iSuppli

Emerging Displays Review

Emerging Display Technologies
Monthly Report - September 2005

Emerging Displays Review

By Kimberly Allen, Ph. D, Director of Technology and Strategic Research

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News Analysis

Solid-State Lighting: Agilent Turns Off and Philips Turns On

By Jagdish Rebello, Ph. D.

Agilent Technologies Inc.'s decision to exit the market for High Brightness (HB) and Ultra High Brightness (UHB) LEDs reflects changing conditions in the LED market that are leading to a short-term slowdown in sales growth. In a major corporate realignment, Agilent recently announced the sale of its semiconductor business unit to buyout firms Kohlberg Kravis Roberts & Co. and Silver Lake Partners for $2.66 billion. The company also agreed to sell its 47 percent stake in Lumileds to Royal Philips Electronics for $950 million.

iSuppli Corp. in 2004 predicted that Agilent might sell its Lumileds stake to Philips. Agilent Technologies' semiconductor business is one of the leading suppliers of standard-brightness and HB LEDs to the solid-state lighting industry. And Lumileds, with LED lighting sales of $324 million during the past 12 months, is the technology leader in the development and commercialization of UHB LEDs.

Near-Term Prospects Dim Somewhat for LEDs

While 2004 was a marquee year for the solid-state lighting industry, with growth of nearly 26% compared to a year earlier, 2005 finds the lighting industry at a critical crossroads. During the past two years, backlighting of LCDs and keypads for mobile phones emerged as the dominant applications for LEDs. But beginning in 2005, growth in unit shipments in the mobile-phone industry began to decelerate as wireless penetration reached saturation in Europe, North America, South Korea and Japan.

Furthermore, new suppliers in Taiwan, China and South Korea have entered the LED manufacturing and packaging supply chain and are reducing prices aggressively as they compete for market share. Finally, except for camera-flash lighting, many of the new applications in the automotive and general-illumination industries that are being targeted by the next generation of high-flux UHB LEDs are not yet close to commercialization.

Consequently, iSuppli projects that the solid-state lighting market will grow by only 11% in 2005, less than half the rate of 2004.

Promising Applications Fail to Light Up Demand

iSuppli also predicts that some high-profile applications for LEDs, such as the backlighting of large-screen LCD displays, will not live up to the early hype. In large-screen LCDs, LED backlighting will add a significant price premium compared to competing technologies like Cold-Cathode Fluorescent Lamp (CCFL), External Electrode Fluorescent Lamp (EEFL) and Hot Cathode Fluorescent Lamp (HCFL) backlighting. Consequently, LED backlighting of large-screen LCDs will be limited, in the near term, mainly to specialty markets requiring high-dynamic range imaging, where users are willing to pay a premium for improved front-of-screen performance.

In light of these developments, it is likely that the decision by Agilent to exit the solid-state lighting industry will benefit the company as it seeks to focus its corporate resources more effectively on the semiconductor testing equipment business. As HB LEDs increasingly become commodity items, with aggressive annual ASP erosion of 10 to 15%, Agilent would not have been able to compete effectively in this market while maintaining satisfactory gross margins. It is likely that the buy-out firms eventually will sell Agilent's former LED-manufacturing unit to an existing LED manufacturer in the Far East.

Simultaneously, Philips' decision to acquire nearly the entire ownership of Lumileds is a reflection of the growing role that UHB LEDs will play in the next growth phase of the LED industry, which will commence after the year 2005.

A Brighter Tomorrow for LEDs

UHB LEDs are forecast to drive increased penetration of solid-state lighting in applications including electronic signage, exterior automotive lighting, and general illumination. General illumination is a multi-billion-dollar global market. However, LEDs now account for a negligible percentage of general-illumination sales. LEDs simply do not have enough luminous intensity to compete in a cost-effective manner with traditional light sources.

However, with LED technology advances by companies like Lumileds, Nichia, Osram and Cree, new lighting applications are expected to emerge that traditional lighting sources like incandescent lamps and fluorescent lighting will simply not be able to address.

