SID 2003 REVIEW ISSUE

Information DISPLAY

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Innovation and LCD TV Highlight SID 2003

- SID 2003 Review
  - Show Overview • LCDs
  - Emissives • Microdisplays
  - Equipment and Materials
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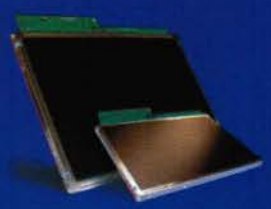

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Cost reduction, evolution, and innovation could all be seen at SID 2003, which bodes well for the display industry's future.

Greg Pease for SID

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- Tiled Displays
- LCD TV
- LCoS Projection

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When Did PCs Get Boring?

Maybe it was the "dot bomb" that blew the excitement out of computer technology. Or maybe we got tired of waiting for a new "killer ap" that never came. Maybe they realized that each generation of faster processors did not really change what they did with their computers. Maybe computers just became routine parts of our professional and personal lives.

Although computers are more embedded in modern life than they have ever been, they have also become annoying. The main feature of Microsoft's latest operating system seems to be that it offers hackers more opportunities to corrupt my network. E-mail is an essential tool, but my cyberspace mailbox is just as full of junk mail as the steel mailbox at the end of the driveway. In other words, the PC has become a tool instead of a passion, and although we will forgive the objects of our passions almost anything, we tend to be critical of our tools.

Generalizations, of course, are risky. One of the kids that filled my barbecue grill's propane tank last week was talking about installing a liquid-cooled motherboard in his computer, but he's a gamer, and gamers still think that computers are fun. In a recent survey of corporate PC purchasers, the thing that was of most concern in IT purchases was reduced cost. Obtaining competitive advantage through technology purchases was only rated third. Some analysts and purchasers were so defeatist as to say that it is not possible to gain a competitive advantage by buying commodity hardware and software. Others disagreed with that pessimistic position, saying that the uniqueness of the technology is far less important than the innovative things done with it, but it is very clear that for corporate users the bloom is off the computing rose.

That is true in a way of the display industry, too. Computer aps will remain critical to the industry, of course. At SID 2003, David Mentley of iSuppli/ Stanford Resources told members of the press that notebook PCs and LCD desktop monitors together would account for more than 60% of the LCD market in 2005, as they did in 2000. But it was clear at SID 2003, as it is clear from discussions with display makers (and from reading their press releases), that the technological excitement has turned to medium-to-large-screen displays for television and smallish displays for portable applications, despite the fact that these markets are much smaller than the market for computers.

Why is that? Well, the "Wow!" factor is pretty much gone from notebook displays and LCD monitors. There are lots of good ones, and the business has become one of high investment, high volumes, very slender margins, and never-ending pressure to reduce cost. That is not fun for the makers of the displays, even though the products remain attractive to consumers. And while there are some technologies in the background that could – and may – reduce the cost and improve the performance of computer displays in exciting ways, large-screen TV and high-performance portables are using some really interesting technology to deliver the "Wow!" now. And, at least as important, they also promise to provide some decent margins to manufacturers, at least for a while.

– KIW

We welcome your comments and suggestions. You can reach me by e-mail at kwerner@ nutmegconsultants.com, by fax at 203/855-9769, or by phone at 203/853-7069. The contents of upcoming issues of *ID* are available on the *ID* page at the SID Web site (http:// www.sid. org).

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Finding a Theme

Cost reduction, evolution, and innovation could all be seen at SID 2003, which bodes well for the display industry's future.

by Ken Werner

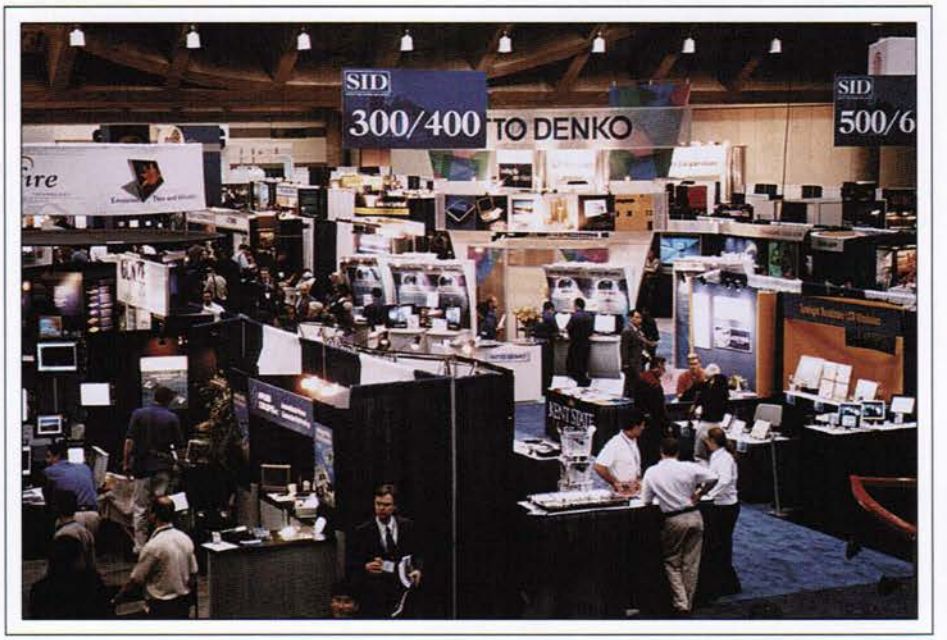
THE 2003 Society for Information Display International Symposium, Seminar, and Exhibition (SID '03), held May 18–23 in Baltimore, Maryland, was large, lively, and complex. This entire issue of *Information Display* – nine articles written by six correspondents, plus two expert opinion pieces by Yoichi Taira of IBM Research Japan and Gary Feather of Sharp Laboratories America – is devoted to it. We have organized our coverage by both technology and event, as we do each year. This year, the articles cover LCDs, emissive displays, microdisplays, and display electronics and semiconductors, and we also have articles on the new SID business conference, the annual awards dinner, and the evening panel.

The details are fascinating, and it is easy to get lost in them. But if one stands back far enough, does a theme – or a few themes – emerge from the all the activities of hundreds of exhibitors, hundreds of technical-paper presenters, and thousands of attendees? Let's see, keeping in mind that a large event like SID can be like the fabled elephant that is examined by the six blind wise men. Depending on the part each grabbed first, the different wise men got very different ideas of the nature of the elephant. Nonetheless ...

Last year, it seemed that OLED prototypes were everywhere. This year, they still were, but a few more modules were actually available for sale – or soon will be – and some new players had entered the fray. As David Lieberman notes in his "Backlight" column, this is the year that DuPont (with Olight®), Kodak (with NuVue®), and OSRAM (with Pictiva™) thought the time was ripe to come up with brands for their OLED displays. The lifetimes and efficiencies of OLED materials have improved impressively over the last year, but not enough to ease the intensity of materials development.

Kodak's AM550L full-color OLED, which appeared at SID 2002 ready for sampling, showed up at SID 2003 as the monitor/viewfinder in Kodak's LS633 digital still camera. It is the first full-color OLED to appear in a commercial product. And the title for largest demonstrated OLED was passed to ***Chi Mei Optoelectronics*** and ***IDTech***'s 20-in. prototype. There were a goodly number of line and dot defects, but the big news was that this unit was using an amorphous-silicon active-matrix backplane – an important advance that promises lower-cost large OLEDs to come.

Even more obvious than the OLEDs were the large LCD TVs from ***Samsung*** (54-in. diagonal), ***LG.Philips LCD*** (52-in.), and ***Sharp*** (37-in.). Substantial efforts have been



Greg Pease for SID

Fig. 1: *The exhibits at SID 2003 were often innovative, and the show was lively.*

Ken Werner *is the editor of* Information Display *magazine.*

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Ken Werner

Fig. 2: Baltimore's famous Inner Harbor – which SID attendees passed as they walked from the headquarters hotel to the convention center – was lively, even when the weather was gray.

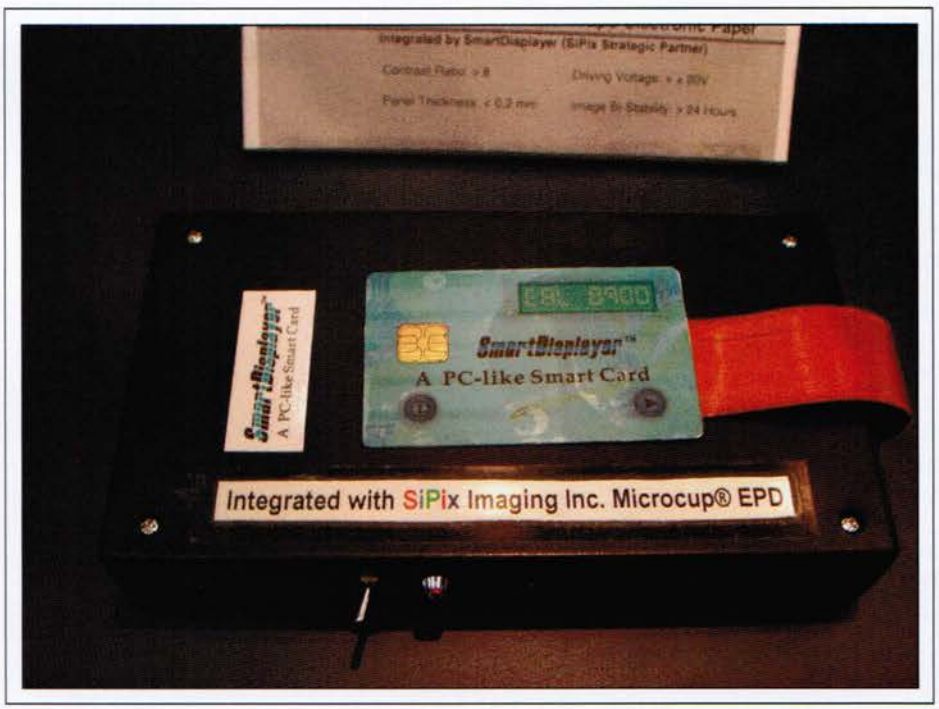
made to improve not only the viewing angles of these modules and monitors, but also to minimize changes of color with viewing angle. The results are impressive. On another front, the major manufacturers are implementing versions of feed-forward driving, which significantly speeds pixel switching between gray levels. This goes a long way toward eliminating the motion smear that has beleaguered LCD TVs, and there are even more improvements coming in the next 12 months. The best large LCD TVs are impressive, although the largest are not yet available for sale. Sharp's 37-in. model is available in quantity, and Samsung's 40-in. has been in limited distribution for well over a year.

Except for Sharp, very-large (37-in.-and-higher) LCD TVs are not in wide-scale circulation – that's plasma territory. So the excitement and optimism of the large-screen LCD brigade is very interesting. Large LCDs have not yet joined the retail-sales battle with PDPs, but some of their proponents are already predicting victory – at least through 42 in.

On the small-LCD front, ***Sharp*** showed its truly impressive Advanced TFT (A-TFT) LCD technology. This transflective LCD architecture splits each subpixel in two and gives each part a different structure, one optimized for the transmissive mode and the other for the reflective mode. The result can be startling. A display in Sharp's booth looked very nice in the ambient light of the convention floor. When a 500,000-candlepower spot was shone on the display, its color balance barely seemed to change, and it remained highly readable. Implemented in the company's continuous-grain-silicon (CG Silicon) TFT material, a full-VGA pixel format fits on a 3.7-in. A-TFT display. The display is not just a laboratory prototype; it will be available to OEMs by the time this issue goes to press.

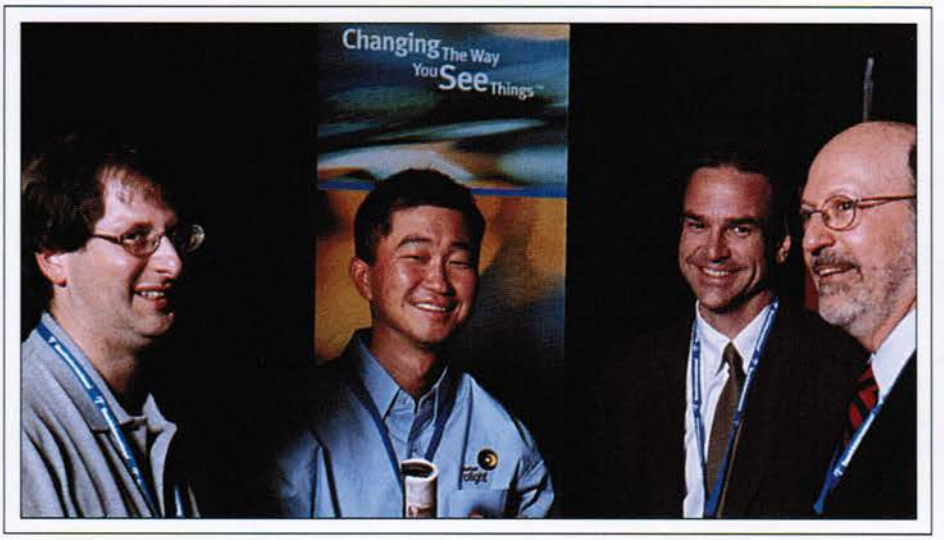
Another innovative small display in the Sharp booth was a switchable 2-D/autostereoscopic 3-D display for cellular telephones. The display module is available, and it is being used in cellular telephones in Asia.

Clairvoyante Laboratories' Pentile Matrix™ LCDs popped up in several places on the show floor. The company's technology re-maps the usual pixel geometry and uses subpixel rendering in two dimensions to increase the modulation transfer function (MTF), a measure of image sharpness, of the



Ken Werner

Fig. 3: SiPix Imaging, Inc., has a customer for its bistable Microcup™ electrophoretic display, the first commercial display to be made with a roll-to-roll process.



Greg Pease for SID

Fig. 4: *A conversation in DuPont Displays' booth, which focused on the company's Olight™ OLED displays.*

image without increasing the number of drivers. Alternatively, the number of drivers (and the cost) can be decreased while maintaining the existing MTF. The technology has been under development for several years, but this year it was on exhibit at the ***Samsung*** and ***Wintek Electro-Optics Corp***. booths, as well as in a 17-in. Chi Mei Optoelectronics panel in ClairVoyante's booth that was equivalent to a conventional 1280 × 1024 panel.

Philips was showing the latest version of its single-panel scrolling-color 1280 × 720 LCoS rear-projection TV. The picture quality was impressive, and it is now a product. Forty-four and 55-in. versions were scheduled to go on sale in North America in August under the brand-name Cineos with a projected price of $3000–4000.

Devices That Do Not Fit

The problem with grouping coverage into established technology categories is that it is hard to find a place for devices that are so novel they do not fit into a specific category.

As an exercise to see how far the miniaturization of an integrated module can be pushed, ***Philips Mobile Display Systems***' C4 prototype cellular-telephone module was described as impressively small. It consists of two displays of a clamshell cellular telephone, backlight, vibra-motor, transceiver, and integrated camera with all video processing on board.

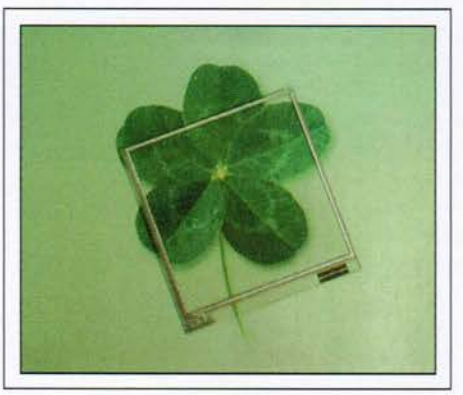
Genoa Color Technologies combined with Philips on a rear-projection TV using five color primaries to produce a 60%-wider color gamut, which was evident. A significant part of the technology is the algorithm that selects on the fly the optimal combination of primaries (of the many possibilities) for creating each displayed color, the importance of which may have been indicated by the presence of Genoa's Algorithm Manager. (How many display companies have an algorithm manager?)

SiPix Imaging, Inc. (Milpitas, California) was showing the first commercial application of its process for making roll-to-roll bistable electrophoretic displays (EPDs) using its Microcup® micro-patterned plastic substrate. The customer, SmartDisplayer®, was sharing the booth and showing the display in its "PC-like Smart Card." The seven-segment EPD was striking, not because it stood out on the card but because it did not: it looked remarkably like the printing on the rest of the card and lived under the same protective transparent film. Is this the first roll-to-roll display in commercial use?

And, in poster paper P-52, "Large Fiber-Based Displays," Chad Moore of Nupix (Corning, New York) demonstrated potentially large displays based on structures consisting of shaped optical fibers with co-drawn wire electrodes. On display were a plasma display and a plasma-addressed Gyricon® electronic-paper display. This is classic garage-shop technology development (backyard development in this case because the fiber drawing tower is reportedly in Moore's backyard). There always seemed to be a crowd around Moore's poster, and many of the comments in the surrounding crowd were along the lines of "This is either a brilliantly simple, incredibly disruptive technology or it is absolutely nuts." There is more to come on this one, I am sure – and Moore is looking for partners.

Toshiba America Electronic Components showed a system-on-glass (SOG) AMLCD that incorporated an optical sensing device in each pixel location that allowed the display to function also as a small scanner, although one without moving parts.

