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Calculation of charge density and electric stress in XLPE compounds

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Resume

Au cours des dernières années, un intérêt considérable a été porté à la mesure de la distribution des charges d'espace dans les diélectriques soumis à une contrainte électrique.
Cet intérêt a entraîné le developpement de techniques non-destructrices, parmi lesquelles la méthode de l'onde de pression "Laser Induced Pressure Pulse" (LIPP) qui permet à l'utilisateur d'estimer l'emplacement et la quantité des charges piégées dans les diélectriques.
Cet article décrit brièvement une méthode d'analyse des résultats bruts, obtenus à partir d'essais de rampe en tension et d'essais de vieillissement. Une estimation de la distribution de charges d'espace et du champ électrique à travers l'épaisseur du matériau est donnée sans avoir recours à une analyse mathématique complexe.

Abstract

Over the last few years there has been considerable interest in the measurement of the space charge distributions within dielectrics under electric stress conditions. This interest has led to the development of a number of non-destructive techniques one of which is the Laser Induced Pressure Pulse (LIPP) method that enable the experimenter to estimate the position and magnitude of the trapped charge within the dielectric. This paper briefly describes a method of analysing the measured raw data from ramp voltage and ageing tests to give an estimation of the space charge and electric stress distributions across the bulk material without resorting to a complex mathematical treatise.

Introduction

Space charge is the term given to electrical charges that become trapped within the bulk of a dielectric and can occur as a result of, electron beam irradiation [1], or an electric potential applied across the insulation [2, 3]. In many cases the trapped space charge will be extremely stable and may exist in the dielectric for many months after the electrodes have been shorted together. A stable charge distribution is of great use in the area of electret microphones, where the incident pressure will interact with the space charge induced field and cause a current to flow in an external circuit. However, space charge in high voltage insulation systems (eg polymeric power cables) can eventually result in its premature failure at stresses well below anticipated or design values.

Space charge trapped in the bulk of the dielectric can significantly alter the internal electric stress profile. Therefore, there is a particular interest with assessing the performance of high voltage insulations which may be susceptible to this phenomena. At high voltage the trapped space charge can interact with the applied electric field such that the stress may be increased in one area and decreased in another [2 ,4]. Consequently, the electric stress distribution within the insulation cannot be predicted by standard numerical techniques (e.g. finite element method) and thus there is an added complexity in the design of electrical systems. Clearly for both electret and insulation applications it is extremely useful to determine the magnitude and type of charge, its mobility characteristics and its location in the bulk of the material.

Measurement Technique

The Laser Induced Pressure Pulse LIPP method to measure the space charge distribution in solid dielectrics is well known and its principle has been described in detail [5] The ablation of a target fixed to the sample by a short duration laser beam produces an acoustic wave or pressure pulse which propagates through the electrode and across the sample. This pressure pulse perturbs the space charge in the sample and thereby induces a change in charge on the electrodes and hence a current in the external circuit. Measurement of this time dependent current enables a profile to be obtained which is related to