Space Charge in Solid Dielectrics

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Abstract In this paper several popular non-destructive techniques are briefly reviewed, followed by description of some advanced space charge measurement facilities housed in our laboratory. The selected results reveal that the interfaces play important role in space charge formation. Work on ac ageing of polymeric materials has clearly indicated that ageing under high ac electric field results in the formation of space charge deeply trapped, indicating the formation of deep traps due to ac ageing. Simulation based on a bipolar charge model shows a good agreement with experimental results.

INTRODUCTION

Space charge and its effect in dielectrics have been known for many years. A number of methods for measuring charge distribution non-destructively have been developed two decades ago. They can be broadly divided into thermal and acoustic techniques based on their underlying principles. High voltage laboratory at Southampton University has been researched in this area over a decade. Several novel measurement systems have been established, including the improved LIPP system, simultaneous current and space charge measurement system, cable PEA system.

SELECTED RESULTS

Fig. 1 shows the effect of electrode materials on space charge formation in pure LDPE after application of 10 kV for 30 minutes. They are volts off measurements and the results clearly indicate the importance of electrode material.

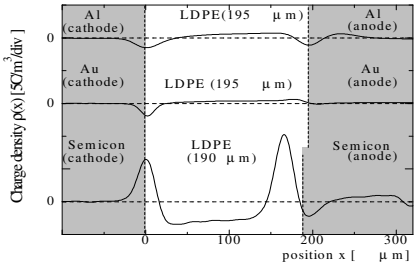


Fig. 1 Space charge in LDPE with different electrodes.

Simultaneous measurements of charge and external current are important. Fig. 2 shows measured external current and space charge in 200μm XLPE film stressed at 100 kV/mm. Several transient current peaks occur which correspond to the charge packets observed.

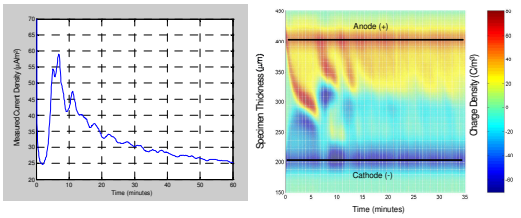
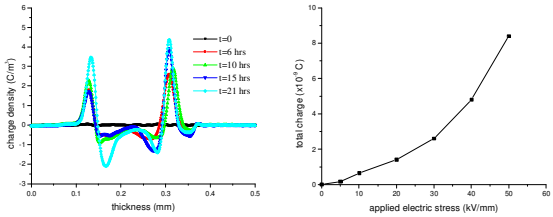


Fig. 2 Current and space charge in XLPE at 100 kV/mm.

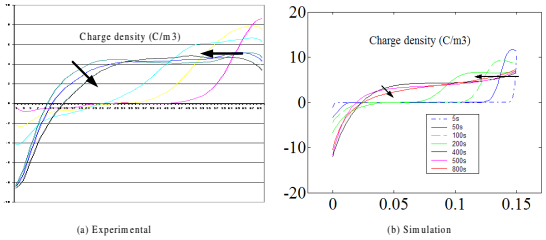
Space charge accumulated in LDPE after aged at 50 kV/mm rms ac (50 Hz) is illustrated in Fig. 3 (a). The amount of charge increases with the ageing time and the applied electric field (Fig. 3 (b)).



(a) (b)

Fig. 3 Charge accumulation in ac aged LDPE.

Modeling charge dynamics in the sample based on known physical principles may shed some light on the possible mechanisms.



(a) Experimental (b) Simulation

Fig. 4 Space charge measured in LDPE at 50 kV/mm.

Fig. 4 shows both experimental and simulation results for 150 μm LDPE sample stressed under 50 kV/mm. The simulated charge distributions clearly bear resemblance to the experimental results.

SUMMARY

Understanding of space charge in solids has been improved steadily and it may be possible to use space charge to diagnose ageing taken place in solids.