

液晶エラストマの温度・電気特性

(九工大・情工*、九大・工**) 許 宗焄*、甲斐 昌一**

Thermo and electro properties of a nematic elastomer in a liquid crystal

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Electro-mechanical effects for a swelling liquid crystalline elastomer have been investigated. Due to the director reorientation, its deformation has been directly observed in unconstrained elastomer gel states. By using an optical image analysis, the amplitude and characteristic times of its deformation have been quantitatively measured with changing voltage and temperature.

I. Introduction

Liquid crystalline elastomers (LCEs) have much attracted due to their anisotropic mechanical, electrical, and optical properties [1,2]. LCEs are unusual and complex materials that couples the elastic property of rubbers with the anisotropy of the director orientation. In general, they consist of cross-linked networks of polymers with side- and/or main-chain mesogens. Owing to this structure any external stimulus such as temperature, radiation or electric/magnetic fields on the polymer network gives rise to any change of the orientation order, and then the resulting change induces any shape and/or dimension deformation of LCEs. In this report we address electro-mechanical effects for a swelling LCE (SLCE) in a low molecular weight liquid crystalline solvent. We have quantitatively investigated the deformation amplitudes, the threshold voltages, the temporal characteristics (arising and relaxation times), the temperature influence, and the oscillation properties of SLCEs.

II. Experiment

We have used a LCE synthesized by Finkelmann group, where the side-chain mesogen is macroscopically well orientated in the network. Basically, the LCE was chemically synthesized from the monofunctional side-chain mesogen and the bifunctional liquid crystalline main chain (cross-linker) with PMHS (poly-methylhydrogensiloxane) as a polymer backbone (See Ref. [2] for details of our sample). The dimension of the present LCE was $L_x \times L_y \times L_z = 4000 \times 500 \times 20 \mu\text{m}$. A low molecular weight liquid crystalline solvent, 5CB

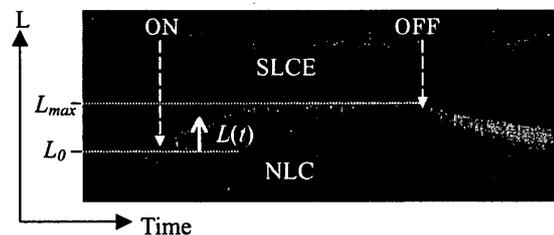


Figure 1 Shrinkage and recovery of a SLCE in the field-on and off (6V). The size of time-space image is $40 \mu\text{m} \times 10 \text{s}$.

(4-*n*-pntyl-4'-cyanobiphenyl), which is one of stable NLCs in room temperature, was used for our present SLCE. In sandwich-type cells whose surfaces were coated with transparent electrodes (indium tin oxide) the LCE has swollen in the NLC (5CB). The cell gap $d=200$ μm between both electrodes with lateral (active) size $1\times 1\text{cm}^2$ was maintained by a polymer spacer (Mylar). An alternating electric field $E=E_0\cos(2\pi ft)$ [$E=(0,0,\pm E_z)$] was applied across the cell.

III. Results and Discussions

Figure 1 shows a changing displacement $L(t)$ of a certain selected position (with one dimensional line across between the SLCE and NLC) in the course of time when applying and removing voltage V . On applying V , the SLCE shrinks immediately, and it recovers slowly on removing V . Increasing V , the shrinkage becomes rapider, while the recovery shows nearly constant. Moreover, it is shown that the maximum displacement L_{max} of the deformation increases smoothly and saturates with increasing V in Fig. 2. While controlling the orientation degree of the SLCE by temperature T , we have measured the displacement L_{max} with changing V , as shown in Fig. 2. The $L_{max}(V)$ decreases monotonously with increasing T . At $T=34$ $^\circ\text{C}$ near $T_{NI}=35$ $^\circ\text{C}$ for the nematic-isotropic transition temperature of the present NLC (5CB) the L_{max} decreases to about 13 μm above $V_{max}\sim 25$ V. However, $V_{max}(T)$ was nearly constant. In the shrinkage process the $L_{nor}(t)$ was measured with changing T at a fixed $V=6$ V and $f=100$ Hz. As shown in Fig. 3, the $L_{nor}(t)$ decreases more rapidly with increasing T . In our presentation we will report the detail of dynamics in shrinkage and recovery processes, and oscillation properties of the SLCE.

References

- [1] M. Shahinpoor, *Electroactive Polymer Actuators and Devices in Smart Structures and Materials 2000*, edited by Y. Bar-Cohen, Proc. of SPIE, 3987, 187 (2000).
- [2] H. Wermter and H. Finkelmann, e-Polymers no.013 (2001) in <http://www.e-polymers.org>

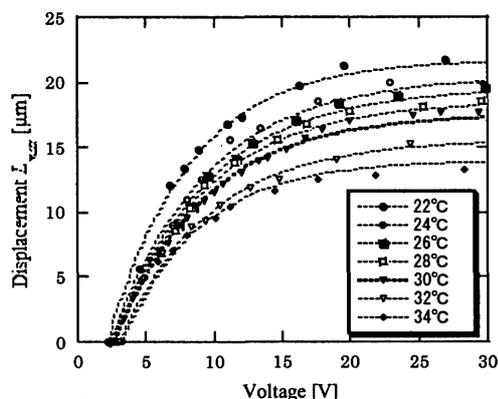


Figure 2 The temperature dependence of $L_{max}(V)$ of the deformation.

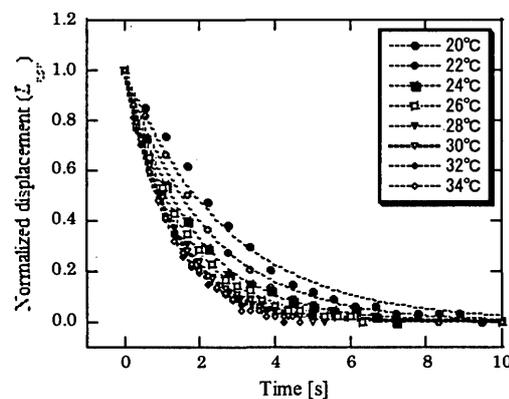


Figure 3 The temperature dependence of $L_{nor}(t)$ in the shrinkage process.