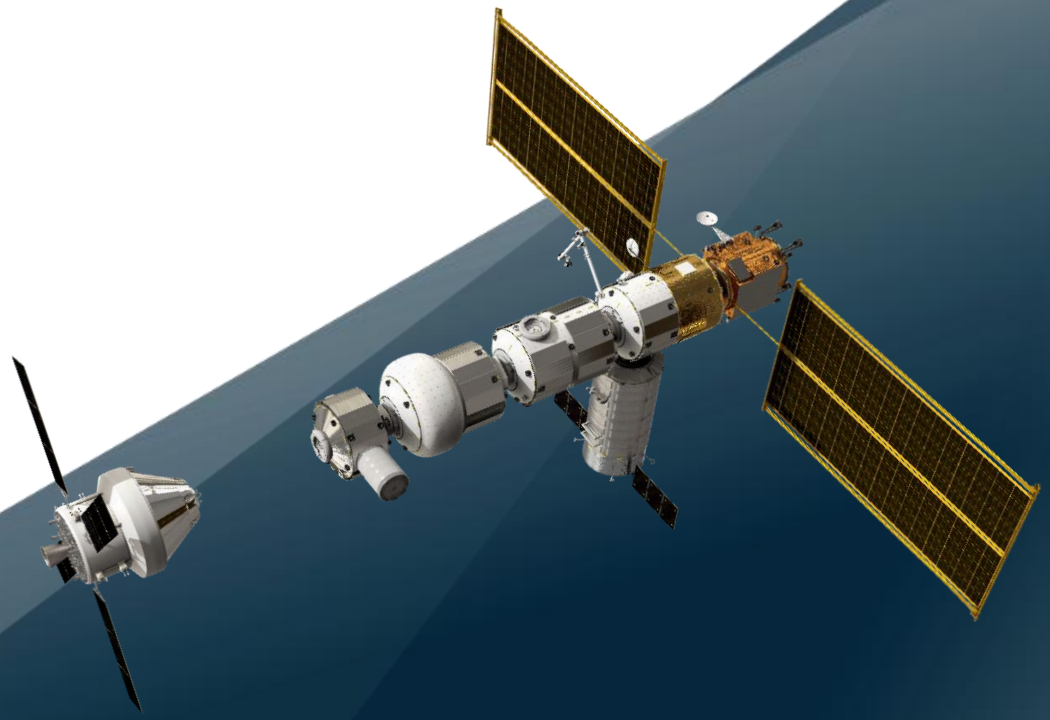

MATERIALS PHYSICS GROUP

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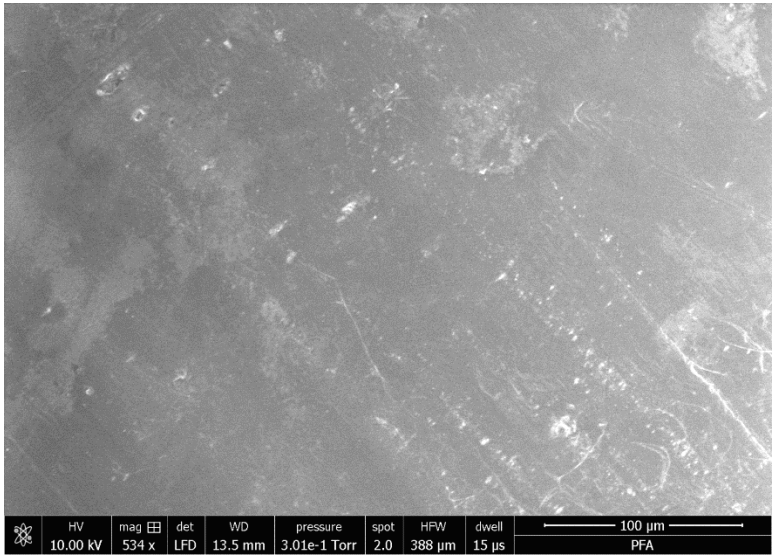
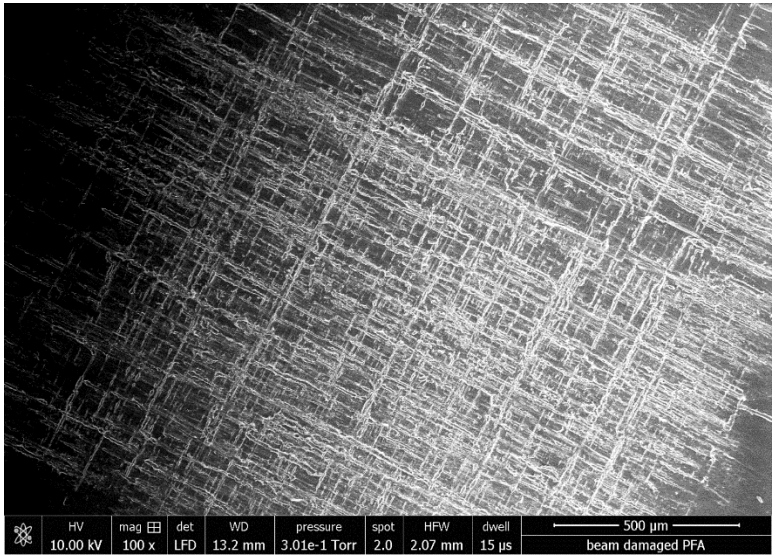
Gateway and Electrostatic Breakdown

