9-2004

Comment on "Self-Organized Periodic Photonic Structure in a Nonchiral Liquid Crystal"

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Ruan *et al.* [1] described "a very regular, almost hexagonal, periodic pattern" in a hybrid-aligned (normal orientation of the director **n** at one plate and planar at the other) smectic *A* (Sm*A*) cell and explained it as a lattice of spherical-cylindrical domains (SCDs). We demonstrate that (1) the model does not account for an important energy term caused by discontinuity walls, and (2) the structure is formed by focal conic domains (FCDs) [2] rather than by SCDs.

(1) According to [1], each SCD is composed of a hemispherical domain of radius $a \approx (2\text{–}5)$ μm and elastic energy $w_s = 4\pi K a/3$ placed on top of a cylinder with the energy $w_c = (1/3)\pi K(d - a)\ln(a/r_c)$; K is the splay constant, r_c is the defect core radius at the cylinder axis, and d is the cell thickness. The period is deduced from the balance of w_s and w_c [1]. However, the SCD model implies discontinuity walls [such as the plane containing line *AB* in Fig. 1(a)] with the energy density $\sim K/\lambda$, where $\lambda \approx 3$ nm is the layer spacing in the studied Sm*A*-4-octyl-4′-cyanobiphenyl [2]. The wall energy, not accounted for in [1], $w_{\text{wall}} \sim (K/\lambda)a^2$ is about $a/\lambda \sim 10^3$ times larger than w_s and w_c. Usually the discontinuity walls in Sm*A* relax into defects such as FCDs [2]. The present situation is no exception, as shown below.

(2) We use fluorescence confocal polarizing microscopy (FCPM) that allows one to obtain the vertical optical slices of Sm*A*-4-octyl-4′-cyanobiphenyl samples doped with 0.01 wt.% of dye BTBP [3]. The intensity of light in FCPM texture is maximum when the polarization of light **P** is parallel to **n** and minimum when $\mathbf{P} \perp \mathbf{n}$ [3]. We use polyimides JALS-204 (JSR Microelectronics) and rubbed PI2555 (Microsystems) for normal and planar alignment, respectively. For 3 μm $\leq d \leq$ 10 μm, the textures are similar to the "almost hexagonal periodic patterns" of Ref. [1]; the period increases with d. However, FCPM imaging of the vertical *XZ* planes [Fig. 1(c)], especially for slightly tilted samples [Fig. 1(d)], reveals that the structure is formed by FCDs rather than SCDs. Each FCD has an elliptic base at the planar *XY* substrate and a hyperbola *H* in the *XZ* plane. Dark regions in Fig. 1(c) correspond to $\mathbf{n} \parallel Z$ near the boundary between two FCDs. The tilt [Fig. 1(d)] reveals an additional dark band associated with the hyperbola *H*. In the SCD model, such a dark part would not occur; on the contrary, the dimmed part would disappear as **n** would depart from $\mathbf{n} \parallel Z$ [Fig. 1(b)]. In both FCD and SCD, the layers are perpendicular to the planar plate and experience tilt and splay at the opposite plate.

Contrary to SCDs, the FCD groups do not require drastic discontinuity walls [2,4]; compare lines *AB* in Fig. 1(a) and line *CD* in Fig. 1(e). What is new in the present case with the *rubbed* planar substrates is that many FCDs are of a fragmented type with incomplete ellipses. The missing parts of ellipses correspond to **n** orthogonal to the rubbing direction. We relate the fragmentation to azimuthal anchoring caused by rubbing; it is absent at azimuthally degenerate interfaces such as Sm*A*-isotropic fluid. It is well known that the hybrid-aligned Sm*A* at the isotropic substrates shows hexagonal structures formed by FCDs with complete circular bases; see, e.g., [4].

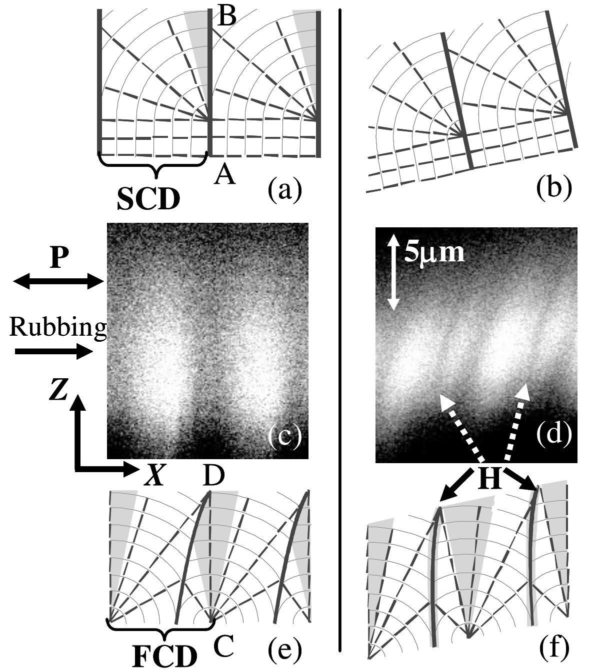

FIG. 1. (a),(b) SCD model of a hybrid-aligned Sm*A* film. (c) FCPM textures of vertical cross section *XZ* of the Sm*A* sample. (d) the same, tilted by 12°. (e),(f) FCD model that fits the FCPM textures.

The work was supported by NSF grant DMR-0315523.

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Received 19 February 2004; published 3 September 2004
DOI: 10.1103/PhysRevLett.93.109401
PACS numbers: 42.79.Dj, 61.30.Jf, 42.70.Qs

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