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Commercial LCD TV Breaks the 40-in. Barrier

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Although a 40-in. LCD TV has been in limited distribution, the introduction of Sharp's 45-in. model brings commercial LCD TV solidly into traditional plasma territory. The contenders will be exhibiting at SID 2004 in Seattle.

Commercial LCD TV Breaks the 40-in. Barrier

Sharp Corp.

Next Month in *Information Display*

OLED Issue
- Phosphorescent OLEDs
- Comparing Backplanes for AMOLEDs
- Value Growth of Display Technologies
- Impulse Driving Method for AMLCDs
- Consumer Electronics Show Report

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editorial

The Times Are Changing

I'm writing this in between the Consumer Electronics Show (CES) in early January and the SID Symposium in late May. But that doesn't mean the display world is in any kind of lull. There are major developments afoot. Many of them are being widely discussed, quite a few in the pages of this issue of *Information Display*. I'll try to flag a couple of things that are not being talked about quite as widely, although they are certainly not secrets.

At CES, substantial numbers of Asian companies that are not household words were jumping onto the flat-panel-TV bandwagon. Many of them are interested in private branding and OEM customers, but some are manufacturing under their own names or have licensed well-known brand names – some of which, like Westinghouse, have not been associated with television for many years.

Next, it has certainly not escaped the attention of those who follow such things that mainland Chinese companies are working hard to bring various aspects of the FPD parts, materials, and manufacturing infrastructure into their backyards. The goal, initially, may be to provide labor-intensive services such as module assembly to foreign companies and to incorporate as much local value as possible into TV sets and other consumer products built around imported panels for the domestic Chinese market. But the time will come when China will be a major supplier of large FPDs and FPD TVs to the world. It will be exciting to live through such a major global transition.

For my part, I'm encouraging my teen-aged son to learn Chinese. I hope he listens.

— KIW

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

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The Next Big Thing

by Charles W. McLaughlin

In the post-CES glow, it is hard not to conclude that television is the current Big Thing happening in the display space. A range of display technologies is all teed up and ready to satiate consumers' demands for big, beautiful digital video. DTV market saturation will take at least 10 years, portending a massive growth opportunity.

But for those of us pushing the envelope of display technology, what is next? What applications and markets will follow in the string of Big Things that stretch all the way back to watches and calculators and were followed by notebooks, cellular phones, PC monitors, and now television?

We do not have to listen very hard or long to the proponents of technology push to develop a list of candidate Next Big Things. At the top of the list: OLEDs. Next, with strong support from the U.S. Government: flexible displays. Following on down the list, we find a range of new display concepts with less widespread support: 3-D, wearable personal displays, and micro-projectors.

While technology push is interesting, it is market pull that is the determinant of Big Thing status. If we use the experience of the last decade to prioritize the display features and benefits that generate market pull, we see low-cost full-color video at the top of list. From cellular phones to televisions, the modern display user demands color and wants video. And to penetrate and saturate the market, the path to low cost must be pursued. If new technologies cannot be better and cheaper than the incumbent LCD, plasma, and projection solutions, then it must enable new use paradigms.

The OLED developers are betting that they can be competitive with LCDs in established markets. The good news is that OLEDs produce full-color video very nicely. The bad news is that costs for LCDs continue to decline 10% annually, and trying to catch up with the LCD learning curve is next to impossible. On top of the cost challenge, OLEDs must demonstrate improved lifetime and lower power consumption. No one is claiming a new use paradigm for OLEDs as a path around directly competing with LCDs – other than a flexible version discussed below. The bottom line is that OLED technology has the strongest fundamentals, but faces a very difficult competitive battle in carving out market share in existing LCD markets.

Flexible displays face even more obstacles, the biggest being higher cost. Full-color video-capable flexible displays are second- or third-generation products and are many years down the road. Nearer-term products are more likely monochrome, dramatically restricting market applications. But the cost hurdle is the killer. Materials costs for flexible displays are much higher than for glass displays, much like flex print circuits are much more expensive than FR4 semi-rigid boards. Flexible displays may enable new use paradigms in vertical markets, but without lower costs and full-color video performance they will not be competitive in major markets and at best may be a Little Thing.

The recent promotion of 3-D as the Next Big Thing by a consortium of major players, led by Sharp, is yet another example of technology push. Certainly stereo has its place in a range of vertical professional markets and may find a role in high-end gaming. But stereoscopic imaging is fundamentally flawed,

continued on page 86

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tutorial

Organic Electronics for Flat-Panel Displays

OLEDs represent the most advanced organic electronic technology, but organic TFTs may prove to have even greater impact.

by Michael G. Kane

A group of related technologies based on organic electronic materials may alter the landscape of electronic displays. What do these technologies have in common? How are the organic materials like and unlike conventional inorganic semiconductors? What are their advantages and limitations?

