Electrostatic Surface Charge Decay of Floating Dielectrics

Z. Cardenas*, B. Esser*, I. A. Aponte*, M. LaPointe*, J. C. Dickens*, J. J. Mankowski*, J. Stephens*, D. Friesen**, N. Koone**, D. Hattz**, C. Nelson**, A. A. Neuber*

Texas Tech University, Lubbock, TX*

Pantex, Amarillo, TX**

Electrostatic surface charge accumulation on dielectric materials, followed by surface charge decay, is investigated. This work focuses on charging floating dielectric surfaces to the limit of electric breakdown in atmospheric air in humid and dry conditions, succeeded by the slow charge decay on the timescale of minutes to hours. The mechanisms leading to reducing the surface charge density include surface charge cancellation from ions attracted from the surrounding gas medium as well as charge migration along the dielectric. A 100 mm diameter sphere of varying materials (Teflon, Acrylic, and metal as a reference) was triboelectrically charged to tens of kilovolts and allowed to decay uninterrupted in relative humidities of 40% and 12%.

While the metal sphere charge decay was largely unaffected by the humidity, the dielectrics exhibited a much faster surface charge density decay in humid conditions, particularly when the surface charge initially covered only a fraction ~ 10 to 25% of the sphere. That is, the humid conditions cause moisture layers to form on the dielectric's surface, impacting the surface conductivity of the material and allowing charge to redistribute along the surface. For instance, one finds an exponential dependence of the conductivity on the number of adsorbed water layers for Teflon and quartz reported in the literature.

For acrylic, in humid air, an initial drop in voltage upwards of 30% of the initial charging voltage was observed over 5 seconds. This rapid voltage drop is attributed to charge redistribution occurring on a much faster time scale than the air-ion to surface charge recombination. Further experimentation on decay behavior from uniformly charged dielectric spheres and partially charged spheres was conducted. This work provides details on the nonlinear surface conductivity, which is found to be electric field dependent.

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