Space charge properties of XLPE and PDMS dual-dielectric with graphene coating

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ABSTRACT

Charge injected from electrode will accumulate in the insulation of High voltage DC insulation systems, which leads eventually to electric field distortion and degradation of insulation. In order to block space charge injection into Cross-linked polyethylene (XLPE) and Polydimethylsiloxane (PDMS) layers, in this paper a graphene coating was used. The graphene was first covered to the outer side of two-layers specimen. Then, the space charge profile of the specimen was measured by means of the pulsed electroacoustic (PEA) technique at 10 kV/mm and 40 kV/mm. Comparing space charge profiles of different graphene coating specimens, the presence of graphene coatings blocks injected charge at cathode, and changes space charge build up at anode and the PDMS/XLPE interface, thus providing a beneficial effect for the electrical insulation thanks to a lower electric field distortion.

KEYWORDS

Space Charge, Graphene coating, XLPE, PDMS

INTRODUCTION

For High voltage DC power system, the degradation and ageing of insulation depends on space charge distribution. How to limit charge injection from electrode into the insulation is one of the prime problems needed to be solved. As the insulation materials, Cross-linked polyethylene (XLPE) and Polydimethylsiloxane (PDMS) are widely used in the DC power system, such as in the joint of power cables.

For limiting the injection and accumulation of space charge in insulation system at DC electric field, researchers have presented some methods. Generally, different types of nanoparticles have been added into insulation materials, which can change the conduction and polarization properties of insulation, thus influencing space charge distribution [1]. The surficial fluorination also has been used to change the surface charge accumulation, and further affect the properties of bulk charge buildup [2]. In addition, nano-AgNPs covered by a very thin film of plasma polymer was deposited on the surface of LDPE, which could suppress the charge injection [3].

In order to block space charge injection into the XLPE and PDMS layers, the paper makes use of a graphene coating layer spread over the surfaces of the samples. The space charge profile of the samples was measured by means of the pulsed electroacoustic (PEA) technique at 10 kV/mm and 40 kV/mm. Space charge properties were analyzed for understanding how the graphene coating influences the mechanism of charge accumulation and transportation.

SPECIMEN PREPARATION

XLPE tapes were obtained from the peeling of a Prysmian HV cable with the thickness of 140 μm. During the specimen preparation, XLPE was cut into a disc with the diameter of 75 mm and pasted on a flat Bakelite substrate. Then, PDMS, 184 Silicone Elastomer from Dow Corning, was manually mixed with curing agent by a weight ratio of 10:1 for 5 min. The mixture was degassed at vacuum for more than 15 min to make sure all bubbles removed. Before the substrate with XLPE was place into the spin coater, the mixture was evenly poured on the XLPE surface. After that, the substrate was spun at 350 RPM for 120 s. A thin film PDMS with the thickness of about 140 μm was deposited on the XLPE surface. Finally, the specimen was cured at 65 ˚C for more than 60 min. Figure 1 shows the pictures of PDMS (upper) and XLPE (under). For analyzing the effect of graphene coating on space charge, graphene dissolved in an appropriate solvent was mechanically applied on the side of XLPE or PDMS, and both side of XLPE and PDMS by Nanesa S.r.l.

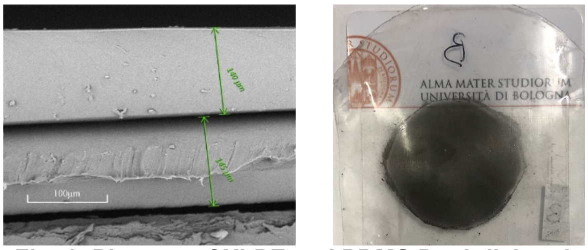

Fig. 1: Pictures of XLPE and PDMS Dual-dielectric

SPACE CHARGE MEASUREMENT PROCEDURE

The Pulsed Electroacoustic technique (PEA) was used for testing the space charge distribution in the paper [4, 5]. During the test, a semi-conductive material was installed between the upper electrode and the specimen, in order to attenuate sonic impedance mismatch between metal electrode and insulation. Through a coupling capacitor, a voltage pulse with the amplitude of 500 V and the width of 10 ns was applied to specimen. The specimen was poled for 10000 s at 10 or 40 kV/mm, respectively and depolarized for about 1000 s. All PEA tests were carried out at room temperature.

The space charge profiles of same sample at different electric field were recovered by the first waveform acquired at 10 kV/mm. Then the density of space charge was calibrated according to the potential distribution. However, the calibration factor was calculated though the space charge data after volt-on 10 s, because the amplitude of power source took several seconds to reach the steady output after turned on.