Dynamic layer response of electroclinic effect in ferroelectric liquid crystals by time resolved X-ray micro-diffraction

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Introduction

In smectic liquid crystals, the dynamic response of the layer structure upon applying an electric field is of great interest both from device application and fundamental physics. Recently, the irreversible and reversible layer transformation in (anti)ferroelectric liquid crystals has been analyzed with the time resolved micro-diffraction measurement[1]. In a SmA phase, the electric field induces a tilt of the director (electroclinic effect). The electroclinic effect is the fastest electro-optical effects in liquid crystals. This effect has been studied as electro-optical phenomena of molecules, though the local layer response has not been clarified yet.

In this report, the local layer responses to an electric field in SmA phase of FLC cells is measured using time resolved microbeam X-ray diffraction.

Experimental

The experiment was carried out on BL-4A. The x-ray energy was 8 keV. Experiments were performed with a beam size of about 4×4 μm^2. The diffracted intensity was measured by a PSPC as functions of ω and χ angles; ω angle corresponded to a layer rotation angle from the rubbing direction around an average layer direction, and χ angle was a layer deflection angle around surface normal. Time resolved measurements were carried out with a MCS mode and a gated MCA mode for ω and χ-profiles, respectively. X-ray diffraction data were collected synchronized with an applied electric field, which was a triangular form wave of 5 Hz, ±20V.

The sample was TK-C101 (Chisso), sandwiched between ITO-coated glass plates rubbed one-side after coating a polyimide film. The cell gap was 6.8 m. The sample was kept at T_C+1°C during experiments, where T_C was SmA*→SmC* transition temperature (56°C).

Results

The time resolved microbeam x-ray diffraction profiles are shown in Fig.1. The MCS-mode ω-profile measured with 0.2 ms time resolution (b) shows that a peak near ω =1° at low voltage changes to a broad one at high voltage, and peaks appear at both the high and low angle side and change their angular position continuously with applied voltage. Corresponding MCA-mode χ-profiles at ω =1° (c) shows that a single peak shifts depending on the voltage. The absolute angle and the direction of the peak shift depended on the analyzing position. From these results, it is shown that the initial bookshelf structure transforms to the combination of the deformed horizontal chevron and the vertical chevron to compensate the reduction of layer spacing due to the molecular tilt.

With the time-resolved X-ray micro-diffraction, the local layer deformation in the electroclinic effect was revealed for the first time.

References

[1] Y.Takahashi et al. Jpn. J. Appl. Phys. **40**(01)3294, Mol. Cryst. And Liq. Cryst. **365**(01)853

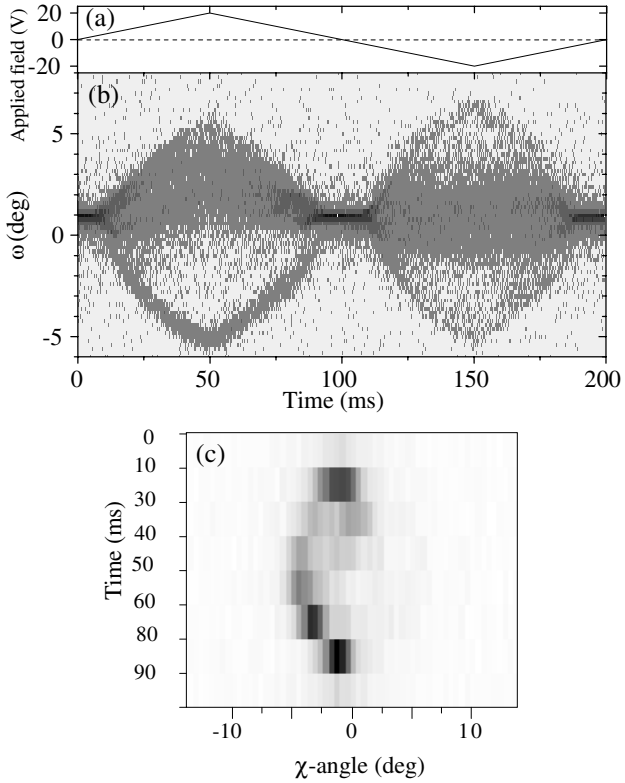

Fig.1 Time resolved micro x-ray diffraction profiles. (a) Applied field, (b) MCS-mode ω-profile, and (c)MCA-mode χ-profiles. 0.2ms and 10ms time resolution for (b) and (c), respectively.

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