Defect-Driven Dynamic Model of Electrostatic Discharge and Endurance Time Measurements of Polymeric Spacecraft Materials

Charles Sim  
_Utah State University_

Alec Sim  
_Utah State University & Irving Valley College_

JR Dennison  
_Utah State University_

Matthew Stromo  
_Utah State University and College of the Desert_

Follow this and additional works at: https://digitalcommons.usu.edu/mp_presentations

Part of the Physics Commons

Recommended Citation

Sim, Charles; Sim, Alec; Dennison, JR; and Stromo, Matthew, "Defect-Driven Dynamic Model of Electrostatic Discharge and Endurance Time Measurements of Polymeric Spacecraft Materials" (2012). 12th Spacecraft Charging Technology Conference. Presentations. Paper 54.  
https://digitalcommons.usu.edu/mp_presentations/54
Defect-Driven Dynamic Model of Electrostatic Discharge and Endurance Time Measurements of Polymeric Spacecraft Materials

USU Materials Physics Group

Charles Sim, Alec M. Sim, JR Dennison, and Matthew Stromo

University of Utah, Logan, Utah 84322-4415

Phone: (859) 559-3302, FAX: (435) 787-2492, E-mail: charles.the.sim@gmail.com

Abstract

Electrostatic aging causes breakdown in insulating materials. Aging in the spacecraft environment is induced by high energy particle flux into or through the material, medium to high applied fields, and contact initiated. It has been shown by many authors that electrical aging can be characterized by the rate of bond breaking, the fracture created within the material, and bond stress due to local and applied fields.

Assuming that an applied field produces a pressure on a defect, we find that the increase in trap concentration (rate of bond breaking) as a function of time and temperature.

The measured endurance time data in Figure 11 shows that there is a distinct transition between two separate regimes, suggesting that a new composite model incorporating at least two breakdown mechanisms is required. A two-breakdown model is proposed in Eq. 18 in Fig. 11. In the process of breakdown of the material is due to creation of new traps resulting from damage or from a delamination, which is the most important line on this graph. The critical electric field strength required for breakdown in common spacecraft environments is similar to that for dielectric breakdown in thin films.

Analysis of Breakdown Results

Breakdown results include a critical electric field strength required for breakdown in the range of 172 to 280 MV/m. Breakdown tests conducted in the range of 120 to 260 MV/m were determined using a test chamber. Maximum charge densities observed were the most important line on this graph. The critical electric field strength required for breakdown in common spacecraft environments is similar to that for dielectric breakdown in thin films.

Electrostatic Discharge Theory

Electrical aging causes breakdown in insulating materials. Aging in the spacecraft environment is induced by high energy particle flux into or through the material, medium to high applied fields, and contact initiated. It has been shown by many authors that electrical aging can be characterized by the rate of bond breaking, the fracture created within the material, and bond stress due to local and applied fields.

Energy loss and energy transform into heat. In general, the material has been shown to be characterized by the rate of bond breaking, the fracture created within the material, and bond stress due to local and applied fields.

The measured endurance time data in Figure 11 shows that there is a distinct transition between two separate regimes, suggesting that a new composite model incorporating at least two breakdown mechanisms is required. A two-breakdown model is proposed in Eq. 18 in Fig. 11. In the process of breakdown of the material is due to creation of new traps resulting from damage or from a delamination, which is the most important line on this graph. The critical electric field strength required for breakdown in common spacecraft environments is similar to that for dielectric breakdown in thin films.

The measured endurance time data in Figure 11 shows that there is a distinct transition between two separate regimes, suggesting that a new composite model incorporating at least two breakdown mechanisms is required. A two-breakdown model is proposed in Eq. 18 in Fig. 11. In the process of breakdown of the material is due to creation of new traps resulting from damage or from a delamination, which is the most important line on this graph. The critical electric field strength required for breakdown in common spacecraft environments is similar to that for dielectric breakdown in thin films.

The measured endurance time data in Figure 11 shows that there is a distinct transition between two separate regimes, suggesting that a new composite model incorporating at least two breakdown mechanisms is required. A two-breakdown model is proposed in Eq. 18 in Fig. 11. In the process of breakdown of the material is due to creation of new traps resulting from damage or from a delamination, which is the most important line on this graph. The critical electric field strength required for breakdown in common spacecraft environments is similar to that for dielectric breakdown in thin films.

The measured endurance time data in Figure 11 shows that there is a distinct transition between two separate regimes, suggesting that a new composite model incorporating at least two breakdown mechanisms is required. A two-breakdown model is proposed in Eq. 18 in Fig. 11. In the process of breakdown of the material is due to creation of new traps resulting from damage or from a delamination, which is the most important line on this graph. The critical electric field strength required for breakdown in common spacecraft environments is similar to that for dielectric breakdown in thin films.

Acknowledgements

Research was supported by funding from the NASA/WST Electrical Systems Working Group at Goddard Space Flight Center, a U.S. office grant, and the Utah State University Physics Department Howard L. Blood Memorial Scholarship.

References