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Test of polymers for high voltage DC cables

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In this paper we show the results from test on planar samples made from a polyethylene grade specially designed for high voltage DC cables. Measurements of insulation current vs. time, temperature and electric field have been performed as well as space charge measurements using the *Laser Induced Pressure Pulse* (LIPP) method. Conductivity measurements are performed at electric field strengths from 10 to 40 kV/mm and at temperatures between 40 and 80°C.

Special consideration is given to the decay in current which is observed after voltage has been applied to the specimens. This decay in current is compared to results from space charge measurements on similar samples, performed using the LIPP method. The space charge measurements are performed at room temperature and at 40°C at fields from 0 to 25 kV/mm. The samples used are made from cross linked low density polyethylene and have a thickness of 1 mm, both for conductivity measurements and for LIPP measurements. The spatial resolution of the LIPP system is approximately 0.1 mm, giving a fairly accurate picture of the charge distribution inside the samples. A well tested and reliable measurement system has been used for the space charge measurements. An amplifier with a very low cut-off frequency and a high impedance input is used, resulting in a direct measurement of the electric field in the sample. The results are then differentiated in order to obtain the space charge distribution.

The build-up and transport of space charge in the samples are recorded by measuring the charge density at different times after application of voltage. The results are compared to the rate of decay in sample current. A 3D plot, showing the charge movements as function of time can thus be made. It shows charge build-up and movements which are not easily explainable. Positive space charge is formed next to the cathode and gradually moves towards the anode.

The results are presented and discussed in relation to theory on conduction mechanisms and space charge build-up. An attempt to explain the decaying current as an initial mismatch between the cathode injection current and the bulk conduction current is made. The initial large current can be seen as a result of impurity atoms (donors) giving of electrons when an electric field is applied. The injection current across the semiconductor-polymer interface, however, is much smaller than the initial bulk current, resulting in a lack of electrons close to the cathode. This again results in an increased field close to the cathode, which increases the injection current. Eventually a steady state situation will emerge when the injection current matches the transport current in the bulk. The initial transient phenomenon lasts from several days up to weeks, depending on temperature and applied field. The space charge remaining in the sample after the initial transient phenomenon may be attributed to material in-homogeneities.