Comparison of Polarization Switching in PVDF and P (VDF-TFE) Thin Ferroelectric Films

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Copolymers have some advantages over pure PVDF in a group of polymers based on vinylidene fluoride. The most studied is a trifluoroethylene copolymer P(VDF-TrFE), while only a few studies were devoted to tetrafluoroethylene copolymer P(VDF-TFE). That is why our goal was to study formation and relaxation of the polarized state in the P(VDF-TFE) in terms of its applicability for the manufacturing of sensors with high and stable polarization.

The method developed for PVDF [1] was applied to polarization switching in P(VDF-TFE). The films were electrified in a strong field for 200 s to obtain a fully polarized state. Then, the switching voltage pulses from 10 μs to 100 s duration from were applied. After each switching, the formatting was performed. The difference between the electric displacement in the first and in the second case gave the kinetics of the ferroelectric polarization switching [1].

The following conclusions were made from comparison of the PVDF and P(VDF-TFE) data: (a) the value of switchable polarization in the copolymer was significantly higher than in PVDF; (b) the total switching occurred in $t \sim 10^{-4}$ s, whereas saturation in PVDF was not reached even after 100 s; (c) displacement graphs had almost rectangular shape indicating the absence of the unstable polarization; (d) abrupt changes in displacement during the switching in the case of P(VDF-TFE) was significantly smaller than in PVDF indicating the smaller value of the effective permittivity in P(VDF-TFE) compared to PVDF.

These features were, probably, due to the lack of the amorphous phase and the lower conductivity. The characteristic shape of the charging current with the presence of a flat section was marked in the first microseconds. By subtracting the capacitive current from the total current, we obtained the polarization switching current, which has a maximum at 3 μs. Namely this value can be considered as the switching polarization time for P(VDF-TFE).

The dependence of polarization switching from the applied field and exposure time were studied. A comparison with the corresponding graphs for PVDF shows that the coercive field has the same order as in PVDF (~ 50 MV m). Therefore, the application of lower fields is impractical, because polarization is very small. At the same time, if the field of 120 MV/m is used, there is no significant difference in applying pulses of 5 ms, 50 ms, or even 5 seconds, because of very fast switching of the ferroelectric polarization.

1. H. von Seggern, S. N. Fedosov *IEEE Trans. Diel. Elect. Insul.* 2004. – v. 11, – p. 232– 241.