

Flexible Cholesteric Displays

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ABSTRACT

The state of the art of flexible bistable cholesteric reflective displays at Kent Displays will be reviewed in this paper with emphasis on full color displays using ultra thin 12 μ m substrates. Current trends in applications will be discussed as well.

INTRODUCTION

Bistable reflective Cholesteric displays (ChLCDs) [1,2] from Kent Displays have been in the market for over 10 years now. These are all glass based and rigid; however, recently, the technology has been extended to flexible and even drapable displays. Flexible cholesteric displays are now entering active product development with numerous customers. Manufacturing capacities are being ramped up to meet demands for new products. These flexible displays offer amazing design freedom in terms of conformability, customization, high resolution, thinness, ruggedness, and shape. These attributes give these displays a unique look that is being leveraged by customers to enhance products and put displays where displays have not been possible before. The state of the art in flexible displays will be presented. New products being developed as well as the status of manufacturing will be discussed.

Fig. 1 shows a photograph of a typical flexible ChLCD using the phase separation approach. The thickness of each of the two substrates is 50 μ m. The display is segmented.



FIGURE 1. Bistable flexible cholesteric display showing flexibility. The display in the photograph is made of two 50 μ m substrates.

ENCAPSULATION

Flexible cholesteric displays have typically used two encapsulation methods – polymerization induced phase separation (PIPS) [3] and emulsification [4,5]. Both methods have intended uses and applications. However, both approaches maintain the properties of cholesteric displays such as bistability, passive addressing, reflectivity, high contrast, and good viewing angle. At Kent, we are primarily focused on the phase separation approach. This method is in active product development as well as manufacturing. This approach enables simple manufacturing, low voltage driving, and high contrast. Here, the material is first coated

and then the droplets are created via polymerization induced phase separation. The emulsification approach provides a single substrate coatable solution for ultra flexibility and ability to use virtually any substrate material.

FLEXIBLE DISPLAYS

The simple cross section of typical flexible cholesteric displays from Kent is shown in Fig. 2. The liquid crystal is encapsulated using phase separation. The phase separation method involves laminating a homogeneous single-phase mixture of pre-polymer materials (acrylate chemistries) and liquid crystal between two flexible substrates. The pre-polymer is only about 20% by weight of the mixture. The space between the substrates is maintained by spherical plastic spacers dispersed in the pre-polymer/LC mixture. This is then exposed to low intensity UV radiation. The UV radiation starts polymerizing the monomer materials which in turn phase separate from the liquid crystal. Small droplets are created bounded on two sides by the substrates.

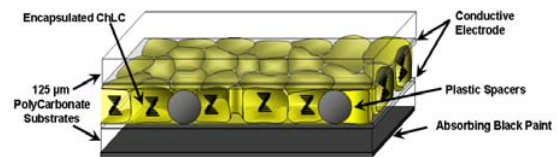


FIGURE 2. Schematic diagram of the two substrate phase separation based flexible encapsulated ChLCD.

Stacked color flexible displays have also been reported using ultra thin substrates [6]. Due to the highly flexible substrates, conducting polymers are used as the electrodes in place of the usual indium tin oxide (ITO). The total display thickness is about 60 μ m and the photographs in Fig. 3 show the high degree of flexibility as well as ruggedness of these displays. The displays only have four substrates with the R, G, and B layers stacked on top of each other. This results in maximum reflectivity, an essential criterion for reflective color displays. The displays are driven with a passive drive scheme allowing for simple customizing of display designs, formats, and resolutions.

Flexible display manufacturing takes place in Kent, Ohio with a sheet process where displays are made on an array and then singulated after lamination. The display is made in array form with an approximate sheet size of 320mm \times 370mm. The displays are then laser singulated and heat seal interconnects are attached. The drivers are standard off-the-shelf LCD drivers. Roll to roll manufacturing will start in Q1 of 2008 with the sheet process serving low volume and prototyping efforts. The roll to roll process will be used for high volume products.

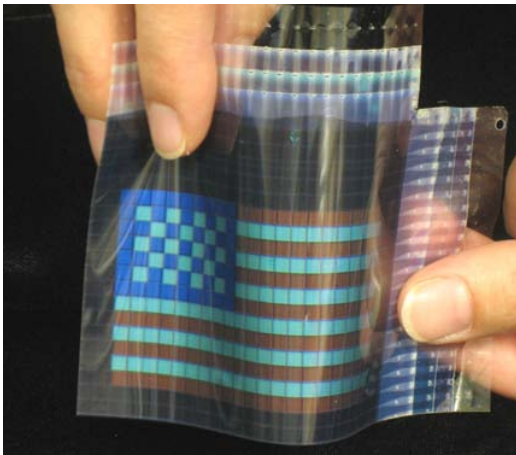
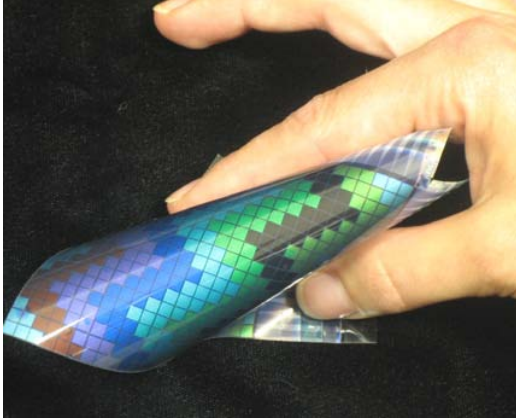


FIGURE 3. Ultra thin phase separation based reflective ChLCDs using thin PET substrates. The total display thickness is approximately 60 μ m and the format is 20 \times 24.

APPLICATIONS

We are working with several key customers at present to develop custom flexible displays for a variety of applications. These flexible

displays in their first embodiments will have fixed curvature for a conformed application.

One of the most exciting applications for both rigid and flexible ChLCDs is the electronic book. Although the mass acceptance of such devices is yet to become reality, bistable technologies such as ChLCDs are ideally suited for these displays. High resolution, high number of gray levels, good brightness, and contrast are key aspects that benefit the e-book applications. With thin flexible substrates, stacked full color e-book displays are nearer to reality.

With flexible substrates, the applications for ChLCDs continue to increase. Since flexible displays maintain all of the cholesteric display attributes such as bistability, reflectivity, high contrast, and wide viewing angle, the same applications are ideally suited as well. However, the added dimension of design freedom render flexible cholesteric displays to be used in new concepts and applications. These can be curved signs, flexible electronic books, name tags, wrist watches, etc.

CONCLUSIONS

Bistable cholesteric displays have been in the market for several years. With the advent of conformable and flexible displays, the market penetration is increasing. Furthermore, the displays are being introduced in consumer devices in places where displays did not exist before. Kent Displays has aligned manufacturing plans to meet customer expectations while retaining flexibility to address emerging markets.

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