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Chiral smectic transition phases appearing near the electric field-induced phase transition observed by resonant micro-beam X-ray scattering

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1 Introduction

Chiral smectic (tilted) C liquid crystals are characterized by a one-dimensional layer structure and an average molecular orientation tilted from the layer normal. Various sub-phases in the chiral semctic C phases are classified by the q_T number, where q_T = [F]/([F] + [A]) and [F] and [A] are the numbers of synclinic and anticlinic orderings in a unit periodicity, respectively; the ferroelectric phase SmC*(q_T=1) and the anti-ferroelectric phase (SmC_A*(q_T=0)). The close relation between the temperature and electric-field induced phase transition has been shown and the electric field vs. temperature (*E*-*T*) phase diagram has been studied [1]. The chiral smectic intermediate phase appearing under the electric field is important for revealing a phase transition mechanism of the successive phase transition. For the smectic phase identification, resonant X-ray scattering (RXS) has been the most powerful technique [2].

In the previous report [3], a new long range order sub-phase appearing between the ferrielctric and the ferroelectric phases in the Br contained liquid crystal was reported. In this report [4], the experiments were carried out at higher temperature range to confirm the long range new transition phase. An X-ray intensity analysis based on the Ising model was also performed.

2 Experiment

The Br contained liquid crystal used was the (*S*,*S*)-bis-[4'−(1-methylheptyloxycarbonyl)-4-biphenyl] 2-bromo-terephthalate and is sandwiched between 80 μm thick glass plates coated with indium tin oxide as an electrode. The phase sequence of the material is Iso 201.3°C SmA 155°C SmCα* 151.5°C SmC* 147°C SmC_A*(qT=1/2) 145°C SmC_A*(qT=1/3) 142°C SmC_A*(qT=0). The detailed characterization of this new chiral smectic liquid crystal was reported previously [2]. The applied electric field was a square wave form with 20Hz.

Resonant X-ray scattering (RXS) experiments were performed on the beam line 4A using a KB focusing system. The incident energy was set at the absorption edge of Br (13.48 keV) and the beam size was about 5 x 5 μm^2. A pixel array detector (Pilatus-100K, DECTRIS) located at 80 cm from the sample (focusing point) was used for the measurement.

3 Results and Discussion

At 144°C, *m*/3-order (m=1 and 2) reflections appeared below ±26.5 V (Fig.1(a)).

Near the phase boundary between three-layer periodicy and ferroelectric phases, the RXS diffraction pattern exhibited the spotty streak pattern (Fig. 1(b)). At 145.2°C (assigned as SmC_A * (q_T=1/2)), between ±18 V and ±20 V, there first appeared the spotty reflection between the *m*/3-order reflections and the layer reflection, and then a weak streak remained at ±22 V.

Detailed measurements near the phase boundary between three-layer periodicity and ferroelectric phases, the 12-layer periodicity transition phase was confirmed. An X-ray intensity analysis based on the Ising model suggested that the 12-layer periodicity phase was composed of two 3-layer ferrielectric blocks and six synclinic layers(Fig.2).

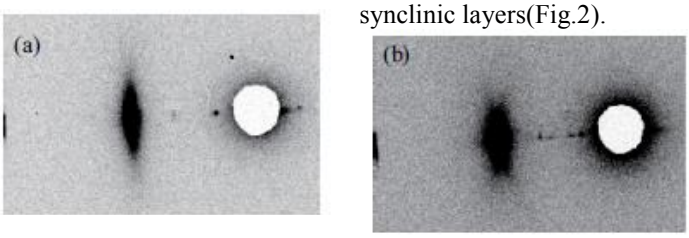

Fig. 1 RXS patterns at applied fields of (a) 0 V and (b) ±26.5 V at 144 °C.

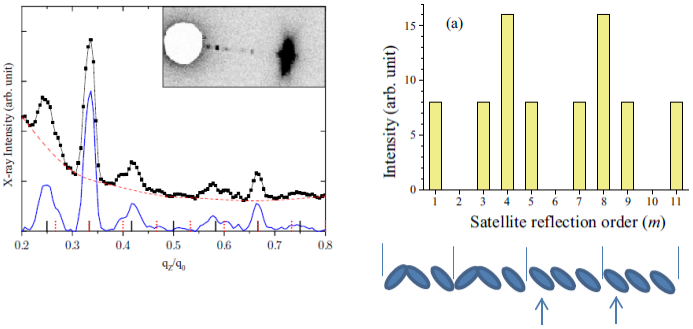

Fig.2 (left) The intensity distribution along the layer normal as a function of the normalized scattering vector. (right) Calculated RXS satellite intensities for the 12-layer periodicities shown in the lower panels.

References

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