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The development of a quality control technique to quanitify the cleanliness of semiconductive materials

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Résumé

Les câbles PRC dans les années 70 ont montré un degré non négligeable de claquage dû à la présence d'arborescences d'eau provoquant la dégradation de l'isolant. Cette étude a permis d'identifier un type de contaminant dans les matériaux semi-conducteurs pouvant donner naissance à des arborescences de surface. Ces contaminants de nature inorganique ou "grit" proviennent du procédé de fabrication des noirs de carbone. Bien que le niveau de ces agglomérats inorganiques ait été réduit d'une façon drastique au cours de ces deux dernières décennies, il n'en reste pas moins important de pouvoir s'assurer que leur niveau reste bas et controlable. Cette étude a permis d'identifier une technique utilisant les rayons X mous capable de détecter d'une façon efficace ce type de contaminants.

Abstract

Crosslinked polyethylene from the 1970's have a relatively high failure rate due to water treeing degradation. Work reported in this paper identify one type of contaminants in semiconductive material that may initiate vented tree growth, namely inorganic grit from the carbon black production process. Although the grit level in carbon black for cable applications has dropped dramatically during the last decades, we have conducted a study to find ways to detect this type of contaminants. A system using soft X-rays was proved to be efficient.

1. Introduction

Several studies have shown that the growth of vented trees in extruded medium voltage XLPE cables is enhanced by impurities in the semiconductive screens, especially water soluble ions [1]. The main source for these impurities is and has been the conductive carbon black that constitutes up to 40 weight percent of the semiconductive compound. This notion has been the driving force to the work in the 1980's and 1990's leading to a dramatically reduction of impurities in carbon black [2].

We have conducted some basic investigation work in order to find the precise reason to water treeing in cables from the 1970's and have found particular chemical impurities to be the source of the individual vented trees. A system for detection of particles of this kind is presented in this paper.

2. Background

The XLPE medium voltage cables produced in the 1970's have a relatively high failure rate. Most failures can be attributed to the growth of vented trees. During the last two decades the failure rate has dropped dramatically due to improved compounds and cable production techniques. Extensive two-year tests are showing the improved long-term stability of presently manufactured cables.

Experience from both field and laboratory aged cables have shown that there are in principle three types of defects that might initiate vented trees:
- Protrusions
- Particles at interface or inside semiconductive layer
- Corrosion on conductor

The protrusions are normally caused by inferior dispersion of the carbon black and/or impurities in the semiconductive compound. The correlation between the surface smoothness and the water treeing performance is small [1], suggesting that the chemical nature of the protrusions is more important than their geometrical dimensions.

A study of tree-initiating protrusions and particles in strippable screens of medium voltage cables from the early 1980's is described by Bruaset et al [3]. The