Thus, LEDs can probably start to penetrate the general illumination market in 2010. And Philips, with its leadership position and well-established channels to market in the incandescent lighting industry, will be well-positioned to continue to dominate when the industry transitions to LEDs.

LCD: Improved Infrastructure in Japan

Two major Japanese suppliers of materials and components for LCDs have announced plans for major upgrades of their capacity. DaiNippon Printing (DNP) plans to spend 55 billion yen ($497 million) to increase its output of large-sized color filters, while Sumitomo will invest 30 billion yen ($271 million) to boost output of polarizing plates for large LCDs.

DNP will invest 30 billion yen in an eighth-generation color filter production line at its factory in Kita Kyushu, southwestern Japan, as well as 25 billion yen in a sixth-generation plant. An eighth-generation line can handle filter sheets measuring 2.16 meters by 2.4 meters, which are 1.5 to two times the size of seventh-generation sheets. They are expected to be more cost-effective. The sixth-generation factory handles filters measuring 1.5 meters by 1.8 meters. The new production lines will begin operations by the end of 2006.

Sumitomo will invest about 10 billion yen to raise the annual output capacity of polarizing plates at its factory in Niihama, Ehime Prefecture by 6 million square meters. It will also spend 20 billion yen to bolster the annual output capacity of polarizing plates at its South Korean unit, Dongwoo

Fine-Chem Co., by 12 million square meters. The company's total output of the product will rise by 75% to 42 million square meters per year. The planned upgrades will be completed by October 2006.

Such investments are expected given the rising demand for large LCDs, such as for LCD TVs. One point to notice, however, is how much more this investment is than recent commitments to the development of OLED. Sumitomo recently purchased the Lumation business of Dow Chemical and also agreed to set up a joint venture with CDT in polymer OLED materials. The details of the transactions were not made public, but are not in the realm of hundreds of millions of dollars. DNP is a CDT licensee, and has announced plans to develop OLED-based signage. But again, the commitment is far below hundreds of millions of dollars.

Given the relative sizes of the LCD and OLED markets (around $60 billion and $650 million, respectively, for 2005), the disparity in investment is hardly surprising. However, it is a clear reminder that the immediate revenue comes from the roaring LCD market, and even players that are quite interested in OLED development will continue to drink from the LCD trough for a long time.

Mobile Phones: Dial "M" for Manga

Comics called *manga* are a particularly Japanese phenomenon, as is spending an entire train ride engrossed in entertainment on a mobile phone. The two are now being combined successfully by a number of companies serving Japanese of all ages. This is a natural progression in a nation where people already download music, games and even novels onto their phones.

Sony Pictures Entertainment Inc. will almost triple the number of comic books it formats for viewing on cell phones in a move that will make it the No. 1 provider of *manga* comics for cell phones. Sony will increase the number of titles it offers to 300 over the next year, more than double the number offered by top rivals NTT Solmare and Toppan Publishing combined. But these two competitors also plan to boost their libraries.

Sony has signed exclusive contracts with 10 popular *manga* artists, including Shigeru Mizuki, creator of Gegege no Kitaro, a 1970s classic featuring a young ghoul boy who fights monsters. Japanese viewers pay 315 yen ($2.90) to download five *manga* titles a month by an artist of their choice.

Mobile-phone comics use a technology called Comic Surfing, developed by Celsys, which takes viewers through *manga* stories at a carefully calculated speed and sequence. The frames are specially formatted to fit on tiny mobile phone screens. Pop-up frames and vibration during action scenes add to the drama, and preprogrammed sound effects are expected to be included soon.

Suppliers of newer display technologies intended for mobile phones, such as OLED, electrophoretic, or the iMod of Qualcomm, should find ways to optimize their displays for this type of content and viewing experience. It could help sell the new displays to OEMs.

LCD: To Get Thinner, Just Add Plastic

Although LCD glass gets thinner and thinner, the thickness of the total module is still criticized. Many have pointed out that plastic substrates could be thinner, and OLED companies have noted that the use of thin-film encapsulation would allow OLEDs with only one solid substrate. These thinner packages, although not yet technically feasible, could provide competition to traditional LCDs.