A final item that does not fit easily into our organizational structure is touch technology, which is growing in importance with the increasing popularity of portable devices, kiosks offering various services, and tablet computers. ***Fujitsu Components*** was particularly featuring its new surface-acoustic-wave (SAW) touch screens, which can have an extremely high transmissivity. SAW is an old technology, but Fujitsu has 10 recent patents covering a new transducer/receiver design, manufacturing processes, DSP circuitry, and algorithms. (I wonder if Fujitsu, like Genoa, has an algorithm manager?) Also exhibiting their touch-screen technologies were ***Elo TouchSystems***, ***CyberTouch***, and ***USA EELY-ECW***. But the importance of touch technology was indicated by the fact that no less than 26 companies had themselves listed under "touch screens" in the SID 2003 Prod-



Fujitsu Components

Fig. 5: *As a major touch-screen participant, Fujitsu Components is attempting to revive surface-acoustic-wave (SAW) technology. Because nothing is applied to the active area of the display, such touch displays can be highly transmissive.*

uct Guide. Many of these companies made substrates for touch screens or integrated touch screens made by others into their own monitors, but the vigor of the segment is clear.

To sum up, in addition to cost reductions in mature and maturing segments, evolutionary technological improvements, and commercialization of new technologies, there was no shortage of genuine innovation at SID 2003, and there is every reason to expect more in the future. Perhaps that is one reason why the display sector is sailing along rapidly while the rest of the electronics industry remains becalmed.

The Numbers

Overall attendance at SID declined moderately to 5700 from 6500 in 2002. Far from being a disappointment, this was considered an achievement in a year in which terrorism threats, war, and SARS during the run-up to SID caused many to weigh travel plans very carefully, and in which attendance at some other trade shows dropped by 20 or 30%. The number of exhibit booths only dropped to 451 (from 474), and exhibitors were generally pleased with the quantity and quality of their contacts. The new SID Business Conference, held on the Monday of Display Week, was, with over 400 registrants and good reviews, even more of a success than its enthusiastic organizers anticipated.

That is one person's overview of the shape of the elephant that was SID 2003. To zero in on the pachyderm's various parts in more detail, please turn the page. ■

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Liquid-Crystal Displays: Big and Bigger

Manufacturers are pinning their hopes on the entertainment market to use up increasing production capacity.

by Alfred Poor

At the SID 2003 exhibition, more than 40 exhibitors showed up with LCD panels and related products. It is not possible to give a detailed review of all the exhibits, but a brief synopsis of the highlights reveals some important new themes. While there were a number of trends and new developments in evidence among the booths, none were so obvious as the impact of LCD television on the industry.

Many manufacturers are counting on LCD TVs to transform their businesses. The development of the new Gens 6 and 7 fabrication lines capable of handling 3–4 square meters of glass per sheet makes larger displays more practical. At the same time, if LCD technology can make significant inroads into the enormous worldwide television market, then the manufacturers will be able to find buyers for this rapidly increasing output capacity. Ross Young of DisplaySearch projected that the prices of LCD TVs 33–37 in. on the diagonal will drop below $1500 by 2006, at which point LCDs will become the dominant technology, accounting for nearly half of all TV modules larger than 30 in.

Alfred Poor *is President of Working Papers, a technical writing service that creates white papers and other documents for display industry and other technology companies. He is also a contributing editor to* Information Display *and* PC Magazine, *a columnist for* Computer Shopper, *and a founding member of the Society for Information Display's Display of the Year Award Committee. He can be reached at 700 East Walnut, Perkasie, PA 18944; telephone/fax 215/453-9312, e-mail: alfred@working-papers.com.*

The bellwethers of this movement were easy to spot. ***LG.Philips LCD*** had a monster prototype 16:9 display with 1920 × 1080 pixels that measured 52 in. diagonally, yet it still was not the largest LCD TV on exhibit. ***Samsung Semiconductor*** had a pair of displays with the same resolution as the LG.Philips LCD unit, but measured 54 in. diagonally. In both cases, the displays were as lovely as they were large, with bright, colorful images.

The commercial LCD products ready for market were not all that much smaller. ***LG.Phillips LCD*** has a 30-in.-diagonal model with wide-XGA resolution – 1280 × 768 pixels – shipping now and a 42-in.-diagonal unit that is slated to ship in the third quarter of this year. ***Samsung Electronics*** already has

Greg Pease for SID

Samsung's large booth contained its 54-in. LCD-TV module – the world's largest – and a variety of advanced-technology prototypes and smaller commercial LCDs.

0362-0972/03/1909-016$1.00 + .00 © SID 2003

32- and 40-in. wide-XGA panels in mass production. ***Sharp Microelectronics of the Americas*** has a 37-in. module that is designed for television applications. Sharp was one of the first companies to announce a commitment to the LCD-TV market, and already has 31 different TV models available. Sharp's 30- and 37-in. modules were initially used only in Sharp's own TV sets, but the company was announcing at SID that modules would now be available to other OEMs.

Improved Performance

Just as important as larger size was the better performance demonstrated by many LCD-TV panels. Viewing angle is a key factor in creating a satisfactory viewing experience, and most manufacturers were demonstrating their latest designs, including variations of in-plane switching and multiple-domain liquid-crystal alignments.

Speed is also an important factor in television applications because the liquid-crystal cells must respond rapidly so that fast-moving images do not smear or blur. Years ago, Hitachi demonstrated Feed Forward Driving™ that would overdrive a cell in order to change it from one gray level to another faster than it would change otherwise. At SID 2003, that technology was incorporated into a panel demonstrated by ***Optrex*** and intended for a wide range of industrial applications requiring fast image response times. ***LG.Philips LCD***, ***Samsung Electronics***, and ***Sharp Microelectronics of the Americas*** were among the companies demonstrating similar "overdrive" strategies to increase liquid-crystal-cell response times. The Sharp implementation has feedback loops that take the temperature of the glass substrates into account and adjust the driving signals accordingly.

LCD televisions must also be bright, and ***Samsung Electronics*** demonstrated panels that managed to enhance both resolution and brightness at the same time. Using technology licensed from ClairVoyante Laboratories, the panels use special color-filter patterns for the liquid-crystal subpixels. Instead of using just the red-, green-, and blue-striped filters found in conventional designs, the Samsung panels use a checkerboard pattern that also has clear subpixels that show as white. According to company representatives, this approach increases brightness by 30–70%. The design is analogous to the four-segment color wheels – red, green, blue, and white – used in Digital Light Processing™ (DLP)™ micromirror projectors to increase image brightness.

Another fast-growing market segment for LCDs is the automotive industry, especially entertainment displays for rear-seat passengers. ***Sharp*** has an 8.8-in.-diagonal panel in use in a BMW SUV model. ***Optrex*** showed a 7.0-in. wide-format panel with 480 × 234 pixels. ***LG.Philips LCD*** has wide-format panels from 6.5 to 8.0 in. on the diagonal scheduled to ship this year.

Mobile Telephones

As important as they are, there is more to the LCD market than just giant televisions. The mobile-telephone segment is consuming acres of glass, and many manufacturers are seeking ways to increase their share of the sales. Active-matrix panels on amorphous silicon (a-Si) and low-temperature polysilicon (LTPS) abound, while passive-matrix LCDs in monochrome and full color continue to play an important role in lower-cost products.

Philips Mobile Display Systems (MDS) is one company that hopes to make it easier for telephone makers to incorporate Philips displays in their products. In a move reminiscent of the recent "smart panel" designs for desktop monitors, the company has designed complete modules that incorporate many components. The latest is the Compact Clam Color Camera Module – known as the C4 – that includes a full-color active-matrix main display, a full-color passive-matrix external display (or sub-display), and a VGA camera. The self-contained module also has a single backlight that is shared by the two LCDs. Working samples are available now, and the modules will be in full production by the end of the year.

Panel makers are focusing on ways to improve performance for mobile telephones and portable devices while reducing weight and increasing battery life. ***Philips***, ***NEC***, and ***Sharp*** are some of the companies that have developed transflective technology so that the level of reflectivity can be adjusted in response to the requirements of different consumer-product applications. Approaching the problem from a different direction, ***Wintek Electro-Optics Corp.*** has created a 2.8-in. 320 × 320-pixel panel based on ClairVoyante Laboratories' PenTile™ matrix technology. Compared with equivalent panels, the Wintek design requires one-third fewer column drivers, which makes it possible for designers to choose between lower power consumption and higher brightness.

Environmental factors are of growing concern, including the mercury found in typical cold-cathode fluorescent LCD backlights. ***Sharp*** has developed a 3.5-in. QVGA panel with a white LED backlight. The company is also investigating xenon lamps and backlights that use red, green, and blue LEDs.

Other companies demonstrating a range of LCD products for mobile-telephone and portable-device applications included ***Vision Display Systems Co.***, ***Three-Five Systems***, and ***Info Incorporation***.

Backplanes

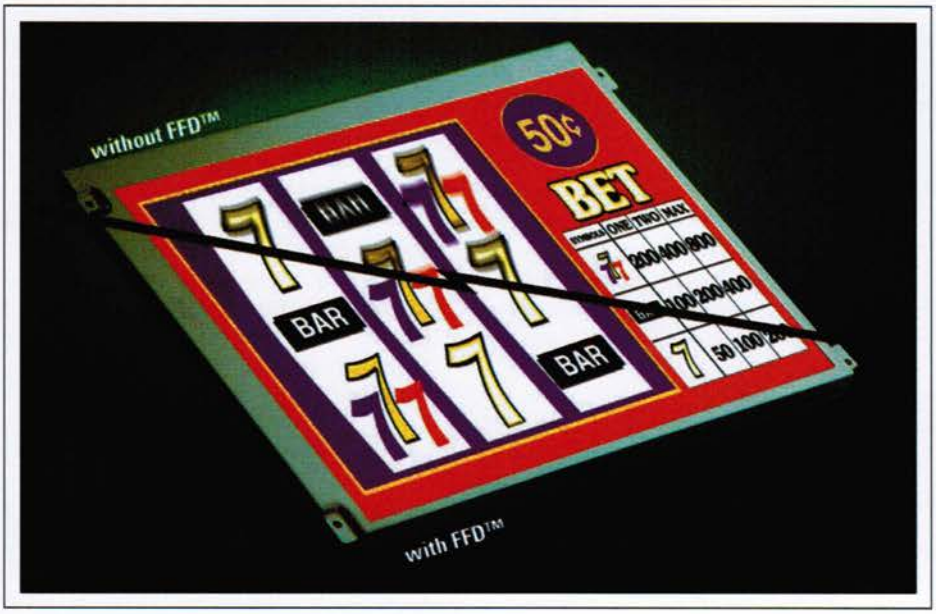
Amorphous silicon remains dominant for active-matrix LCD backplanes, and some attendees were surprised to see demonstrations of a-Si substrates for OLED displays. Representatives of ***Planar Systems*** presented a paper that may point the way to a new feature for a-Si panels. Using a panel with red, green, blue, and white subpixels, researchers put a small TFT optical sensor in every fourth white subpixel. This makes it possible to track a finger or stylus on the surface of the panel, providing touch-screen functionality without the extra layers required for capacitive, inductive, or resistive touch technologies.

Another approach to adding touch-screen capabilities was shown by ***Toshiba America Electronic Components***. The company has 10.4- and 12.1-in. AMLCD panels using LTPS backplanes, which only require connections along one edge. This makes it easier to slide touch-screen components in between the panel and the backlight, which can save development time for designers of tablet-PC products. The company also demonstrated a system-on-glass (SOG) prototype 3.5-in. LTPS panel that includes monochrome photosensors that let the panel also act as a scanner. It can be used to capture business-card images or bar codes, or can scan fingerprints for biometric security applications.

Sharp continues to develop continuous-grain-silicon (CG Silicon) substrates for the AMLCDs which are used in the Sharp Zaurus SL-C700 PDA and certain Sharp digital cameras. The company is opening a new CG Silicon plant this summer.

Novel Technologies and Designs

A number of companies demonstrated LCD panels with some unusual attributes. Both



Optrex

Optrex showed a 15-in. LCD with Feed Forward Driving™ (FFD™) for industrial applications, perhaps the first commercially available FFD™ display intended for applications other than large-screen TV and video.

Sharp and ***Samsung*** had 3-D displays that did not require the use of special glasses. Samsung's panel was 22.2-in. on the diagonal, with a 1280 × 800-pixel format.

NEC Electronics America had some unusual displays. One was a two-sided "double-wide" panel designed for retail applications, in which a pair of 21-in.-diagonal panels with 1280 × 462 pixels shared a common backlight. The company also showed panels that were designed to be mounted in portrait orientation. The liquid-crystal cells in most panels are arranged to provide the best viewing angles while in landscape mode, but in these panels the cell structure is rotated 90° so that the best performance is seen in portrait mode.

While most bistable displays rely on materials other than nematic liquid crystal, ***Nemoptic*** continues to develop their BiNem® technology, which makes standard liquid-crystal material bistable. Picvue Electronics has licensed the design and is starting production in Taiwan for an e-book application. Nemoptic hopes to sample color versions of their display in the third quarter of 2003.

Rainbow Displays – known for tiling LCD panels to create large displays – was conspicuously absent from the exhibit hall, as their booth sat empty. ***Landmark Technologies*** was present, however, with their own tiled demonstration panel that was made from four 15-in. XGA panels. And for applications that require smaller or unusually shaped panels, ***Tannas Electronic Displays*** can custom-cut panels to fit specific applications.

Faster Development

Given the accelerated product life cycles in many industries, many manufacturers made a point of the fact that newer panels were plug-compatible and physically compatible with older models of the same size, making it easy to upgrade products.

In addition to backward compatibility, ***Optrex*** has focused on other ways to make it easier for designers to incorporate LCD panels into new products. The company showed its new LCD ToolKITs, which include a 10.4-in. VGA or 15-in. XGA panel and all the required components, including controller board with on-screen display, backlight inverter board and power cable, power supply, analog RGB cable, video-input cable, and a CD-ROM with documentation.

Other Applications

Many exhibitors were showing LCD panels designed for industrial, avionics, or outdoor applications in which high brightness and environmental ruggedness are important factors. For example, ***Kristel Corp.*** showed a 17-in. screen that produces 1000 nits. ***Industrial Siemens Flatpanel Technology (i-sft)*** had a range of sunlight-readable displays that included a 15-in. XGA model rated at 1600 nits. ***Digital Systems Engineering*** enhances standard LCD panels to make them sunlight-readable, increasing their efficiency so that the power requirements are lower; their products are designed to run longer on batteries or solar power.

IDTech and ***Planar Systems*** both demonstrated high-resolution monochrome LCD panels designed for medical applications. Both have 21.3-in. gray-scale panels with 5 Mpixels (2560 × 3 × 2048 pixels) offering 154 pixels per inch (ppi).

Passive-matrix LCDs continue to play a significant role. ***Three-Five Systems*** and ***Emerging Display Technologies*** both produce STN panels. ***Philips*** also showed new fast-switching full-color STN panels that can display moving images at a lower cost than active-matrix panels.

Global Display Solutions (GDS), "providers of industrial display solutions across five continents," was showing its new 30-in. LCD public-information display (PID) and several of its custom products for various customers. Among them was a weatherproof 20-in. on-platform PID for a major European railroad system that is sunlight-readable and self-diagnostic. A "tri-sensor" senses ambient light, light from the panel, and temperature. A more unusual application was a "cashless ATM." Part ATM and time clock, the device is used to check an hourly worker in and out and determine the hours worked. It calculates deductions for each worker and deposits the worker's wages in his or her debit account, which the worker can immediately access from a conventional ATM. GDS customizes the display and builds the entire unit for its customer.

A number of LCD-panel distributors were also present, including ***JACO Electronics***. ***Advantech Embedded Computing*** showed ruggedized panels they provide for custom applications.

Lessons Learned

The televisions made a visual splash at this year's exhibition, but it remains clear that mobile-telephone and computer-display applications remain a driving force in the LCD

market. There is still plenty of room for older and less-expensive passive-matrix displays, but advances in active-matrix technology and declining production costs are making these high-resolution high-performance displays more practical in a broader range of applications.

While novel technologies, such as OLEDs and bistable displays, may capture the attention of the press and the imagination of users, LCDs continue to improve and strengthen their position. This makes them less vulnerable to attack by the new technologies, many of which have not even achieved mass production yet. LCDs already dominate the mobile telephone and computer-display markets, and should they succeed in the large and lucrative television market, they will clearly be the leading display technology. ■

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Emissive Displays Shine On

Light-emitting displays are being used in applications from head-mounted viewers to stadium displays – and everywhere in between.

by David Lieberman

THE exhibits, technical sessions, demonstration rooms, debates, and conversations at SID 2003 were rife with emissive displays, ranging in diagonal sizes from less than 1 in. to more than 60 in., and varying in maturity from laboratory curiosity to commercial reality. With the exception of two sessions in the technical program (one on magnetics and signals and one on materials and processing) not a CRT was to be found. The cast of characters included the plasma-display panel (PDP); the field-emission display (FED), some of the carbon-nanotube variety; the electroluminescent (EL) display; and the organic light-emitting-diode (OLED) display, including polymer and small-molecule variations and miniature OLED-on-silicon microvarieties.

The PDP has become the information and demonstration display of choice at the SID exhibition, as it has at other industry conventions and in bars, airports, and other public-information venues. Nevertheless, there were significantly fewer PDP makers at the exhibition than in previous years.

