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PRELIMINARY COMMUNICATIONS

Alignment of guest–host liquid crystals with polarized laser light

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Surface-mediated alignment of nematic liquid crystals with polarized laser light was reported recently [1]. In this communication we describe the alignment of a guest–host liquid crystal medium with polarized laser light. Liquid crystals in the illuminated region orient perpendicular to the direction of the laser polarization and remain aligned in the absence of laser radiation. The liquid crystals can be reoriented again by subsequent illumination. The kinetic feature of this surface-mediated liquid crystal orientation is characterized by the presence of coexisting liquid crystal regions of directors pointing away from the initial alignment.

We reported recently the alignment of a nematic liquid crystal medium by illuminating a dye-doped polymer alignment layer with polarized laser light [1]. Liquid crystals in contact with the illuminated area homogeneously aligned perpendicular to the direction of laser polarization (see figure 1). Liquid crystals remain aligned in the absence of laser light.

In this communication we describe our study of laser light-induced alignment of liquid crystals in a guest–host liquid crystal system. In contrast to our recent report [1], the alignment layer for the guest–host liquid crystals does not contain dye chromophores. The dye chromophores were dissolved in the liquid crystal host to form a guest–host mixture. Upon illumination with polarized laser light, similar laser-induced liquid crystal alignment was achieved. Most interestingly, the memory and erasable characteristics were also observed. Possible applications of the laser alignment process may exist in the fabrication, reconfiguration and repair of guest–host type liquid crystal displays first described by Heilmeier and Zanoni [2].

A liquid crystal cell with a spacing of 11 μm was made from two glass substrates coated with a thin layer of polyimide. Both plates were rubbed with a cloth prior to assembly and then assembled with the rubbing directions parallel. The cell was then filled with a dye–liquid crystal mixture of 1·8 wt% tetraazoperimidine dye [3] in ZLI 1982 (EM Chemicals, Hawthorne, New York) at room temperature. The dye structure and absorbance spectra are illustrated in figure 2. Using a polarizer, we observed the dichroic dye/nematic liquid crystal mixture to line up along the rubbing direction of the cell.

The guest–host liquid crystal cell was then illuminated with an argon ion laser (514·5 nm) polarized along the direction of the rubbing axis. After 120 min exposure at

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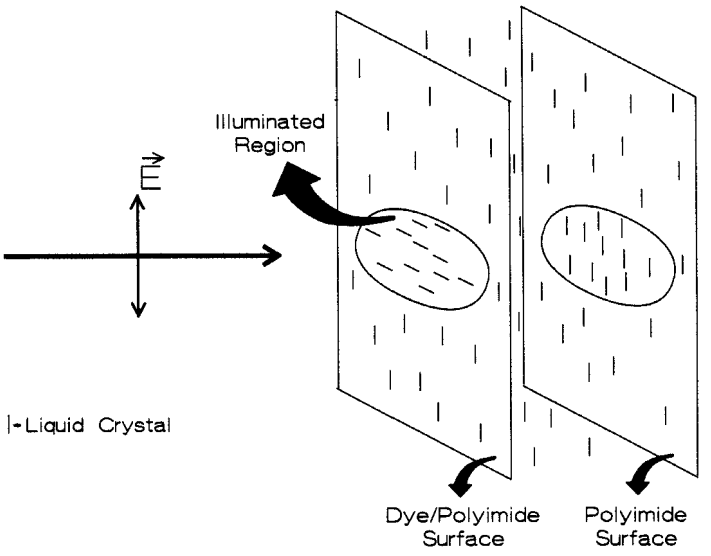


Figure 1. The geometry of the illuminated liquid crystal cell of [1]. The glass substrates of the cell are not shown for clarity. The rods represent the liquid crystal orientation near the substrates before and after illumination.

