The negative piezoelectric effect of the ferroelectric polymer poly(vinylidene fluoride) - DTU Orbit (08/11/2017)

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Piezoelectricity describes interconversion between electrical charge and mechanical strain. As expected for lattice ions displaced in an electric field, the proportionality constant is positive for all piezoelectric materials. The exceptions are poly(vinylidene fluoride) (PVDF) and its copolymers with trifluoroethylene (P(VDF-TrFE)), which exhibit a negative longitudinal piezoelectric coefficient. Reported explanations exclusively consider contraction with applied electric field of either the crystalline or the amorphous part of these semi-crystalline polymers. To distinguish between these conflicting interpretations, we have performed in situ dynamic X-ray diffraction measurements on P(VDF-TrFE) capacitors. We find that the piezoelectric effect is dominated by the change in lattice constant but, surprisingly, it cannot be accounted for by the polarization-biased electrostrictive contribution of the crystalline part alone. Our quantitative analysis shows that an additional contribution is operative, which we argue is due to an electromechanical coupling between the intermixed crystalline lamellae and amorphous regions. Our findings tie the counterintuitive negative piezoelectric response of PVDF and its copolymers to the dynamics of their composite microstructure.

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