From the outset, things are off to a bad start: the term "organic" lacks a precise definition. At least we can dispense with the idea that organic materials must have been alive once. In 1828, Friedrich Wöhler synthesized urea, demonstrating that there is no special quality that distinguishes compounds found in living things from compounds made in the laboratory. Wöhler noted that his synthesis was "a noteworthy result in as much as it provides an example of the artificial production of an organic, indeed a so-called animal, substance from inorganic substances."

Today, the most widely accepted definition is that organic materials are made from carbon-based compounds. This definition is not perfect because it includes a few materials that have never been regarded as organic, such as carbonate minerals. But it is as good as any other definition and works pretty well.

Why do carbon-based compounds get a name – and a branch of chemistry – all their own? In the first place, we have a personal interest: they are responsible for many of the chemical processes that go on in living organisms. In addition, organic chemistry has considerable depth and complexity because the carbon atom has unique properties that allow it to bond to itself and other types of atoms in ways that allow a huge variety of molecules to be formed. As a result, nearly all of the approximately ten million known compounds are organic. Some are very simple, such as methane (CH_4), and others are very large and complicated.

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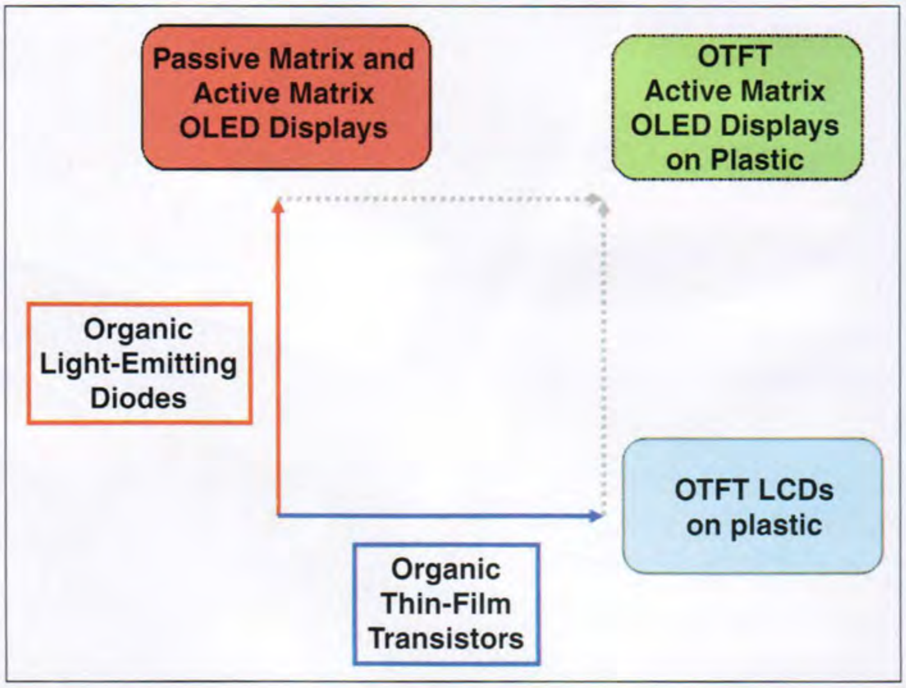

Fig. 1: *Organic light-emitting diodes (OLEDs) and organic thin-film transistors (OTFTs) are complementary technologies for displays. Either technology can stand alone, but they complement one another when used together.*

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Organic electronics uses organic materials as the active layer in electronic devices. This is more than just using organics to perform passive functions. An example of a passive function is the very important and longstanding use of organics as insulators, as in plastic-coated wire. More recently, organic conductors have found wide application as low-cost transparent conducting films for anti-static coatings. But this is also a passive use of organic materials.

The basic concept and rationale of organic electronics is to replace traditional electronics based on inorganic semiconductors (for example, silicon) with electronics based on organic semiconductors that can be deposited onto large areas using plastic and other low-cost substrates. Organic electronics has the following benefits:

- Flexible, foldable, unbreakable electronic systems and displays can be made on ordinary materials, such as plastic and coated paper.
- Low-cost light-emitting components can be fabricated on large-area substrates.
- Electronics fabrication can be performed in a high-throughput facility without large capital investment.
- There may be performance advantages over inorganic semiconductors for some applications, such as chemical and biological sensors.

The best-known organic electronic technology is organic light-emitting diodes (OLEDs). The first organic electronic product to appear in the consumer market was Pioneer's DEH-P8000R CD player, which was introduced in 1999 and was available with a 256 × 52 multicolor passive-matrix OLED display. Since then, other OLED products have entered the marketplace. The Kodak EasyShare LS633 camera, introduced in 2003, was the first consumer product with an active-matrix OLED display. For these and other products containing OLED displays, the primary selling point for consumers is the appearance of the display, which is bright and has high contrast and saturated colors.

