Mechanical Stability of Pixel Isolated Liquid Crystal Mode for Flexible Display Applications

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Abstract

We have characterized the mechanical stability of the Pixel-Isolated Liquid Crystal (PILC) mode for flexible display applications. In our device, the liquid crystal (LC) molecules are isolated in pixel by polymer wall and layers. The device shows good electro-optic properties against external mechanical distortion due to the polymer wall structures.

1. Introduction

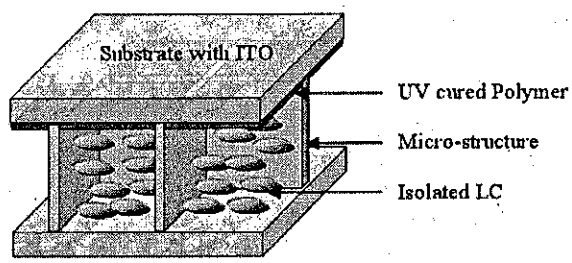
At resent, LC device using plastic films substituting traditional glass substrate is much attention for use in application of mobile phone, PDA, smart card, head-mount displays because of their light-weight, thin packaging and flexibility[1-3]. However, using the plastic film substrates makes big problems. Plastic substrates could not give hard support for LC alignment and could not sustain cell gap by external mechanical distortion. And also, they are easily separated.

To overcome these problems polymer walls and/or networks as supporting structures have been proposed and demonstrated [4-6]. These structures were fabricated using an anisotropic phase separation method from polymer and LC composite systems by applying patterned electric filed or spatially modulated UV intensity. But, these methods require high electric filed to initiate the anisotropic phase separation or there remains the residual polymers in an unexposed region that reduce optical properties and increase the operating voltage of the device.

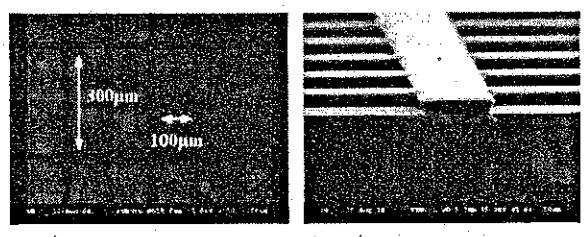
In this report, we propose a method of enhancing the mechanical stability of a plastic LC device using polymer wall structure and an anisotropic phase separation method. And we characterize electro-optic properties in the presence of external mechanical condition in our device.

2. Experimental

Figure 1 (a) is a schematic diagram of the proposed PILC device. As plastic substrates, ITO-coated polyethersulphone (PES) plastic films are used. Pixel-isolating polymer wall structures are fabricated on the one plastic film by conventional photo-lithograpic method using negative photo-resist SU-8 (Micro-Chem). Figure 1 (b) and (c) are SEM images of polymer wall structure which isolate LC molecules in the pixel. For the alignment layers, we use 2 wt% Nylon 6 (Aldrich) solution, that are spin-coated on the wall structure and rubbed unidirectionally. The materials used for nematic LC (NLC) and UV curable polymer were E7 (Merck) and NOA-65 (Norland), respectively. A solution of the LC and pre-polymer with weight ratio of 90:10 was dropped on the microstructure and covered bare ITO-coated substrate. For complete phase separation, we expose UV light using 200W Xenon lamp (λ=350 nm).



(a)



(b) (c)

Figure 1. 1 (a) Schematic diagrams of the PILC device. (b) and (c) are SEM images of the microstructures.

3. Results and Discussion

We tested the alignment stability of our PILC cell against an external mechanical pressure and bending. Figure 2 shows polarizing microscopic textures of a normal plastic LC cell and a plastic PILC cell in the presence of an external point pressure with a sharp tip. Under the same amount of the point pressure, the alignment texture of the normal sample was severely distorted due to the cell gap variation and the LC-orientation variation. Figure 2 (a) shows only point pressure can cause crucial damage to the optical properties of the normal plastic LC cell in a large area. However, that of the proposed PILC sample showed no appreciable structural changes since the hydrodynamic properties of the LC are spatially restricted and the cell gap are sustained by the pixel-isolating polymer wall structure shown in dark regions of Fig. 2 (b).

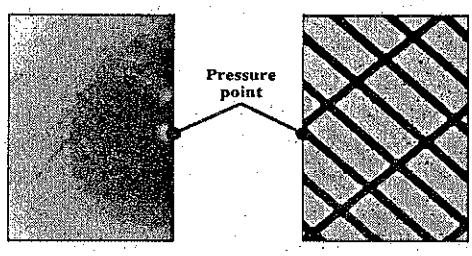
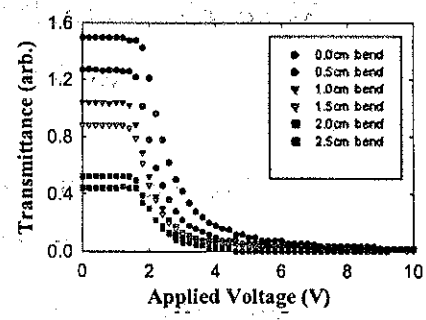


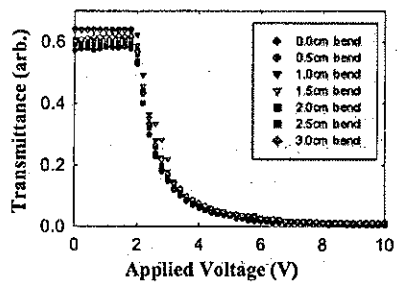
Figure 2. Alignment textures of (a) a normal sample and (b) a PILC sample fabricated with the plastic substrates. The polarizing microscopic textures are taken in the presence of an external point pressure with a sharp tip.

Figure 3 shows the electro-optic properties of a normal plastic LC cell and a plastic PILC cell in the presence of an external bending pressure with a pair of linear stages. At bending normal plastic LC cell, the cell gap varies depending on the bending amounts since the difference of the bending radius curvatures between the bottom substrate and the upper substrate varied. Such effects resulted in the decrease of the transmittance as shown in Fig. 3 (a). However, our PILC cell shows almost same transmittance properties irrespective of the amount of the bending pressure in the whole operating voltages.

Notice that the transmittances of Fig. 3 (a) are degraded by 70 % under the same bending pressure condition of Fig. 3 (b). Figure 3 (b) represents the LC alignment and the cell gap of our PILC cell are supported well by the polymer structures against external bending pressures



(a)



(b)

Figure 3. Electro-optic properties of (a) a normal sample and (b) a PILC sample depending on bending amounts

4. Conclusions

We demonstrated the PILC mode for enhancing mechanical stability. The mechanical stability tests of the proposed PILC structure shows good EO properties irrespective of the point pressure or the bending pressure. Therefore, it is expected that the PILC structure would be suitable to solve current main problems in plastic LC devices.

5. References

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