INVESTIGATION OF MECHANISMS ASSOCIATED WITH EPOXY RESIN NANOCOMPOSITE DIELECTRICS

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject: ELECTRIC POWER ENGINEERING

The original of the complete thesis is on file
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December 2009
(For Graduation December 2009)

ABSTRACT

Epoxy resin has been widely used in the power industry for its superior insulating properties. By mixing micron scale fillers into epoxy resin, better thermal and mechanical properties can be achieved. However, in most cases, the introduction of the fillers will deteriorate epoxy resin's insulating properties. With the development of nanotechnology, the inclusion of nanometric fillers in polymers to form nanodielectrics has drawn much attention. the size of fillers reduces to nanometric level, the interface between the particles and polymer becomes the dominant factor in determining the composite's bulk properties.

This study examines the dielectric properties of epoxy resin based nanocomposites. Practical measurements show that nanocomposites have superior short-term breakdown strength and voltage endurance capability over microcomposites. The particles dispersion, the curing characteristics, and free volume of nanocomposites were first examined and compared to microcomposites. The results show that the nanoparticles could affect epoxy resin's crosslink density and increase the free volume of the composites. Dielectric spectroscopy measurements indicate that at elevated temperatures, nanocomposites have lower chain activation energy compared to microcomposites. Mechanistic study reveals that space charge plays a significant role in composite's properties. In nanocomposites the charge accumulation is reduced and the time constant of charge dissipation is much shorter. Furthermore, space charge in nanocomposites is featured a deeper trap depth of 1.57 eV compared to a trap depth of 1.21 eV in microcomposites. It was concluded that the interface between the epoxy resin matrix and the nanoparticles provides a higher conductivity path for the space charge to transport. The nanoparticles work as scattering centers and lead to the homocharge accumulation near the electrodes in nanocomposites. The improved breakdown strength and voltage endurance in nanocomposites is related to the shielding effect from the homocharge.