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Molecular Orientation Response of Electroclinic effect in Ferroelectric Liquid Crystals by Time Resolved X-ray Micro-Diffraction

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Introduction

For the direct determination of the microscopic local layer structure in the smectic liquid crystal under the external field, time-resolved synchrotron X-ray micro-diffraction has become a powerful tool[1]. With this technique, the local layer response to an electric field in SmA phase, known as an electroclinic effect, has been revealed [2]. The vertical-chevron is realized at the low electric field and the combination of the spatially alternate vertical-chevron and the horizontal-chevron is generated at the high field. Furthermore, the transient layer response time for the ac applied field is a few μs to a few tens of μs and is as fast as the electro-optical response time. The relation between the layer structure and the molecular orientation, however, is discussed based on the indirect observation of optical response.

In this report, the molecular orientation is analyzed by the time resolved high-angle micro X-ray halo pattern in the electroclinic effect. The comparison is made with the layer structure obtained so far by the small angle X-ray micro-diffraction.

Experimental

The experiment was carried out on BL-4A. The x-ray energy was 14.3 keV for the halo pattern observation. Experiments were performed with a beam size of about 3×4 μm^2. The diffracted intensity was measured by an image intensified X-ray CCD camera as functions of time and position. X-ray diffraction data were collected synchronized with an applied electric field.

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.

Results and Discussion

The applied electric field was a triangular wave form (5 Hz, ±20V) and the time resolution of the gated X-ray CCD was set for 12.5ms. Fig.1 corresponds to the time resolved x-ray micro X-ray halo pattern obtained at +20V and -20V after the proper data processing. Short segments of the arc (up and down) represent the halo-pattern due to the intra-layer disorder of the molecular arrangement. Outer concentric spotty rings are the powder diffraction pattern from the ITO thin film electrodes of the sample cell. The change in the peak angular position, which corresponds to the average molecular orientation, is clearly observed. Fig.2 shows the angular position as a function of the applied voltage. The molecular rotation angle within a single stripe domain was obtained for the first time. The comparison between this molecular orientation and the layer deformation is now in progress.

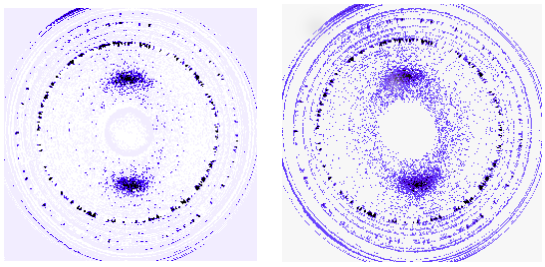

Fig.1 Time resolved micro X-ray halo patterns at +20V (left) and -20V, (right) application.

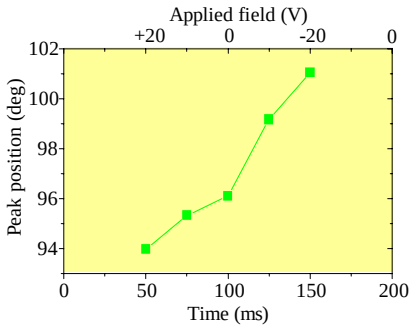

Fig.2 Peak angular positions of the halo pattern as a function of time (applied voltage).

References

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