A retort came recently from the government-sponsored Industrial Technology Research Institute (ITRI) in Taiwan. The organization has completed the development of a compound plastic-glass LCD technology, which can reduce the weight of LCD displays by 36% and the thickness by 35%.

This technology can be applied to portable electronic devices such as a 2- to 3-inch handset panels up to 7-inch automobile displays. A prototype display 4-inches in size and 0.9 centimeters thick with 100-ppi resolution has been shown. ITRI aims to reduce the thickness of the display to 0.6 centimeters in the next generation.

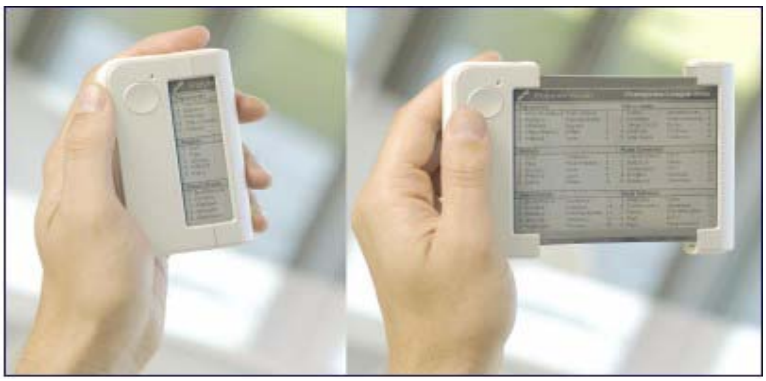
LCDs have already greatly improved their color gamut through the use of LED backlights. They have very wide viewing angles, and can be made to have low power consumption in reflective mode. If the thickness can also be improved, rival technologies have even fewer advantages to promote. Could the era be approaching where price is truly the only area of competition?

Flexible Displays: Ready to Roll?

Building on the question posed by the previous news item, it is possible that flexibility—or complete rollability—is a property that LCDs cannot counter effectively. Now Philips' Polymer Vision has shown a working prototype of a rollable e-reader that uses E Ink's electrophoretic technology. The five-inch, quarter-VGA (320 x 240 pixels) display has four gray levels and is a bistable reflective type. The device is roughly pocket-sized (100 mm x 60 mm x 20 mm).

The Readius™ (*Figure 1*) is not a product, nor is it intended to be commercialized. Philips is using it as a proof-of-concept demonstration model, from which designers may get ideas and skeptics may feel more convinced.

Figure 1: Polymer Vision's Readius Prototype



Source: Polymer Vision

Polymer Vision is in the process of seeking funding in order to become a spin-out from the Philips incubator. When it has completed this step, it will serve as a designer and promoter of these types of rollable displays. Without in-house manufacturing, it will have to work hard to convince investors that it offers sufficient value in the supply chain, but the Readius itself, and similar products that can be imagined, are likely to trigger the interest of many OEMs and end users.

Industry Issues

Solar Moving Toward Its Day in the Sun?

In the era of battery and charger dependence for our many devices, much effort is going into ways to improve display efficiency or battery energy density. But some users are taking an even more novel approach and finding ways to employ solar power to recharge—or even run—their electronic devices.

Consider the notebook computer. One way to charge it is with a folding solar charger panel, such as those from SolarMAX, Connecticut Solar, Sierra Solar Systems, or Sunshine Solar (*Figure 2*). They are generally available in 10W, 20W, and 30W versions, weigh a few kilograms, and fold down to about 15x17 inches in the largest size. They cost between $250 and $300. Very few notebooks can run on only 30W (older PowerBooks may be the only kind still in use), so solar power can be used in these three ways:

- Use a 30W charger in conjunction with the normal battery to extend battery life
- For true real-time solar operation, use two 30W panels, or a combination of one solar panel and the DC in-car charger option.
- Use solar simply to charge a higher-wattage notebook, not run it. One user claims that a 32.2W solar panel charges the 14.8V, 2400-mAH battery in a Dell Inspiron 700m in about six hours in full sunlight.

