

The Nano Investor

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Michael Sinkula
mjsinkula@usnano.biz

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The Flat Panel Display Players

The display industry is one that will be considerably impacted by new light emitting materials. Cathode ray tubes are being replaced by new classes of displays that are lighter and much thinner than traditional television and video displays and are usually less than 10 cm thick. The following list demonstrates the variety of current and emerging flat panel display technologies:

- Plasma displays
- Liquid crystal displays (LCDs)
- Digital light processing (DLPs)
- Organic light-emitting diode displays (OLEDs)
- Field emission displays (FEDs)
- Liquid crystal on silicon (LCOSs)
- Surface-conduction Electron-emitter Displays (SEDs)
- Nano-emissive display (NEDs)

Only the first three of these displays are commercially viable today, while OLED and NED technologies look particularly interesting and are finding a lot of incumbent R&D dollars. OLED displays are beginning deployment in small sizes, while the NED is in the prototype stage.

Leaders in the plasma flat panel display market include Hitachi, Matsushita, and Pioneer, while the LCD market is dominated by Samsung, Sharp and LG Philips. Prices for these products have historically been very expensive, but competition from PC manufacturers has caused prices to decline. Dell currently sells LCD TVs for almost half the price of an equivalent from Samsung. Dell using its low-cost distribution channel to take on traditional Japanese electronics companies like Sony, Matsushita Electric's Panasonic division, and Sharp. In order to put a halt to the flat panel invasion by PC makers like Dell, Sony and Samsung have teamed up to make new LCD displays. Computer makers will probably come out on top simply because of their track record of innovating quickly while keeping costs low. More sales of flat-screen TVs means a higher demand for LCD panels, leading to a decline in LCD panel prices.

All competitors in the flat panel display market will eventually have the opportunity to license carbon nanotube display technology from companies like Motorola (who does not intend to commercialize their technology). Motorola uses nano emissive display technology – whereby carbon nanotubes are grown directly on glass – in its 5-inch-screen prototype.

Instead of one electron source behind the screen of a television, each pixel in NED will have a carbon nanotubes acting as the electron gun. DuPont, Dow Chemical, and Samsung are also playing in the same area, and even a few small start-ups such as Nano-Proprietary, have a chance to be a thorn in the incumbents side because of their strong patent position. For example, Nano-Proprietary claims the basic patent for several emissive display technologies, including those using carbon nanotubes.

Firms, such as CDT, E Ink, Philips and Plastic Logic are working towards displays that employ a flexible substrate and hence can be rolled up just like paper. The term "electronic paper" has been coined for this type of product, which is paper-like not only in its flexibility and thinness, but in its ability to be read from many angles. In terms of display manufacturing, there are two primary techniques: Vapor deposition and ink-jet printing. The former is a mature process, but expensive, while the latter is a new technique but could be revolutionary because of the potential economic benefits. Ink-jet printing of displays may be the economic catalyst that boosts new flat panel display technology into the mass markets.

Display Demands Beyond Color and Size

Mobile electronics are normally the early adopter of new display technology. But mobile electronics development has been constrained by power supplies. And no other component of mobile electronic applications that raises more concern over power consumption than the display.

In a typical laptop, the LCD display accounts for 30-35% of the power consumption (when wireless capabilities are not actively transmitting and receiving data). To put this in perspective, the display consumes more power than the CPU, chipset and hard drive combined. In wattage terms, the display can consume 3-6 watts, while the CPU and hard drive are normally below 2 watts each.

The cooling fan on notebook PCs uses only about 4 percent of total power and as a corollary, improved fans are not capturing much attention from PC makers in terms of improving power consumption.

Similarly, in handheld and cell-phone design, the big power concern is the new generation of color displays. In these devices, it is not so much the difference in power consumption from the black-and-white counterparts as it is the increase in the time that the screen is used. This relates directly to the increased usage of wireless connections for greater functionality. In small portable devices, there is also a desire to have larger screens with more pixels. This tends to also create the need for larger optics in order to have full coverage of the screen, which increases the size of the phone. Since this does not welcome thinner designs, companies are trying to make the pixels smaller. However, this reduces the low light sensitivity of the device, which requires enhanced flash capability, which in turn requires significantly more power.

As an alternative, LED (LED) technology is being explored to replace LCD screens. LEDs are advantageous because they need no backlight, they can be thinner, lighter and less power-hungry than LCDs (although today's LEDs use at least as much power as conventional lighting technologies). They can also switch on and off almost instantly, and can be viewed from almost any angle. But higher costs associated with LED production have limited its presence in the market. To improve the costs associated with LED technology, organic LEDs (OLEDs) are being pursued because their polymeric nature could circumvent the chip fabrication process of normal LEDs.