As at last year's exhibition, ***Samsung SDI*** demonstrated a handful of large PDPs among a very broad selection of other display technologies, ranging from a 2.2-in. transparent OLED to a 61-in. rear-projection HDTV based on Texas Instruments' digital micromirror device (DMD). The PDPs included several wide-format displays, a 42-in. model using a delta color-filter arrangement, a very-fine-looking 50-in. high-definition display, and a 42-in. autostereoscopic 3-D monitor. ***Plasmaco, Inc.***, did not demonstrate its 50- and 60-in. PDPs. Instead, they demonstrated the latest 2003 iterations of two Panasonic 42-in. displays from parent company Matsushita – an 852 × 480-pixel standard-definition PDP and a superb 1024 × 768-pixel high-definition model.

Organics on the Move

The SID 2003 exhibition demonstrated that the progress towards the commercialization of OLED displays is continuing, slowly but steadily. At the time of SID 2001, only Pioneer was shipping OLEDs – sometimes referred to as organic electroluminescent (OEL) displays. By SID 2002, Kodak Display Products, RiTDisplay, and Philips had all joined the fray, with Kodak sourcing its displays from its joint venture with Sanyo, SK Display Corp. Philips's OLEDs are of the polymer variety, while the others are small-molecule devices. This year's exhibition saw three new polymer players: ***DuPont Displays, OSRAM Opto Semiconductors, Inc.,*** and ***Delta Optoelectronics***. DuPont and OSRAM have both recently started shipping evaluation kits, with DuPont relying on RiTDisplay as its manufacturing partner.

Also at SID 2003, one other company announced its imminent entry into OLEDs. ***Optrex Corp.*** has formed a 50-50 joint-venture company with Nippon Seiki to manufac-

Eastman Kodak Co.

Kodak showed the first full-color OLED incorporated into a commercial product, the company's EasyShare LS633 digital still camera.

David Lieberman *is a veteran display journalist living in Massachusetts and is a Contributing Editor to* Information Display *Magazine.*

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ture OLEDs. The newly formed company, ADEON Co., Ltd., will begin production at Nippon Seiki facilities in September and is scheduled to began shipping OLEDs to its parents soon after. Nippon Seiki will integrate the OLEDs into its own products, which include automotive instrument clusters, while Optrex will modularize and resell the OLEDs.

Optrex and Nippon Seiki have been collaborating on LCD production since 1976. Asahi Glass Co., one of Optrex's parent companies, has been developing OLEDs for some time, according to Optrex, and has been actively pursuing their commercialization since 1999. Nippon Seiki started OLED development in 1996 and began setting up a production line in 2002.

The SID 2003 exhibition was also a site at which manufacturers showed a number of real-world products incorporating OLEDs. These included an Eastman Kodak digital still camera (using a Kodak display), a number of near-to-eye applications using eMagin's miniature OLED-on-silicon displays, and a pair of MP3 players, one from Evolution Technologies using a DuPont display and one from Delta Optoelectronics, a licensee of Cambridge Display Technology, using Delta's own OLED. The OLED in the Kodak camera is rated for a 2000-hour lifetime, compared to 1000–1500 hours for a comparable LCD, according to Kodak Display. And according to DuPont, the remotely controllable Evolution MP3 player has a distinct advantage over LCD equivalents: its display is readable from across a room.

PFE, Ltd.

Printable Field Emitters, Ltd., discussed a demonstration performed prior to SID 2003 of a second-generation field-emission display that cranked out 2000 nits in a vacuum chamber.

Out on the Show Floor

For the third year running, ***RiTDisplay*** demonstrated dozens of small monochrome small-molecule OLEDs at its booth, with this year's line-up ranging between 0.81 to 2.93 in. on the diagonal and having formats between 80 × 48 and 128 × 128 pixels. The largest of the formats shown are being targeted at instrumentation applications, while the remainder are being aimed at cellular telephones. The larger cellular-phone devices are intended for use on the inside of clamshell-design cellular-phone displays, while the smaller devices are intended for use in the so-called "sub-display" on the outside of the cellular phone.

A few blue models were interspersed among RiTDisplay's primarily green-emitting line of small-molecule OLEDs. The line features a contrast ratio above 100:1, a viewing cone of more than 160°, and a 10-µsec response time, while luminance specs range between 30 and 40 nits.

This year, RiTDisplay added quite a bit of variation to its offerings. It demonstrated, for example, two blue-emitting OLEDs with 16 gray shades. One was a 1.28-in.-diagonal 128 × 128-pixel device; the other, a 1.31-in. 128 × 96-pixel device. Neither seemed quite ready for prime time. The company also demonstrated a full-color 0.95-in. OLED and several 0.81–1.05-in. sub-displays with separate sections displaying different colors. These so-called "area color" displays offer separate colors: green, blue, yellow, and/or red.

RiTDisplay's booth also had one area dedicated to polymer OLEDs, which are not yet in volume manufacture. With sizes and specs similar to those of the small-molecule devices, these polymer devices included monochrome green, red, blue, and yellow OLEDs, and one 0.83-in. 96 × 39-pixel area-color device that was manufactured using ink-jet printing. The company's ink-jet-printing technology is still in the development phase, according to a RiTDisplay spokesman.

DuPont Displays is not shipping polymer OLEDs in volume yet, but it is sampling to a few select customers in targeted market segments, and the displays will be showing up "in the retail channel in the next few months," said General Manager Tom Miller. "We have customers in the advanced-medical-instrumentation area and for a specific industrial-instrumentation application," he said, noting that customer Evolution Technologies would start shipping its OLED MP3 player in June 2003.

DuPont demonstrated a 2.1-in. 128 × 64-pixel yellow-green OLED, included in one of their evaluation kits, plus a 1.4-in. QVGA (320 × 240-pixel) device, a 2.2-in. QCIF+ (176 × 220) device for flip cellular telephones, and a full-color 9.1-in. WVGA (800 × 480) device for home-entertainment use. The early stage 9.1-in. device was demonstrated in a flip-down back-seat TV in the very dark ambient of an automobile mock-up.

DuPont is involved in a great deal of advanced OLED-development work, Miller

Optrex plans to ship OLED modules from ADEON, its newly formed joint venture, by the end of this year. Targeted applications include automotive instrument clusters.

noted, with plans to move to full-color active-matrix OLEDs in 2004/2005 and then to flexible plastic-substrate OLEDs. Active-matrix variants using amorphous silicon, low-temperature polysilicon, and continuous-grain silicon are all under investigation, a company spokesman said.

DuPont's work with its materials partners, Covion and Dow Chemical, has advanced the efficiencies and lifetimes of OLEDs, "getting a 4–10 times improvement by tweaking the architecture and materials science," said Michael Moore, who heads up the DuPont materials effort. The company is also conducting a joint development effort with Universal Display Corp. on what Moore calls "Gen 2 materials," which will be solution-processible phosphorescent small-molecule organics. Small-molecule OLEDs have hitherto not been able to take advantage of solution processing, a major strength of polymer OLEDs, but have relied on vapor-deposition techniques.

These Gen 2 materials are "probably 6–9 months away from mass production," said Moore, and they will "solve the problem of deep blue" that polymer materials have run into. "We could have doped phosphorescent material into a polymer instead but this is more elegant," he said. It is much easier to purify small-molecule material and to tune the colors, he said.

Samsung SDI demonstrated a trio of advanced color active-matrix OLEDs based on small-molecule materials and low-temperature polysilicon (LTPS) backplanes: a novel 5-in. WVGA (800 × 480) device using OLED materials from Universal Display Corp., which was a follow-on to the 2.2-in. phosphorescent OLED it demonstrated last year; a 15-in. WXGA (1280 × 768) device; and a 2.2-in. QCIF+ (176 × 220) transparent OLED. The 5-in. WVGA device, based on phosphorescent rather than conventional fluorescent materials, has impressive characteristics, including more than 300 nits of peak luminance and 70% of the NTSC color space (compared to 45% for comparable LCDs). But it is clearly in the early stage, with many flaws, including confetti-like color spattering over about one-third of the display area.

The Samsung SDI 15-in. model, on the other hand, displayed an exceptionally fine image. And the transparent OLED, which is able to provide both the main display and sub-display of a clamshell cellular telephone in one device, also performed very well.

Among the other displays, ***Universal Display Corp.*** demonstrated a flexible small-molecule phosphorescent OLED built on a plastic substrate and integrated into a fanny pack. The small 64 × 64-pixel display uses both a Barix protective coating from Vitex Systems and a monolithic encapsulant, explained Janice Mahon, V.P. of Technology Commercialization. She pointed to a prototype full-color 4-in. 160 × 234-pixel display from AU Optronics Co. as strong proof of the great efficiency of phosphorescent organic materials. This display was discussed at a technical session and was said to be demonstrated during the show.

Mahon noted that UDC and its development partners have made great strides in phosphorescent materials "in power, efficiency, and lifetimes. Now we need to combine them." But blue, she noted, "is still a challenge."

As for ***Kodak***, they showed multiple product mock-ups incorporating the full-color 2.16-in. small-molecule OLED they introduced last year. Also shown and commercially available in Europe was the EasyShare LS633, which is the world's first camera incorporating an active-matrix OLED. The company also demonstrated a superb 15-in. display. While the small display has discrete RGB pixels, created using shadow masks, the 15-in. model is based on white emitters and color filters.

According to Daniel D'Almedia, Vice President of Sales and Marketing at Kodak Display Products, the company has developed a new suite of OLED materials that provides "2.5 times the lifetime and an improved color gamut" over the current generation in addition to higher efficiency. Both larger and smaller displays are under development, he said, although the company remains tightly focused on small sizes for cameras, camcorders, and hand-held video devices. The SK Display Corp. factory, he noted, has an ultimate capacity of 1 million 2.16-in.-equivalent displays per month, and is now "on a steep production ramp."

Cambridge Display Technology was itself featuring a suite of long-lived polymer-OLED

materials, a yellow that lasts 30,000 hours and a red and green with 40,000-hour lifetimes. The company's booth contained a number of spin-coated monochrome (greenish yellow) displays, including a large 5 × 7-segment device about 1.5 in. high and 1 in. wide and a 112 × 80-pixel device. A 128 × 64-pixel polymer OLED manufactured by ink-jet printing was also demonstrated.

Cambridge recently scored two significant partnerships, a 2-year joint R&D program with Thomson and the granting of a manufacturing license to Dai Nippon Printing Co. Dai Nippon is planning to make displays for applications such as point-of-sale (POS) advertising, according to a CDT spokesman.

At its booth, ***Philips Mobile Display Systems (MDS)*** demonstrated the 1.6-in. 101 × 80-pixel monochrome (yellow) polymer OLED it introduced last year and a 1.4-in. device in a choice of three colors: green, blue, and orange. According to CEO Peter Hopper, the company has received an order from L3-Communications for OLEDs to be used in cockpit instrumentation, "a first-of-its-kind OLED order for avionics."

Philips also showed a section of a 0.8-in. full-color OLED manufactured using ink-jet printing. According to CTO Johan van de Ven, the company started using ink-jet printing in its production line at the end of February and "it needs a little time to mature." A 1.6-in. model with 4-bit gray scale was also shown, but suffering from some image smearing. The reason, said van de Ven, lies in the preliminary nature of the 4-bit silicon. "It is not the final driver," he said.

For its part, ***OSRAM Opto Semiconductors*** showed a 1.2-in. greenish yellow 128 × 64-pixel polymer OLED it is now shipping as part of an evaluation kit, as well as a 94 × 54-pixel version. These displays boast a luminance of 100 nits, a 100:1 contrast ratio, a 160° field of view, and a –30–+70°C operating temperature range. According to the company's Jason Alexander, OSRAM is talking to potential customers in automotive, cellular telephone, consumer electronics, health-care, and industrial markets.

OSRAM is "working with various colors and gray-scale levels," Alexander said, and went on to say that among the company's particular strengths are an in-house driver-IC capability and its status as an inorganic LED manufacturer. "We are able to do color matching [of an OLED to an LED]," he noted.

Toshiba demonstrated two 260,000-color OLED prototypes based on LTPS backplanes, a 2.2-in. 176 × 220-pixel device for cellular telephones that Toshiba first demoed at SID 2001 and a 3.5-in. 240 × 320-pixel device for PDAs. The 17.1-in. OLED prototype it showed at SID 2002 was nowhere in sight, nor was Sony's competing 13.1-in. LTPS OLED prototype, which was demonstrated at SID in 2001 and 2002. A prototype 24-in. OLED from Sony, however, was reportedly demonstrated sometime during the show. And a 20-in. WXGA AMOLED prototype from ***International Display Technology (IDTech)***, a joint venture of Chi Mei Optoelectronics and IBM Japan, was discussed in the technical sessions and shown intermittently at IDTech's booth on the show floor. The panel carried a sticker saying "World's Largest OLED Panel!"

Elsewhere on the show floor, ***Three-Five Systems*** demonstrated a 2.1-in. 128 × 64-pixel yellow OLED with 16 gray shades, a development from Three-D OLED LLC, the company's joint venture with DuPont Displays. And ***Optrex*** demonstrated two 256 × 64-pixel area-color OLEDs that will be targeted at automotive-dashboard audio systems. The company expects to be shipping these blue-and-red and green-and-red OLEDs in Q4 '03.

In the miniature-display arena, both ***eMagin Corp.*** and ***MicroEmissive Displays, Ltd.***, demonstrated sub-1-in. OLED-on-silicon displays, the former using small-molecule materials and the latter relying on polymer. Both demonstrated performance that was superior to most of the more conventional liquid-crystal–on–silicon (LCoS) microdisplays. MicroEmissive Displays demonstrated 320 × 240-pixel monochrome and color devices which the company is now sampling with mass production slated to begin in Q3 '03. One Asian customer that makes digital still cameras and camcorders has agreed to use these devices, according to company spokesman Jeff Wright.

As for eMagin, which has been in production for some time, the company demonstrated its SVGA+ displays in a number of real-world applications. These included the Land Warrior HMD from Kaiser Electro-Optics, the HelmetVue thermal-imaging HMD for firefighters and rescue workers from Sage Technologies, and the Knight-Eye weapon-mounted thermal-imaging system from Liteye Systems. According to company President

Universal Display Corp.

Universal Display Corp. demonstrated a prototype flexible 64 × 64-pixel OLED built on an encapsulated plastic substrate and incorporated into a fanny pack.

Gary Jones, a very bright 4000+-nit SVGA display is under development, government funding for a high-brightness SXGA device has been renewed, and the company may pursue a quarter-VGA design with a partner.

A FED Revival?

Two booths on the SID 2003 show floor demonstrated a bit of an uptick in activity in so-called second-generation field-emission displays (FEDs). For the second year in a row, ***Noritake*** was showing its large carbon-nanotube FEDs in addition to a wide range of vacuum-fluorescent (VF) devices. Intended for giant TV screens for stadiums and similar venues and bearing a striking resemblance to large vacuum tubes, the FEDs come in red, green, blue, and white, with luminances ranging from 6800 to 23,000 nits. A 5 × 7-matrix module using red, green, and blue FEDs was also demonstrated.

Another second-generation FED technology was shown by ***Printable Field Emitters (PFE), Ltd.*** As the company name implies, PFE can screen-print the emitters of its displays, rather than having to use the expensive semiconductor-like processing of first-generation microtip FEDs. According to Marketing Director Bill Taylor, the company's "pFED" technology works on a different principle from first-generation FEDs, eliminating their susceptibility to contamination and breakdown. It represents "the only path to profitable large flat-panel TV," he claimed.

PFE has demonstrated a 5.7-in. monochrome QVGA pFED and, in a collaborative effort with "a major TV manufacturer," has built a prototype that is capable of producing 2000 nits. "That is a world record," said

This 4-in. 160 × 234-pixel prototype OLED from AU Optronics uses red phosphorescent materials from UDC, which help reduce overall power consumption.

Taylor who added that he expects commercial products from PFE partners to be on the market "in about 4 years at the earliest."

The EL Plot Thickens

Last but not least, the thick-dielectric electroluminescent (TDEL) displays of ***iFire Technology*** made an impressive showing on the exhibition floor. A full-color 17-in. demo appears ready for prime time and, according to Project Manager Derek Luke, iFire will bridge the technology to a 34-in. prototype by the end of 2004, with production expectations for 2005. The company is collaborating with both Sanyo Electric Company, Ltd., and Dai Nippon Printing Co., Ltd., on TDEL modules for mid-30-in. TVs.

The iFire 17-in. model makes use of a newly developed color architecture called "color by blue." Development began, according to Xingwei Wu, V.P. of Science and Technology, in October 2002, and the scheme was first incorporated into the overall design in April of 2003. The technique avoids the manufacturing costs and complexities of depositing discrete red, green, and blue phosphors. Rather, it makes use of a single blue-emitting phosphor material and "down converts" the light with color-conversion materials at the appropriate pixel locations. "There is a huge number of color-conversion materials to choose from," said Wu, "both photoluminescent phosphors and organic materials. We're still looking at newer materials."

The iFire TDEL technology was also demonstrated in a multicolor 4.25-in. display from TDK Corp. which will start shipping later this year. This 240 × 180-pixel 200-nit 27-color device has a 140° viewing cone and a response time under 2 msec. Target markets include automotive, industrial, and medical devices. ■

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LCoS Projects a Bright Future

At SID 2003, more companies were showing real LCoS-display products, and with supporting components commercially available, more microdisplay-based products will reach consumers during the next year.

by Stephen P. Atwood

LAST YEAR'S SID 2002 review article on microdisplays was entitled "Cautious Optimism." In it, I noted that the liquid-crystal–on–silicon (LCoS) industry had shaken out the year before, but was looking forward to some promising commercial milestones in 2002/2003. At SID 2003, it did not look to me as if the commercial milestones were wholly accomplished, but the industry did continue to grow, and the products shown this year were much closer to the performance one would expect from a more mature technology.