A second organic electronic technology that is attracting considerable interest is organic thin-film transistors (OTFTs). These devices are a low-cost flexible alternative to the silicon-based TFTs currently used in direct-view active-matrix displays. The OLED and OTFT technologies are not competitive but complementary (Fig. 1). Either of these organic technologies can stand alone, but they complement one another when combined. In particular, the capability of OLEDs to provide a high-quality low-cost flexible display can not be fully exploited without an active matrix of OTFTs that share the same qualities.

Organic Electronic Materials

The variety and complicated nomenclature of organic electronic materials make it hard for a newcomer to enter the field. Some difficulty also arises from the separate historical development of the fields of chemistry and solid-state physics, which has produced two different sets of models and terminology. Unfortunately, there are few introductions to this interdisciplinary field, such as those that are well known in the two separate fields.

Nevertheless, we can make a start. Organic semiconductors are composed of molecules weakly bound together and spaced rather far apart, in contrast to the closely spaced atoms rigidly bound together in a crystalline or amorphous inorganic semiconductor. This is why organic solids tend to be soft and pliable: the molecules can move around each other easily. It is common to distinguish two types of organic semiconductors: small-molecule materials and polymers. In small-molecule materials, the molecules are composed of only a few tens of atoms each, while polymers are made up of long chain-like molecules containing hundreds or even thousands of atoms.

It is remarkable that, despite the different structure of organic semiconductors, many of them have electronic properties that are similar to those of inorganic semiconductors. There are also important differences (Table 1). The similarities arise because the energy bands of organic electronic materials are in many ways similar to the bands in inorganic semiconductors. But in organic materials the electronic carriers tend to be localized on individual molecules and do not move easily from one molecule to the next because the molecules are far apart. One is tempted to call these materials insulators, but electric current can indeed flow at practical voltages if the carrier transport is not too sluggish and if good contacts are formed for injecting and extracting carriers. Then these materials can be used as active layers in electronic devices, replacing inorganic semiconductors.

Organic Light-Emitting Diodes

The OLED revolution began in 1987. Much earlier, in the 1960s, researchers at RCA Sarnoff Labs and elsewhere had experimented with forcing an electric current through a crystal of the organic semiconductor anthracene sandwiched between two electrodes. They observed emission of blue light as electrons and holes injected from the electrodes recombined in the organic crystal. However, high voltages of 100 V or more were required to get significant current to flow, and light emission was weak.

These problems arose because it is difficult to make good electrical contact with anthracene, and injection of electrons and holes from the electrodes was unbalanced, as was transport of the two carrier types through the crystal. Although RCA was awarded a patent on the anthracene electroluminescent device, no practical application was seen, and interest in using organics as light emitters flagged in the 1970s.

In 1987, Tang and Van Slyke at Kodak reported a two-layer organic heterostructure

Table 1: Comparison between Organic and Inorganic Semiconductors

Similarities	Differences
1. There are energy bands, with an energy gap between filled and empty bands.	1. Mobility of charge carriers is typically lower in organics.
2. Bands can be populated with electrons and holes.	2. Carriers are localized on one organic molecule at a time and move from molecule to molecule.
3. Electrons and holes can be injected from contacts.	3. It can be difficult to form good contacts to organics for injecting and extracting carriers.
4. Light can be emitted through electron–hole recombination.	4. Dopants in organics tend to move around and are not often used (except in conducting polymers).

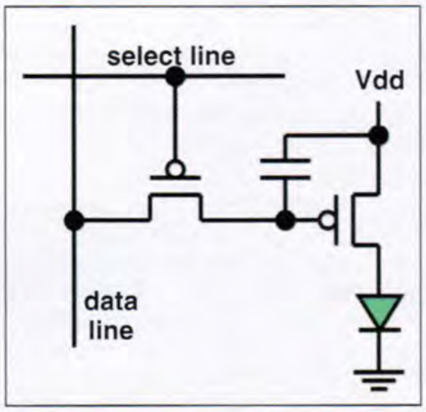


Fig. 2: This simple active-matrix OLED pixel uses two p-channel thin-film transistors to form a sample-and-hold circuit.

that overcame these difficulties. Careful selection of the organic layers and the electrodes gave good contacts and balanced carrier injection, and also allowed a recombination zone to be created where electrons and holes pile up near the organic–organic interface in the middle of the OLED, promoting light emission. The OLED is an efficient low-voltage light emitter. The huge variety of organic materials allows more freedom in the choice of colors than is possible with inorganic LEDs.

