

**Communications****The Viewing Revolution**

DIPLOMATIC PLANET PRESENTATION

**Universal Display Corporation****The Viewing Revolution****Universal Display Corporation (NASDAQ: PANL)**

Diplomatic Planet looked at the Display Revolution in 1999 with a focus on Universal Display Corporation, Inc. and its OLED (Organic Light Emitting Diodes). The technology was advanced but the markets were to be developed as the "mobile" world of anywhere, anytime communication and data access was more talk than reality.

Today – the prospectus on Universal Display would read about the same as it did almost ten years ago. Great Technology. Great Partners and Licensees. Still Waiting to be a Break-Out Company.

The company is not cash flow positive. Its balance sheet is, at more than USD\$80 million, liquid. As a teenager, it is facing issues with a market still more focused on plasma screens and LCD (Liquid Crystal Display) rather than on the OLED. Its current market cap is around USD\$550 million (May, 2008).

But the future is getting closer day by day..

OLED is still an eye-brightening technology primarily due to the flexibility it offers for displays – scotch tape flexibility.

There is a market – Samsung SDI, a technology licensee-partner, is recognized as the biggest OLED maker in the world and is producing commercial volumes of a two-inch OLED screen. The customers include Toshiba, Sony Ericsson, Kyocera, Hitachi and Nokia which features the Samsung SDI screen on one of its newest handsets. Cellphone makers - as storage and computing power increases - are very much in need of higher picture quality and low power requirements from the display which are key attributes of the OLED based display technology.

Universal Display reports it has over 30 business agreements with leading manufacturers in Japan, Korea, Taiwan, China, Europe and the U.S. including with companies such as Chi Mei EL, DuPont Displays, Konica Minolta, LG.Philips LCD, Samsung SDI, Seiko Epson, Sony, Tohoku Pioneer and Toyota Industries.

There is also competition from Eastman Kodak and Cambridge Displays, a subsidiary of Sumitomo Chemical – as well as a Sony small-screen television using non-PANL OLED technology.

Universal Display continues its long-term research and sourcing contracts with DuPont, Sony and others as its patent portfolio is proving solid in the OLED field.

In a Press Release (May 13, 2008) the company states it is working:

“to develop lightweight, rugged, low power displays that can replace printed paper maps on pilots’ knees and be rolled up for stowage when not in use. Rollability is also important for a variety of novel commercial applications, including the Company’s concept Universal Communication Device.”

“We are excited to continue the research and development of flexible and rollable OLED technology – an idea that is moving quickly from being a vision to becoming a reality,” said Steven V. Abramson, President and Chief Executive Officer of Universal Display. “The U.S. Air Force as well as other branches of the U.S. Department of Defense have been strong supporters of our flexible OLED technology. Also offering thinness, light weight and ruggedness, rollable displays may revolutionize the way soldiers view information on the battlefield and in the cockpit. This program should also support our efforts to commercialize FOLED technology for a variety of novel consumer applications.”

“Beyond current military concepts, flexible OLED displays are considered the next potential disruptive technology for several industrial, consumer and medical applications, such as in automobiles, cell phones and personal electronic devices. DisplaySearch, the worldwide leader in display market research and consulting, has projected that the worldwide market for flexible displays has the potential to grow to \$4 billion in 2015. Companies like Universal Display are introducing key advances in OLED technology that will bring flexible displays closer to commercialization.”

Liquid Crystal Displays (lcd) were invented in the US in the mid 1960's but were licensed, relatively inexpensively, to the Japanese electronic manufacturers which dominate the industry today.

OLED (Organic Light Emitting Diodes) is a US invention - with underlying patents in the names of Princeton University, the University of Southern California and the University of Michigan. PANL has exclusive license to these patents as well as to sole sublicensing rights for OLED patents from Motorola, Inc. Both Princeton and USC have become shareholders in PANL -- in fact this was the first time that Princeton had ever taken an equity stake in a company for which it was conducting research.

Technology prototypes will be appearing during 1999, with commercial prototypes being reviewed in 1999 and commercial products and applications in the marketplace in 2000. Emphasis is currently on products that utilize the technology's differentiations from liquid crystals - higher resolution, less power requirement and better color.

Liquid crystal technology is based on a sandwich of crystals between two glass polarized filter panels. As light enters and passes through each pixel sandwich, the liquid crystals twist the light ray 90-degrees so that the second filter panel also

passes the light ray. By electrifying the liquid crystal, the twist of the light ray is negated and the second filter panel blocks the light. An electrified pixel is dark, an unelectrified pixel allows the light source to pass through. Each of these pixels requires a transistor to be turned on or off. To add color, a red, a green and a blue transistor are added.

