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Can low temp poly-silicon meet the large display challenge?

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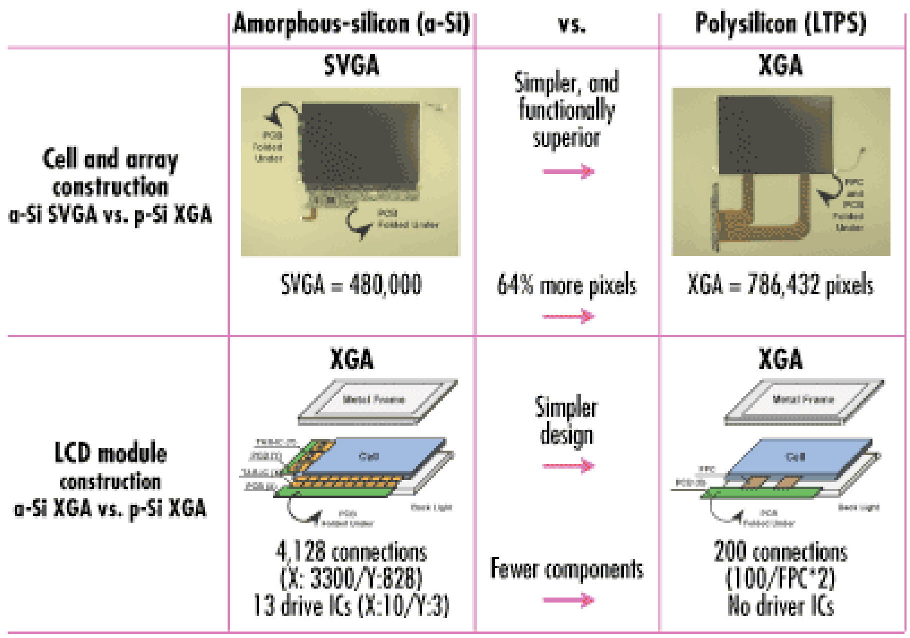
Systems engineers face several design challenges as they try to increase the size and resolution of displays in portables such as notebook PCs. As a result, liquid crystal display (LCD) technology is evolving to improve size, weight, brightness, power, reliability and the amount of data displayed.
While it is uncommon for a single technology development to enable improvements across a wide range of attributes, the advent of low-temperature poly-silicon (LTPS) technology has succeeded in realizing a number of display performance improvements. It has already proved itself as a display option for emerging applications such as information appliances, WebPADs, electronic books and electronic photo viewers. It's unclear, however, whether LTPS can meet the display requirements for mainstream large-sized notebook PC applications.

LTPS eliminates the need for the row and column driver integrated circuit (IC) chips used in typical amorphous-silicon (a-Si) thin-film transistor (TFT) LCDs commonly found in today's notebook, desktop and industrial LCD applications. LTPS displays offer high-resolution formats-up to 300 pixels per inch-and are lightweight, low in power consumption, high in brightness, durable and highly reliable. In addition, they offer designers relatively seamless design integration.

In the glass substrate of a typical a-Si TFT LCD, the silicon grains are very small and the grain structure is random, which greatly inhibits electron mobility in the substrate. However, on a poly-silicon (p-Si) TFT LCD substrate, the silicon grain structure is much larger and more uniform, permitting electrons to flow approximately 100 times faster than in an a-Si substrate.

The electron mobility in the LTPS substrate is high enough to permit the fabrication of the row and column driver circuitry directly on the glass substrate. LTPS technology makes it possible to completely eliminate the tape automated bond (Tab) or chip on glass (Cog) row and column driver IC chips that normally surround the periphery of a-Si TFT LCDs.



The more simplified LTPS XGA panel has far fewer components and connections than an a-Si SVGA panel, even though it has 64 percent more pixels. Basically, the tape automated bond or chip-on-glass row and column driver IC chips that normally surround the periphery of a-Si TFT LCDs are eliminated in LTPS. The number of row and column display connections in a typical XGA display can be reduced from more than 4,000 to as low as 200. Thus, the cell and array construction of a typical a-Si 10.4-inch SVGA TFT LCD is more complex than that of an LTPS 10.4-inch XGA TFT LCD.

