The Effects of Radiation-Induced Defects on The Electrostatic Discharge of polymers

Kip Quilter, Alexandra Hughlett, J.R. Dennison

Materials Physics Group, Physics Department, Utah State University
Tests were done to see how radiation-induced defect states affect the electrostatic discharge (ESD) breakdown potential of a material.

Electrostatic discharge is one of the most common reasons for spacecraft failures.
Defect states

Visualization 2-D lattice defect states

Symmetry of movement in lattice

Thermally assisted hopping conductivity
APPLYING A VOLTAGE

Creates electrically assisted hopping conductivity

Makes current flow in one direction

Energy of electron is equal to $dE_{eq}$
Creates electrically assisted hopping conductivity

Makes current flow in one direction

Energy of electron is equal to $d\text{Eq}$
ESD occurs when electrons have enough energy to excite other electrons and freeing more and more electrons.

ESD is seen as an extreme limit of conductivity.
ESD is determined when an ohmic slope is observed and is set by the current limiting resistors.
Beta Radiation

- Known to cause more defect states
- Defects are normally more shallow
- Less energy needed of ESD
Method

- Backed out samples to remove moisture
- Exposed samples to 5K Gy of radiation in vacuum using a strontium-90 source creating more localized defects sights
- Ran test in ESD chamber which is set up in a parallel plate geometry voltage steps up at rate of 20 volts every 4 seconds until break down
- The thickness of the sample is then measured and used to calculate the electric field strength at breakdown
- ESD Assembly  
  A. adjustable pressure springs  
  B. insulating layer  
  C. cryogen reservoir  
  D. thermally conductive, electrically isolating layer  
  E. sample and mounting plate  
  F. sample  
  G.
RESULTS

Probability of ESD for irradiated and unirradiated LDPE

- LDPE Irradiated
- Normal LDPE
- Error in Irradiated LDPE
- Error in normal LDPE

Electric field [MV/m]
Probability
CONCLUSION

- Found LDPE that has been exposed to radiation is more likely to have ESD to occur at lower electric fields than standard LDPE.

- Tests need to be performed on other polymers that have different tolerances to radiation.