A few notables from last year were missing, but overall the companies that came last year came back this year, showing substantial product improvements and much more system engineering, indicating that liquid-crystal microdisplays will be around for a long time. With one exception, all the product demonstrations were of LCoS technology. (Texas Instruments has a mature product line of microelectromechanical imagers, but has not exhibited at SID recently.)

The big buzz was clearly around consumer projection television. Several excellent displays made it evident that both single- and three-panel LCoS designs are technologically very capable of producing uniformity, brightness, and contrast sufficient to compete with direct-view displays. ***Brillian Corp.*** (Three-Five Systems), ***Philips***, and ***SpatiaLight*** all had eye-catchingly impressive demonstrations of designs with various arrangements of panels and light engines.

Last year's concerns about bright-spot defects and poor production yields were mostly gone, although, even off the record, no one would disclose real defect rates. There were new rumblings about lifetime challenges (resulting from long-term UV light exposure) and high-power-dissipation needs, indicating that manufacturers are trying to provide much more contrast and higher lighting levels – good problems to be dealing with. Most

Greg Pease for SID.

Fig. 1: *At SID 2003, there was often a crowd surrounding the Philips "Cineos" 55-in. LCoS rear-projection HDTV and the Philips–Genoa Color Technologies five-primary scrolling-color LCoS rear-projection TV prototype. Genoa Color Technologies' Algorithm Manager Doron Malka (in white polo shirt) and V.P. Shmuel Roth (with mustache) seem happy with the response.*

Stephen P. Atwood *is the Engineering Manager for Three-Five Systems, Inc., Advanced Video Technologies, based in Marlboro, MA; telephone 508/485-3380, fax 508/485-3509, e-mail: satwood@mail.35sys.com. He is also Director of the New England Chapter of SID.*

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importantly, there was almost universal agreement that the LCoS-technology platform is fully capable of supporting high-resolution HDTV requirements. The only remaining debate was whether single- or three-panel architectures made the best platforms. Given the strong players involved, this debate will not be decided definitively for many years to come.

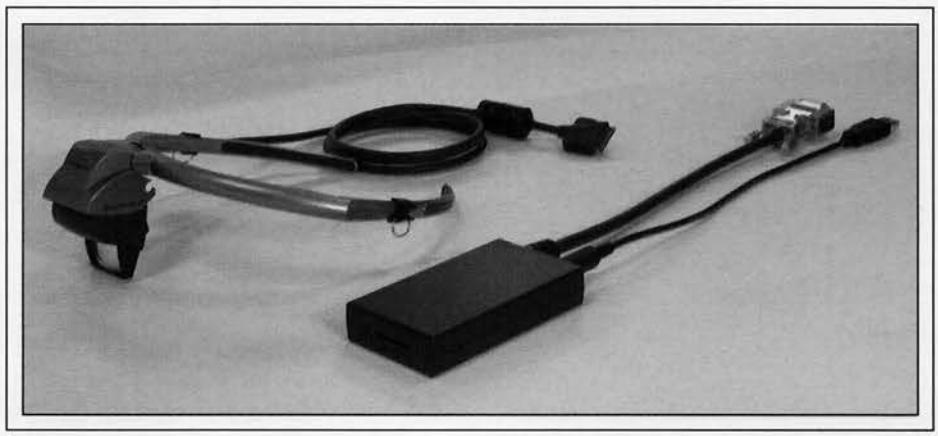
Philips Components is now producing LCoS devices using the group name ***Philips LCoS Microdisplay Systems*** based in Briarcliff Manor, New York (www.LCoS.Philips.com). The company's imagers have changed significantly from those shown last year, although they are still larger than most other offerings. Philips has switched to a more-conventional flex-circuit connection scheme instead of the previous PGA package.

Philips is banking heavily on single-panel architectures and has optimized their imagers to run at field rates up to 540 Hz (or 180-Hz frame rates). When this is combined with either scrolling color or drum-mode color wheels, the company's representatives assured me, color-field break-up would not be an issue for consumers. Philips imagers are available in 1280 × 768 and 1920 × 1080 formats. Specifications include a typical contrast ratio of 800:1 or better (*f*/2.5) and white-state reflectivity of 62–65%. Philips also offers a proprietary driver ASIC to make third-party product development easier and faster.

To show the performance of their imagers, Philips was demonstrating its "Cineos" 55-in.-diagonal LCoS rear-projection HDTV product, which its press release asserts will be "available to retailers throughout the country [U.S.] later this summer." This demonstration constantly drew a very impressed crowd.

Also on display at the Philips booth was a clever development called "Multi Primary Color (MPC) Technology," which allows a wider gamut of colors to be presented by the display through the use of additional primary colors during the image-forming process. Although theoretically possible in many display technologies, it is relatively straightforward to implement this approach in microdisplay projection by simply adding additional color primaries to the color wheel. As long as the imager can display a high-enough color-field rate, the system can be made to work.

Working with a startup-company partner named ***Genoa Color Technologies*** (www.genoacolor.com), based in Israel, Philips was demonstrating the first such rear-projection TV using additional colors cyan and yellow to extend the color space by about 60%. Genoa Technologies provided all the algorithms and translation technology necessary to convert a conventional video-image stream to this new format while optimizing color rendition and brightness efficiency. Philips intends to commercialize this architecture into a high-end consumer-television platform. Of course, this technology could also be implemented in a DMD-style projector. In either case, it shows how microdisplay projection architectures open up some interesting new avenues.



Shimadzu Corp.

Fig. 2: *This monocular headworn viewer by Shimadzu Corp., which uses a Brillian Corp. Z86D-3 SVGA imager, was shown in Three-Five Systems' booth.*

With its feet firmly planted in the three-panel camp, ***SpatiaLight*** (www.spatialight.com) was showing its latest prototype consumer-television product. Developed for Skyworth Display, Ltd., a Chinese TV manufacturer, this display was a 52-in. three-panel 1280 × 960 rear-projection television with a Fuji optical engine. The SpatiaLight imager is a vertically aligned nematic (VAN) mode device with integrated drivers in the backplane. The VAN mode has been shown to produce exceptional contrast, and can be made to produce a normally black device, reducing the occurrence of white-spot defects in the black backgrounds of the projected images.

For the prototype on display, SpatiaLight advertises a contrast ratio of better than 2000:1 with a nominal 70% white-state reflectance. Another promoted advantage of the VAN mode is that it does not require polyimide for the alignment layer, thus reducing the imager's sensitivity to detrimental UV energy. This improves lifetime and allows more light energy to be focused on the imager than is desirable in some other designs. The Fuji engine produces a contrast ratio of at least 500:1, typically 650:1, with a claimed 85% brightness uniformity. SpatiaLight demonstrated a less mature prototype of this display at SID 2002, and the image quality was very much improved this year.

The other big news was from ***Three-Five Systems***, announcing the pending spin-off of their microdisplay business into a newly created and separately traded public company which has been named ***Brillian Corp.*** This spinoff covers the entire LCoS-microdisplay business, including all related manufacturing and business assets, personnel, and intellectual property.

Brillian Corp. (www.brilliancorp.com) demonstrated rear-projection television systems which were utilizing the company's latest-generation high-contrast panels. The most impressive system was a 65-in.-diagonal 720p HDTV development system created in partnership with ***3M Optical Systems Division***. This demonstration was actually held "by appointment" in a private room just off the show floor, and the performance seemed comparable to that of direct-view displays of similar size.

The Brillian Corp. imagers are a significant evolution from earlier demonstrations and utilize a proprietary LC mode that company representatives would not discuss. They did say that the imagers produce a contrast ratio better than 2000:1, which puts them on a par with VAN-mode devices. The basic resolution is 1280 × 768 with 12-μm pixels.

MicroOptical Corp.

Fig. 3: MicroOptical Corp. showed this compact BV-1 stereoscopic viewer that uses dual Kopin imagers.

3M Optical Systems Division developed the optical engine with Brillian Corp. as a technology platform for 3M's new polarizing-beam-splitter (PBS) technology and other proprietary advances, which they are offering to rear-projection-TV system designers for further commercialization.

A Closer Look

There were also some notable advances in near-to-eye (NTE) displays using LCoS technology. ***Brillian Corp.*** was showing two new products using the company's recently announced Z86D-3 NTE SVGA imagers. These imagers are specified for use up to a 120-Hz frame rate (360-Hz color-field rate) and produce a true 18-bit color depth. The first was a monocular headworn viewer being marketed by ***Shimadzu Corp.*** was developed for use as a virtual display for PCs and test equipment. The product, called Dataglass2, produces a virtual field-sequential-color SVGA (800 × 600) image 13 in. high, and operates directly off a standard VGA port. The power consumption is much lower than that of a typical AMLCD backlight, which will extend the battery life of a notebook PC significantly.

The second demonstration was of a recently announced stereoscopic headworn product from ***Optimize, Inc.*** (www.optiva.com). The OptiVu HD3, designed to be worn by surgeons during endoscopic procedures, presents the image in the surgeon's line of sight without blocking his or her downward line of sight or peripheral vision. Both devices were relatively easy to wear and presented very-good-quality images. Optimize, Inc., currently has these systems in use at several well-known medical facilities, including Cedars-Sinai and UCLA. These designs have evolved dramatically over the last several years, taking advantage of lightweight materials and more highly integrated electronics and optics. However, while these devices continue to improve each year, several attendees commented that the ergonomics of such headworn NTE devices still needs to improve. The main issues continue to be weight and optical adjustments leading to long-term viewing comfort.

MicroOptical Corp. (www.microoptical.net) was also demonstrating several NTE headsets, all based on their eyewear-attached viewer that can be built into, or attached to, existing eyeglasses or safety glasses. MicroOptical uses ***Kopin Corp.*** (www.kopin.com) transparent LCoS QVGA imagers and produces a very lightweight virtual viewer. The displays are transparent, which suits them for instrumentation and task-training applications. For the most part, the viewers were newer versions of last year's, but the improvements were mostly in the applications. Most notable was a Bluetooth-enabled wireless version that allows direct communication with PDAs and other Bluetooth-enabled devices. The display still requires a cord to a control module which is worn on the shoulder of the user, but eliminating the cable to the computer is a very convenient feature. Particularly interesting was the company's BV-1 stereoscopic display, which seats very easily on the user's face and includes headphones for both ears. This particular device is unusual for MicroOptical in that it is used without regular eyeglasses, which may be a positive or a negative for some users.

The NTE market is really comprised of two components, headworn devices and electronic viewfinders. The electronic-viewfinder market is much more mature and has been established for several years now. ***Kopin Corp.***, a solid player in the viewfinder market, was showing a variety of transparent LCoS displays. These devices are specifically designed for the NTE market, and many are fully commercialized in high-volume production. Kopin markets these displays under the trade name Cyberdisplay™, and has been very successful producing QVGA field-sequential-color displays for camcorders and digital still cameras.

Last year, Kopin demonstrated some very interesting higher-resolution field-sequential devices, some with a resolution as high as 1280 × 1024. This year, the company is offering a variety of high resolutions and aspect ratios in true RGB format. This eliminates the need for frame-sequential images, which sometimes produce visible color-field breakup. The company's new configurations include 640 × 480 RGB color subpixels, a 4:3 aspect ratio, and a display that includes analog-video inputs and runs at frame rates up to 75 Hz. When combined with a white-LED backlight, this device is literally a miniature version of a desktop AMLCD monitor. The image quality and brightness were very good compared to other demonstrations, and the absence of color-field breakup is a significant advantage.

Kopin is also offering this architecture in 800 × 225- and 521 × 218-pixel formats, which are designed as replacements for similar Sony products in NTE viewfinders. For those who need a quick implementation, Kopin now offers a complete electronic-viewfinder (EVF) module incorporating the

521 × 218-pixel RGB color imager and all required optics in a very simple plastic housing.

CRL Opto, Ltd., continuing to develop ferroelectric liquid-crystal technology for microdisplays, beam-steering systems, and LC shutters, was demonstrating an SXGA field-sequential-color FLCD viewer developed by NVIS using the CRL Opto imager. In conjunction with its partner company MicroVue, CRL Opto is also heavily involved in drive electronics and related support engineering for rear-projection consumer-TV designs. When I asked a company representative to summarize what was "new" for this year, the answer was that last year was the year for proof of designs and low volume; this year, the company has several design wins and is making higher quantities of devices with consistently good quality and ready availability.

This comment from CRL Opto seemed to be very descriptive of most of the players interviewed this year. The biggest change from 2002 is that for many exhibitors there are now real display products, that supporting components are commercially available, and that they are looking forward to the right final product. However, with the exception of electronic viewfinders, there are still very few microdisplay-based products available to general consumers, so the wait for market feedback will continue for yet another year.

Another group anxiously awaiting the growth of LCoS products are the suppliers of optical test systems. Both ***Westar Display Technologies*** (www.displaytest.com) and ***DisplayCheck*** (www.displaycheck.com) – a company in which the author of this article was formerly an officer and in which he continues to have a financial interest – were demonstrating test systems designed to characterize all the important optical characteristics of LCoS devices for both laboratory and in-process manufacturing inspection.

It is widely believed that projection imagers in particular will need to be screened to very demanding optical standards in order to ensure the high-contrast and defect-free images required for this market. Unlike larger-format LCDs, LCoS devices cannot be readily inspected to these standards visually, and this has created a niche market for machine-vision-based systems. Westar was demonstrating its familiar MDIS system, which is a semi-automated system for laboratory and low-to-medium-volume production use. Westar also offers a fully automated materials-handling version for higher-volume production, a machine that was developed in conjunction with the USDC. Since SID 2002, Westar has continued to evolve its microdisplay test systems, and has also continued its work on an extensive line of large-format-LCD test systems for laboratory and production use.

DisplayCheck was promoting its new MDT205L system, which is a cost-reduced version of the earlier MDT210L system. The MDT205L is targeted at the projection industry for quality-assurance and quality-control use. By focusing on a very specific set of test requirements, DisplayCheck claims a lower total cost of ownership as well as a significant reduction in total test time: "several panels per minute *vs.* several minutes per panel," asserts the company's press release. DisplayCheck also has an extensive line of full-feature test systems suitable for all levels of in-process microdisplay inspection.

Several attendees commented that now that the optical engines and imagers have improved, there is renewed interest in test solutions. Some form of sophisticated optical testing will be a strategic component of each company's proprietary process.

Perhaps the real LCoS headline for SID 2003 is that the focus is now turning to system developments, proving that the devices can work, and work well. Projection-imager companies are looking much further ahead now and focusing on good reference designs following the commercialization model that Texas Instruments developed so painstakingly and so successfully for its DMD microdisplays. Last year, industry veterans were asking if LCoS microdisplays could be successfully commercialized; this year, the question is not "if," but "when." The LCoS brigade is looking forward with excitement to SID 2004. ■

Please send new product releases or news items to Information Display, c/o Palisades Convention Management, 411 Lafayette Street, 2nd Floor, New York, NY 10003.

Manufacturing: Equipment and Materials

This year, about one-third of the SID exhibitors were equipment or materials suppliers – not counting chip suppliers.

by Patrick Dunn

THE SID 2003 exhibition was quite busy this year despite the apparent doom and gloom concerning the state of the general economy. The SID show is always a great place to go and see a wide variety of suppliers, from large to small, from mainstream to esoteric. Walking the show floor is always a challenge because there is so much to see. About one-third of this year's exhibitors were equipment or materials suppliers, and that does not include chip suppliers.

OLED and FPD Manufacturing

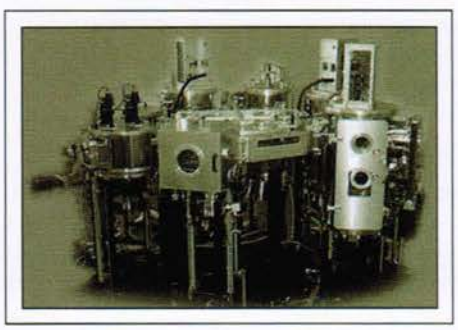
As has been the trend in recent years, OLEDs continued to expand their visibility at the show, with the much-publicized new trend of branding the various OLED and POLED materials and products. Of course, OLED materials are not useful without the equipment to process them. There were several suppliers of OLED manufacturing and prototyping equipment in addition to suppliers of FPD processing equipment and materials.

ANS (Advanced Neotech Systems, www.ansinc.co.kr) was established in November 1998 as a supplier of PVD and CVD equipment, evaporators, and various types of vacuum equipment for the display industry in Korea. At SID 2003, they discussed their latest development, the Helisys, a modular cluster system for producing full-color, monochrome, and area-color OLED devices (Fig. 1).

Patrick Dunn *is Senior Program Manager at Samsung Electronics America, 6603 S. Andrews Way, Austin, TX 78746; telephone 512/589-1746, fax 512/338-5555, e-mail: patrick@sea.samsung.com.*

The 200 × 200-mm system is capable of continuously forming organic thin films that are comprised of a hole-injection layer, a hole-transport layer, emissive layers, an electron-transport layer, an electron-injection layer, and a metal electrode in vacuum. It can support process modules for load/lock, pretreatment, organic deposition, metal-electrode deposition, passivation deposition, substrate transfer, alignment, and encapsulation.

