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Effects of Acoustic Coupling Layer Electrical Conductivity on Pulsed Electroacoustic Measurements

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Abstract

Determining the spatial distribution and evolution of embedded charge in thin dielectric materials has important applications in high-voltage DC power cable insulation, high-power electronic device, semiconductor, high-energy and plasma physics apparatus, and spacecraft industries. Pulsed Electroacoustic (PEA) measurements nondestructively probe internal charge distributions. This is achieved by applying a voltage pulse across a charged dielectric material. The pulsed electric field interacts with the embedded charge, creating an acoustic pressure wave that is detected by a piezoelectric sensor. The sample is placed between two electrodes in a parallel plate capacitor configuration. The spatial resolution of PEA measurements depends largely on pulse width, but can be further limited by the electrical properties of the coupling material adhering the sample to the electrodes. Our investigations studied the effects of coupling material, electrical conductivity, and thickness to optimize electrical impedance matching and voltage drop across the sample to improve PEA signal fidelity and resolution. Thin layers of cyanoacrylate (super glue), light machine oil, and silicone oil were used to adhere samples to Al disc electrodes used in the PEA sample stack. Typical adhesive layers are 5-10 µm thick; additional pressure was applied here to achieve layers of ~1 µm, as measured using optical thin film interference. Electrical properties of the coupling materials were also measured. The effects of adhesive thickness on spatial resolution and amplitude of signal for the PEA system were measured and simulated using a pulse with signal rise time of 0.4 ns and a pulse width at half height of 0.7 ns giving a characteristic frequency of ~100 MHz.