- **Lunar Orbital Platform-Gateway** (LOP-G)
  - Small space station intended to orbit the moon
  - Susceptible to great amounts of solar radiation
- **Electrostatic Breakdown** (ESD)
  - Material damage caused by a buildup of charge
    - Can occur for materials that are unable to disperse charge easily (low conductivity)
  - May result in an unintended electrical path within materials or between components (arcing)
  - ESD can lead to circuitry or structural damage, possibly resulting in mission failure
- **Docking Issue**
  - Occurs when two spacecraft of different potentials meet each other
  - This may result in electric discharge between the two bodies

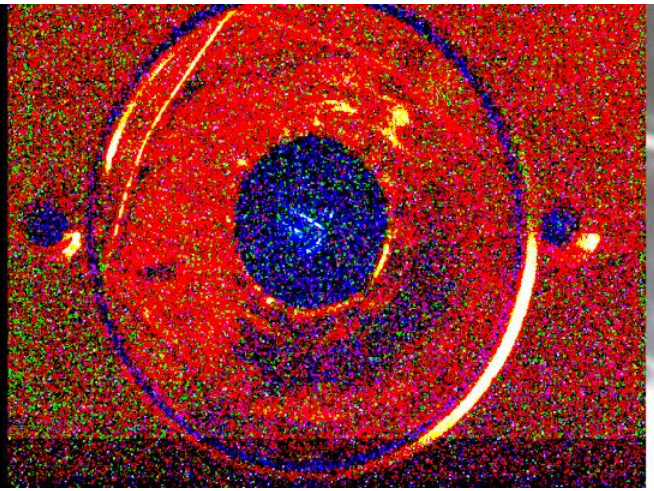
Example of ESD – PFA undamaged vs beam damaged PFA