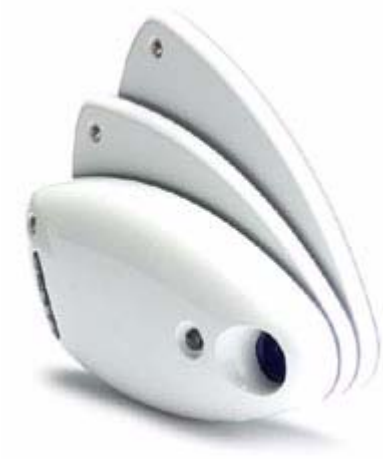
Figure 2: Solar Recharger from Sunshine Solar

Source: Sunshine Solar

Obviously, these are hardly solutions for on-the-go businesspeople, given the large size of the charger. But field workers find them useful, and the concept may ultimately give birth to a solution that is practical for city use.

Another way to use solar power is to charge a sealed lead-acid (SLA) battery using a solar panel, then run off the battery (this works well if the sun is not immediately available). A $60 solar charger called the Solio using this principle is available for the iPod (*Figure 3*). It can also be used during operation to extend the battery life, so that the iPod runs for 9-12 hours. The Solio can also be used with a mobile phone, Gameboy, GPS device, or PDA. In general, smaller devices such as cell phones and PDAs consume less power, and hence are more amenable to solar operation.

Figure 3: The Solio

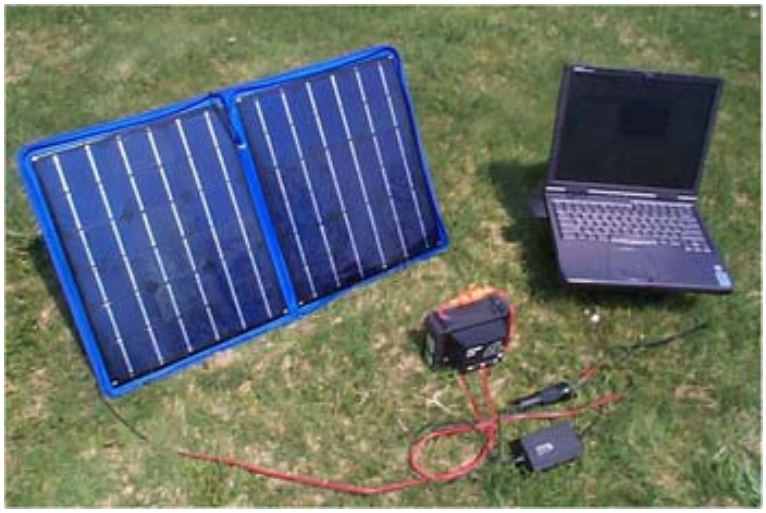


Source: Apple

SLA options are available for notebooks too, such as a 12V, 8 amp-hour option from Connecticut Solar (*Figure 4*). The disadvantage of SLA versions is that they are heavier than plain solar panels, weighing up to a few pounds for a notebook-sized battery.

Although this is a niche interest, it is worth noting as a potential future trend. Solar panels are moving toward lighter weight, flexibility, and higher efficiency with the advent of polymer (rather than silicon) technology.

