Response and Characterization 7: 4:50 - 5:10 p.m.

Electromechanics of Monodomain Chiral Smectic C Elastomer: Mechanical Response to Electric Stimulation

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So far, we have succeeded in obtaining monodomain SmC* elastomers with macroscopic C2 symmetry of the unwound SmC* state by biaxial mechanical deformation, such as two successive deformation processes and more perfectly mechanical shear deformation. Moreover, we confirmed these samples exhibits a biaxial shape change under thermal stimulation, which means spontaneous and reversible shear deformation in a heating and cooling process where successive phase transitions occur. The purpose of this paper is to show a macroscopic mechanical response to electric excitation of the monodomain SmC* elastomers obtained by the shear deformation. We estimate an electric-field-induced deformation $\Delta L = L(E) - L(0)$, which is defined as shrinkage and/or elongation in the direction of the layer normal. ΔL is plotted as a function of an electric field strength in Fig.1 which is measured just above the SmC*-to-SmA phase transition temperature at 80ºC. The elastomer shrinks by application of the positive electric field, where ΔL decreases with increase of the field strength and reaches about -5 μm under an electric field at +2.5 V/μm. On the other hand, the elastomer elongates by application of the negative field, namely the electric field in the opposite direction; ΔL is estimated at about +3.5 μm under an electric field of -2.5 V/μm. Because a coupling between polarization and electric field contributes to the electric-field-induced deformation in the monodomain chiral smectic elastomer, the direction of deformation depends on the polarity of applied electric field in the field dependence of ΔL.

To investigate the critical behavior of the electroclinic effect, an electric-field-induced deformation, $\Delta L{\pm}E = L(-E) - L(+E)$ estimated under a rectangular electric field of ±2.5 V/μm (Fig. 2), is plotted as a function of temperature. A small deformation at about $\Delta L{\pm}E$ = 2 μm is recognized in the vicinity of the SmA-to-Iso phase transition temperature. The value of $\Delta L{\pm}E$ increases with decreasing temperature in the temperature region of the smectic A phase and reaches a maximum value of 12 μm at about the SmA-to-SmC* phase transition temperature, where the softening of the collective fluctuation of θX takes place because of the critical behavior of the electroclinic effect. The value of $\Delta L{\pm}E$ seems to keep at about 10~12 μm during a part of the SmC* temperature region between 80ºC and 60ºC. One may notice that not only the soft mode corresponding to the electroclinic effect but also the Goldstone mode describing the fluctuation of azimuthal angle is excited by electric field in SmC* systems. However, the Goldstone mode seems not to contribute effectively the sample deformation, because the layer spacing d does not change by the fluctuation of the azimuthal angle. Therefore, the field-induced deformation observed in the SmC* phase may be mainly caused by the contribution of electroclinic effect.

For further decrease in temperature in the SmC* region, $\Delta L{\pm}E$ decreases to 2 μm at 40ºC where the SmC*-to-SmF* phase transition takes place. In addition, we point out that the deformation has been recognized for a wide temperature range between the isotropic phase and the SmF* phase, though the electroclinic effect of a pretransitional phenomenon is generally exhibited in a narrow temperature region near the SmC*-to-SmA transition temperature. The contradiction implies polymer network may affect the critical behavior of the electroclinic effect.

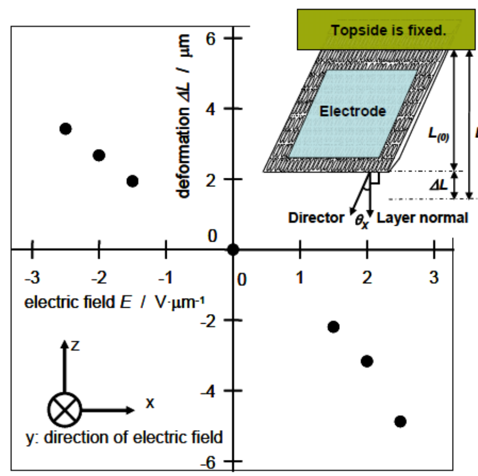

Fig. 1 Electric filed E vs. induced deformation ΔL.

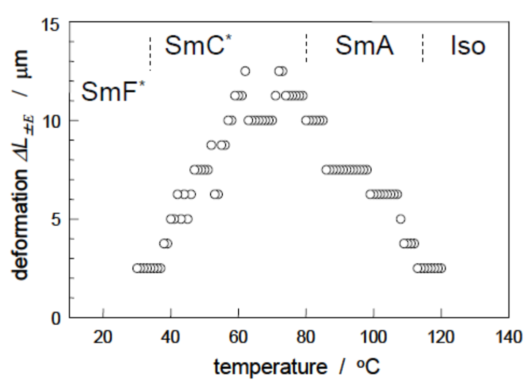

Fig.2 Temperature dependence of induced deformation $\Delta L{\pm}E$ under rectangular wave ±2.5 V/μm.