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sputtering. IR spectra indicated different proportion of the ferroelectric β-phase in relation to the non-polar α-phase. Poling and switching experiments were performed utilizing an electronic high voltage / high current push-pull switch capable of supplying voltage pulses from 100 ns to 1000 s duration controlled by a low-voltage pulse generator. The measuring branch consisted of the sample, a current limiting resistor and a series measuring capacitor.

Polarization – field dependence in most studies was considered as a quasi stationary one assuming that independently on the field value, polarization instantly follows the field. For the first time we introduced time in the polarization – field relation considering not only the value of the applied field, but also the polarization dynamics at a definite field.

By solving numerically a set of differential equations, such as the current equation, the intrinsic polarization dynamics, hysteresis of the ferroelectric polarization, accumulation and release of the screening charges at the interphase boundaries and by comparing experimental data with results of appropriate modeling we were able to explain a two stage behavior of the polarization build-up during poling and switching. Moreover, the reason of a huge discrepancy between expected and observed poling and switching times in the ferroelectric polymers has been also explained.

It is shown that conductivity during initial poling is responsible for the second slow stage of the polarization build-up. In the case of short circuiting, the conductivity prevents undesired back-switching of the already formed ferroelectric polarization. During the switching of polarization, the critical dependence of the polarization phenomena on conductivity was also revealed. The results stress the importance of an instantaneous release of the screening charges in the fast phase of switching and its reconstruction to screen the reversed polarization in the slow part of the switching process.

The authors strongly believe that the discovered features related to the effect of conductivity, in general, are characteristic not only for ferroelectric polymers, but also for other two-component ferroelectric systems, such as the ferroelectric ceramics and polymer-ferroelectric composites.

FEP/ePTFE/FEP FERROELECTRET SANDWICHES

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A new option for constructing piezoelectric sensors are three layer structures called ferroelectrets consisting of two solid blocking layers of fluorinated ethylene propylene (FEP Teflon) films and fibrous polytetrafluoroethylene (ePTFE) in between them. The piezoelectricity of such FEP/ePTFE/FEP sandwich results from charge layers of opposite polarity formed due to charges generated by Paschen's breakdown and trapped at the interfaces between FEP and ePTFE films. A unique combination of the charge storage ability with a low elasticity modulus makes the sandwiched structures very promising objects for applications in electromechanical sensors.

We investigated limits of the piezoelectric d_{33} coefficient and possibilities of optimizing interrelation between solid and porous layers thicknesses, the Young modulus of the porous layer and dependence of the breakdown field on thickness of the porous layer. The following expression was obtained for the maximum value of d_{33} coefficient

$$d_{33}^{\max} = \frac{\varepsilon_o \varepsilon_F \varepsilon_P E_B}{Y_P\left(\varepsilon_F + \alpha\varepsilon_P\right)} \tag{1}$$

where Y_P is the Young modulus of the porous layer, E_B the breakdown field, ε_o permittivity of a vacuum, ε_F and ε_P dielectric constants of blocking and porous layers, respectively; $\alpha=2d_F/d_P$ the geometric factor characterizing interrelation between layer thicknesses d_F and d_P.

Thus, for obtaining high values of the d_{33} piezoelectric coefficient, the intrinsic Young modulus Y_P of the porous layer, as well as the geometric factor α should be as small as possible. The real modulus Y_p=0.3 MPa was calculated using experimental results of d_{33}=550 pC/N for samples with d_F=12.5 μm, d_P=63 μm (α=0.4), ε_F=2.1, ε_P=1.1, and E_p=22.3 MV/m.

From the first glance, a rather simple formula (1) could easily show how to obtain high values of the d_{33} piezoelectric coefficient. However, experimental results have shown that the situation is not so simple. It was found that the experimental data correspond to the theoretical model only in the range of α from 1 to 8, while different behavior of d_{33} was observed at α<1. Instead of decreasing with α, as predicted by (1), d_{33} increased in contradiction with (1).

The reason is that d_P affects E_B and the d_{33} coefficient. It appeared that the breakdown field for the various ePTFE layers in the sandwich structure exceeded the Paschen values by a factor of ~1.8. Substituting the experimentally measured function $E_B(d_P)$ in (1), we obtained dependence of d_{33} from α in good agreement with experimental points. Thus, considering the thickness dependence of the breakdown field, the conclusion concerning inverse proportionality between d_{33} and α should be corrected. At a constant thickness of the porous layer *dp*, d_{33} increases with decrease of α, i.e. at the smaller thicknesses of the solid layers. However, if the decrease of α is the result of increasing the porous layer thickness with the same blocking layers, the d_{33} coefficient is smaller in the case of the thicker porous layers.

The final conclusion that we made is as follows: the thinner a porous layer of the sandwich, the higher d_{33}, if the solid layer is not too thick. For example, at d_P=25 μm and d_F=5 μm one can obtain the d_{33} value of about 1000 pC/N. Considering low elasticity of ePTFE and creep at low frequencies, one effective way for increasing d_{33} could be the substitution of the porous material by closed air gaps guaranteeing the lowest possible Young's modulus.

BUILD-UP AND SWITCHING OF FERROELECTRIC POLARIZATION IN POLYVINYLINDENE FLUORIDE

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Ferroelectric polymers have an advantage over traditional ferroelectric materials due to their good mechanical properties. At the same time, the magnitude and stability of the ferroelectric polarization in ferroelectric polymers are not sufficient to ensure their wide scale practical application in sensors and actuators. Since both parameters depend on the poling conditions a deep understanding of polarization related phenomena is important for improving these material properties.

Polyvinylidene fluoride (PVDF) is a ferroelectric polymer undergoing a fast polarization reversal called also as polarization switching [1,2]. Its ferroelectricity originates from molecular dipoles associated with positively charged H atoms and negatively charged F atoms. The all-trans conformation of chain molecules and their parallel packing cause an alignment of all molecular dipoles in one direction to induce a large spontaneous polarization. Polarization reversal occurs as a result of the rotation of molecules about their chain axes.

Polarization and switching phenomena in 12 μm-thick PVDF have been studied experimentally by application of 500 to 2500 V voltage pulses from 100 ns to 100 s duration and short-circuiting with the total displacement continuously monitored. All displacement components were identified and evaluated, such as the remanent polarization, the ε-related displacement, the unstable reversible component and the conduction currents. It has been found that contrary to theoretically predicted fast switching of polarization at high fields, the ferroelectric component continued to increase even for times 5-6 orders of magnitude longer than the switching time indicating that apart from the fast component a slow one exists. A phenomenological model of

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