In both organic and inorganic LEDs, the light-emission process is imperfect, and some of the energy released during electron–hole recombination is wasted, going into thermal vibrations and other excited states of the semiconductor. Most of the wasted energy ends up as heat, simply raising the OLED's temperature. Unfortunately, in the organics the non-radiated energy can also produce chemical and structural damage that does not occur in the tightly bound structure of inorganics. As a result, the brightness of an OLED can decrease by 50% over a few thousand hours of operation, while inorganic LEDs have operational lifetimes of over 100,000 hours. Not only does this cause an OLED display to become dimmer during the product lifetime, but it also causes a pattern that remains on the display for an extended period to leave an unsightly permanent afterimage, just as images could be burned into older cathode-ray tubes.

The lifetime problem has presented a serious challenge to the commercialization of OLED technology. The situation is expected to improve as we gain a better understanding of the physics and chemistry of organic light emitters, with accompanying improvements in power efficiency and color gamut.

The first OLED displays used a passive-matrix architecture, with row and column electrodes separated by the organic layers, and this is still the most common approach. In a passive matrix, the display is driven one row at a time, but fast enough that the viewer sees a continuous image. However, row-at-a-time addressing means that the OLED element at each row–column crossover is driven at a low duty cycle and at high peak currents. There are significant limitations to this mode of operation.

When an OLED is pulsed at high current levels, its power efficiency is lower than when it is driven continuously at the same average current. This and other loss effects grow worse as the size of a passive matrix is increased. As a result, for high-resolution displays the passive-matrix architecture is generally considered practical only for displays up to several diagonal inches.

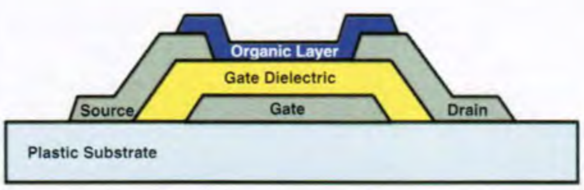
Active-matrix addressing of OLED displays deals with the problems of the passive matrix by allowing each OLED element to operate at or near 100% duty cycle. A transistor circuit in each pixel performs a sample-and-hold function for that pixel's data. The display data are written one row at a time, but the OLEDs are driven continuously. As a result, the power-sapping high-current effects of the passive matrix are eliminated in an active-matrix OLED display. By one estimate, a high-resolution active-matrix OLED display with a 3-in. diagonal requires less than half the power of a passive-matrix display of the same size.

Of course, the efficiency comes at a cost: the display must now incorporate transistors – specifically, TFTs on glass for direct-view displays. Furthermore, the sample-and-hold function in each pixel is not simple to implement. In contrast to the simple one-transistor switch used in TFT-LCD pixels, the sample-and-hold circuit requires two or more transistors per pixel (Fig. 2). More-complicated circuits can be used to render the display more tolerant of TFT nonuniformities. Despite the additional cost and complexity of an active matrix, the power advantage is compelling, especially for portable devices, and this accounts for Kodak's use of an active matrix for the OLED display in their EasyShare LS633 camera.

The Kodak display uses low-temperature-polysilicon (poly-Si) TFTs on glass. Until recently, it was commonly thought that only poly-Si TFTs had sufficient drive current for direct-view active-matrix OLED displays. Doubts concerning the ability of the lower-cost amorphous-silicon (a-Si) TFTs to satisfy the drive requirements were put to rest after display demonstrations at the 2003 SID International Symposium. However, the poly-Si technology has the added benefit of allowing driver circuits to be integrated on the display. This would be very difficult using a-Si TFTs. We can expect to see a contest between these two TFT technologies to determine whether the performance advantage of poly-Si TFTs compared to a-Si TFTs justifies the extra cost.

Organic Thin-Film Transistors

Organic thin-film transistors are the complementary technology to OLEDs. Although OTFT technology is less developed than OLED technology, the first OTFT was reported in 1983 – four years before the first



Pennsylvania State University

Fig. 3: The schematic and photograph reveal that the structure of an OTFT is the same as that of an a-Si TFT except for the replacement of amorphous silicon by an organic semiconductor.

reported OLED – by Ebisawa and colleagues at NTT Laboratories in Japan.

OTFTs use the same inverted, staggered structure used in a-Si TFTs, but with the amorphous silicon replaced by an organic semiconductor (Fig. 3). Like all field-effect transistors, current flow from source to drain is controlled by the voltage applied to the gate. As in inorganic TFTs, both *n*- and *p*-channel devices are possible, in which the current carriers are electrons and holes, respectively. However, unlike the case of inorganic devices, the difference between *n*- and *p*-channel OTFTs does not lie in how the devices are doped with impurities. Organic electronic devices are typically undoped because dopants are difficult to control. Whether an OTFT is of the *n*- or *p*-channel type depends on the choice of organic semiconductor used, and, for reasons that are not completely understood, the best OTFTs have been *p*-channel devices. Ultimately, we would prefer a complementary OTFT technology with high-performance *n*- and *p*-channel devices, similar to silicon CMOS technology.