Ito America (www.itousa.com) is a distributor of Sony Anisotropic Conductive Film (ACF), COF substrates, and other Sony Chemicals products for all displays, ranging from microdisplays to large-sized PDPs. In addition, Ito supplies products from Nippon Graphite, such as heat-seal connectors, EL backlights, touch screens, and other materials. To implement these materials, Ito also markets all of the associated processing equipment by Ohashi, primarily bonding equipment (for ACF, heat seals, *etc.*), alignment and mounting equipment, laminators, and display-packaging equipment.



Advanced Neotech Systems

Fig. 1: *Advanced Neotech Systems' Helisys OLED processing cluster tool produces full-color, monochrome, and area-color OLED devices.*

Litrex Corp. (www.litrex.com) products were featured in the booths of several OLED suppliers at the show, most notably in the large booth of Philips Displays. Litrex is now a wholly owned subsidiary of Cambridge Display Technology (CDT) and specializes in ink-jet processing as applied to FPDs. It is especially focused on developing its Piezo Micro Deposition technology for the manufacture of light-emitting polymer (LEP) displays.

Litrex showcased its premiere production system, the Litrex 140P, designed to print on glass substrates up to 370 × 470 mm for use in the manufacture of color LEP displays (Fig. 2). Its piezo ink-jet technology, devel-

Litrex Corp.

Fig. 2: *Litrex Corp's 140P IIJ ink-jet polymer-LED printer is designed to print on glass substrates up to 370 × 470 mm in the manufacture of color LEP displays.*

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oped and used in the graphics printing industry, has been redesigned to satisfy the precise tolerances and materials requirements for creating electronic displays.

Litrex is also developing a newer version called the 700M, expected to be released in Q2 '04, which will be able to support a 2×2-m substrate (Gen 7). This system will have a processing area that is about 23 times as large as that of the 140P's.

Sunic Systems (www.sunicsystem.com), based in Suwon, Korea, provides systems that are used in FPD manufacturing, such as sputtering, CVD, etching, and various plasma processes for ashing and cleaning. At SID 2003, Sunic was showing off its SUNICEL Series OLED vacuum evaporation and encapsulation systems for use with small-molecule OLED materials. The SUNICEL Series are cluster-type tool systems for the deposition of organic thin films on ITO glass surfaces, metal electrodes, and passivation layers. The system's EL source can also be changed without breaking the vacuum. The machines are for substrate sizes of 200×200 and 400×400 mm.

TLC International (www.tlcinternational.com) manufactures high-quality precision glass-cutting equipment for flat-panel-display applications and other special applications that require the precision cutting of glass, such as mirrors and precision windows. Its equipment uses cutting wheels and employs the scribe-and-break method, as opposed to the use of laser technology by some other manufacturers. TLC's primary display market is not specifically the large TFT-LCD fabs, but smaller manufacturers and R&D facilities which demand greater precision. Although the machines are not intended for mass production, their head speed of 20 in./sec are fast enough for many customers.

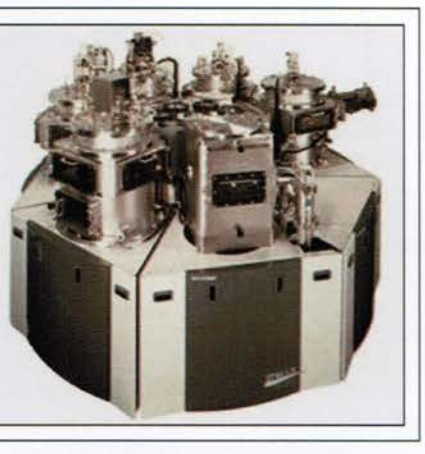

Fig. 3: *Ulvac Technologies' Satella OLED cluster tool performs all production steps including OLED evaporation and encapsulation.*

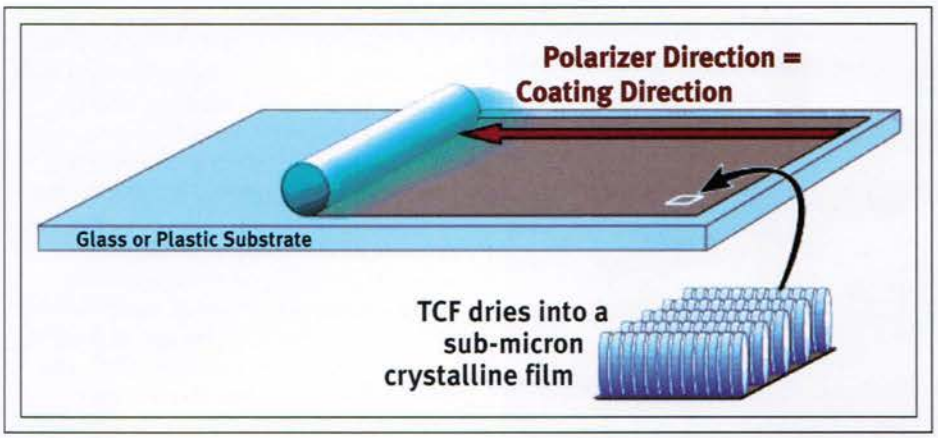

Fig. 4: *Optiva's polarizing films are applied to the inside of LCDs, rather than laminated to the outside.*

The latest version of TLC's scribing gear is called the Phoenix-600 High-Accuracy Mechanical Rectilinear/SHAPES Glass Cutter, which has one scribe head, a 24×24-in. stage, and a tolerance of ± 0.002 in.

Toray Engineering Co. (www.toray-eng.com), specializing in synthetic fibers, plastics, and polymer-synthesis technologies, has expanded and diversified into a wide range of chemical technologies, and has developed original automation and computer-applied technologies. The company's twofold product mission is plant engineering and machinery manufacturing.

For LCD manufacturers, Toray offers equipment that is primarily associated with back-end electronics-packaging processes. Its line-up includes flip-chip bonders for COG (as well as a version for COF) and LCD-panel inspection systems. Toray has developed a special "flat-board" probe to interface the panel that is much more efficient than needle-type probes and lasts longer. Toray also offers a labeling system that uses an LCD shutter that acts as a photomask and can label a display with a distinct serial number.

Ulvac Technologies (www.ulvac.com) is a supplier of vacuum deposition systems for all segments of the FPD industry. Ulvac has recently been distinguishing itself as a supplier of systems to manufacturers of small-molecule OLEDs (SMOLEDs) that need to evaporate their organic materials and deposit them in a vacuum. Ulvac provides equipment for users of all sizes, from R&D to pilot production and all the way to mass production. The company's Satella cluster tool performs all production steps, including OLED evaporation, through encapsulation (Fig. 3).

Display Lighting

Display lighting is always an interesting segment because it is critical to LCD technology and is among the more expensive components in an LCD module in terms of both materials cost and power budget.

OSRAM Sylvania (www.sylvania.com) showed an improved version of its Planon® planar backlight technology. Instead of the old design that used spacers to separate the top and bottom substrates, a dimpled top substrate now provides the spacing. This makes the unit lighter and much less expensive to manufacture. The new OSRAM Planon® source generates light using a xenon excimer discharge. A high efficacy of ultraviolet photon formation is achieved by adding an electrically insulating barrier over the electrodes and creating special voltage-input patterns, said a representative of OSRAM. The 10-mm-thick Planon® lamp has a claimed lifetime of up to 100,000 hours, is mercury-free, and has an output that is virtually independent of ambient temperature. OSRAM believes the Planon backlights will be extremely cost competitive with CCFL solutions at sizes of 30 in. and greater.

Axometrics

Fig. 5: Axometrics's polarization-measurement system allows the Mueller Matrix Polarimeter instrument to obtain a complete Mueller Matrix of any sample, which completely describes its polarization properties.

Microsemi Corp. (www.microsemi.com) was demonstrating its new high-powered white LED based on its patented Powermite3® packaging; integrated circuits for powering up to 60 LEDs; power-inverter modules for single-, dual-, and four-lamp CCFL displays; and two innovative light sensors for automatic control of display brightness. Microsemi's newest white LED uses a surface-mounted package with a full metal-bottom heat sink that provides the industry's lowest thermal resistance and allows customers the unique ability to mount PowerBright LEDs using standard infrared reflow mounting techniques.

Microsemi also displayed its power-management integrated circuits and modules for lighting CCFL lamps. The single- and dual-lamp PanelMatch™ inverter modules included the LXM1643™ and LXM1644™ modules for quad-lamp applications. Also announced at SID 2003 was Microsemi's soon-to-be-introduced LX1691™ single-supply inverter that requires only 15 total components to build a complete CCFL power inverter.

JKL Components (www.jkllamps.com) was demonstrating its broad line of lamps and inverters and offering its backlighting design services. JKL offers CCFL lamps as well as incandescent lamps for many applications besides displays. For the LCD industry, JKL is seemingly focused on the replacement market for CCFL lamps in notebook LCDs.

Lambda Research (www.lambdares.com) was demonstrating its latest version of the renowned optical software, TracePro®. This ray-tracing program used for optical analysis accounts for all the major optical properties of materials, including the absorption, scattering, specular reflection, refraction, and diffraction of light. TracePro® can also import geometric solid model drawings from most CAD software packages. Lambda Research also demonstrated their optical-design programs OSLO and LensVIEW – a database of lens designs with more than 30,000 lenses.

Display Films

Display films have a great impact on the viewability and performance of displays, even though they cannot be seen. They play a large role in the never-ending improvement of LCD technology.

3M-Nitto (www.3m.com/vikuiti and www.nitto.com) – yes, that reads correctly. Although 6 months ago no one could have been convinced that this collaboration would happen, 3M (manufacturer of DBEF and other high-value-added films that increase the brightness and viewing angle of LCDs) and Nitto Denko (the largest linear-polarizer manufacturer in the world and developer of NIPOCS brightness-enhancing film and viewing-angle films) have co-developed a line of films known as Advanced Polarization Conversion Film (APCF). These films are an improved version of Nitto's PCF films, and incorporate a multi-layered optical film (MLOF) supplied by 3M. They have superior viewing angles and less color shift with viewing angle, the companies say.

Adhesives Research (www.adhesivesresearch.com) was offering several newly developed products at the show, including its new self-wetting contact film that seems to be an excellent solution for attaching touch screens to FPDs. The company demonstrated the film by placing it on a glass window, and it actually adhered to the window completely, after being applied only along one edge. The adhesive films have a transmissivity of greater than 99% and a refractive index of 1.458.

Adhesives Research also showcased its materials for OLED construction, including the dual-stage PSA/UV film for OLED encapsulation. The company indicated that instead of using the typical method of encasing the OLED material and encapsulating it in a metal "can," an OLED could be completed by simply placing PSA/UV film over the top of the OLED material. This would also preclude the need for a getter.

Fig. 6: Otsuka Electronics' LCD-7000 LCD characterization system can accommodate a display of 410 × 256 × 60 mm, and can measure voltage threshold, contrast ratio, response time, spectra, and chromaticity/luminance/color difference.

Optiva/Nakan (www.optivainc.com) demonstrated the progress they have made in the development of polarizing films that are applied to the inside of LCDs rather than laminated to the outside (Fig. 4). In fact, Optiva won the 2002 SID/*Information Display* Display Material or Component of the Year Gold Award. Optiva was happy to announce that it had secured $30 million in financing for further production of its technology. The company is partnering with Nakan, the large Japanese manufacturer of offset-printing equipment that prints alignment layers for LCDs. The two companies will continue to work together to develop machinery and materials for display manufacturers.

Measurement and Characterization

How do display companies know if their new technology really works? How do they verify that the competition has developed a similar device with a faster response time or less contrast? They use characterization equipment that keeps them all honest, and also ensures that incoming and outgoing products meet their listed specifications.

Axometrics (www.axometrics.com) showed its unique Mueller Matrix Polarimeter, which is used to determine the polarization states of

an object, in this case, displays. Polarization efficiency is a key parameter for LCDs. The two-sided unit uses the method of dual rotating retarders, one side to create various polarization states as the retarder is rotated and the other to analyze a different set of polarization states at a different speed of rotation. This approach allows the instrument to obtain a complete Mueller Matrix of any sample, which completely describes its polarization properties (Fig. 5).

Keithley Instruments (www.keithley.com) showed a variety of equipment for measuring the electrical performance of display devices, including measuring the voltage- and/or current-switching performance of TFTs, OLEDs, and even the driver ICs of any type of display. Keithley Instrument has historically built equipment for testing in a matrix configuration, which allows data to be analyzed more easily by computer. In addition to the analysis instruments, the company also manufactures precision voltage and current supplies for energizing devices under test.

Otsuka Electronics (www.photal.co.jp/english/index.html) has been manufacturing LCD characterization systems for over 20 years, and is perhaps the best-known name in the Asian TFT-LCD manufacturing industry. At SID 2003, Otsuka introduced its Optical Characteristics Inspection System for EL displays and showed its other characterization systems. The LCD-7000 system can accommodate a display of 410 × 256 × 60 mm, and can measure voltage threshold, contrast ratio, response time, spectra, and chromaticity/luminance/color difference (Fig. 6). Its variable parameters can include temperature, humidity, XY measuring-point coordinates, light-projecting/receiving angles, rotational angle, and LCD drive waveform. ■

Electronics Is Where You Find It

The display-electronics environment is changing so rapidly that it is hard to recognize a single trend – except that every conceivable ecological niche is being explored for competitive advantages.

by Ken Werner

BECAUSE electronic information displays are electro-optical devices, they are inherently dependent upon electronics. Early in my former career as a power-semiconductor-device design engineer, I was charged with modifying silicon control rectifiers (SCRs) so that they would perform more reliably in the SCR-based deflection circuits used in RCA's early "solid-state" color TVs of the late '60s. (These difficult circuits were made somewhat more appealing by RCA's inability to make a reliable high-voltage switching transistor at the time.)

Also at this time, George Heilmeier and the co-inventors of the dynamic-scattering-mode (DSM) LCD at RCA Laboratories were trying to interest RCA's operating divisions in commercializing their invention. I was present at one of these presentations, which had the flavor of a laboratory demonstration and was not likely to impress device designers with a limited time to get devices into factory production. And it didn't. As is well known, it was Sharp (for calculators) and Optel, with disgruntled RCA Labs alumni on board (for wristwatches), that first commercialized the DSM LCD in 1970. But from the time flat-panel displays did become commercial products, drivers and timing controllers were essential components, and graphics controller cards (and ICs) were and are critical parts of PCs and other host systems.

An expansion of high-level electronic functions has been an ongoing part of FPD development (multi-line addressing is only one example). But we are now in the midst of an exciting period of rapid expansion, integration, and repartitioning of electronic functions, and all of this was evident at SID 2003. Particularly exciting was that early versions of the long-predicted glass chassis or system-on-glass (SOG) could actually be seen, although not necessarilyin the forms that had been predicted.

All of which leads to a warning for readers: display electronics is where you find it, and where you find it may not be in a traditional IC package with a type number on it. It may wind up on the display itself, as a logical core dropped into somebody else's IC, or on a graphics card in the display's host system.

Feed Forward Driving™ on a Third-Party Chip

Feed Forward Driving™ (FFD™) and overdriving circuits (ODCs) are electronic approaches to improving the switching speed of LCDs, particularly between one gray level and another. Using knowledge of the current and the desired state of a subpixel, the driving circuit applies a greater voltage difference to the pixel than would ordinarily be used to drive it to the desired state, which produces faster switching and a substantial reduction in the "smear" that has bedeviled moving images on LCD TVs. Only recently available on some LCD modules and complete TV sets – and now in a mid-sized industrial LCD from Optrex – FFD and ODCs are incorporated into the modules that an OEM buys from display suppliers.

At SID 2003, ***National Semiconductor*** introduced its response-time compensation (RTC) technology, which is their version of FFD or ODC. Jim Schuessler of National Semiconductor said that the circuitry resides in the timing controller (TCON) but uses external SDRAM. Using the circuitry, an AMLCD panel went from "normal TFT speeds" to 16-msec switching times without any modifications to the panel, Schuessler said. The logical core can go into anybody's TCON. Now, said Schuessler, "good TV images will be nearly a commodity." Hannstar (Taiwan) is using National's TCON with RTC in its latest 23-in. LCD-TV panel.

National Semiconductor also introduced a low-power highly integrated chipset – the FPD94128 controller/column driver and the FPD93140 power-supply/gate driver – for driving mobile-telephone a-Si AMLCD panels that support full-color graphics, video, and still images. The chipset analyzes a histogram of the image gray levels and decides on the fly whether this is a high- or low-contrast image. If appropriate, the chipset reduces power to the backlight unit (BLU). This, said Schuessler, can save 50 mW of the BLU's full-on power of 150–200 mW for alpha-numeric content.

The PFD94128 also allows the user to select a color depth of 3, 9, 12, or 18 bits for a trade-off between image quality and battery life. The chipset costs $9.99 in lots of a thousand.

Supertex (Sunnyvale, California), the manufacturer of high-voltage mixed-signal ICs and MOSFETs, did not seem to be featuring

Ken Werner *is the editor of* Information Display *magazine*

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anything new at SID, but the company was showing its line of display drivers for EL, plasma, VF, and cholesteric displays, as well as drivers for EL backlights and printer heads. Supertex wants it to be known that the company designs and manufactures custom drivers.

