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TESTING METHODS OF MEASUREMENTS OF LIQUID CRYSTAL-TO-SOLID SURFACE ANCHORING ENERGY

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Abstract Anchoring energy values were determined using two testing methods in the same LC-cell for the pair NLC 5CB - silicon elastomer orienting surface coincided within the limits of experimental accuracy.

Anisotropic intermolecular interaction at a liquid crystal-non-liquid crystal interface mostly determines NLC uniform alignment. Anchoring induced by LC cell bounded surfaces is characterized by anchoring energy W_o and interaction potential W_s. These quantitative characteristics of anchoring produce a decisive effect on LC devices operating parameters: threshold of orientational effects, relaxation times ets. The development of reliable methods of the anchoring energy determination is still urgent unresolved problem. A large body of data concerning measurements of W_o has been amassed over the past years, but the spread of W_o values measured by the available methods is rather high even for the same NLC-surface pair.[1] Such a spread in values may be caused by technological inequivalence of cells or by the difference in techniques based on some external impact.

It is interesting to measure the anchoring energy by two methods using the same LC cell. The development of testing methods, when LC layer is subjected only to

the aligning action of the cell substrates, espesially suits the situation. Two testing methods were chosen: measurement of the topological-defect parameters[2] and the recently proposed technique of the small-angle laser light scattering on the NLC director fluctuations[3]. Using these two methods we determined the value of anchoring energy of 5CB on silicon elastomer, which aligns this LC homeotropically in 50 μm thick cell.

The silicon elastomer ($(CH_3)_3SiO((CH_3)_2SiO)_nSi(CH_3)_3$, n=2500) layer was precipitated out of 10% solution of elastomer in toluol. After the precipitation the obtained 100 nm thick layer was drying at 60°C. Using both techniques, the anchoring energy corresponding to the director deviation from its average position on the plane perpendicular to the cell substrates was determined. In the topological-defect method one needs to measure the steady-state width D of domain walls, where the director twists about the axis parallel to the substrate. Such a width is determined by the equality of the elastic and surface energy contributions to the energy balance. Assuming a uniform twisting and using the surface potential $W \simeq W_0 \cos^2\beta$, where β is the angle between the director and substrate surface, and minimizing the sum of the elastic and surface energy with respect to D, one obtains the expression for W_0:

$$W_0 = \pi^2 K_{22} L / 2D^2 .$$

Here K_{22} is the twist elastic constant, L is the cell thickness. The measured value of D was about 11 μm, $K_{22}=4\cdot10^{-7}$dyne for 5CB, thus $W_0=(2\pm1)\cdot10^{-3}$erg/cm^2.

It is well known that thermal fluctuations of the director around its equilibrium position give rise to an intense scattering of light. The second testing method of the anchoring energy determination is based

on the sufficient influence of anchoring on the long wavelength spectrum of nematic director orientational fluctuations $\langle|\delta\vec{n}(\vec{q},W_o)|^2\rangle$ where $\vec{q}$ is the scattering wave vector. Macroscopically this dependence shows itself in the NLC-cell light scattering characteristics, namely in the angular distribution of the scattered light intensity in the region of small $\vec{q}$.[3]

Experimentally the influence of polar anchoring could be noticed, for example, in the scattering of extraordinary wave without changing of the state of polarization (e-e scattering) in the region of very small scattering angles θ. Intense e-e scattering takes place in the optical geometry when the wave vector of the incident light makes an angle $\varphi \neq 0$ with the director. For this geometry, choosing the director to be parallel to the scattering plane, the expression for the scattering cross-section is:[3]

$$\sigma^{ee} = \left(\frac{\Delta\varepsilon^2 \omega^2}{4\pi c^2}\right)^2 \sin^2(2\alpha - \theta)\,\langle|\delta\vec{n}_1(\vec{q},W_o)|\rangle^2 ,$$

where $\Delta\varepsilon$ is the optical anisotropy $\varepsilon_e - \varepsilon_o$, α is the angle between $\vec{E}$-vector of the incident light and the director, $\alpha = 90^o - \varphi$ for the homeotropic alignment, n_1 is the amplitude of the splay-bend mode; its explicite form is presented in Ref. 3.

To determine the anchoring energy value for a LC-solid surface pair one needs to record the angular distribution of the scattered light relative intensity in the region of $\theta \approx 3 - 15$ mrad with high spatial resolution, and fit the experimental data to a set of theoretical curves, calculated for different values of W_o. To achieve high spatial resolution, laser source of light has to be used with divergence not higher than 1 - 1,5 mrad and low power (10 - 15 mW), not to affect

the LC-layer.

Experiments were performed employing Ar^+ or He-Ne TEM_{00} lasers, whose emission wavelengthes are not absorbed by NLC 5CB. Experimental set up was described in previous papers .[3,4] Measurements were performed using the same cell, filled with 5CB, oriented by silicon elastomer layer. The obtained anchoring energy value coincides within the limits of experimental accuracy with that measured by the topological-defect method. This result shows the reliability of these two testing methods, which offers an advantage to measure W_o not only in specially prepared sample but in commercial cells.

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