Many small-molecule and polymer organic semiconductors have been used successfully to make OTFTs, with some materials being vacuum-deposited while others are deposited from solution. One organic semiconductor, vacuum-deposited pentacene ($C_{22}H_{14}$), stands out as consistently yielding *p*-channel OTFTs with field-effect mobilities of about 1 cm^2/V-sec, similar to or better than a-Si TFTs (Fig. 4). The superior properties of pentacene compared to other organic semiconductors appear to arise from its ability to form well-ordered polycrystalline films when it is sublimed slowly in vacuum onto a substrate held at or slightly above room temperature.

Recent research has focused on understanding the structure and electronic properties of pentacene and on further improving these properties by a proper choice of gate dielectric and by chemical treatment of the dielectric surface. Very recently, other materials similar to pentacene, such as vacuum-deposited tetracene ($C_{18}H_{12}$) and rubrene ($C_{42}H_{28}$), have been used to make OTFTs that may be as good as those made of pentacene.

The lifetime deficiencies of OLEDs are also seen in OTFTs, although the data are still sketchy and it is unclear whether similar physics is at work. It is certain that air and water vapor can degrade the performance of OTFTs, just as they do OLEDs. In the manufacture of plastic active-matrix OLED displays, it would be convenient if the same hermetic-sealing technologies being developed for plastic OLED displays would work for OTFTs as well.

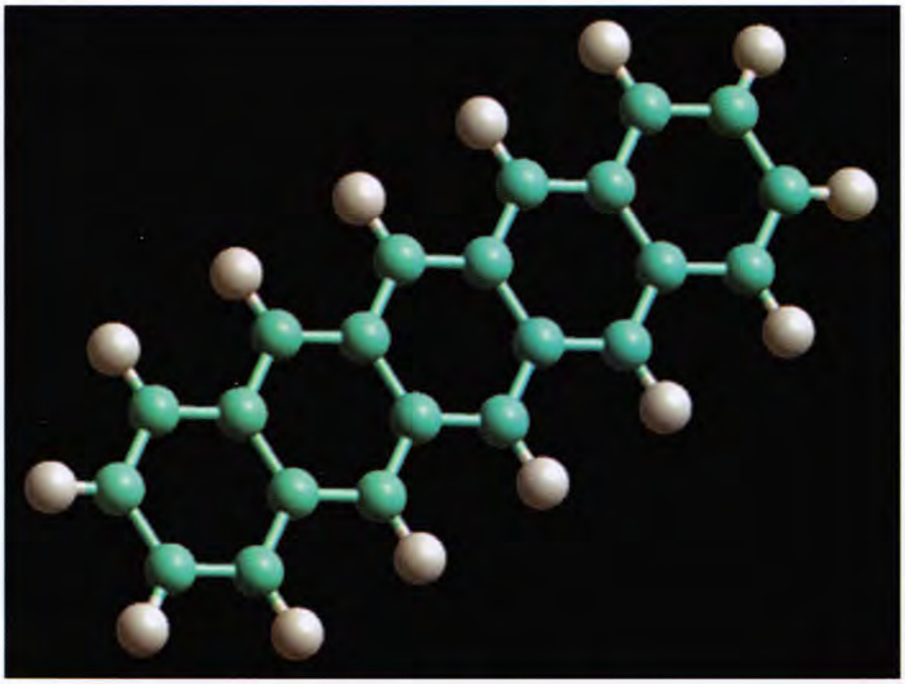


***Fig. 4:** The molecular structure of the organic semiconductor pentacene is shown with the carbon atoms in blue and the hydrogen atoms in white. Vacuum-deposited pentacene consistently yields* p*-channel OTFTs with field-effect mobilities similar to those of a-Si TFTs.*

However, there are reasons why OTFTs may be more stable than OLEDs. An OLED requires a small-work-function cathode to inject electrons and a large-work-function anode to inject holes. Small-work-function metals are chemically reactive, and the reactivity of the cathode contributes to the lifetime problems of OLEDs. On the other hand, in *p*-channel OTFTs both the source and drain electrodes are large-work-function conductors, and are therefore chemically unreactive. Thus, the OTFT may be a more stable device than the OLED. Of course, OTFTs may have lifetime issues of their own, such as mobile charges in the gate dielectric, a problem that plagued MOSFETs in the early days of silicon technology.

