



## Electric Field Dependence of the Time to Electrostatic Breakdown in Insulating Polymers

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### ***Abstract***

Electrostatic breakdown can be thought of as the point at which a buildup of local defects in insulators leads to a catastrophic change in electrical conductivity. Defects can be produced by temperature, radiation, or a prolonged exposure to constant electric fields. The endurance time is the time it takes to generate enough defects to create a conduction path for electric current to flow more readily. The literature for electrostatic breakdown in polymeric highly disordered insulating materials discusses two competing theories for electrostatic breakdown, based on generation of either recoverable defects or irrecoverable defects. Such defects in the polymer chains can be produced by the electric field and result in localized trapped states for the conduction electrons. Both mechanisms are characterized by the density of electron traps and the corresponding energy to create such defects. We propose a hybrid thermodynamic model for the electric field aging process that predicts the mean time to failure (the endurance time) as a function of applied electric field and temperature. The hybrid model incorporates both types of defects, and proposes an interdependence of the two production mechanisms. Measurements of the dependence of endurance time on electric field in the insulating polymer Low Density Polyethylene (LDPE) were fit against this hybrid model. Higher electric fields produced breakdown times of 4 s to 1 hr and were associated with creation of irrecoverable defects. Lower electric fields resulted in breakdown times on the order of 2 hours to several months; these were associated with recoverable defect generation. Intermediate range electric fields produced interesting results that illustrate the interdependence of the two types of defects. We end with consideration of an important application of the research. Charge buildup on insulating materials in the space environment can produce long exposure to electric fields, which can lead to breakdown at lower fields. This charge buildup is the leading cause of spacecraft failure due to space environment interactions. Understanding the electric field dependence of the time to electrostatic breakdown can assist designers in selecting appropriate materials for spacecraft construction and in mitigating these destructive processes.