The high-end displays have over 50,000 transistors and give fine tuned control so that thousands of colors can be produced , while low end displays, (calculators, cell phones) do not have transistors at every pixel and electrical charges are sent across the display -- causing ghosts and blurring, and creating a response time characteristic that defeats display of motion.

Liquid crystals do not generate light but act as light traffic controllers. Therefore a light source is required either behind the display, alongside the borders of the display with reflective material directing the light to the display pixels, or by using a mirror behind the display that reflects the available lighting from the environment in front of the display.

### **Technology's Next Generation**

The key advantages that OLED technology has are its lower power requirements, its lighter weight and its lower cost components.

Organic LED uses carbon based molecules ('organic' ) which can be synthesized and mass-produced, layer by layer of molecule. Because of their physical thinness, they can be manufactured on films that appear transparent, that are flexible and they are bright -- since the molecule itself is generating the light (stacks of molecules can generate light combinations) at the pixel.

You also obtain greater viewing angles for this type of pixel, since it is not a polarized tunnel of light, as in the liquid crystal technology. Because there is no broadcasting of the electrical charge to groups of pixels, there is no lag time and no ghosting effects which allow OLED to produce a full motion display.

To understand the basic re-orientation that OLED will bring to displays, consider this: The light bulb that Thomas Edison invented in the 19th Century was a heat generating device that was manipulated to give off a controlled amount of light. The OLED is a light generating device that gives off practically no heat.

### **Weigh the Impact !**

- How critical are the processors (hardware)?
- How critical are the instructions (software)?
- How do either of these manifest without a Display?

### **A National Focus**

Universal Display is a member of the U. S. Display Consortium, a government / industry effort which is developing the infrastructure for a North American flat panel display industry. Steven Abramson (CEO of PANL) is on the Board of the Consortium which includes Princeton, University of Southern California and Hughes Electronics. This industry's goal is to replace the current CRT and LCD technology with the OLED

technology based on its benefits of brightness, higher resolution, more energy efficiency and its significant cost advantages.

The Department of Defense and the National Science Foundation have also funded PANL's development efforts.

### **Investment Approach to Research and Commercialization**

The marriage of university research and commercial entrepreneurship represents should continue as a signal to investors, both as to the leading edge research and to the practical, commercial aspects that this technology encapsulates. The intellectual property base consists of nearly one hundred patents from the research partners, all of which are exclusively licensed (or sub-licensed) to Universal Display.

The keys that Universal Display holds are the abilities to make displays that use very little power, that become highly portable and which can effectively display movement in a high resolution manner. These OLEDs result in display devices that are 85% transparent, making the 'heads-up' display for automobiles or other applications very practical. The film on which the OLEDs can be imbedded can be very flexible, and very transparent, allowing displays to wrap contours and to be viewed from a full peripheral range rather than only from straight-on.

The possibilities for these Flexible OLEDs (FOLED) that can be built on flexible plastic and other unbreakable and/or formable surfaces include a rollable, durable newspaper that updates the news automatically via transmitted signals, keeps you abreast of the latest breaking stories, Stock Market prices, sports scores, etc., while still retaining the easy transport properties of a standard newspaper.

The development methodology of this industry has given Universal Display the added advantages of being the key center for this technology while the development of strategic partnerships and the dissemination of licenses is fully encouraged. This Consortium effort maximizes the exchange between research centers and profit-based companies each of which occupies a core area of competency and each of which is allied with the other strategic players for integration and leveragings of the basic technology.

Not only is there a 'born in the USA emphasis', but the retention of the core patents and the oversight of the development of this nascent industry is a marriage of government's recognition of the pivotal necessity for this technology -- with the academic research centers 'pure science' -- in an entrepreneurial, venture-capital-esque environment that focuses on bringing applications to market. This method is too simply described as 'core competency and strategic partners development.

That does not mean that the industry will be based only in the US. The expertise and impact that the Asian and particularly the Taiwanese manufacturers have in this market are fully recognized and partnerships and alliances for the development and the commercialization of the flat panel technology with these world class companies is well underway.

**Corporate Outlook**

Universal Display continues to look for its market to develop and its licensees and partners to bring it prosperity. The future is a lot closer than it was ten years ago. In fact, the addressable markets estimated then are mini when the current actual market is sized today.

Continue to watch for the announcements of the "Who's Who" list of companies that become licensees and partners. The display market is a large sand-box and the world's leading tech companies know that the OLED technology change is one of the biggest opportunities they will embrace in the near-term.

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Sources: Universal Display Corporation ([www.universaldisplay.com](http://www.universaldisplay.com)) and The U S Display Consortium ([www.USDC.org](http://www.USDC.org))

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