# Characterization and Modeling of Electrostatic Discharges on Floating Dielectric Materials

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Electrostatic Discharge (ESD) waveforms are measured for polymeric materials – PTFE, PMMA, PA6 – with high-speed (sub-nanosecond) current viewing resistors (CVR). These waveforms are used to create lumped element models which capture the behavior in addition to a comparison to a drift-diffusion numerical simulation. Cylindrical dielectric samples without a well-defined ground (i.e. samples are 'floating') are of particular interest in this study. The ~100 mm diameter samples are charged primarily via triboelectric means to high voltage – greater than 20 kV. The surface charge distribution is mapped before and after a discharge to determine energy lost to establishing the spark, conduction to ground, and radiation – captured with a B-Dot probe. A three-axis – R, Z, and rotational Phi – movement system was created to perform the mapping of charges and control the approach speed of the discharging electrode. Discharge electrodes consisting of spheres of 5-20 mm diameter and pointed electrodes with tip radii ranging from 0.1 to 1 mm are used with approach speed ranging from 10 to 150 mm/s. The radiated field from the B-dot probe exhibits a sharp peak at ~1.5 GHz, temporally coinciding with peak current. Discharge waveforms are similar in shape between materials and charging polarities; however, peak current and length change. For instance, PTFE charged negatively creates a spark 150-200 ns in length, whereas positively charged PMMA creates a spark 100-150 ns in duration. Peak currents, on average, are similar between materials and polarity, ~0.2 A, and peak dI/dt range from 0.3 to 0.57 A/ns for PTFE and PMMA, respectively.

Through pre- and post-mapping of the surface charge, the discharged area of the charged dielectric is captured. The discharged areas range from 4 to 8 $cm^2$, with the charge maps revealing extended surface tracking mainly parallel to the symmetry axis of the cylinder.

With the spark length mainly dependent upon the approach speed for the same voltage, namely that faster approach speeds result in shorter sparks, one may expect lower speeds to exhibit lower peak current – that is, a longer spark would be suspect of losing more energy in establishing the spark. However, in experimental studies, this doesn't always occur. While a Rompe & Weizel spark model with an RC object model captures the basic behavior of the discharges, the drift-diffusion model reveals the fundamental physics at play. The numerical simulation captures the electron and ion motion/generation/loss and includes modeling the emission process of charges from the dielectric surface.

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