Source: Toshiba

As a result, the cell and array construction of a typical a-Si 10.4-inch SVGA TFT LCD is much more complex than that of an LTPS

10.4-inch XGA TFT LCD, even though the XGA LTPS panel has 64 percent more pixels than the a-Si SVGA panel.

With the Tab or Cog driver chips eliminated, it is possible to reduce the number of row and column display connections in a typical XGA display from more than 4,000 to as low as 200, achieving as high as a 95 percent reduction. In addition, 13 driver chips can be eliminated in an XGA LTPS display, which substantially reduces component material and assembly costs, compared with an equivalent a-Si TFT LCD. Routing the row and column trace lines along the edges to one side of the display where a flexible ribbon cable connects directly to the glass further simplifies the LTPS cell. This flex cable then connects to a printed circuit board located on the back of the display, which in turn connects to the graphics system.

The key issue that today's system designers face is reliability. Eliminating Tab or Cog driver IC chips make LTPS panels inherently more reliable. In fact, the most common cause of field failures in portable a-Si TFT LCD notebooks is breaks in the driver IC bonds, which result from the severe mechanical stresses caused by dropping or other abuse. More than two-thirds of field failures are related to driver ICs. LTPS pretty much eliminates this problem, because the driver circuitry is fabricated directly onto the glass so there are no bonds to break. A test in which the display was twisted at two opposite corners demonstrated the increased reliability. The LTPS display was able to withstand 10,000 twists compared to 1,000 twists for a standard a-Si LCD display with row and column tab drivers. In any complex system, reliability inherently increases if designers eliminate components. Therefore, by reducing the number of components and related connections, LTPS displays produce improved product reliability.

Eliminating the tab drivers also reduces the electromagnetic emissions from an LTPS display by a few decibels when compared with an a-Si display. Reducing system electromagnetic interference (EMI) to acceptable levels invariably challenges designers, who resole the problem only after a very time-consuming process of troubleshooting, modifying and retesting of the system. The EMI reduction in LTPS displays will help control EMI emissions in the system design.

Display diagonal	Resolution and format	Resolution density
1.9-inch	QCIF (144 x 176)	119 ppi
4.0-inch	VGA (640 x 480)	202 ppi
5.8-inch	Wide-VGA (800 x 480)	160 ppi
6.3-inch	XGA (1,024 x 768)	202 ppi
7.0-inch	Wide-SVGA (1,024 x 600)	169 ppi
7.7-inch	VGA x 2 (640 x 960)	150 ppi
8.4-inch	SVGA (800 x 600)	119 ppi
10.0-inch	Ultra Wide SVGA (1,280 x 600)	141 ppi
10.4-inch	SVGA (800 x 600)	96 ppi
10.4-inch	XGA (1,024 x 768)	124 ppi
10.4-inch	UXGA (1,600 x 1,200)	192 ppi
11.3-inch	XGA (1,024 x 768)	113 ppi
12.1-inch	XGA (1,024 x 768)	106 ppi
14.1-inch	XGA (1,024 x 768)	91 ppi
14.1-inch	SXGA+ (1,400 x 1,050)	124 ppi
14.1-inch	UXGA (1,600 x 1,200)	142 ppi
15.0-inch	XGA (1,024 x 768)	86 ppi
15.0-inch	SXGA+ (1,400 x 1,050)	117 ppi
15.0-inch	UXGA (1,600 x 1,200)	133 ppi

A | LTPS technology is unlimited with regard to size and resolution compared with a-Si displays. LTPS also offers a high-density pixel format not easily accomplished with a-Si technologies.