LCD screens turn black when taken outdoors because the backlight can't compete with the sunlight and all the colors are produced by shining light through the display. As a result, LCD modules have gone to transfective and reflective type LCDs for outdoor applications. Transfective being a combination of transmissive and reflective where a backlight is used in low light conditions but in the outdoor environment, that backlight can be shut down and it's used in a reflective mode.

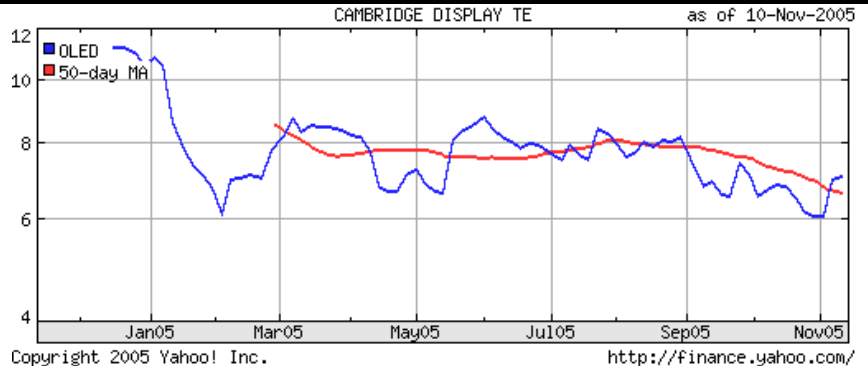
Power consumption can be reduced using this strategy. In addition, screen fabricators now use a polysilicon substrate that lets a screen work at lower voltage levels with smaller transistors. This also allows more light to pass through the screen, reducing the backlight's power requirements, which can account for half of all the power the screen needs. LED displays falter here because they are by nature an emissive technology and cannot be adjusted for ambient light. Some mobile phones, particularly the flip phones, have incorporated a dual display format where the secondary display can be activated when the main display is completely shut down. LEDs will need to incorporate this strategy because the stand-by power consumption is so high.

While current improvements in LCD technology, such as increased pixels, will continue to burden power sources, future display technology should actually help to reduce power needs. While today's LCD displays require an energy-draining backlight to shine through the liquid-crystal layer, future LED displays emit light, which should significantly reduce power consumption. LED technology is one new display technology that, in addition to improved display clarity, will have an impact on the power requirements for displays is the advent of advanced LED technology. The drawback with LED is the fact it cannot use ambient light because it is emissive. While LEDs are still over a year from penetrating the mobile market, LEDs could potentially produce the same amount of light for 10 percent of the power (even though current prototypes take 50% more power). OLEDs have been reported to potentially reduce power consumption by two thirds (compared to LCD displays).

Equity Research: Cambridge Display Technologies (Nasdaq: OLED)

Cambourne Business Park
Building 2020
Cambridge, CB3 6DW
Phone: 44 19 5471 3600
www.cdtltd.co.uk

Recent Price (11/11/05): \$7.34
Market Capitalization: \$143.02 million
Price/Earnings: N/A
Shares Outstanding: 19.49 million
EPS (ttm): -4.32
52 Week High/Low: 13.00 / 5.50
R&D/Sales: 107%



Profile

Cambridge Display Technology, Inc. (CDT) is the inventor and current leader of Polymer Organic Light Emitting Diodes (P-OLED) as they can be applied to flat panel displays (FPDs). While the company currently generates revenues largely from licensing its extensive patent portfolio, in the future, the company hopes to generate the lion's share of its revenues from flat panel products. To date, CDT has licensed its P-OLED technology to numerous companies including Seiko, Epson, Osram, DuPont, Philips and Delta Optoelectronics. Several products incorporating CDT's licensed P-OLED technology have been introduced into the commercial market, such as a mobile phone, several MP3 players, and medical devices. In May 2004, Seiko Epson unveiled a prototype 40-inch color P-OLED display. CDT has also formed relationships with Philips, Samsung, Casio, Toshiba, Thompson, and Matsushita Displays.

P-OLED Technology

The technology was derived from the realization that 'organic' Light Emitting Diodes (LEDs) could be made using conjugated polymers. Polyphenylene vinylene (PPV) was found to emit yellow-green light when sandwiched between a pair of electrodes. From this, researchers were able to manufacture components of displays that emit their own light. This technology offers significant improvements over current display technology where a separate light source has to be filtered in several stages to produce the image we see.

The company lists the following as primary benefits of P-OLEDs over LCDs:

- P-OLED is an emissive technology: it emits light as a function of its electrical operation.
- A P-OLED display consists of polymer material manufactured on a substrate of glass or plastic, and does not require additional elements such as backlights, filters and polarizers. The simpler structure should lead to significantly lower capital and material costs.

P-OLED technology is very energy efficient and lends itself to the creation of ultra-thin lighting displays that will operate at lower voltages.