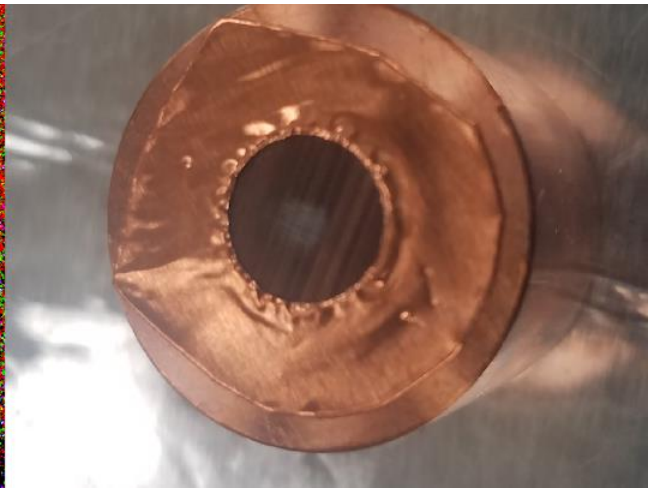
Undamaged pfa vs beam damaged pfa





Examples of ESD – Arc and Spark PFA

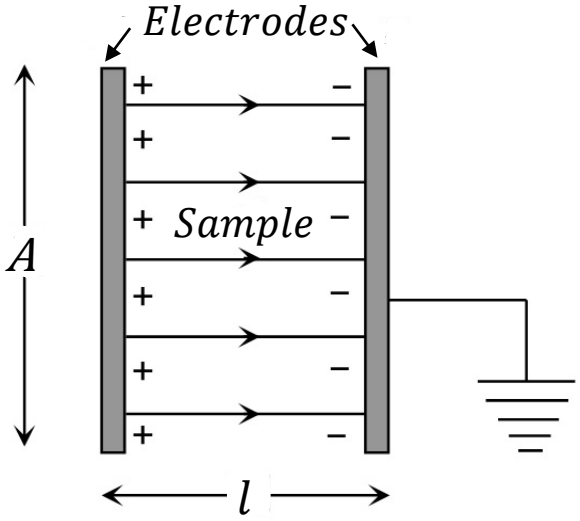


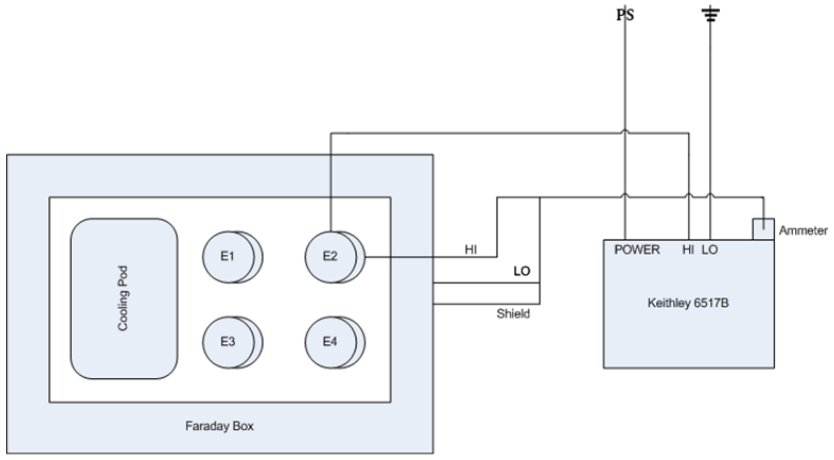


Conductivity

$$V = IR \qquad \sigma = \frac{l}{RA} \qquad J = \sigma E$$

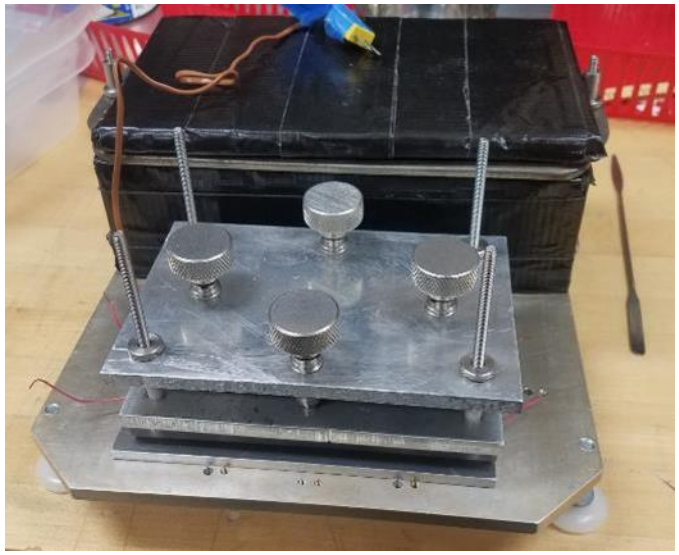
- **Conductivity** is a measurement of how easily an electric charge can pass through a material
  - Low conductivity materials make it difficult for charge to move through, resulting in a buildup of charge





3 Methods

- **Setup 1**: voltage supplied by Keithley 6517b
  - Low conductivity materials; $\sigma < 10^{-16}\ (\Omega \cdot cm)^{-1}$
  - Method uses increasing voltage steps from lower bound to upper bound
- **Setup 2:** voltage supplied by 192 V battery pack
  - Battery reduces noise
- **Setup 3:** voltage supplied by Keithley 199
  - High conductivity materials; $\sigma < 10^{-2}\ (\Omega \cdot cm)^{-1}$

