CMOS Backplane Liquid Crystal Microdisplay

Akihiro Mochizuki
Displaytech, Inc.
2602 Clover Basin Dr. Longmont, Colorado 80503 USA
akihiro@displaytech.com
Phone: (303)772-2191, Fax: (303)772-2193

CMOS backplane liquid crystal microdisplays are emerging as an important new category of display components. By combining integrated circuit and liquid crystal technologies, liquid crystal microdisplays provide onboard processing capability with high quality imaging, drawing on decades of development in these two core technologies. The idea of CMOS backplane liquid crystal display is not new. In 1981, Suwa Seiko (now Epson) marketed a CMOS base liquid crystal TV-watch with 210x200 resolution on a 1.6-inch panel.1 The recent emergence of microdisplays has been enabled by technologies and business models of the past decade.

Displaytech fabricated the first microdisplays made with foundry silicon in 1990, demonstrating both technical feasibility and identifying CMOS processing issues not yet addressed in 1990.2 Although these early FLC panels produced images, the reflective surface of their IC backplanes was neither flat enough nor reflective enough to provide the image uniformity or optical throughput required for commercial applications. As the IC industry began practicing chemical mechanical polishing (CMP) as a standard CMOS fabrication process in the mid-1990s, the smooth, flat, highly reflective surface required for microdisplays became available from commercial foundries.

Small form factor of the microdisplay with enough image quality enables us to apply wide variety of applications, in particular viewfinders, cell phone displays and head mount type of displays. Viewfinders for camcorders and digital still cameras are current one of the most promising applications of microdisplays. QVGA viewfinder module is now available for camcorders, digital still cameras and head mount types of applications. This module is consisting of silicon backplane display panel, substrate board and LED mounted illuminator. This all-in-one type viewfinder module has significantly small size and lightweight. This small form factor with high image quality makes design of viewfinder module for digital still camera and camcorder very easier. Small power dissipation due to high light use efficiency also promotes microdisplay for wide variety of mobile systems such as cell phones, personal organizers. One of the most beautiful points of this microdisplay is continuous image without disturbed by black matrix lattice and substantial high image density due to field sequential color reproduction. These image continuity and high image density make QVGA image more than conventional QVGA image. Actually, this product provides more beautiful image than the spec of "QVGA".

Current one of the biggest interest in consumer electronics market is HDTV. CRT, direct view LCD and PDP are competing each other to obtain initiative in this market. Projection TV using small display panel is now increasing its significance in this particular market due to its high cost performance. Silicon backplane microdisplay now attracts market's attention as projector panel due to its high cost performance. Extremely high aperture ratio at high resolution panel such as XGA, SXGA and HDTV formats without being disturbed by black matrix lattice on screen is one of the most attractive point of microdisplay. Smaller pixel pitch with high image quality is one of the most important technical and cost requirements for HDTV application. Also eyeglass type or head mount type of displays are focusing many interests in terms of new types of display devices. Lightweight.
low power consumption and reasonable cost with high image quality are key function for this kind of applications. As mentioned above, FLC base microdisplays give rise great opportunity to create new category of information equipments by their unique performance with affordable cost.

Spontaneous polarization gives FLCs fast optical response. In video display systems, fast switching FLCs create sharp, CRT-like motion images without the smearing often seen with nematic LCs. FLC speed also enables single-panel video projection displays with field sequential color. Compared to three panel projection displays, single-panel systems cost less due to their inherently simpler design, requiring fewer components and fewer manufacturing steps. Also related to spontaneous polarization, symmetric switching is characteristic of FLCs and gives FLC microdisplays a built-in light throughput advantage. Throughput is further advantaged in FLC microdisplays by in plane molecular bistable switching which increases the angle of light acceptance (lowering the f/#).

The fact that ferroelectric liquid crystals can be switched at standard CMOS voltages (3.3V and 5V) is an additional advantage by comparison to nematic LCs, which sometimes require higher voltages (>9V). This drive voltage difference increases the complexity of the IC backplanes required for nematic-on-CMOS displays. In addition to the advantage of standard CMOS voltage, FLC IC backplanes are typically simpler due to the binary switching of FLCs, allowing entirely digital backplane designs. Backplanes for nematic LCs, on the other hand, must be designed to support the inherently analog electro-optic effect of nematic LCs.

Microdisplay, in particular ferroelectric liquid crystal microdisplay is one of the above new generations of high cost performance displays. High video image quality with small form factor, small power dissipation and good cost performance of FLC microdisplay are being expected to be widely used for new types of applications such as video cell phones, personal image viewer, eye-glass displays, ultra mobile business projectors, single-panel personal projection TVs, single-panel rear projection monitors and large screen rear projection TVs, and so on. In particular, HDTV, which is required high resolution and high information contents, is one of the most promising application fields of FLC microdisplays.

High cost performance will also create new types of application, which used to be not realized due to economical reason. Multi-screen display system for business use is one of the examples. Multiple function of desktop computer is now requesting more functional and reasonable cost of screens. FLC microdisplay will provide effective solution to these needs.

In highly advanced IT society, it is inevitable to be required higher information contents and wider variety of information. However, information cost needs to be lower to meet with these requirements. FLC microdisplays will give effective solutions to these demands.

References