Novel single-cell-gap transflective LCDs with photoalignment

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A single display mode employs different pretilt angles to deliver matched voltage driving for both transmission and reflection.

Transflective LCDs have extensive application in mobile devices such as cell phones, palmtop computers, and camcorders because of their good readability in both indoor and outdoor environments. In these displays, each pixel is divided into two regions (subpixels). One region is reflective (R) and operates in intense ambient light, and the other is transmissive (T) and functions under dark illumination. The idea is that the two subpixels should exhibit matched electro-optical properties, thus requiring only one driving circuit to generate identical gray levels.

The electro-optical properties of an LCD are governed by the phase retardation of an LC pixel, \( \delta = \Delta n \times d \), where \( \Delta n \) and \( d \) are the birefringence (double refraction) and thickness of the pixel, respectively. When the phase-retardation ratio of the T and R subpixels is 2:1, the single pixel that contains them will exhibit optimized electro-optical properties, and the regions are said to achieve matched phase retardations. In a ‘single-cell-gap’ transflective LCD, same-thickness T and R require different birefringence properties to achieve the ideal ratio. To address this problem, previous efforts have adopted different subpixel display modes—for example, vertically/hybrid or homogeneously/hybrid aligned—but the results are not consistent for all driving voltages. Moreover, mixing display modes leads to discrepancies between the voltage-dependent transmission and reflection curves, requiring complicated driving circuits and thus additional expense.

We recently reported a simple photoalignment method in which both the T and R regions use a single display mode but have different pretilt angles to give different birefringence modes. Our approach consists of exposing an LC cell doped with photocurable monomers (lauryl acrylate and biphenyl diacrylate) to UV irradiation (with a light intensity of 16 mw/cm² and centered at a wavelength of 365 nm) through a photomask and subjecting it to an AC voltage of 9 V (see Figure 1). The specific steps are as follows. In the sample cell, the UV light was blocked in the T region and transmitted in the R region for 10 min. After removing the photomask, the entire sample was exposed to UV light for 35 min. The process formed polymer layers on the inside surfaces of the glass substrates to support the surface tilt of the LC layer on terminating application of the AC voltage. Alternating pretilt angles of 54° and 65° for T and R were produced, yielding optimal phase retardations of half-wavelength (180°) and quarter-wavelength (90°), respectively (see Figure 2).

Figure 3 shows optical photographs of the bright (at 0 V) and dark states (at 10 V) in the transflective LCDs with backlight illumination. The different transmitted-light intensities for T and R indicate their different phase retardations. Those measured at

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birefringence modes with different pretilt angles of 54 and 65°, respectively. This type of transmissive LCD exhibits optimal half- and quarter-wavelength phase retardations at zero bias and excellent phase match between the T and R pixels at all driving voltages, consequently requiring only one thin-film transistor. The alignment technique enables a variety of LC-layer pretilt angles on which many new applications depend. We will further develop new LC devices (e.g., twisted optically compensated bend mode, bistable cell) with pretilt in the range of 20–60°.

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