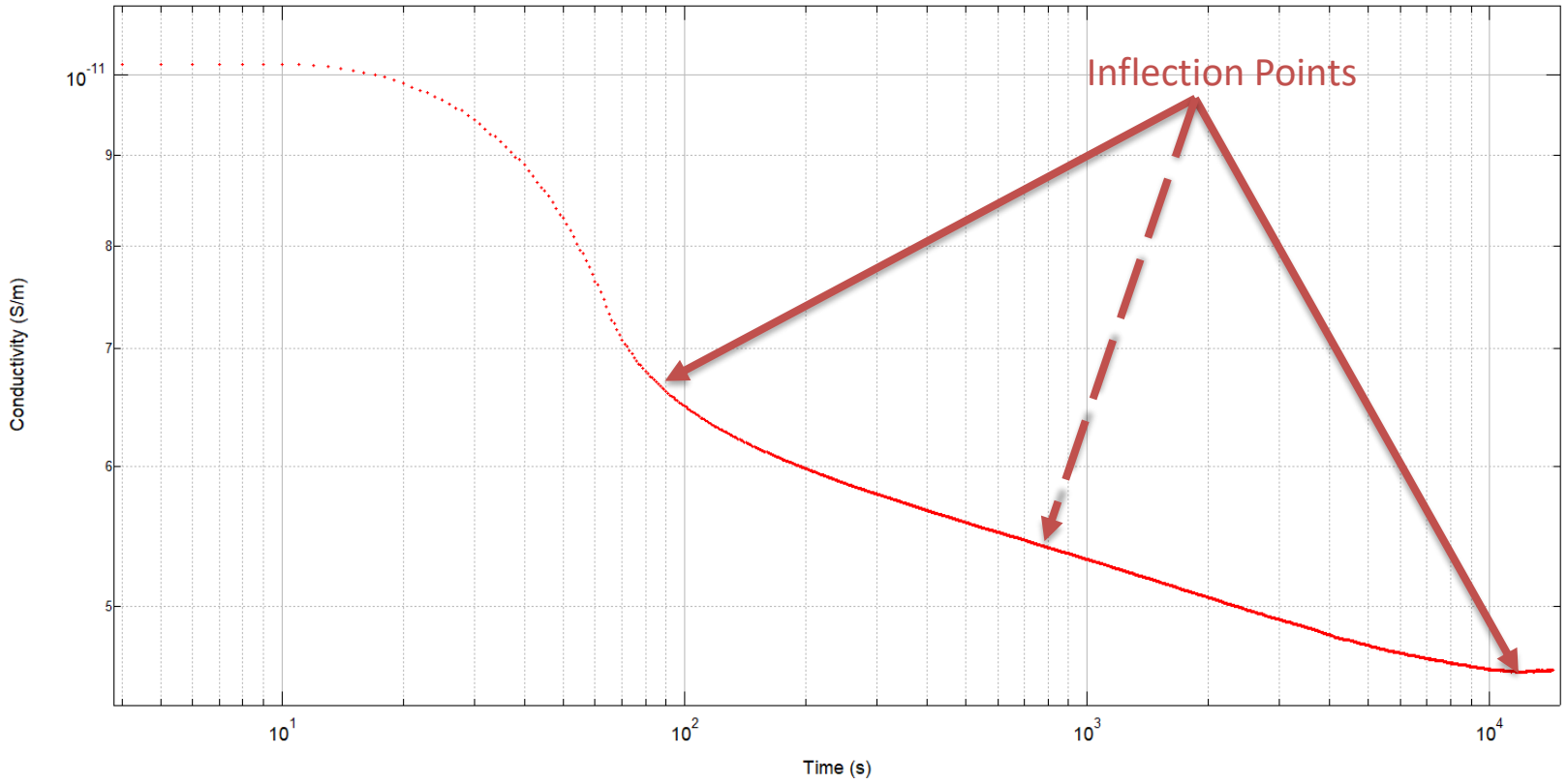


Gateway Sample Candidates

- Samples we will look at:
  - **Polymers**
    - Silicon Rubber (PVMQ– Phenyl-Vinyl-Methyl-Polysiloxane)
    - PFA (perfluoroalkyox polymer)
  - **Composites**
    - PTFE (polytetrafluoroethylene or Teflon) on aluminum
    - Braycote 815z on AISI 9310 steel
      - Perfluorinated polyether-based polymer grease

Analysis

- Labview was used to collect data
- Analysis was done in Igor Pro



Results

- PVMQ
  - $\sigma = 2.4631 \times 10^{-12}$ S/cm
  - Standard deviation = $2.1978\ 10^{-11}$ S/cm
- PFA
  - $\sigma = 2.8409 \times 10^{-18}$ S/cm
  - Standard deviation = 2.1186×10^{-17} S/cm
- PTFE 736
  - $\sigma = 5.4645 \times 10^{-15}$ S/cm
  - Standard deviation = 8.2645×10^{-15} S/cm
- Braycote 815z (954)
  - $\sigma = 4.6729 \times 10^{-6}$ S/cm
  - Standard deviation = 1.3755×10^{-5} S/cm

Conclusion

- **Low conductivity**:
  - PVMQ
  - PFA
  - PTFE
- **High Conductivity**:
  - Braycote (Teflon)
- Low conductivity materials should be used inside the station
  - Limits exposure to radiation, making it less susceptible to spacecraft charging
  - Most likely to become damaged as it dissipates charge less effectively
- Higher conductivity materials can possibly be used outside the station

Future Work

- More gateway samples
  - Different testing of materials (CVC)
    - Constant Voltage Chamber
  - ESD
    - Tests for electrostatic breakdown of material
- Electron Yield of materials

Acknowledgements

- Research supported by NASA Marshall
- Images taken in microscopy lab
- Docking image from European Space Agency https://www.esa.int/ESA_Multimedia/Images/2019/05/Gateway_with_Orion_docking_transparent_background