SPACE CHARGE AND DC DIELECTRIC BREAKDOWN IN POLYMERIC INSULATION

George Chen and Junwei Zhao
University of Southampton
Southampton, SO17 1BJ
United Kingdom

Dielectric breakdown of solid insulation has been studied for many years but the mechanisms that cause breakdown have not been fully understood. Charge injection always occurs at high electric fields and especially under dc conditions. The presence of space charge in solid dielectrics will result in distortion of electric field distribution. Dielectric breakdown can be initiated in the region where electric field enhancement takes place if the electric field exceeds the "threshold strength" of the material. Evidence of the presence of "threshold strength" has emerged from recent experimental work [1].

In the present paper, a new model based on space charge dynamics under very high dc electric field has been proposed. Bipolar charge injection model has been successful in simulating charge dynamics in polymeric insulation under dc conditions [2]. By setting threshold strength it is possible to achieve dielectric breakdown when the applied voltage rises linearly with time. Based on the time to dielectric breakdown (TTDB), it is possible to calculate the applied electric field at which breakdown occurs. Our simulation results clearly show that the dielectric breakdown under dc conditions is dependent on the sample thickness and voltage rising rate, i.e. the applied electric field at which the breakdown occurs decreases with sample thickness and increases with voltage rising rate. Both effects have been clearly observed in practical dc breakdown tests but the mechanisms never properly understood. The new model also allows one to examine charge dynamics prior to breakdown and influential factors that govern charge dynamics in the polymeric insulation, therefore, provides a strategy of how to improve dielectric performance of polymeric insulation.

1. K. Matsui, Y. Tanaka, T. Takada, T. Fukao, K. Fukunaga, T. Maeno and J. M. Alison, "Space Charge Behaviour in Low density Polyethylene at Pre-breakdown",IEEE Trans. Dielectr. Electr. Insul. 12, 2005, pp. 406-415.
2. G. Chen and S. H. Loi, "Space Charge Modelling in Solid Dielectrics under High Electric Field Based on Double Charge Injection Model. MRS Fall Meeting, Boston, USA, 2005.