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Study of layer rotation of ferroelectric liquid crystal under asymmetric electric field by time-resolved SAXS

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Introduction

Liquid crystals have several meso-phases; isotropic, nematic, smectic and crystal. Smectic phase has a layer structure of molecular alignment. Ferroelectric property in the smectic phase is caused by chirality and electric dipole moment of molecules.

Recently, surface stabilized ferroelectric liquid crystal (SSFLC) attracts attention as a possible material for a new liquid crystal display (LCD). However, it has been found that SSFLC shows gradual “layer rotation” which deteriorates the contrast characteristic as a display when an asymmetric electric field is applied [1].

The purpose of our study is to investigate the mechanism of “layer rotation” with time-resolved SAXS using CCD X-ray detector coupled with an X-ray imaging intensifier. If we could observe “layer rotation” in one asymmetric cycle with millisecond time-resolution, the mechanism of gradual (minute-scale) “layer rotation” would be clarified.

Experimental

The sample used was ferroelectric crystal, CS-1024 (Cisso Co.). As a sample cell, we used a pair of standard borosilicate 100μm-thick cover glass, which was coated with a thin film of ITO approximately under 50 Ω and was rubbed 30 times with a velvet cloth. The thickness of sample was 9μm, which was determined by the spacer of mylar. The sample temperature was maintained at 56 °C, that was 6 °C below the SmC* to SmA phase transition.

The sample was monitored by a polarizing microscope during the SAXS experiment [Fig.1]. The camera length was approximately 800 mm. The x-ray flux was approximately $4x10^{10}$ photons per second at a wavelength of λ=1.5 Å.

Slope- or duty-ratio- asymmetric voltage-waves were supplied to the sample cell with a voltage (=70 V) and time period (=300 msec) fixed. The data acquisition system was gated synchronously by the pulse generator so that one cycle (=300 msec) was divided into 30 phases of a 10 ms slot. SAXS of each 10 ms slot was accumulated 33 times (total exposure time 330 ms) in order to get enough signal-to-noise ratio. Bragg peaks due to smectic layers were observed to rotate gradually during the repeated cycles of asymmetric electric field [Fig.2].

It was found, however, that the move or rotation of the Bragg peaks in one cycle was within the spatial resolution of the Be-XII-CCD detector. In the next beam time, we are going to introduce a high-resolution CCD detector to resolve the move of the Bragg peaks in one cycle.

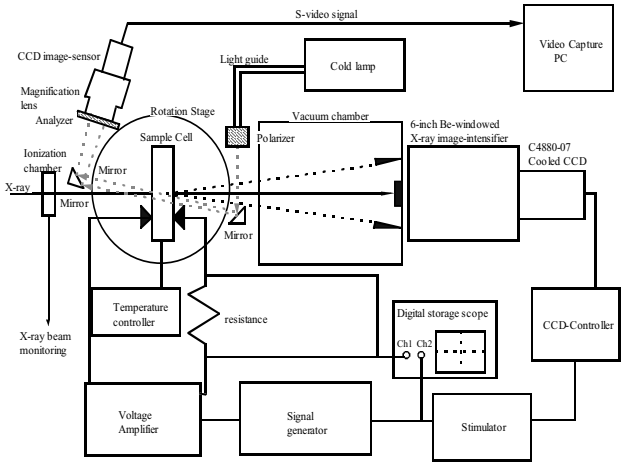

Fig.1: Schematic setup for time-resolved SAXS.

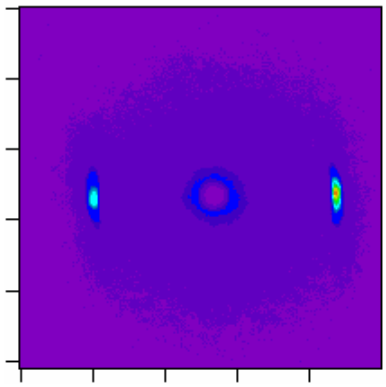

Fig.2: SAXS image recorded by Be-XII-CCD. Two Bragg peaks originating from the layer structure of liquid crystal (d=27Å) are observed at right and left. These peaks were rotated gradually while the asymmetric electric field was applied to the sample.

References

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