Because OTFTs can achieve performance similar to that of a-Si TFTs, they are a natural candidate for plastic active-matrix displays. The first video-capable TFT-LCD on plastic was demonstrated in 2001 by Sarnoff, Penn State University, Kent State University, and Rensselaer Polytechnic Institute. The displays used vacuum-deposited pentacene TFTs fabricated on polyester film. However, a vacuum-deposited OTFT process is not expected to be lower in cost than conventional a-Si TFT processes on glass because it will have similar capital-equipment costs and throughput. But it is possible that the plastic substrate can be exploited to reduce manufacturing costs below what is possible with glass substrates by employing low-cost high-throughput fabrication methods.

Several research laboratories are at work developing new materials and processes for organic electronics on plastic by exploring non-lithographic continuous methods. Most of this work focuses on solution-deposited semiconductors that are patterned and deposited using printing methods such as ink-jet printing.

A year-and-a-half ago, Sarnoff, DuPont, and Lucent began a three-year project to develop new materials and processes for low-cost OTFT fabrication on plastic using thermal multilayer (TML) laser printing, a dry printing method. The TML printing method involves the digitally defined pixelated transfer of a thin solid layer from a donor film onto a receiver film, using a 40-W 780-nm diode laser, split into 250 individually addressable 5-μm square pixels. Multiple patterned layers can be built up sequentially.

The printing engine can handle large flexible substrates, and, as long as the substrate is not removed from the printer, alignment between layers is automatically maintained. The new printed-electronics technology will first be demonstrated using plastic active-matrix OLED displays, to be commercialized by DuPont Displays. Other spin-offs of the printed-electronics technology are expected, such as printed TFT-LCDs and printed digital x-ray-imaging panels on plastic.

The Challenge Ahead

Overcoming entrenched technology is always a difficult challenge. For organic electronics, niches must be found that allow the technology to grow gracefully as revenue generation begins. For OLEDs, the entrenched technology is TFT-LCDs, and makers of OLED displays will look for applications in which a premium is placed on image quality and power efficiency. The OTFT technology takes its stand on the advantages of plastic active-matrix displays, namely, mechanical flexibility and reduced manufacturing cost in a continuous line. But OTFT performance and lifetime are still unpredictable. The initial applications will be ones that are less sensitive to these issues, such as small high-resolution displays for low-cost digital cameras, PDAs, and handheld games. ■

Volumetric 3-D Liquid-Crystal Displays

Until recently, true 3-D displays have not proven to be practical except for a very narrow range of applications. Could LCDs bring volumetric displays to a wider audience?

by Igor N. Kompanets and Sergey A. Gonchukov

MOST of the displays we call three-dimensional (3-D) merely create the illusion of a 3-D world on a 2-D screen. This illusion is a far cry from the rich 3-D world that could be created with a high-quality volumetric display that fully recreates a scene within a volume of 3-D space.

A good 2-D display can exhibit in the neighborhood of 1000×1000 (10^6) pixels. An equivalent 3-D display must also exhibit 1000 pixels of depth, or $1000 \times 1000 \times 1000$ (10^9) voxels (volume pixels). Unfortunately, it is not feasible to implement such a display. So, we are faced with a basic question: Is it possible to build a true volumetric display that offers sufficient quality at a less-than-ridiculous cost?

Volumetric displays are under development and investigation all over the world. The range of applications is extremely wide and includes volumetric TV, the display of dynamic scenes and complicated technological and geophysical processes in video-information systems, computer simulation and design, navigation, visualization of tomographic information in medicine, simulation of different tasks in science and technology, computer trainers and games, advertising, and entertainment.

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2-D and 3-D

Developers are now making good progress in fabricating 3-D displays that use 2-D screens to form different points of view. But, as previously indicated, this type of 3-D display can not form the volumetric image needed for the 3-D model of an object, which requires a real 3-D image that can be observed from different sides by many observers simultaneously, thus enabling them to look around the object. Such an image can be formed only in a 3-D medium, slice by slice along the z-axis (the direction of depth into the display).

This approach makes a relatively modest demand on computer resources because point of view are not specially calculated, but are observed naturally by any observer when looking around the volumetric image. Of course, this entire image must be formed in 1/25 sec or faster if it is to be perceived without flicker.

