Dielectrophoretic Manipulation of Isotropic & Nematic Droplets

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Thermotropic liquid crystal (LC) exhibits a series of different phase with critical temperatures (T_{NI}), at which phase transitions occur including the transition from nematic to isotropic phase. Nematic and isotropic phase can coexist simultaneously near T_{NI}. In this work, we manipulated isotropic droplets or nematic droplets by using dielectrophoresis. Dielectrophoresis is the motion of electrically neutral particles under spatially non-uniform electric fields. As shown in Fig. 1, isotropic droplets within nematic phase appear dark under crossed polarizers (Fig. 1(a)), and nematic droplets within isotropic phase look bright (Fig. 1(b)). The position of isotropic droplets was different from that of nematic droplets.

Dielectrophoresis in these systems can be expressed as

$$\mathrm{F} = \frac{1}{2}\varepsilon_0(\varepsilon_i - \varepsilon_n)\nabla E^2.$$

Here ε_i ε_n and ε_0 are the dielectric constants of isotropic phase, nematic phase, and of vacuum, respectively. Because of the difference between dielectric constants between isotropic and nematic phase, isotropic droplets are expelled from the high electric fields region, and nematic droplets are attracted by the high fields regions.

We made a cell using two substrates with comb-shaped electrodes and vertical alignment layers. One substrate was covered by another one so as that the electrodes on the upper substrate are perpendicular to those in the bottom substrate. When heating the cell after filling with liquid crystal, isotropic droplets appeared near T_{NI}. By applying electric fields of 10V on both substrates, we could relocate the isotropic droplets as shown in Fig. 1(a). By heating the cell further, we could obtain nematic droplets, which were also electrically manipulated. This technology may be applicable to optical switching device or displays.

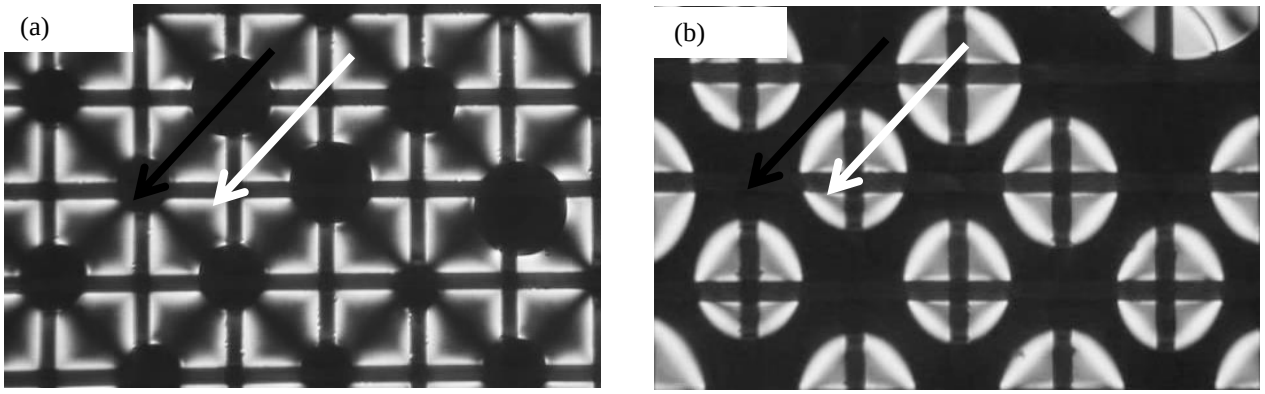

Fig. 1) POM image for (a) cell in heating state from the nematic, (b) the cell in cooling state form the isotropic: these images explain the motion of droplet moving along the dark or white patterned line. In all experiment, we applied 10Vppm (60Hz, square wave) at each cell

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References

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