P-OLEDs offer better scalability (compared to OLEDs) since they are solution processable, allowing for printing techniques.

The company owns the fundamental intellectual property and know-how portfolio for P-OLED technology (primarily because CDT invented P-OLED technology). This technology combines the simple construction of traditional LEDs with large area patternability associated with LCDs. In other words, if this technology becomes the de facto standard in displays, then CDT will be rewarded with every sale. In 2002, Opsys sold its Oxford, UK-based business to Cambridge Display Technology for an immediate payment in cash and a deferred payment in CDT shares. This acquisition has given CDT a strong patent portfolio in dendrimers.

CDT holds over 180 patent filings. The company has 62 patents issued in the U.S., 26 patents issued in Europe, 13 patents issued in Japan, and 6 patents issued in China and other IP developed with partners such as Epson.

Growth Strategy

In the near term, CDT will have plenty of licensing opportunities in P-OLED technology as it owns the core IP. The company has eight licenses for display services, four licenses for P-OLED materials, and two technologies for semiconductor driver technologies. In the past several years, Dow Chemical, Sumitomo Chemical, and Covion have worked on developing new blue P-OLED materials. But these companies will either be forced to pay CDT royalties on the sale of these products or enter into partnerships with CDT. In fact, the company recently announced a joint venture with Sumitomo Chemical called Sumation.

The long term objective for CDT is to enter mainstream flat panel graphics display markets, currently valued at over \$62 billion and predicted to be over \$100 billion by 2008. Over 30% of this market is the growing portable market including laptops, mobile phones, and converged devices. CDT believes that the computer market, including laptops and PCs, is unattractive in the short term and instead is addressing all other flat panel display applications (that make up half of the current market).

Competition

In CDT's IPO disclosure, it mentions Eastman Kodak (with its Sanyo partnership) as one of its primary competitors, in addition to the companies mentioned in the beginning of this issue. But one of their main competitors from an OLED technology standpoint is Universal Display with its healthy cash position. In 2001, Universal Display signed Samsung as a licensee, and in May 2005, Samsung was evidently pleased with its progress and moved up to being a full commercial licensee (it has already demonstrated a 40-inch organic light-emitting diode (OLED) display). This signing bodes well for CDT too as it validates the technology. If Samsung continues its success, then other incumbents will begin to seriously consider CDT technology.

Financial Condition

The company relies on a business model that relies heavily on the licensing of its technology. While this creates high gross margins and generally low overhead, this model also requires convincing manufacturers and incumbents that the technology is worth major investment. And for the amount of money that has been invested in CDT, the licensing fees generated thus far have been lackluster. This may have contributed to the dismal IPO in January 2005 where the opening day price was higher than the price at close. The stock is considerably down from its \$12 IPO price, but its latest quarter has seemingly renewed interest from Wall Street.

The company has steadily increased its operating margins while maintaining a commitment to R&D. In November, the company sold its remaining interest in Litrex for \$11.6 million and increased its cash position to \$16 million, although it has steadily decreased from \$26 million in December 2004.

CDT Financial Metrics

	2002	2003	2004
Revenues (\$M)	7	11	13
R&D (\$M)	20	17	14
Operating Income (\$M)	(35)	(20)	(23)

Source: CDT

Interestingly, CDT is considerably undervalued in comparison to its closest competitor in terms of size and footprint, Universal Displays. CDT has a Price to Sales ratio of 10 while that of Universal Display is over 46. In addition, Universal Display generates less revenue than CDT leading us to conclude that investors are strongly rewarding the licensing deal with Samsung.

Revenues in the third quarter of 2005 were \$6.6 million, compared with \$1.6 million for the same quarter last year, representing quite a jump. Year to date revenues for 2005 were reported at \$10.8 million, compared with \$5.5 million for the first three quarters of 2004, an increase of 96%. In the third quarter of 2005, the largest source of revenue was equipment and supplies, including the significant sale of four ink jet printers and associated ink supply.

Commentary

The company is one of the most successful private companies in the history of the UK, garnering nearly £100 million in venture financing (including \$10 million from Intel) and securing relationships with many incumbents in several industries. The company is at the forefront of the P-OLED display technology, one of the fastest growing technologies in the flat panel display market. The technology has a relatively short history, yet it has already begun to be commercialized and it may soon replace LCD and cathode ray tubes. CDT has a unique position in the space because it is the originator and developer of the basic P-OLED materials. The company supports a full spectrum of P-OLED solutions within the supply chain including the world's largest P-OLED printing facility. CDT offered its shares to the public markets in December 2004 and the value of the company has been met with some scepticism from Wall Street. Since 66% of CDT is currently owned by insiders (particularly management), investors may be waiting until the insiders are able to sell their shares on the public market. But at a book value of \$4.74 and no debt, the company is undervalued considering the potential upside.