For a long time, there was no appropriate volumetric medium with which to design an effective 3-D display. It was only about 2 years ago that the Perspecta™ 3-D System,

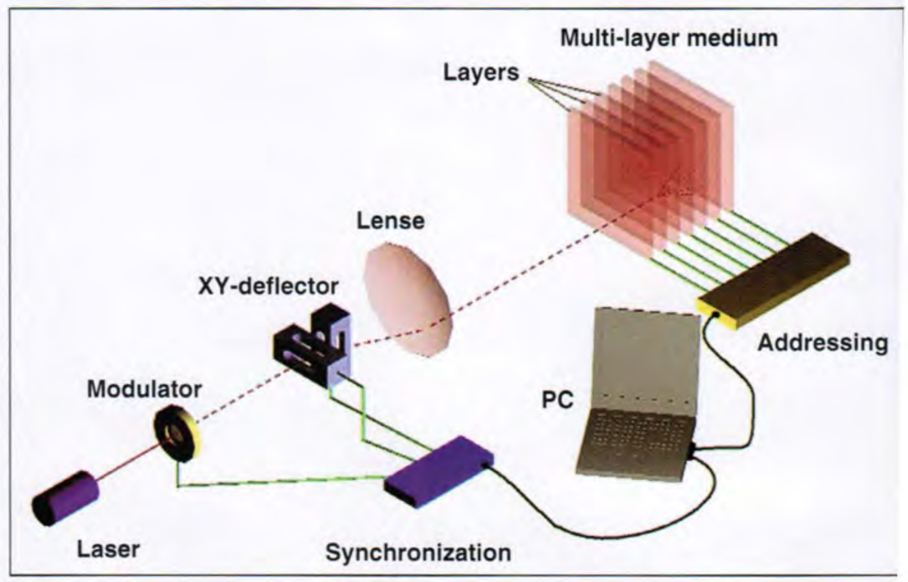

Fig. 1: This volumetric 3-D display system employs a multilayer FLC medium and optoelectronic addressing.

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made by Actuality Systems, Inc. (Burlington, Massachusetts), was first demonstrated. The system uses an optomechanical method for voxel addressing. A 2-D fluorescent or light-scattering plate – which serves as the screen – is fastened to a rotated disc that imparts to the screen periodical translations along the z-axis – the axis of image depth. The screen is illuminated with an xy-scanned laser beam. Software and the plate profile compensate for the different linear velocities of different points on the plate.

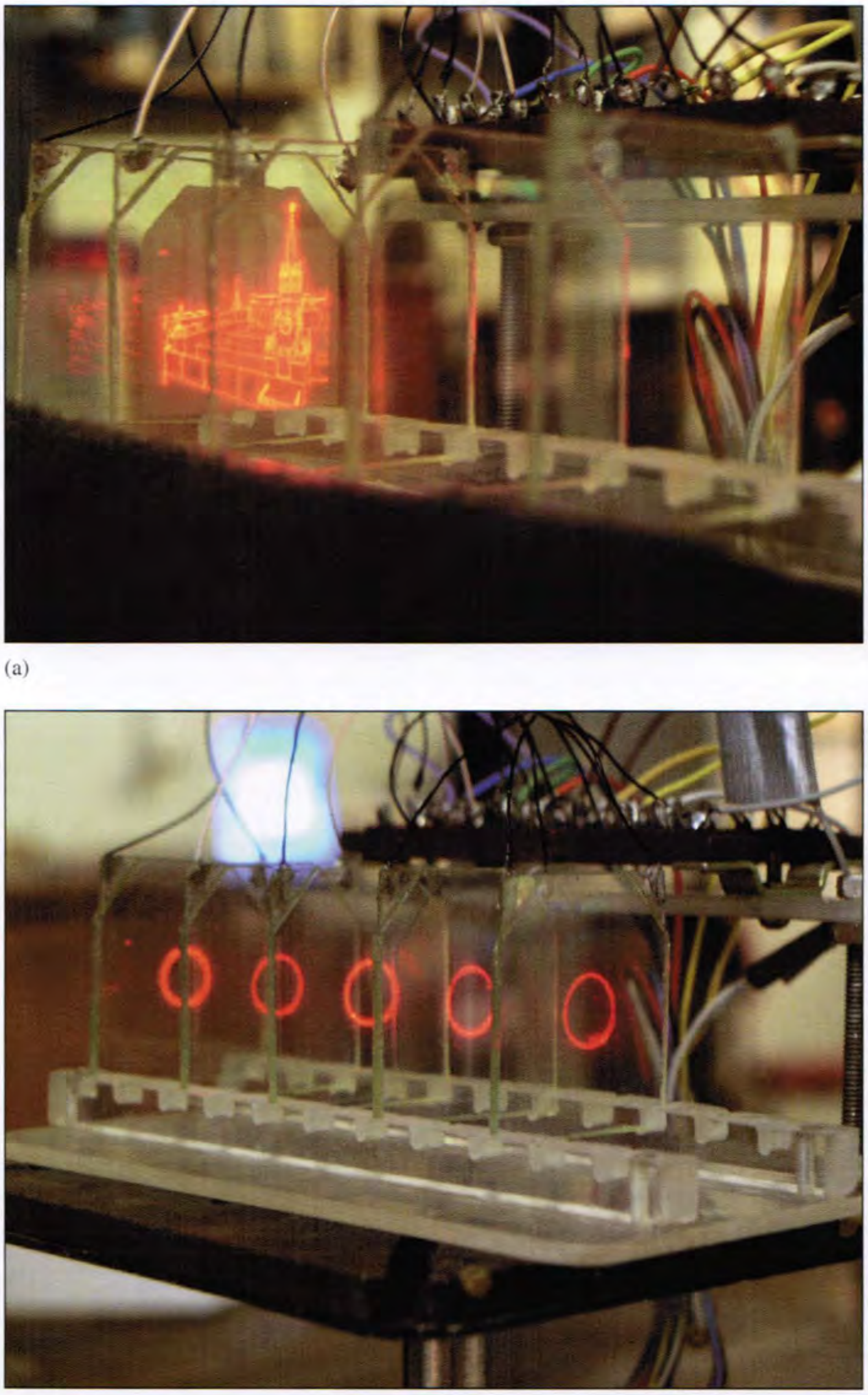
The Perspecta™ optomechanical system represents a substantial step forward in volumetric displays, but there are disadvantages. The system has rapidly moving components that require a protective cover and a relatively small part of the space under the cover is devoted to the effective display volume.