Microsemi Corp. announced that its Integrated Products Group in Garden Grove, California, had just shipped its millionth RangeMax® extended-temperature CCFL inverter used in automotive telematics displays. The company's exhibit featured a new PowerBright™ high-power white LED (up to a 350-mA current rating), ICs for powering as many as 60 LEDs, various power-inverter modules, and a light sensor for automatically controlling display brightness. The LX1970 visible-light sensor mimics the response of the human visual system, "making it insensitive to ultraviolet and infrared wavelengths that often confuse conventional brightness-control devices," the company said. The price is $1.41 each in lots of a thousand. Both samples and production quantities should be available now.

Applied Data Systems (ADS) located in Columbia, Maryland, was showing recently introduced single-board computers (SBCs) based on Intel's PXA255 processor, which incorporates Intel's XScale™ technology: "big-system graphics for small computers," as an ADS press release put it. What XScale is, said ADS's Fred Salloum, is an on-board graphics accelerator that enables displays up to SVGA and 16-bit color without external graphics chips or accelerators. "StrongArm's accelerator ran out of gas at 8-bit VGA," said Salloum. "We have been waiting for XScale." The Intel PXA255 uses the ARM architecture, incorporates sophisticated power-management low power consumption, and is designed to support a wide range of wireless and networking applications. ADS's 4 × 6-in. AGX SBC "has virtually all I/O available on a single board that can be either populated or de-populated," said Salloum. He also commented that there was a good deal of interest in the AGX at SID 2003. He has said that in past years product designers came to SID to find the displays that they needed and were delighted that they also could find the SBCs to drive them.

Also on display was the 3 × 5-in. PXA255-powered "Bitsy-X" SBC intended for PDAs, Internet appliances, and similar applications,

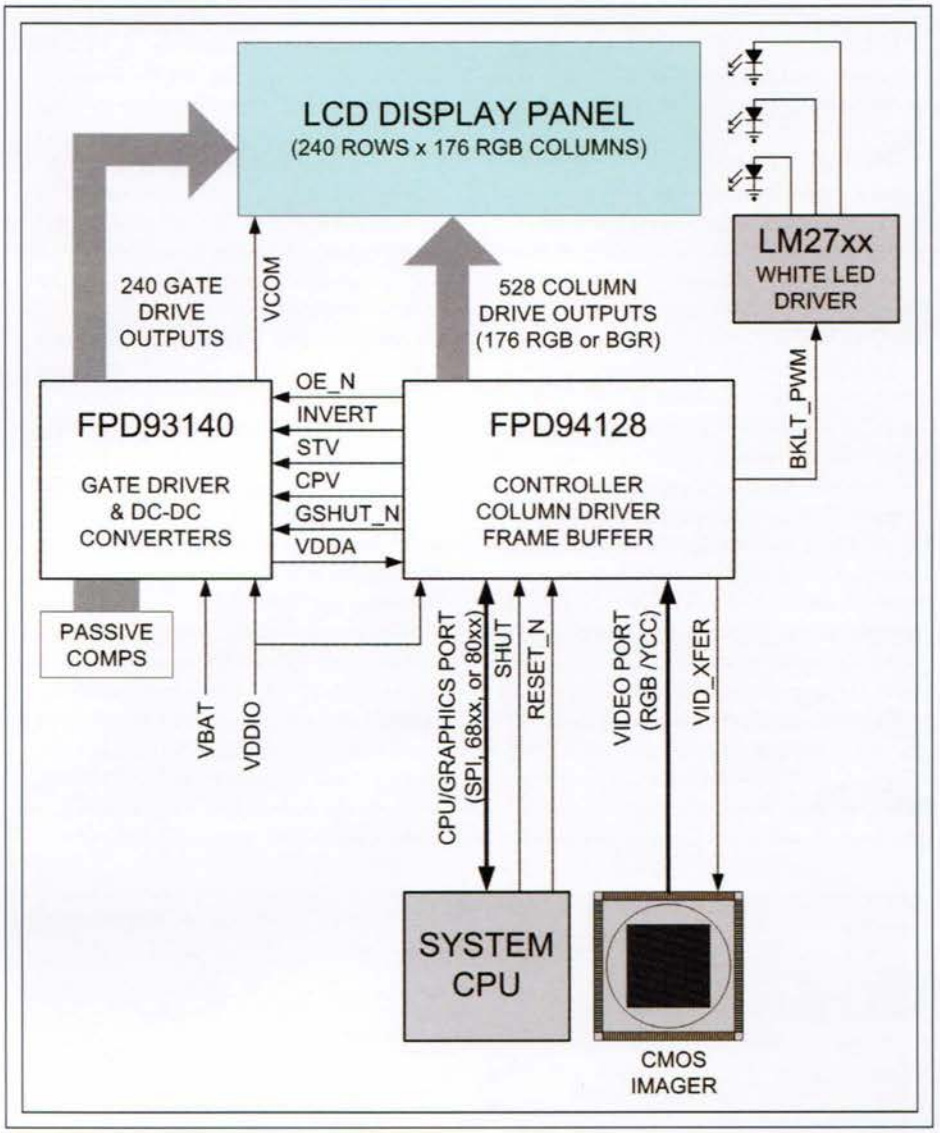


Fig. 1: *This diagram of a display subsystem for an advanced cellular telephone uses National Semiconductor's intelligent power-saving FPD93140/FPD94128 chipset introduced at SID 2003.*

and interfaces to FPDs up to XGA. A development system could be bought for about $3800 and production units for about $400 (prices depend on options and on how many of those slots are populated).

EarthLCD (formerly Earth Computer Technologies, San Juan Capistrano, California) showed its recently introduced MDK-001 mARMalade development kit, which is an SBC powered by an ARM720T RISC and a color touch-screen LCD. The key component is a Sharp LH79520 system-on-chip IC which combines a 32-bit ARM720T, a color-LCD controller, cache, local SRAM, and other peripherals. mARMalade also includes Ethernet, a touch-screen controller, compact flash and smart media memory slots, two PWMs, 4-MB flash, and 16-MB SDRAM, among other features and peripherals. With a $299 street price, this is "the lowest-cost Linux embedded kit on the market today," said Randy Schafer, EarthLCD's President and Chief Design Engineer.

Endicott Research Group (ERG) of Endicott, New York, was showing its broad range of backlight inverters, many of which

are now available with (or without) on-board PWM dimming. ERG's Bill Abbott and Jim Moronski explained the issue. It is now quite common for suppliers of BLUs to be asked to supply 4–8-tube units for 21- and 23-in. LCDs, but as tube lengths get longer, parasitics go up and current bleed-off increases further down the tube. If such tubes are dimmed by simple analog dimming, the luminous column in the fluorescent tube becomes shorter, an unpleasant feature Moronski called the "thermometer effect." Another limitation of analog dimming is low dimming ratios. PWM dimming solves both of these problems, and also permits DIP-switch programming (in some models) of such things as voltage range and polarity, which are not standardized.

Endicott Research Group was also offering its 8m Class low-profile 5-W inverter in kit form that gives LCD designers greater packaging freedom. The kit includes the circuit design, critical magnetic components, and complete layout validation. Kits cost as little as $3.00 in production quantities.

Genoa Color Technologies (Herzelia Pituach, Israel) and ***Philips*** showed a Philips single-chip LCoS scrolling-color rear-projection TV using Genoa's five-primary-color technology, which produces a color gamut 60% wider than that of an equivalent three-primary-color system, said Genoa CEO Ilan Ben David. Because a given displayed color can be produced by a large number of combinations of the primaries in a multi-primary system, a key part of the Genoa approach, said Ben David, is the algorithm that selects the optimal combination for each pixel on the fly. If this becomes popular, the algorithm could become another piece of silicon (or another logical core) that goes into a display.

Gennum Corp. (Ontario, Canada) was showing its Visual Excellence™ image processors that offer format conversion for displays and professional applications. Included are devices for HDTV/SDTV de-interlacing and scaling (including devices that provide motion adaptation with edge detection) and transparent color-space conversion between YCbCr and RGB for SDTV broadcast applications.

STMicroelectronics (Geneva, Switzerland) was showing off its ADE family of LCD controllers that drive both conventional and "smart panel" displays. They integrate up and down scaling, 9-bit ADC/PLL, on-screen display (OSD) controller, and sRGB color warp. A third-generation context-sensitive scaler yields sharp image-enhanced text. The OSD controller allows bordering, shadowing, transparency, fade-in, fade-out, font rotation, and four subwindows. The ADE3700XT incorporates a programmable timer controller that provides highly programmable support for XGA "smart panels," including dual-function TTL and RSDS output signals, and flicker detection and reduction.

Liesegang Electronics (Hannover, Germany) was featuring its LEHK-2 and LEHK-3C display-controller ICs. The recently introduced LEHK-3C is an SOC controller IC for high-end digital display applications. It uses DSP to do scaling, frame-rate conversion, de-interlacing, OSD, and PIP. The chip's most striking feature is its ability to electronically correct optical distortions such as keystone, barrel, pincushion, and tilt.

Electronics on Glass

System-on-glass (SOG) was big news at SID 2003, but architecturally simpler variations of the old active-matrix backplane also generated excitement.

Plastic Logic, Ltd. (Cambridge, U.K.), the developer of solution-processed polymer-semiconductor technology, showed an experimental display consisting of a Gyricon Media SmartPaper™ bistable display combined with an active-matrix backplane made from ink-jetted polymer electronics. The experimental display had 63 × 48 pixels at 50 pixels per inch (ppi) on a glass substrate. Larger displays, higher resolution, and flexible plastic substrates are coming, representatives of both companies said. Plastic transistors are in a very early stage of development, but they have the potential to be very inexpensive, flexible, large-area displays (and other electronics).

IDTech showed a prototype 20-in. OLED from ***Chi Mei Optoelectronics***, and what is interesting from an electronics perspective is that the active-matrix backplane was made with good old amorphous silicon (a-Si). There are very good reasons why there were doubts that a-Si could be used to make the TFTs for OLEDs, including the fact that OLEDs are current-driven – not voltage-driven as LCDs – and have higher current requirements. But IDTech and Chi Mei Optoelectronics have succeeded, using some non-standard processing on the a-Si, and believe it is a critical step toward creating affordable large-screen OLEDs. And they are not alone.

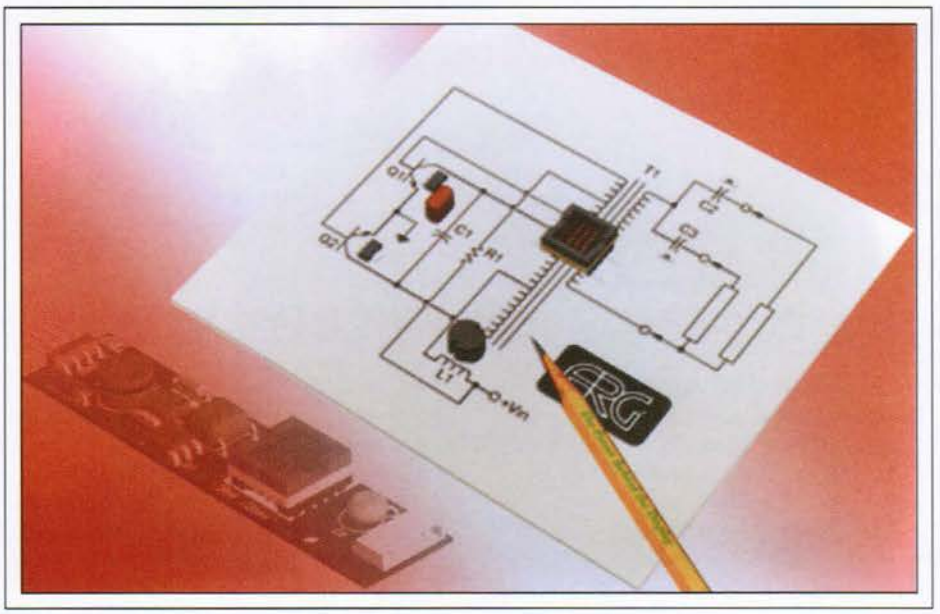


Fig. 2: *Endicott Research Group was promoting its low-profile 5-W 8m Class inverter in kit form for those situations in which standard packaging does not fit, or when designers want to put the inverter on a corner of their own circuit board. The company validates the layout as part of the kit price.*

In Session 4 of the technical symposium, four papers were devoted to the feasibility of a-Si AMOLEDs, and the papers came from widely scattered sources. The first paper was from IDTech, Chi Mei Optoelectronics, the IBM Zurich Research Lab, and the IBM T. J. Watson Research Center; the second was from AU Optronics (Hsinchu, Taiwan) and Universal Display Corp. (Ewing, New Jersey, U.S.A.); the third was from the University of Michigan; and the fourth was from the University of Michigan and Cypress Semiconductor (San Jose, California).

For some time, Toshiba has been leading the industry with backplanes made from low-temperature polysilicon (LTPS), which is a higher-performance TFT material than a-Si. More recently, Sharp has been making backplanes with continuous-grain silicon, an even higher-performance TFT material. Other companies have also been working with enhanced-performance materials. These materials can be used to make TFTs smaller than is possible with a-Si without compromising performance, which is attractive for making small displays with the high pixel densities required for the new generations of high-performance cellular telephones and PDAs. That is what Sharp is doing with its newly introduced family of transflective continuous-grain-silicon TFT-LCDs for advanced cellular telephones.

Using these higher-performance semiconductor materials to fabricate electronic components other than TFTs on the display glass has always been part of the dream. And at SID 2003, ***Toshiba America Electronic Components (TAEC)*** showed a prototype "input sensor display" SOG which has a sensor at each subpixel location. Place a business card or photograph against the display, press the appropriate button, and the display captures the image of the object placed against it, much as a traditional scanner does, but without moving parts. The current version is gray scale, not color.

Late in 2002, Sharp made an 8-bit controller using continuous-grain silicon and has ambitious plans for making increasingly sophisticated "smart displays" using the material, said Sharp's Joel Pollack. Sharp is adding a Gen 4 fab for continuous-grain silicon at the company's Building #3 in Mie, he said. ■

LCD-TV Technology

by Gary Feather

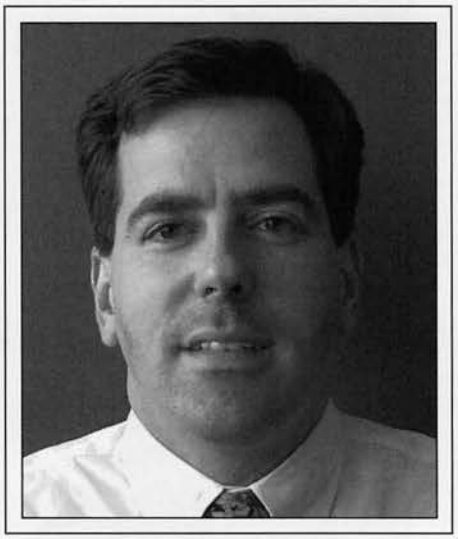
THE SID 2003 symposium marked an exciting year in which key technologists and business have worked together to create new opportunities in the display industry. The dark sky and drizzle of Baltimore could not darken the bright future for so many new display innovations and innovators. Walking around the exhibit floor, one was energized by the excitement generated by the demonstration of new display technologies and techniques. Although new is exciting, everyone noted the unstoppable and unrelenting 30-year development march of the LCD. The LCD, which has experienced dramatic improvements year after year, is now selling in large numbers for television application and will no doubt become a consumer-demanded replacement for CRT television.

The LCD TV has been transformed from a handheld TV display novelty to a big-screen solution in the home today. But what is the future outlook? Will LCD TV always be second to the current king of TV displays, the CRT? All of us were around for the emergence of DLP technology and its promise at SID in 1996 to replace the rear-projection CRT. The DLP is just beginning the difficult task of competing head-to-head with the CRT. What will be the future of LCD TV?

In 2002, about 1.3 million LCD TVs were sold worldwide. Stanford Resources expects nearly 29 million LCD-TV units to be sold worldwide in 2007. Not to be outdone, Ross Young of DisplaySearch presented their view of the future of LCD TV, and the forecasts were shattering. They forecasted that in 2007 the worldwide LCD-TV market would exceed 31 million units, with revenues of over $33 billion.

I had the honor of serving as a panelist on the evening-panel discussion where I addressed the potential market dominance of LCD TV in the future. Dr. Sang-Soo Kim, Executive V. P. of LCD Development at Samsung, provided his company's updates. While Larry Weber defended the current large-area-display dominance of PDPs, I felt that none of the panelists doubted the forecasted unit volumes of LCD TVs. If the investments made by Sharp Corp. in their Gen 6 Kameyama facility to manufacture LCD TVs (in production in Q1 '04) and the announcement from Samsung of its planned Gen 7 plant are considered, it seems the industry is responding aggressively to these forecasts. With over 300,000 LCD-TV units sold in the U.S. in 2002 and a yearly growth rate of over 100% forecasted for the next several years, the success of LCD TVs seems assured. By 2013, it is forecasted that over half of the TVs sold in the U.S. will be LCD TVs. This is a transition of a magnitude never before witnessed by the display industry.