Figure 4: Sealed Solar Lead-acid Battery



Source: iSuppli Corp. | September 2005

Fresh from R&D

New Table Stakes on Inkjet Printing

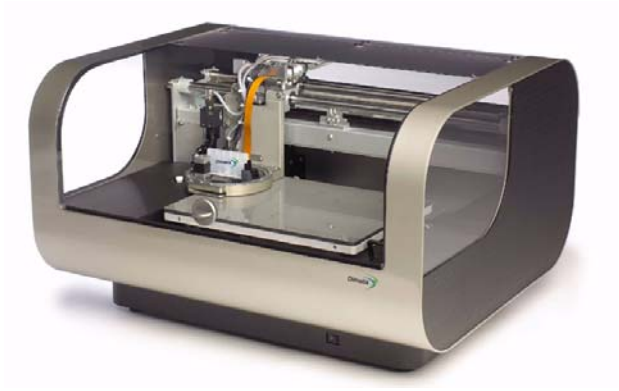
It is often claimed that the next revolution in manufacturing will be a transition to solution processing, particularly in the form of inkjet printing. And it may well be true. But such a change is unlikely to occur if R&D teams cannot test materials and printing processes quickly and easily. Turnaround time is critical when optimizing new methods. Furthermore, the tests must preserve the complexity that will be present in the actual manufacturing situation.

Dimatix, the renamed and restructured version of Spectra Inc (see *EDR*, May 2005, p. 4), has released a product designed to fill this niche. It is a tabletop printer featuring the company's own MEMS-based piezoelectric printhead, and is designed to support R&D in jettable fluids and processes. At a price of just under $30,000, it offers technical sophistication in a price range accessible even to universities and other small research institutions.

All This on a Tabletop

Dimatix's printer (*Figure 5*) has a 67 cm x 58 cm footprint with a 9-inch x 12-inch printing surface, so it can handle up to 8.5x11 (or A4 size) paper. It also includes a 6-inch wafer chuck and multiple vacuum holes so that smaller or unusually-shaped substrates are acceptable too. Flexible substrates are accommodated through lift-up pins or the vacuum chuck.

Figure 5: Dimatix's Tabletop Printer



Source: Dimatrix

The substrate table has x-y motion, with theta movement on the y-axis also, allowing for nonlinear distortion corrections. And z motion is possible to +- 5 cm for thick samples. The platen can be heated to 60°C, and the ink cartridge to 70°C.

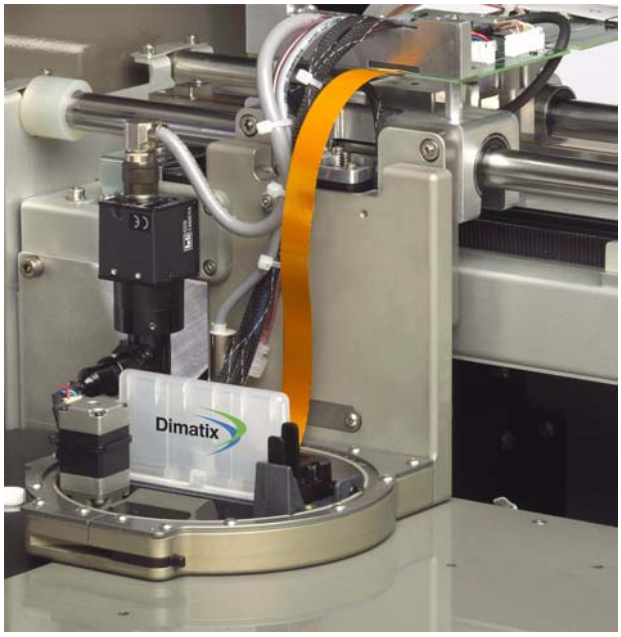
A number of test and measurement features are available. The drop visualization station has a strobing LED light to reveal the ink in motion. Next to the printhead sits a fiducial camera to recheck the alignment after any curing steps. And an integrated maintenance station allows *in-situ* checks of the printhead.

The printhead itself has 16 nozzles, each one individually programmable and controllable, operating at frequencies up to 100,000 Hz. The nozzle diameter is 21 microns, allowing drops as small as 10 picoliters, and they are delivered with speeds around 3-9 meters/sec. The cartridge that holds the ink is designed to be user-friendly (*Figure 6*). It has two parts that are snapped together after the user fills it up with ink (up to 1.5 ml). Once plugged into the printer, the cartridge is taken through a sequence in which it visits the maintenance station for initial checks, then the head is primed, and then taken back to the maintenance station for blotting. At this point, the printer is ready for action (*Figure 7*).

