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The Dynamic Interplay Between Spacecraft Charging, Space Environment Interactions and Evolving Materials

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**Abstract**

While the effects on spacecraft charging from varying environmental conditions and from the selection of different constructive materials have been studied extensively, modification of materials properties by the space plasma environment can also have profound effects on spacecraft charging. This presentation focuses on measurement methods and modeling employed to assess the effects of environment-induced material modifications on physical properties relevant to spacecraft charging simulations. It also reviews several specific studies in which environment-induced material modifications have significant impact on predicted spacecraft charging.

Given the increasingly demanding nature of space missions, there is clearly a need to extend our understanding of the dynamic nature of material properties that affect spacecraft charging and to expand our knowledgebase of materials’ responses to specific environmental conditions so that we can more reliably predict the long term response of spacecraft to their environment.

**Case III: Radiation Effects**

Higher energy radiation causes direct modification of the materials through bond breaking or deposition of energy into conduction electrons.

- **Large Dose** (>106 Rad)
  - Mechanical and Optical Materials Damage
  - Medium Dose (<106 Rad)
  - Mechanical Modification of Electron Transport and Emission Properties
  - Low Dose Rate (>105 Rad)
    - Radiation-induced Conductivity (RIC)
      - Temperature dependent

**Case IV: Temperature Effects**

Many materials properties can change dramatically over the extreme temperature ranges encountered by spacecraft, from <30 K to >1800 K. Electron transport properties of insulators are particularly susceptible to temperature changes.

**Case V: Combined Temperature and Dose Effects**

Case III factors many orders of magnitude in the temperature range typically encountered by spacecraft.

**Conclusions**

- Satellites are complex and require...
  - Complex materials configurations
  - More power
  - Smaller, more sensitive devices
  - More demanding environments
  - There are numerous clear examples where accurate models require accurate dynamic properties
  - Environment/Spacecraft Configuration feedback mechanisms can have numerous new challenges.