Dielectric Response of Polymers at High Electric Field

Abstract: There has been extensive research done on the dielectric behavior of polymers and ceramics using impedance spectroscopy, but mostly at low electric fields. A fundamental understanding of the dielectric response in terms of dielectric properties, conduction mechanisms, leakage current, and space charge development has been developed. Various electrical characterization techniques available at Penn State have been used, such as thermally stimulated depolarization currents (TSDC), I-V measurements, dielectric displacement vs. electric field (DE), and impedance spectroscopy (IS) at high fields. Combining the different techniques allowed us to probe the different potential conduction mechanisms that limit capacitor reliability. The model films we propose to study are synthesized with polyetherimide (PEI), which is a high temperature polymer for power capacitor applications. The main goal up to the current point was to determine the impact of electrodes and polymer surface modification on leakage current. In TSDC measurements, one current peak is observed for all PEI samples regardless of electrode type close to the glass transition temperature (217°C). Aluminum as the electrodes metal limits the depolarizing currents compared to the silver electrodes. In-IV measurements, significant leakage current is observed under high electric fields and high temperatures. The trend was not linear between the applied electric field and the current density which means that the conduction mechanism is not ohmic (which kind of conduction mechanism is involved here are still in the exploratory stage). The addition of a guard ring did not bring any significant improvement to the leakage current measurement.