Figure 6: Dimatix's Cartridge Assembly

Source: Dimatrix

Figure 7: The Carriage, Ready To Print



Source: Dimatrix

The cartridge system supports the jetting and evaluation of fluids ranging from DNA precursors to cell suspensions to carbon nanotubes to silver nanoparticles, as well as specialized display materials such as polymers for OLED.

Finishing Touches

Dimatix' product comes with 40 cartridges (more can be purchased at $60 each), a PC, the control software, and other auxiliary components. It includes a 1-year warranty and 1 year of software upgrades. Dimatix is working on a dynamic system of user support, in which comments and solutions can be shared online through frequently-asked-questions pages and message boards for users.

The main challenge on the software side at this point is that the printer must be controlled by Dimatix' software. It cannot accommodate external pattern files, such as those generated by other CAD programs and saved as jpg or other types of files. The company is working on interface software that will allow importing files, but it is not expected to be available until early-to-mid-2006.

The company is planning for a family of printer products and cartridges. It is currently targeting this initial product broadly among companies, research labs, and universities. Some units have already been shipped.

Will the advent of tabletop printing speed up the adoption of inkjet for such diverse applications as display backplanes, RFID, and new sensor technologies? It certainly seems unlikely to slow it down! This trend should be interesting to follow.

Head Gadgets Getting Cool?

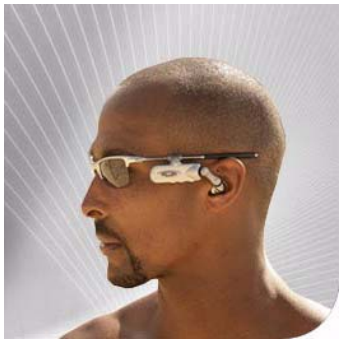
A powerful bane of head-worn displays has always been the "uncool factor." Although a small screen dangling off of glasses or otherwise attached to the face/head might offer utility, few were willing to appear in public wearing such a device.

Recently, a number of head-worn mobile phones have been commercialized, and they are marketed with the implication that they are actually cool. Sleek designs aim to create a fashionable, high-tech look. Might this trend also help the image of the wearable display?

Talking Heads

Motorola and Oakley have teamed up to create a wearable headset called Razrwire (*Figure 8*), sold through Cingular. It connects via Bluetooth to a mobile phone within 30 feet, and it allows 100 hours standby time and five hours talk time. Only the specs for the "core module" are provided (0.75 x 2.1 x 0.4 inches, weighing 0.5 ounces), but the product appears to be relatively small and light.

Figure 8: Motorola and Oakley's Razrwire Phone



Source: Motorola

Jabra also offers several choices of Bluetooth wireless cell phone headsets, such as the one in *Figure 9*. These gadgets are appealing due to their hands-free nature, but are clearly presented as "cool" also.

Figure 9: Jabra Wireless Headset

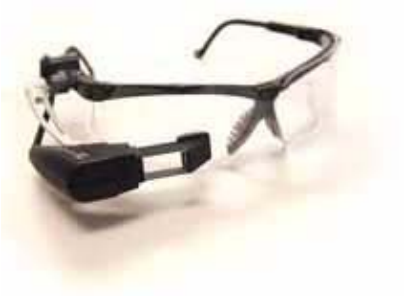
Source: Jabra

Now Add The Display

Now suppose the device is for looking, not speaking. This is the idea behind wearable displays, which could serve to give auxiliary information, present a PC screen in a cramped environment, or even allow movie viewing in a mobile format.

Perhaps the MicroOptical SV-6 PC viewer (*Figure 10*) is starting to look less awkward. Similar devices are offered by eMagin and Kopin. The market for such near-eye display devices has always been very small, despite the potential to outfit every soldier, field worker, urban businessperson, and college student. But the trend toward "cool" head-worn devices could begin to turn some heads and change some minds.

