Partial Discharge Characteristics of Ferroelectric Ceramics

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Piezoelectric ceramics are widely used in many applications such as sensors, motors and actuators. Potential materials have to fulfill high requirements in terms of electrical and mechanical reliability to make them suitable for usage on the industrial scale. However, material defects such as small pores and cracks are unavoidable in ceramics production making them susceptible to electrical and mechanical failure in service. Dielectric breakdown during electric field application is commonly preceded by repeated occurrences of partial discharges (PD), which are determined by the local electric field distribution and the surface conduction characteristics of the discharging pores. Thus PD measurement has been proven to be an effective and non-destructive tool for predicting the electric reliability of ceramic components.

In this work, PD tests have been carried out on piezoelectric bulk ceramics under electric loading in both bipolar and unipolar modes. Both soft and hard lead-zirconate-titanate (PZT) ceramics were tested and compared to the results obtained from epoxy samples. In general, materials with higher permittivity had lower partial discharge inception electric field. This indicates that the intensification of the electric field within the defects is the main cause for the differences in inception field observed for epoxy compared to piezoelectric ceramics. Furthermore, phase resolved PD pattern analysis was carried out for all materials at elevated electric fields. A broad distribution of the discharge events was observed for both epoxy and hard PZT samples, whereas for soft PZT discharge occurs concentrated at electric fields slightly above the coercive field. This intensification of PDs close to the coercive field suggests that PDs may be enhanced due to an increase of the internal field and electron emission rate induced by the domain switching process.