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Molecular Orientation and Layer Structure in Electroclinic Liquid Crystals by Time Resolved X-ray Micro-Diffraction

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Introduction

The electroclinic effect has attracted much attention as a pre-transition phenomenon in the chiral smectic A (SmA) phase near the SmA-Smectic C* (SmC*) phase transition. With the application of an electric field along the layer, SmA molecules tilt in a plane perpendicular to the applied field. The molecular response in the electroclinic effect has been discussed based on the electro-optical measurement in which the h-chevron (book shelf structure) is assumed. To observe the dynamic response of the local layer structure in the smectic liquid crystal under the external field, time-resolved synchrotron X-ray micro- diffraction has been successfully used [1]. In the previous study [2], it is revealed that the vertical-chevron is realized at the low electric field while the compound chevron which consists of vertical-chevron and the horizontal-chevron is generated at the high field. In this report, the temporal and spatial distributions of the molecular orientation as well as the layer structure is analyzed directly by the time resolved high-angle micro X-ray halo pattern together with the small angle layer reflection in the electroclinic effect.

Experimental

The experiment was carried out on BL-4A. The x-ray energy was 14.3 keV and the beam size was about 3×4 μm^2. The diffracted intensity was measured by an image intensified X-ray CCD camera as functions of time and position.

The sample was a FLC, TK-C101 (Chisso), sandwiched between ITO-coated glass plates rubbed one-side after coating polyimide. The cell gap was about 6~7μm. The sample was kept at T_c+1°C during experiments, where T_c, SmA*→SmC* transition temperature, was 56°C [3].

Results and Discussion

A bipolar rectangular wave form electric field (5 Hz) was applied to the sample. Fig.1 shows the time resolved x-ray micro X-ray halo pattern obtained at +13V. The halo-pattern is due to the intra-layer order of the molecular arrangement while two sharp peaks near the center of an image are due to the local layer structure. From the halo-pattern and the small angle scattering pattern, the close relation between the molecular orientation and the layer structure can be discussed. Fig.2 shows the spatial variation of the molecular orientation normal to the rubbing direction. The spatial period is about 10 μm which well corresponds to the stripe texture. The amplitude is about 3~4 degrees which is smaller than the layer deflection angle obtained from the layer reflection. The temporal variation of the molecular orientation was also measured. Further experiment with higher precision is now under way.

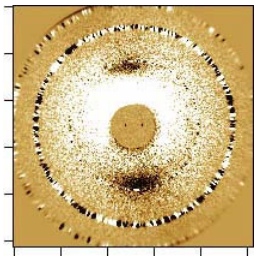

Fig.1 Time resolved micro X-ray halo patterns (short arcs at the upper and lower sides) together with small angle layer reflections (right and left) inside after the background subtraction process. Spotty concentric rings are due to the thin film electrodes. Note that a circular absorber was inserted in the central region to avoid the saturation of the CCD camera. Darker regions correspond to higher X-ray intensities.

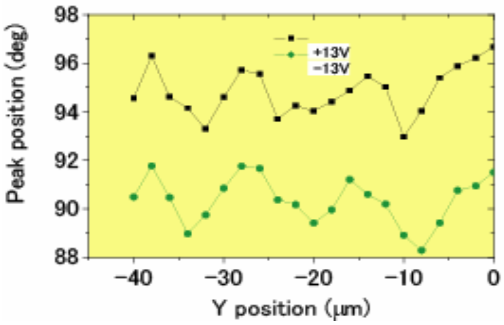

Fig.2 Peak angular positions of the halo pattern as a function of position for the bipolar electric field.

References

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