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Pre-breakdown Arcing in Dielectrics under Electric Field Stress[1]

ALLEN ANDERSEN, JR DENNISON, Utah State University — High electric field stress phenomena associated with electrostatic discharge (ESD) were studied for dielectrics, including low density polyethylene, polyimide, and disordered SiO2. ESD is the free flow of current through a dielectric that has broken down due to high electric field stress. The critical field for ESD was determined by increasing the voltage across 25 μm samples in 20V steps, and monitoring the leakage current. A simple parallel-plate capacitor geometry was used, under high vacuum, to reach fields of up to 590MV/m. Prior to destructive ESD breakdown, pre-breakdown current arcs can occur through a dielectric. For polymers, pre-ESD transient current spikes were observed with measurements at 0.25Hz and 10kHz. The field at which pre-breakdown arcing begins was compared to the critical ESD field for each material studied. Arcing was also observed as part of endurance time measurements, where the sample is held at a fraction of the critical breakdown field and wait time to ESD is measured. These pre-ESD discharge phenomena are explained in terms of breakdown modes and defect generation on a microscopic scale. Pre-breakdown arcs are understood in terms of thermally repairable defects, while ESD requires the creation of defects related to bond breaking in the material.

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Allen Andersen
Utah State University

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