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Developing electrical tree resistant epoxy nanodielectrics with improved thermal properties

Hank, Andrew Marvin

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Abstract:

Two of the main contributors to high voltage insulation failure are thermal and electrical stresses. The failures may be mitigated by using nanodielectrics. The enhanced effect of nanoparticles in nanodielectrics is attributed to an interaction zone/interphase around each individual nanoparticle between the nanoparticle and host polymer. However, particle clumping or agglomerates are a major challenge in nanodielectric technology. In this work mitigation of the clumping challenges was explored through Rheology in determining optimal particle loading levels. The nanodielectrics studies were Boron Nitride and Carbon Nanospheres in Araldite Epoxy. The rheology results indicated an optimal loading level of 1.09 vol % to 1.35 vol% for Boron Nitride in Epoxy and 0.33 vol% for Carbon Nanospheres in Epoxy. Microscopy, dielectric spectroscopy, electrical tree characterisation, thermal expansion and laser flash analysis were used to validate the efficacy of the rheology results. The results indicated improved properties of the resultant dielectric such as; increased mechanical stiffness, increased electrical resistance and the percolation threshold, partial discharge suppression and increased thermal conductivity at the glass transition temperature. This study has established a rheology-based technique incorporated in the manufacturing process to determine the optimal filler loading of C/Epoxy and BN/Epoxy nanodielectrics. Future work is recommended as investigating either new particle types such as Sulphur hexafluoride in Carbon Nanospheres or mixtures of Carbon Nanospheres and Boron Nitiride.