The elimination of the Tab or Cog driver IC chips has yet another important design benefit: Without these drivers, LTPS displays become thinner and lighter than a-Si panels that offer comparable luminance and power levels. The only external connection to the glass is the flex ribbon cable. This makes it possible for LTPS displays to use very narrow bezels and a three-sides-free design approach. Panels may then be designed for tiling and other multiple-display applications.

The greater electron mobility in LTPS means that the signal lines and each individual transistor at each individual subpixel is physically smaller than if fabricated using an a-Si. This produces an increased aperture ratio from approximately 40 percent for a 10.4-inch a-Si display to 60 percent for a comparable LTPS display, which in turn provides increased brightness and/or lower power consumption. For example, a 14.1-inch XGA LTPS display will typically realize a 10 percent increase in brightness or 10 percent decrease in power compared to an equivalent a-Si display. Increased brightness improves legibility, and lower power consumption translates into extended battery life and/or lighter-weight portable systems.

The smaller transistors and signal lines in LTPS also meet the growing demand in notebook computers for greater pixel densities and higher resolution. LTPS technology can achieve pixel densities up to 300 pixels per inch (ppi) and resolutions to UXGA (1600x1200) and beyond. At 200 ppi, text is razor sharp, four-point text fonts are legible and electronically generated computer display images will appear as crisp and clear as a photograph.

Even though LTPS offers dramatic performance improvements and opens up many technological possibilities, the transition from an a-Si LCD to LTPS LCD is transparent to the system design engineer. The design issues engineers face as they adapt LTPS into their systems are minimal. The same design methods are used when working with either a-Si or LTPS. The electrical interfaces of the two technologies are identical, and LTPS displays can be designed to fit mechanically into the same space as a-Si displays. A system design engineer could directly replace an a-Si display with an LTPS display, thus gaining the benefits LTPS offers, including its light weight, lower power consumption and brighter display with improved reliability. By employing LTPS technology in new system designs, engineers can incorporate these advantages, as well as a smaller, thinner, higher-resolution display, into innovative designs.

LTPS technology is unlimited with regard to size and resolution compared with a-Si displays. LTPS also offers a high-density pixel format not easily accomplished with a-Si technologies. LTPS can offer a wide selection of display options for new designs.

It has also opened the possibility of integrating static random access memory (SRAM) directly into reflective or transflective LCDs. By using the higher electron mobility of LTPS technology, engineers can integrate SRAM into every RGB subpixel of the TFT array. The SRAM allows the user to view a static display or image without having to continuously refresh the information. As a result, it's possible to cut the power consumption of an LCD in standby mode by approximately 50 percent when displaying still images with eight colors. Cell phone applications currently are the most popular use for LTPS with integrated SRAM, but the technology may also prove to be beneficial in the future with larger displays for applications such as the sleep mode in a notebook PC.

Another technological breakthrough was the use of LTPS in the development of a full-color polymer organic light emitting display (OLED). In order to realize a full-color OLED display an active-matrix drive technology is needed, which requires a high level of carrier mobility for driving OLEDs. Poly-silicon is the only means by which the current required to drive an active-matrix OLED can be achieved. OLEDs with LTPS will provide fast response times, wide viewing angles and thin, lightweight displays. By adopting a high-polymer ink-jet process, OLEDs can potentially grow from small displays to high-resolution, large displays that can be used in notebook and industrial applications.

As LTPS technology improves and the electron mobility increases, integrating more system functionality directly onto the glass substrate during the cell-fabrication process will be feasible. LTPS will then open up the opportunity to integrate other functionality such as system memory, controller, touchscreen or voice recognition directly onto the glass substrate, enabling the possibility of a "system on glass."

Today, LTPS technology offers distinct advantages over a-Si displays, including high resolution, low power and higher luminance. These advantages, coupled with easy integration into existing systems, make LTPS a good choice to meet growing requirements for larger displays for notebooks and desktop PCs. Further, LTPS technology will continue to address system-level design issues such as durability, emissions, size and weight reduction, to bring engineers leading-edge display-technology solutions now and well into the future.