Figure 10: MicroOptical SV-6 PC Viewe



Source: MicroOptical

Meeting Notes

International Funkausstellung (IFA), Aug 31 – Sept 6, Berlin

By Riddhi Patel

The IFA is one of the largest shows held once every two years in Germany. All the TV makers – premium brands, value brands and even ODMs— were present at the show, but even with such a huge number of participants, few innovations grabbed attention at the event. The only new displays seen were the "rollable displays" by Polymer Vision (see *News Analysis*).

Plasma and LCD TVs dominated the show space. A few rear-projection sets were seen – mainly microdisplay-based. Direct-view CRTs had a small amount of floor space though both LG Electronics and Samsung Electronics were showing off reduced-depth CRTs in one part of their respective booths.

Buzz centered around the flat panels but there was not much seen in terms of product differentiation. Plasma TVs seem to have reached maturity where the talk was more around the technology benefits and improved lifetime, whereas for LCD-TVs, differentiation was done in terms of basic specifications of the panels i.e. how did the panels differ in response time from one another. However, for a keen eye it was easy to see differences between a good and a not-so-good panel based on the overall picture quality. Between the flat panels, now that talk about lifetime and burn-in in plasma has lost its steam, the LCD industry is marketing itself as being capable of "true HD" resolution even for smaller sizes. Also, the LCD industry is claiming that plasma cannot achieve the same at sizes smaller than 50-inches.

Beko, Vestel, and other ODMs were focused on meeting with their customers and planning for their flat-panel line-ups. Their CRT business is hurting from the slowdown in shipments.

Major brands had their complete line-ups displayed and were meeting with customers and end users alike, getting their views on their product offerings. The only surprise was the Sony booth, which had more curtains and fewer products and looked like it was pulled together at the last moment. It points toward the rumor of major problems within the company and with its TV product line.

Walking through the show gave rise to a few observations – it just drew one's attention to how popular the flat panels have become, how much consumer attention they have grabbed with their nice form factors and declining prices, and second how much heat they generate!

Eurodisplay, Sept 19-22, Edinburgh, Scotland

As the chilly fall winds kicked up in this northern setting, several hundred display experts gathered to share their thoughts and plans. The main business event was the Workshop on the first day, which featured around a dozen speakers representing all major branches of displays, from television and signage to cell phones, and including LCD, PDP, OLED, and FED.

iSuppli's Kimberly Allen discussed the growing role of organic materials in the display industry, covering OLEDs and plastic electronics. The OLED panel market has now surpassed a half-billion dollars, and will expand as active-matrix technology moves into full commercialization. Plastic electronics is rapidly becoming a reality for next-generation devices, enabling flexible formats and new applications.

In the OLED panel market, passive matrix displays largely serve as mobile phone subdisplays and MP3 player displays, but sophisticated PMOLEDs are now in a position to serve as main displays that might otherwise use a TFT-LCD (necessarily, these are main displays with smaller pixel counts). AMOLEDs, although trickling into the market in niche products, will not penetrate the critical mobile phone market until early-to-mid-2006, after which they are likely to rise steadily to dominate the OLED market value.

A careful examination of the total available market for flexible displays reveals that many segments are suitable, such as consumer electronics (games, cell phones, etc.), electronic books, signage, and automobile displays. The TAM for flexible displays reaches $18 billion in 2009. However, limitations in technical performance and production capacity significantly reduce the served available market (SAM) and actual expected market in the near term. iSuppli intends to update its Flexible Displays report and forecast in the first quarter of 2006.

The strong influx of resources into R&D at this time suggests that these limitations can be overcome during approximately the next decade. In the meantime, new application segments may be created that can only be served by flexible displays. Hence, the future of organic semiconductors in display applications appears to be on an impressive growth curve at this time.

Talks by CDT and UDC confirmed the continued interest and growth in OLED, while Philips and Merck gave updates on flexible displays progress. A presentation by Robert Meter of CEA-LETI in France reminded the audience that emerging displays have a role to play in the television market too, as he covered the potential market for new types of FEDs.

Overall, Eurodisplay provided a solid update on progress made since the larger SID conference held in Boston in May. And the Workshop in particular provided a venue for business perspectives.

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