Non-Uniformity of Polarization in Thin Ferroelectric Polymer Films

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Polymer ferroelectrics are increasingly used for creating new types of electroacoustic transducers, as well as pyroelectric and piezoelectric sensors. The performance of such elements strongly depends on the value, stability and uniformity of the residual ferroelectric polarization produced in the process of the high voltage application to virgin samples.

Measurement of polarization and space charge profiles provides valuable information on their relationship in the process of formation of the polarized state and in ensuring of its stability. That is why we have experimentally studied the dynamics of polarization profiles in produced by Plastpolymer polyvinylidene fluoride (PVDF) and of polyvinylidene fluoride with tetrafluoroethylene copolymer P(VDF-TFE) films with a thickness of about 25 μm not only in the process of electrification, but also during and after switching of the voltage polarity in fields close to coercive ones (50-60 MV/m) and in strong fields of the order of 160 MV m, as well as during and after the short circuiting of the samples after electrization carried out either by the contact method or in a controlled corona discharge. Measurements were performed at the University of Stuttgart and at the University of Karlsruhe.

We have found that at the field strength of E = 50 MV/m, a sharply inhomogeneous asymmetric distribution of the residual ferroelectric polarization was formed with the presence of about 5 μm thick zone near the negative electrode, in which the residual polarization was equal to zero.

During the switching of the voltage polarity, the strong non-uniformity of polarization was preserved, and it was not possible to improve it by the application of even very strong fields of the order of 160 MV/m.

It has been found that for obtaining the uniform distribution of polarization, the first electrization of a virgin non-polarized sample should be carried out in strong fields of the order of 150 MV/m. In this case, the uniform polarization was formed along the entire sample thickness. The polarization uniformity was continuing during the short circuiting of the samples after charging, as well as during the switching of the applied voltage polarity.

The obtained results have been confirmed by measurements on the same samples by two independent methods, namely by the piezoelectrically induced pressure step method (PPS) and the light intensity modulation method (LIMM). The sensitivity of the PPS method was 3 μm and the resolution of the LIMM method near the illuminated electrode was claimed to be about 0.1 μm.