But why are we buying these higher-priced LCD TVs instead of CRTs, and what is the message for future display technologies? Tamaryn Pratt of Quixel showed me their analysis of placement, use, and satisfaction obtained from consumers. Quixel has gathered usage analysis from consumers which strongly suggests that price is not a key factor in sales. The LCD TV has created new flexibility for the TV in the home. The display industry must search for these new and unique uses created by new and unique technologies and must create new markets. Consumers will pay for perceived value; price is not the only driving factor.



So, can LCD-TV manufacturers really move from producing large numbers of 13–20-in. units and 37-in. HD LCD TVs to producing large home-theater displays that are currently dominated by PDPs and rear-projection CRTs? At SID, the writing was on the wall, or, more to the point, LCD TVs were on the walls. Impressive 40- and 46-in. 1280 × 720 and 52- and 54-in. 1920 × 1080 LCD TVs were displayed for all to compare. The push to compete with plasma technology has begun, and, potentially, LCD TV will soon begin to eat away at the smaller-sized rear-projection-TV market.

With all the momentum of LCD TV, is there any more technology work ahead? The answer is a simple and definite yes. The content of the many technical talks at the symposium showed the rich vein of LCD research and innovation being mined by the display industry. LCD technology development has benefited from over three decades of hard work by display and visual-science researchers. Hiroshi Take of Sharp conducted a seminar on LCD TV covering this history.

The growth in the market for LCD TV assumes and expects significant technical improvements year after year. Technology developments to further improve contrast ratio, speed, backlights, signal processing, aliasing and artifacts, scaling, dynamic range, and color gamut, and lower the cost of manufacturing will provide innovative opportunities in the display industry for decades to come. Poster papers as well as the traditional oral technical presentations at this year's SID symposium explored and proposed innovative ideas in many of these important topics.

SID members should be proud of the significant contributions made in this industry in the past three decades and are, I hope, excited about the great future ahead for all of us. ■

***Gary Feather** is Director of Digital Audio Visual Systems, Sharp Laboratories America, 5750 Northwest Pacific Rim Blvd., Camas, WA 98607; telephone 360/817-7759, fax 360/817-8436, e-mail: featherg@sharplabs.com.*

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Predicting the Future

by Yoichi Taira

I always gain a lot of insight by strolling around the SID exhibition and by joining discussions during the symposium. This year, again, there were many surprising accomplishments displayed at the exhibition, although the real value of some of them could be easily overlooked. Here are some particularly interesting ones that I observed.

The demonstration of a bright and large amorphous-silicon TFT-based OLED was a surprise. There were quite a few polysilicon TFT-driven OLEDs that looked as though they could have been used in a product because of their packaging and perfection. Large 62-in. PDPs and 40-in.-and-over TFT-LCDs displayed amazingly vivid images. The presence of a high-contrast large projection screen might indicate a forthcoming outbreak of projection-type devices. There were numerous impressive new materials, components, design tools, and software.

These accomplishments were really impressive, but we must not forget that they were not a result of business-as-usual activities. Often, they are the result of tremendous effort that includes blood, sweat, and tears. The electro-optical efficiency of OLEDs, for example, is much better now than what was demonstrated a few years ago. This is the result of innovative scientific study on the way the materials are used together with the development of advanced new materials. Impressive displays are the result of underlying material and technology R&D efforts.

NHK's weekly documentary TV program "Project-X" is well received in Japan. In each 45-minute program, a real story about the accomplishment of a very difficult project is reported. It is appealing to see the project leaders' ambition, devotion, discouragement, and joy and sorrow after the project is successfully completed. The pioneering development work on LCDs and PDPs was previously presented. I am sure that all of the excellent work here at SID 2003 deserves its own "Project-X" story.

Workers in technology areas always want to do a great job. In the display area, it might be achievement of the dream of a new high-performance display. However, we are not sure what is required to maintain such a long-term R&D project. The keynote addresses of the symposium were both timely. In particular, the talk by Dr. James Stoffel of Eastman Kodak Co. gave a valuable hint in answering the question of how we can sustain a long and difficult R&D program in the information-display business.

Traditionally, we aim high or set a very high goal so that our output is maximized, but R&D times tend to be long because the goals we set are difficult to achieve. And for businessmen, a long time is a risk because predicting the future is not very accurate. What I learned from Dr. Stoffel's talk is to utilize R&D results in near-term products rather than waiting for the completion of the entire development project.

In fact, our ability to accurately predict the future is quite limited, especially in the time frame during which a technology is developed and applied to a product. The researchers in R&D know a great deal about the principles and the challenges of the technology, but have very little knowledge about how customers will accept the new technology, service, or products. If, in addition to obtaining an excellent technical result, we also are concerned about how to achieve the goals in a short period of time, it is more likely that our ambitions will come true. ■

Yoichi Taira *is Senior Consultant Researcher and Senior Technical Staff Member at the IBM Research Japan Tokyo Research Laboratory, 1623-14, Shimotsuruma, LAB-S76, Yamato, Kanagawa 242-8502, Japan; telephone +81-46-215-4875, fax +81-46-273-7413, e-mail: taira@jp.ibm.com.*

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The First SID Business Conference

by Joe Hallett

ALMOST 40 YEARS AGO, the first annual Symposium and Exhibition of the Society for Information Display was held in Santa Monica, California, with an attendance of 400. This year, in Baltimore, about that same number met for the first SID Business Conference while thousands attended the symposium and exhibition.

In the early '60s, the display industry's focus was on Government-sponsored R&D and applications. Now, consumer products take center stage. Then, engineers were struggling to reach a target price level of $10 per digit of numerical display. Electroluminescent flat displays began to emerge from the laboratories, but only the space program could justify their expense. Yet even then – back in the Dark Ages – proposals for display R&D featured pictures of TVs of the future that hung on the wall like today's LCDs and PDPs.

The contrast between these two SID events is illustrative of how far the display industry has progressed. Adding the business conference this year was a major step for the Society.

"I had to convince SID that it was a good idea," said Elliott Schlam of Elliott Schlam Associates, who conceived of and organized the Business Conference. "Displays are a big business. It was important that SID recognize that its service to the display community has been incomplete without covering business issues." A late surge in interest carried the number of attendees well beyond early estimates. "We had hoped for between 100 and 200 participants," said Schlam. "We are very thrilled with over 400."

The Business Conference, which was held the day before the exhibits opened, provided a good reality check before viewing the exhibits and demonstrations. "It is not about technical fantasy," said Schlam. "It really is about business."

"We invited top-notch speakers," he continued. "There is so much going on with the competition between liquid crystal and plasma for big-screen TV, and monitors are getting bigger."

Harrie Brunklaus, CEO of Philips Electronics New Displays Business Development, keynoted the session by describing a world in which consumers could experience technology that adapts to their needs. Examples ranged from a video-enhanced "social event," in which separated friends and family members could share a sports event, to an "adaptive ambient" that provided activity-appropriate home lighting and background music. "It is all about humanizing technology," he said.

Two speakers, David C. Nagel, CEO of PalmSource, Inc., and Bernard Masson, President, Display Group, Eastman Kodak Company, described ways in which the display industry is driving a variety of non-television products, especially portable items such as PDAs, telephones, cameras, and games. Advances in LCDs and OLEDs are removing significant barriers. For example, the OLED viewing screen in Kodak's new EasyShare digital still camera has a wider viewing angle than that of the previously used LCDs, making it easier to use the camera for overhead shots. Transflective LCDs provide improved viewing in both brightly lighted and darkened environments, a great advantage for PDA and cellular-telephone users.

An overview of microdisplays for small- and large-display applications was given by Robert L. Melcher, Chief Technology Officer, Three-Five Systems (and soon to be the CTO of Brillian Corp., Three-Five Systems' new microdisplay spin-off). He expects to see the rapid market growth of rear-projection displays and for "embedded" displays, including video headsets, electronic viewfinders, and wireless products. The integration of optics and electronics at a subsystem level will continue to be essential.

Citing examples of large LCDs embedded in countertops and wide-format computer monitors showing multiple windows, Bruce Berkoff, Executive V.P. for marketing at LG.Philips LCD, emphasized the importance of larger screen area and more "screens per person" in order to make a growing quantity of information available where and when it is needed.

While presenters showed that viable display opportunities exist across a spectrum of screen sizes and performance, it was large-screen TV that generated the most attention. The stage was set by the market watchers: Sean Wargo of the Consumer Electronics Association (replacing the previously announced Todd Thibodeaux); David Mentley, V.P. and large-screen-display specialist at iSuppli/Stanford Resources; and Ross Young, President, DisplaySearch. Each presented voluminous charts to support expected major market growth for large-screen displays, driven by digital television.

The state of industry readiness to meet market needs for large-screen LCDs was addressed in detail by several speakers. Vincent F. Sollitto, President, Sollitto Associates (and soon to be President and CEO of Brillian Corp.), discussed capital equipment and revenue issues for AMLCD manufacturers. Jun Souk, Executive V.P. of the AMLCD Division of Samsung Electronics, Co., Inc., presented a review of manufactur-

***Joe Hallett** is a business consultant located at 22370 S. W. Grahams Ferry Rd., Tualatin, OR 97062-8022; telephone 503/692-5554, fax 503/692-5649, e-mail: joeh24@aol.com. He has been actively involved in the display industry for over 30 years.*

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ing-economics issues, including the prospects for improving the performance and cost of large LCD panels.

A similar range of issues related to plasma-display panels was covered by Tadatsugu Hirose, General Manager of Product Design, Fujitsu Hitachi Plasma Display, Ltd.

Elliott Schlam concluded the session by touching on some of the up-and-coming technologies (the buzzword is "disruptive"), including LED arrays for large super-bright signboards, electronic "paper" that requires no standby power, and some flat-display technologies that offer the potential for very low manufacturing cost.

After a long day, the audience apparently went away happy. "Even at 5:30 we had a full crowd," said Schlam. "People stayed an extra hour to make up for lost time." (Despite the moderator's earnest call for discipline – "there shall be no breaks" – the conference was forced to evacuate the meeting room several times because of an apparently faulty alarm system.)

SID also must have been happy about the fledgling Business Conference. "I have been asked to put one together again next year," Schlam said. A CD-ROM containing the conference presentations is available by contacting office@sid.org. ■

SID 2003 Honors and Awards

Tsutae Shinida was awarded the Braun Prize for work on color plasma displays, Webster E. Howard was awarded the Rajchman Prize for contributions to the research and development of many flat-panel-display types, and Shunsuke Kobayashi received the Lewis and Beatrice Award for longtime service to the Society.

by Stephen P. Atwood

THE Society for Information Display's annual awards banquet, held on the Monday evening of Display Week, is a notable element of the annual Symposium because it recognizes the outstanding contributions of professionals who have helped create the international display industry. It also allows the Society to honor the many volunteers who have helped build SID.

This year, the Karl Ferdinand Braun Prize was awarded to ***Dr. Tsutae Shinoda*** "For his pioneering inventions and outstanding contributions to commercializing color plasma displays." Dr. Larry Weber, Honors and Awards Committee Chair, expressed his belief that Dr. Shinoda was probably the "most famous plasma-display person in the world." This was high praise coming from Dr. Weber who was also honored by the Society with the Braun Prize in 2000 for his work on plasma displays. Dr. Weber went on to say that Dr. Shinoda was the one that solved many of the fundamental problems that made color plasma technology practical.

A graduate of Hiroshima University, Hiroshima, Japan, in 1973, Dr. Shinoda finally completed his Ph.D. in 2000 from Tohoku University, Sendai, Japan. In between, he gave life to a number of key discoveries, including two- and three-electrode surface-discharge technologies, the striped-rib and striped-phosphor configurations for low-cost manufacturing, and the address-display-period-separation (ADS) method that enabled the display of full 24-bit color. These technologies are now the standard technologies used for all practical color plasma displays.

Dr. Shinoda has worked for Fujitsu for most of his professional life and was also the first student of the very well-known Prof. Heiju Uchiike from Hiroshima University, whom he thanked "for being his teacher and loyal friend for over 20 years." Shinoda-san is a Fellow of SID and holds 59 patents, including fundamental patents for color PDP devices.

The Jan Rajchman Prize was awarded this year to ***Dr. Webster E. Howard*** "For his outstanding contributions to the research and development of many flat-panel-display types." Dr. Weber pointed out that Dr. Howard had probably helped develop every conceivable flat-panel technology during his distinguished professional career. An alumni of Carnegie-Mellon University, Dr. Howard completed his Ph.D. in physics at Harvard. He joined the IBM T. J. Watson Research Center, and over the next 32 years lead research into plasma displays, thin-film electroluminescence, CRTs, and TFT-LCDs. Dr. Howard was instrumental in the formation of DTI, the groundbreaking AMLCD manufacturing joint venture between IBM and Toshiba. From IBM, Dr. Howard moved to AT&T, where he was the Director of High-Resolution Technologies and a consultant to Bell Laboratories. Most recently, he was the Chief Technology Officer at eMagin Corp., where he led the development of OLED microdisplays on silicon.

In his comments, Dr. Howard explained how display development is truly a "team sport" because so many different fundamental scientific disciplines are required to achieve success. He also pointed out that the award was especially meaningful to him because its namesake, Jan Rajchman, built the first active-matrix display at the David Sarnoff Institute (then RCA Laboratories) using electroluminescent technology. He is a Past-President of SID and a Fellow of the American Physical Society, IEEE, and SID.

The Lewis and Beatrice Winner Award for distinguished service to the Society was awarded to ***Dr. Shunsuke Kobayashi*** "For outstanding service and contribution to the Society, especially his efforts to make SID truly international." Dr. Kobayashi received his Ph.D. from the University of Tokyo and is currently Professor of electrical engineering at the Tokyo University of Science in Yamaguchi, Japan. He is a former recipient of the Jan Rajchman Prize (in 1995), holds 45 patents, and has published an astounding 223 papers.

Prof. Kobayashi helped organize the first large-scale display conference in Japan, is

Stephen P. Atwood *is the Engineering Manager for Three-Five Systems, Inc., Advanced Video Technologies, based in Marlboro, MA; telephone 508/485-3380, fax 508/485-3509, e-mail: satwood@mail.35sys.com. He is also Director of the New England Chapter of SID.*

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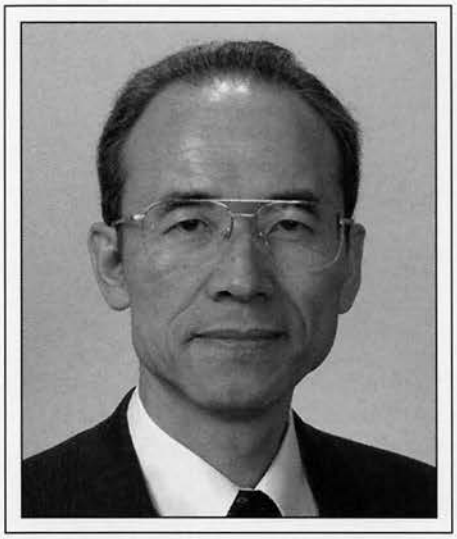


Dr. Tsutae Shinoda

Founding Chair of the SID Display of the Year Award Committee, and has been an invaluable coach helping overseas speakers better prepare for presentations at the Symposium. He served as Asia Regional V.P. of SID from 1992 to 1994, became a Fellow of SID in 1987, and has continually supported SID and its members with his skill and time.

The Society also conveyed the grade of Fellow for unusual professional distinction on six recipients.

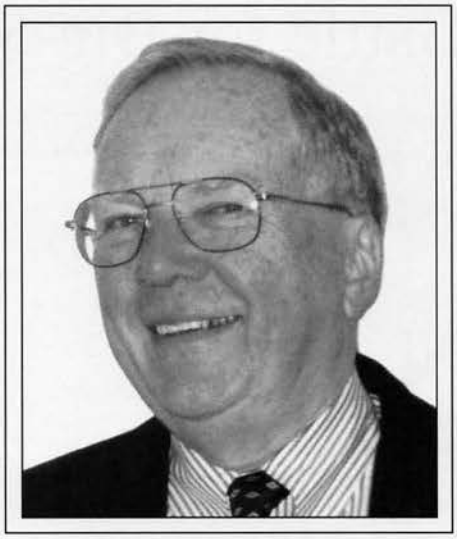
- ***Dr. William P. Bleha*** for the invention, nurture, and implementation of large-screen projection-display technology based on reflective liquid-crystal devices.
- ***Dr. Shui-Chih Alan Lien*** for his many contributions to the science and technology of liquid-crystal displays.
- ***Dr. Eli Peli*** for outstanding contributions in the application of vision science to information-display technology.

Dr. Shunsuke Kobayashi

- ***Mr. Gary K. Starkweather*** for invention of the laser printer.
- ***Dr. Edward H. Stupp*** for outstanding technical leadership and contribution to liquid-crystal projection displays.
- ***Dr. I-Wei Wu*** for outstanding technical contributions and leadership in the development of low-temperature polysilicon displays.

Six distinguished scientists also were recognized with Special Recognition awards.

- ***Dr. Amalkumar P. Ghosh*** for development of novel production-worthy processes for OLED displays and FEDs.
- ***Mr. Paul E. Gulick*** for outstanding entrepreneurial accomplishment founding several successful projection-display businesses.
- ***Dr. Jin Jang*** for outstanding contributions to novel thin-film-transistor technology for LCDs.



Dr. Webster E. Howard

- ***Dr. Noboru Miura*** for his leading research and development of phosphors for full-color inorganic electroluminescent displays.
- ***Dr. Terence J. Nelson*** for sustained and dedicated service to SID both at the chapter level and the international level.
- ***Dr. Michael D. Wand*** for pioneering work on the formulation and synthesis of wide-temperature-range ferroelectric liquid-crystal materials.

