Introduction

The interface between the conductor screen and the insulation of a HV cable is considered to be a major site for the generation of electrical and water trees [1,2]. One reason for the location of trees in this region is due to the enhancement of electric fields at protrusions along the interface. The size and frequency of these protrusions along the cable have been reduced over the last thirty years through improvements to the extrusion process and by using ‘supersmooth’ semiconducting screen.

At low magnifications the quality of the interface can be investigated using optical microscopic techniques [3]. For greater magnification, transmission electron microscopy (TEM) [4] or scanning electron microscopy (SEM) can be used [5]. However it is sometimes difficult to distinguish the interface clearly, because both the insulation and conductor screen have been designed to have similar properties. In addition, the techniques required in the preparation of surfaces for TEM and SEM, e.g. etching, may modify the interface. It is therefore difficult to make a quantitative analysis of the roughness of the conductor screen-insulation interface on a microscopic scale using these techniques.

In this paper a new technique, based upon the Atomic Force Microscope (AFM), has been used to study the interfacial regions of HV cables. The Electric Force Microscope (EFM) measures the electrical interactions between the microscopic cantilever tip of the instrument and the surface under investigation. Stern et al [6] showed that the EFM could be used to measure microscopic areas of charge deposited on a polymeric surface. It can also be used to measure the potential of conductive surfaces via induced charge on the tip [7]. These methods can be applied to HV cables to highlight the interface between the conductor screen and the insulation, because of the different conductivities of these two surfaces. Therefore, since regions of different conductivity can be clearly distinguished in EFM images, it is possible to make an accurate measurement of the size of protrusions along the interface of HV cables.

In this paper the results of both AFM and EFM measurements on two XLPE insulated and two EPR insulated cables with different insulation and screen formulations are presented. Microscopic protrusions at the interface have been identified and a quantitative estimate of the interfacial roughness for all four cables has been made.

High-resolution images of the conductor screen surface, away from the interface were also recorded using both AFM and EFM techniques. From these images the structure and distribution of carbon within...