NEW WAY TO CREATE HIGH-SPEED LCDS BASED ON THE USE OF MODIFIED NANOMATERIALS

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Diamond is one of the most popular materials which can exist in the form of nanoscale particles. Special class of nanodiamond material with characteristic sizes of 4 to 5 nm, often called in the literature “ultradispersed diamond” (UDD) or “detonation nanodiamond” (DND), were produced by detonation of carbon-containing explosives.

For the functionalization of detonation nanodiamonds, we attached carboxylate groups by grafting. Activation of COOH-surface functionalized groups allowed attachment of various organic tails.

Dielectric and electro-optical properties of nematic liquid crystalline mixtures (LCMs) doped with modified DND (MDND) are investigated. It is established that the effect of MDND on the dielectric properties of LCMs depends on the size of nanoparticles and the type of rod-like elongated organic molecules attached to the MDND. It was found that nanoparticles of small size (4-5 nm) do not significantly affect the LCMs parameters. At the same time, MDND-based conglomerates with a diameter of about 50 nm or about 100 nm can increase or decrease the dielectric anisotropy and LCMs response time by 1.5-2.5 times, depending on the polarity of the tails.

The problem of reducing the optical response time in modern displays based on nematic liquid crystals has not yet been completely solved. This is especially important for displays with a vertical orientation of the molecules due to the fact that not many classes of liquid crystal compounds are characterized by negative dielectric anisotropy. To solve this problem, we changed the design of the LC cell and the molecular orientation method. For the orientation of liquid crystals, transparent films of anodized aluminum oxide with an ordered system of pores were used. The pores of the film were filled with MDND. Due to the combination of all these materials, the response time can be improved several times, and the viewing angle can reach 180°. Our results have confirmed that this idea can be used to make high-speed VA LCD with a wide viewing angle.

As mentioned above, a serious limitation to the use of nematic liquid crystals in high-speed electro-optical devices is their slow response time. Liquid crystal materials with ferroelectric properties are characterized by a very high switching speed due to the linearity of the electro-optical effect (in the microsecond range). However, the lack of a stable orientation due to its destruction, even with a small mechanical action, is the main obstacle preventing the commercialization of such devices.

To solve the above problems, we investigated the influence of graphene on the dielectric properties of liquid crystals, since the dielectric characteristics of LCs have the greatest influence on the threshold and dynamic parameters of various devices based on liquid crystals.

Graphene flakes were doped into nematic liquid crystals and ferroelectric liquid crystals, respectively. From the experiment, we found that the dielectric spectra of pure nematic composition and composition doped with graphene are almost identical, except for one effect. The addition of graphene reduced the dielectric anisotropy sign inversion frequency by 100 kHz. Study in this area is promising, since many research centers are actively involved in the development of dual-frequency LC materials, through the synthesis of new classes of compounds. It is an expensive and lengthy process. In our case, this problem can be solved more easily.

It was found that the addition of graphene significantly affects the dielectric properties of ferroelectric LCs, and also leads to an increase in spontaneous polarization and a decrease in viscosity. The addition of graphene increases spontaneous polarization by 20-25% and increases the tilt angle by 15-20%. In turn, these parameters have the greatest impact on the response time of the ferroelectric LCD (reduces the response time by 70-90%). Figure 1 shows that the cell with the addition of graphene FGL-1 is characterized by a significantly faster response time.

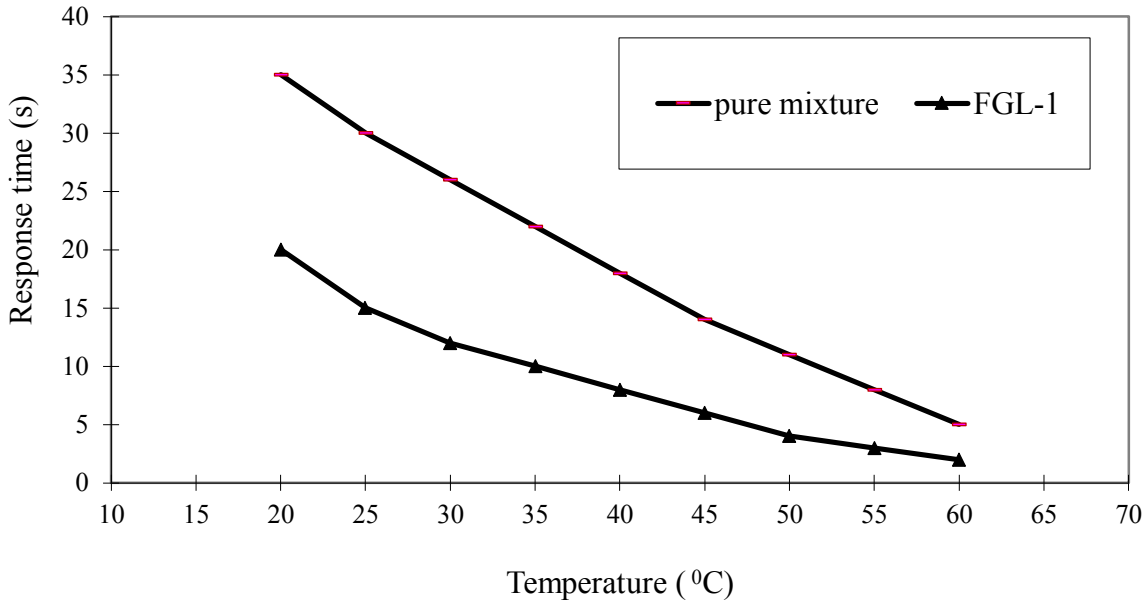

Fig. 1 – The response time of pure LC composition
and LC composition doped with graphene

It should also be noted that the addition of graphene to ferroelectric compositions leads to the effect of bistability, improves orientation and resistance to mechanical deformations. Thus, we can conclude that graphene is promising as an additive to LC compositions for the development of high-speed and bistable displays.