Absorption current spectroscopy study in inorganic/organic interface containing Au nano-island film and LC layers

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Moden applications of liquid crystal materials (LCs) are in the creation of fast switchable devices based on electro-optical change of refractive index [1]. Among them is the usage of nonlinear-optical response in LCs, since LCs rank first in photo-change of refractive index among all known optical materials. But the cost of that is the slowest response time in them, as the main mechanism is the collective reorientation of LC molecules in the cell volume. One of the direction is to development of special designs of LC composites, which can include nanoparticles (NPs) of various kinds and shapes, dyes, polymers, graphene rods, and other additives. This permits the expoitation of different types of confinement effects occuring for thin layers of LC molecules in the vicinity of NPs, or inside small polymer bubbles.

In our research, we investigate confinement effects that can be realized near the surface - close to the solid substrate of LC cell. For this purpose, we creat substrates containing Au nano-island film (Au-NIS). As an experimental method we use two-wave mixing (TWM), when two laser beams form an interference field and this periodic pattern leads to photoexcitation of a phase dynamic grating in the cell. Then many diffraction orders can be observed at the output as a resutl of the diffraction on this grating [2]. We have experimentally observed fast strong flashes of light when TWM in our hybrid LC cells. The changes of the reorientation angle of LC molecules θ can be described by the Erickson-Leslie model [3] and depends on the square of the effective electric field E formed inside the cell:

$$\frac{\partial\theta}{\partial t} = \frac{K_{33}}{\gamma_1}\,\frac{\partial^2\theta}{\partial z^2} + \frac{\varepsilon_0\Delta\varepsilon}{\gamma_1}\,sin(\theta)cos(\theta)\cdot E^2 \tag{1}$$

where K_{33} is tension modulus on bend (B), γ_1 is rotational viscosity, $\Delta\varepsilon$ is dielectric anisotropy of LC. In our case, the effective electric field is due to the creation of unstable charge on the substrate surface under influence of light. In such a nonlinear system, both the relaxation time and the diffraction efficiency are influenced by many parameters: the morphology of Au-NIS, the LC composition, the cell thickness. In the present work, we perform numerical experiments on modeling the nonlinear response in these hybrid LCs, focusing on its relaxation time depending on the morphology of Au NIS. Moreover, since we ourselves fabricate Au-NIS on substrates, as well as hybrid LCs of difference compositions, we have the possibility to compate the results of our numerical experiments with the obtained experimental data for different cells. In this way, a surface-induced photorefractive effect (SIPRE) model for LC materials will be developing it its completed form.

References

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