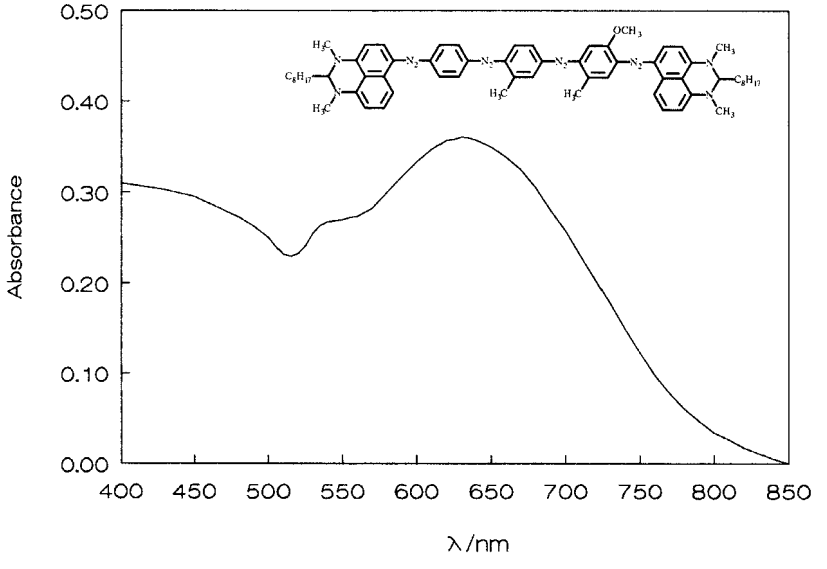
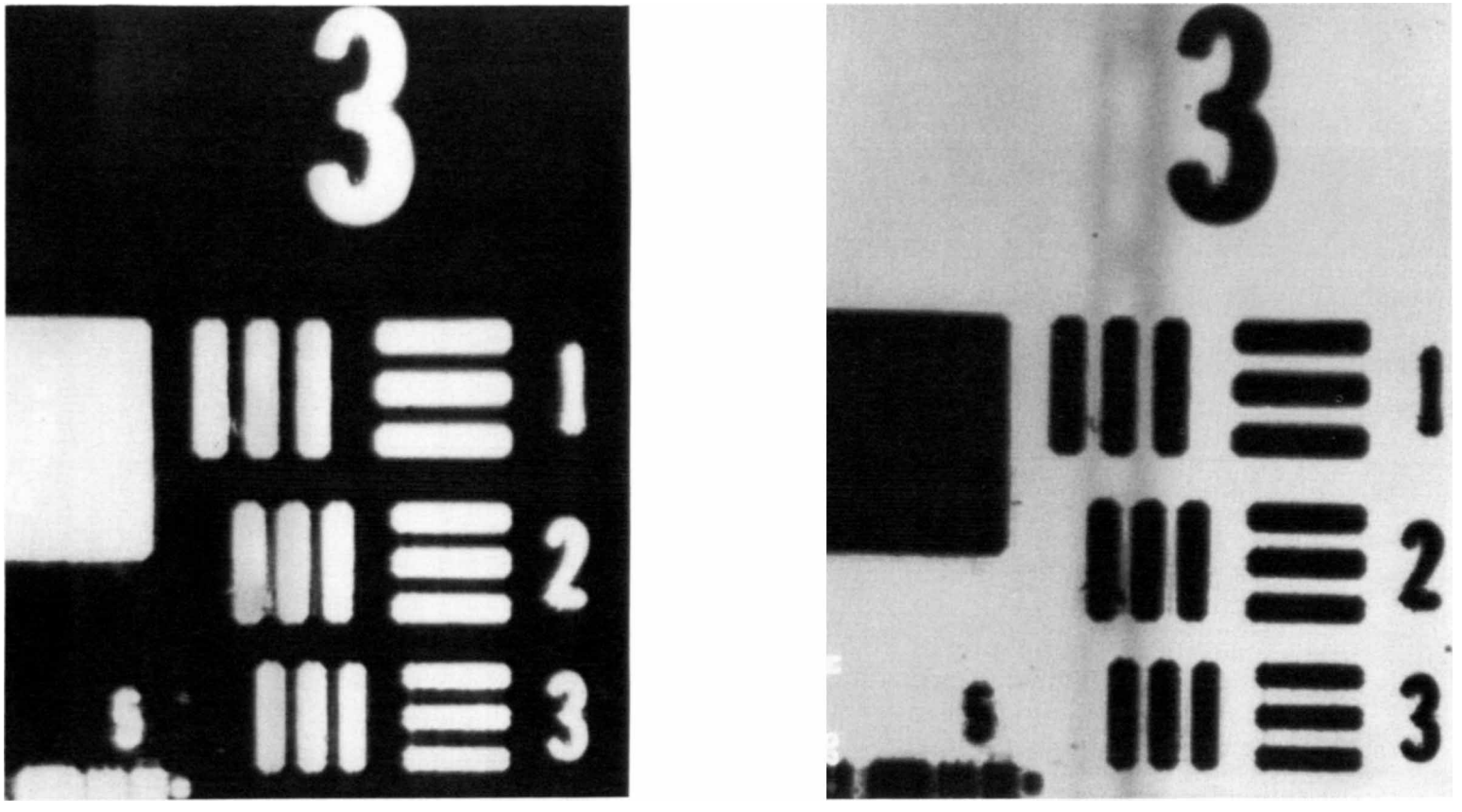