In closing, Dr. Weber thanked the hard-working members of his committee and also expressed gratitude and appreciation to Thomson for sponsoring the $2000 stipend included with the Braun Prize and Sharp for sponsoring the $2000 stipend included with the Rajchman Prize. ■

SID Honors and Awards Nominations

See page 92 of August issue

Nominations Due October 17, 2003

e-mail: sidawards@sid.org

Battle for Big-Screen Bucks

by Joe Hallett

NOT FAR FROM Baltimore Harbor, where a famous battle inspired Francis Scott Key to compose *The Star-Spangled Banner*, SID 2003's own "Battle for Big-Screen Big Bucks" drew an attentive crowd of about 400 attendees away from the lure of the Baltimore Inner Harbor's good food and history.

The discussion quickly focused on issues that affect television, continuing a theme that began with the first SID Business Conference held earlier in the week [please see the author's Business Conference review article in this issue – *Ed.*]. The Consumer Electronics (CE) market – rather than the information-technology (IT) market – is expected to be the source of the "big bucks," even though it is not quite clear where ordinary folks will find those big bucks to spend.

The issues were debated by a blue-ribbon panel representing a variety of technology interests.

Moderator: ***Charles McLaughlin***, McLaughlin Consulting Group

Panelists:

- **AMLCDs**
  - ***Gary Feather***
    Director, Digital Audio Video Systems, Sharp Laboratories America, Inc.
  - ***Sang Soo Kim***
    Executive Vice President, AMLCD Division, Samsung Electronics Co., Inc.
- **Projection**
  - ***Peter Van Kessel***
    Manager, ASIC Development, DLP Products, Texas Instruments, Inc.
  - ***Dave Slobodin***
    CTO, InFocus Corp.
- **Plasma**
  - ***Larry Weber***
    President & CEO, Plasmaco, Inc.
  - ***Harm Tolner***
    Consultant and PDP pioneer

Moderator McLaughlin sounded a bit like his slightly more famous TV namesake, giving the panel ample challenges to fill the 2-hour session while limiting their focus to a 5-year time frame.

Whether digital video comes from TV broadcasts, DVDs, digital cable, or satellite services, it increases choice and quality. "The high quality of DTV video and audio drives consumers to upgrade. Dramatic image improvements are most obvious on big screens."

By 2007, the market for big-screen (greater than 30-in.) TV sets should be in the range of 30–45 million units, according to data from various sources, assembled and summarized by McLaughlin, and shown in Table 1.

McLaughlin closed with some predictions.

- "We expect that the worldwide digital-TV market will grow to US$75 billion, the equivalent of 30 million TV sets, over the next 5 years.
- "The global market for large-sized LCD-TV panels will reach 28.8 million units by 2007, up from 1.4 million units in 2002.
- "Plasma-display-panel televisions, LCD televisions, DVDs, digital cameras, and automobile-navigation systems are the only growing markets.
- "The invasion of plasma color TV and rear-projection TV may force 34-in. CRT TV to withdraw from the domestic market."

The panel discussion explored several overlapping topics. What is the relative importance of image size, image quality, reliability, and the "attractiveness" of the competing products? Which technologies will dominate in various size ranges? What is to be the role of rear projection using both CRT and microdisplay technologies? How will the various technologies compete over the next 5 years for shares of the TV market? Will customers really buy these displays and where will they get the money?

"Large-screen displays are defined by cost," said Peter Van Kessel. "In 5 years, it will be whatever technology you can buy for $1700 (an average price for today's projection CRT TV set) ... 1080i or 720p will make inroads below this price point."

The impact of HDTV continues to be unclear. Harm Tolner noted that high definition is found in Japan but not in Europe, while according to Larry Weber, "It does not pay to have a full 1920 [rows of] pixels for HDTV. They will not be seen. For that a 70-in. panel with at least 3 million pixels would be needed!"

"The market has room for many price paths," agreed Dave Slobodin. "There will be plenty with 480p in smaller sizes and 720p or 1080i for larger sizes."

Larry Weber suggested that LCDs would dominate below 30 in., while PDPs would dominate above 40 in. "Thirty inches is 'itty bitty' for plasma ... PDPs can go where LCDs and CRTs can not go."

Dave Slobodin said, "LCDs will squeeze plasma; microdisplays will produce competition and affordability ... front projection will become an acceptable solution and will become more viable as awareness grows."

Gary Feather said, "The market is so big that there will be no winners and no losers in any of the markets. A "puny" 1.3% market share would let us eat well!" Image quality is a moving target. Buyers are being educated to

Joe Hallett *is a business consultant located at 22370 S.W. Grahams Ferry Rd., Tualatin, OR; telephone 503/692-5554, fax 503/692-5649, e-mail: joeh24@aol.com. He has been actively involved in the display industry for over 30 years.*

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increase their expectations about a "good picture."

Harm Tolner agreed with Bernard J. Lechner's comment from the audience that the big advantage of CRTs is "punch" (peak brightness) not provided by other technologies. "The challenge is how to penetrate the CRT market. Peak luminance is essential, and perfect black is needed for home cinema regardless of brightness ... with no 'dirty-window' effects."

The question of when display measurements will be standardized drew mixed responses. "There is not much hope for standards any time soon." "Standards efforts are sporadic." "There are ANSI standards for projectors." "There is tremendous activity at IEC working groups 2 and 4." "Standards are available – encourage manufacturers to use them."

Will consumers really buy big-screen TV? A 3MPO survey indicates 30% of U.S. households want big screens, according to Chuck McLaughlin. Experience with the ramp-up of home-PC sales in the early 1990s and the explosive growth of DVD sales suggests that "where there's a will, there's a way."

It is not just about technology. The variety of TV big screens gives prospective customers a chance to be creative in interior decorating and in the ways that they use technology in their homes. "LCDs are welcome in the home," suggested Gary Feather. "People create environments. They like the look, light weight, and energy conservation of LCDs compared with CRTs and PDPs."

It is not just the image quality, either. They are accustomed to seeing CRT projection systems at a sub-$2000 price point. "The first thing seen after the picture is the price," said Peter Van Kessel.

Dave Slobodin commented, "Customers will be the big winners as technologies converge, and there are lots of options to [buy larger] screen sizes and higher image quality."

Reliability is a tricky issue because a consumer may have trouble differentiating between failures and routine maintenance. And as noted by Sang Soo Kim, "There are different definitions of 'end of life' for LCDs and PDPs."

"The consumer needs to know the ground rules going in," suggested Van Kessel. "[He or she] may have to replace a lamp sometime. We are seeing improvements from lamp suppliers." The question took on a different meaning for Larry Weber. "Life is not an issue ... a display is obsolete after 13 years."

The key question "What can I buy for $2000 in 5 years?" brought a variety of responses. Dave Slobodin said, "good-quality 55–60-in. DLP rear-projection displays, 42-in. LCDs, and plasma." Harm Tolner suggested, "32-in. PDPs ($1600) or 37-in. PDPs $2000." Chuck McLaughlin commented that "rear-projection products will challenge PDPs in the marketplace." Peter Van Kessel said, "I expect that LCDs and PDPs will dominate smaller 30–40-in.-diagonal screens. Above 40 in., I expect projection to dominate."

Although everyone seemed to agree that digital TV is a major driving force behind the consumer's interest in big-screen sets, there was some disagreement about the role of high-definition TV. Bernard J. Lechner, a longtime advocate of high-definition TV, took issue with some comments made by the panelists that high definition was not fueling TV growth. "You cannot discount high definition; 720p and 1080i are available on 1000 TV stations every day. Sports are important and [require] a big screen – at least 60 in. in 16 × 9. We will see lots of high definition."

It was stated that the ubiquitous CRT projection TV set is a difficult target for marketers of other display technologies. CRT projection "works," and current projection TV sets are relatively inexpensive compared with those that are based on flat-panel technology. But there is an opening for microdisplay-based projection.

The renewed single-session format of SID's evening panel worked well. Discussion was spirited and to the point. At the end, Chi Mei Optoelectronics Corp. received well-deserved applause for its sponsorship of this session and for providing refreshments. ■

Table 1: Market Predictions for Big-Screen TV Sets

Technology	2005 Forecast (M units)	2007 Conservative (M units)	2007 Optimistic (M units)
Rear-projection TV	4.0	5.0	8.0
Front-projection TV	0.2	1.0	5.0
PDP	0.3	3.0	7.4
AMLCD	—	3.0	19.1
CRT Direct View	10.6	16.0	5.8
Total	12.1	28.0	45.3

(Sources of data: FCR, DisplaySearch, PMA, TSR, 3MPO, iSuppi, MCG)

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AMOLED venture with Sanyo Electric Co. called SK Display, and it recently added Varitronix International, Ltd., to its long list of OLED licensees, which includes Denso, eMagin, Lite Array, Nippon Seiki, Opsys, Pioneer Electronics, Ritek, TDK, Teco Electric & Machinery Co., Rohm, Sanyo, and ULVAC Japan.

The Gen 3 materials improve luminance (or reduce power) by about one-third over the company's Gen 2 materials, Kodak estimates. The new Gen 3 red has about 250% better luminous efficiency than the Gen 2 red, and the green efficiency of the Gen 3 color suite more than doubles that of the previous version. The new Gen 3 blue, however, has only about half the efficiency of Gen 3 blue. The reason, according to a Kodak white paper, is a "more equitable power consumption per [three-color] channel." The aggregate result of Gen 3 RGB is an estimated 37% power savings – in one example, for a white image of 120 nits.

OLED-materials suppliers, such as Covion, Cambridge Display Technology, and Dow Chemical, are also forging ahead on efficiency, lifetime, and color purity issues, and work by Universal Display Corp. and several FPD partners in phosphorescent materials promises to make great leaps in efficiency. Thus, "good enough" will quickly become "even better."

Certainly, OLEDs will also carve out some space in small-display applications beyond cellular telephones and PDAs – in hand-held consumer gear such as MP3 players, for example – and in the many instrumentation applications that now rely on LCDs, VFDs, or inorganic LEDs. But as for the 13-, 15-, 20-, and 24-in. OLED prototypes we have seen over the past few years, do not expect them to become commercial products in the near term. For the most part, OLED makers are just getting the first-order problems solved for small passive-matrix monochrome OLEDs.

Yes, the OLED has made a very auspicious beginning, and its greatest days are still to come. But at every step into a new application area, it will come up against entrenched competitors, including the LCD. What the LCD reminds me of most is a virus, recurrently mutating to meet new challenges and constantly reinventing itself. Could the OLED be the antibody that will free the world of the juggernaut LCD virus? That is not likely in the foreseeable future. ■

David Lieberman *is a veteran display journalist living in Massachusetts.*

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Looking at OLEDs

by David Lieberman

We do not yet live in the age of the OLED, but we have clearly entered the era of OLED branding. DuPont Displays now has its Olight®, Kodak its NuVu®, OSRAM its Pictiva™, and who knows what cutesy label is next on the marketing horizon? All this branding of an electro-optic (or is that optoelectronic?) component may seem kind of corny and it reeks of Intel-inside envy, but perhaps OLED makers may be forgiven their sincere enthusiasm for an FPD technology that really shines.

It is worth noting that, historically, an FPD technology does not come to market when it is perfect, but when it is "good enough" to capture a slice of some market segment. It is also worth mentioning, to those who see OLED TVs and monitors just down the road, that OLEDs will start off on the small side and mostly in monochrome versions. Passive-matrix monochrome is "the ticket of entry to a real market and a substantial market," says Tom Miller, General Manager of DuPont Displays, "but full color is where the action is."

How good is good enough? I have not yet bought a car that has an OLED audio system, nor have I seen any data on those OLEDs' performance, lifetime, or durability; and I have not yet discovered any field anecdotes or encountered any user feedback about OLEDs in automobiles. The reviews of Motorola's StarTac cellular-telephone venture into OLEDs were mixed. My kids did not give me either a Norelco–Philips Sensotec electric razor or a Kodak EasyShare digital camera for Father's Day, so in the absence of any evidence (I solicit your experiences with OLED-based products), my only real way of judging is to resort to the ultimate judge when it comes to evaluating FPDs: the human eye.

My eye says OLEDs are good enough for cellular telephones and, in side-by-side comparisons of LCD and OLED PDAs, the upstart OLEDs also fare very well. As emissive displays, they shine in a way that reflective/transmissive LCDs do not, and this is simply very pleasing to the eye. Show consumers two otherwise identical cellular telephones, side by side, one with an LCD and one with an OLED, and they will choose the OLED model every time, I suspect. (But how much extra they would be willing to spend for it is still an open question.) And yet, perhaps, I have not seen the latest, greatest AMLCD cellular telephones; and perhaps polysilicon will improve the picture for AMLCDs. Then again, I have seen some LCDs – coupled with phosphor, if I remember rightly, that glow nicely and compare favorably with OLEDs in cellular-telephone-type applications on the aesthetic front.

And we are just at the beginning of things for OLEDs, which will have more to offer the consumer than just a nice glow. All along, the OLED makers have claimed a power advantage over some types of LCDs, and that is an important factor for battery life in hand-held consumer products. No real-world data has yet been presented to prove the point, however. Nevertheless, recent advances in the efficiency of OLED materials have been major, as have lifetime improvements and color purity as well. And coming generations of OLEDs will have a more powerful story to tell.

Kodak, for one, recently announced a third-generation suite of color-OLED materials that provides a nice boost in efficiency. The company has a joint

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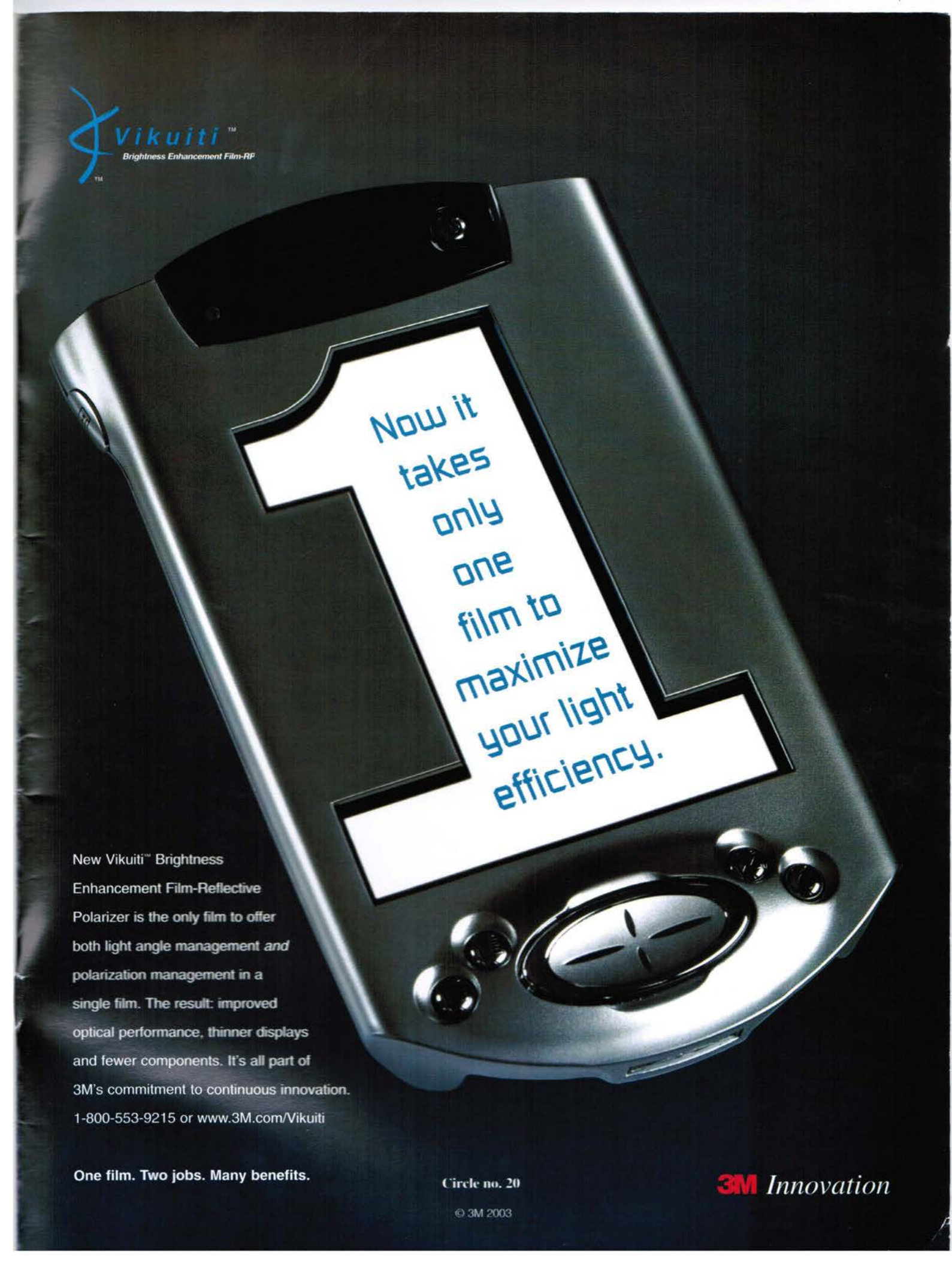
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