Figure 2. The chemical structure and absorbance spectrum of the dye dopant in ZLI 1982 nematic liquid crystal.



(*a*) (*b*)

Figure 3. A laser-aligned resolution chart as viewed through a single polarizer with the transmission axis (*a*) perpendicular and (*b*) parallel to the rubbing axis. The numbers and bars are realigned 90° to the background alignment after an exposure of 120 min at 8 W/cm^2. Diffraction of the laser light by the mask limited the resolution of the final image. The square in the photograph is approximately 2 mm on an edge.

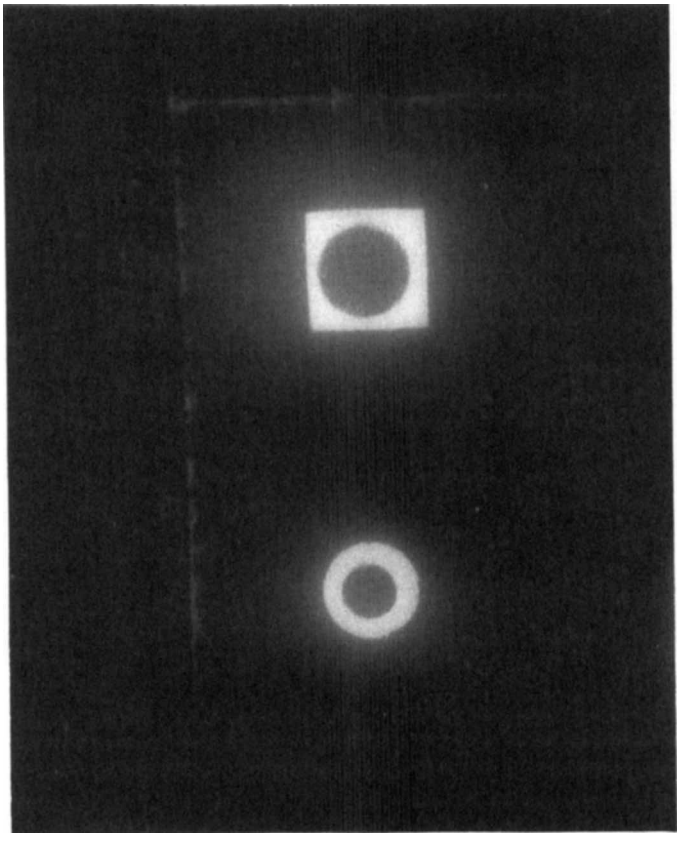


Figure 4. A photograph demonstrating the write/rewrite capability of this process. The resulting laser-aligned patterns were viewed through a single polarizer with the transmission axis perpendicular to the rubbing axis. The square and larger circle were illuminated with the laser polarized parallel to the rubbing direction for 45 min at 8 W/cm^2. This resulted in an alignment 90° to the rubbing direction. This was followed by an illumination through a smaller circular mask for 45 min at 8 W/cm^2. In this case, the laser polarization was perpendicular to the rubbing direction and resulted in an optically aligned region parallel to the original rubbing direction. The dimensions of the square are approximately 1 mm × 1 mm.

8 W/cm^2 power density, liquid crystals within the illuminated region oriented perpendicular to the laser polarization as shown in figure 3. Similar to the case reported earlier, the liquid crystals for the guest–host system remain aligned in the absence of the laser light and can be reoriented again by subsequent illumination (see figure 4).

It was found that the guest–host liquid crystals aligned this way assumed a twisted nematic structure within the illuminated region. Apparently, the aligning polymer layer on the incident glass substrate was altered permanently as a result of the laser–dye interaction which subsequently induces a new aligning direction for the guest–host liquid crystals. Since the laser light was significantly attenuated by the guest–host liquid crystal medium, the aligning polymer layer on the back substrate was slightly affected during long exposures.

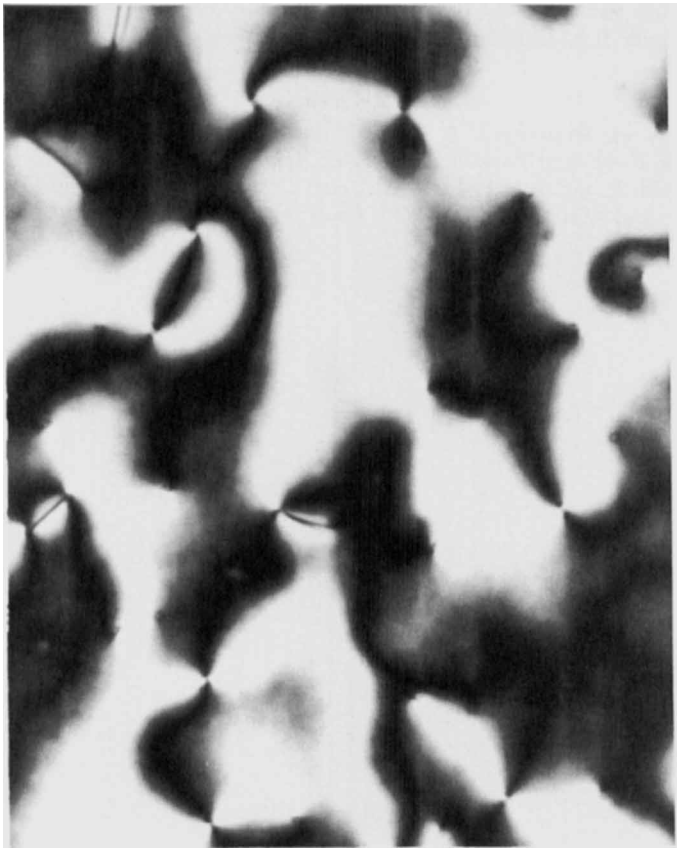


Figure 5. A laser-aligned area as viewed through a single polarizer with the transmission axis at 45° to the rubbing axis. The exposure was for 3 min at 8 W/cm^2 and clearly demonstrates domains with directors pointing clockwise and counter-clockwise from the initial alignment direction.

The light-induced liquid crystal alignment was studied as a function of laser exposure time. A polarizer was used to determine the direction of liquid crystal orientation. At $t = 0$ liquid crystals were uniformly aligned along the buffing direction. Upon the illumination of polarized laser light, coexisting regions of liquid crystals with directors pointing away both clockwise and counter-clockwise from the initial alignment were observed (see figure 5). A uniform single domain was again achieved when the different domains attained orientations of $\pm 90°$ with respect to the initial direction.

The light-induced orientation can possibly be viewed in the context of a phase transition [4]. The applied optical field quenched the initial equilibrium surface state into an unstable region of phase space. The evolution of phase-separated regions of domains is then conveniently followed by memorizing the information on the surface and reading the stored information with guest–host liquid crystals in the absence of laser light. One interesting feature of the system is the apparent degeneracy in both the initial and final states. The system may serve as a model system to probe two dimensional phase transitions at interfaces.

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