Using Liquid Crystals

Could liquid-crystal layers be used as a non-moving volumetric medium for a 3-D display? For many years, a research team at the P. N. Lebedev Physical Institute has studied electro-optics and the application of both nematic and smectic ferroelectric liquid crystals. Some of these materials – the fastest of which has an on/off switching time of a few microseconds – were used in spectacle-type modulators that utilize a light-polarization change that allows viewers to see stereo images on a computer monitor. Cells with polymer-dispersed ferroelectric LC (PDFLC) were studied to determine their suitability for flexible displays, and 15–100-sec response times were achieved in such cells. An intensive light-scattering mode was observed in these materials when the refractive indices of the polymer and the FLC were matched and then changed under electrical voltage.

On the other hand, a research team at the Moscow State Engineering Physics Institute manufactured and studied an excellent 2-D acousto-optic light deflector based on two TeO_2 crystals. Software has been developed that expands dynamic 2-D images produced by this deflector onto a large screen.

These two technological threads were woven together in a proposal aimed at creating a 3-D display based on an FLC or PDFLC volumetric medium (Russia Patent No. 2219588, granted on December 20, 2003). The principle of such a 3-D display is very simple (Fig. 1). Light scattering is used to visualize the z-axis (depth) "slices" of the 3-D scene.



(a)

(b)

P. N. Lebedev Physical Institute

Fig. 2: *(a) A fragment of an image of the Kremlin has been written by a scanned laser beam and visualized by light scattering from a single LC layer. The other cells are transparent, and the picture is observed through them. (b) Rings are formed on all five LC layers sequentially.*

As in the optomechanical 3-D display, a laser beam scans a 2-D plane, and a 2-D image which is adequate to define a slice of the 3-D image is formed. The 2-D image slice is formed by the light scattered from the selected layer of the multilayer electro-optical medium when voltage is supplied to that layer. After the 2-D image slice is formed, the voltage on the selected layer is switched off, light scattering is stopped, and the layer becomes transparent. But the persistence of the human visual system keeps the slice "visible" for about 100 msec. Then the light scattering is provided to another layer, then a third one, and so on, until all the desired slices are formed and an entire 3-D image is visualized for the vision-persistence period. The process is similar to displaying the information on a 2-D display with one difference. In a 2-D display, the row information is stored and presented row by row; here, the slice information is stored and presented slice by slice.

Such a system does not have moving mechanical parts, and the entire volume can be observed, nearly from all sides. The layer size is scalable, and the layers themselves could be demountable. Of course, three laser beams – one for each primary color – would have to be used in a full-color 3-D display.

The basic requirements for a 3-D display system of this optoelectronic (light–voltage) type are fast on/off switching, wide-angle and high-contrast light scattering, and the elimination of light losses. Our experience indicates that FLC- and PDFLC-based multilayer media could satisfy the first requirement. Liquid-crystal compositions, layer orientation, large-sized technology, scattering parameters, and voltage regimes can all be optimized.

The main problems are to reduce the light absorption and depolarization in the layers and to match the refraction index in order to suppress reflections on layer boundaries (antireflection or liquid layers can be used for this). Estimations indicate that these problems can also be solved in the foreseeable future, with the result that it should be possible to provide a medium with more than 100 layers for a real-time 3-D display.

Testing the Volumetric LCD

To test the concept of a volumetric LCD, we created a simple experimental model of a 3-D display controlled by a personal computer. The optical part of the display consisted of a helium–neon laser with 1.5-mW beam power, 6-mm aperture, and diffraction divergence; a 2-D acousto-optic deflector that does not take more than 10 sec to address any of 500 × 500 points at an angle of 0.05 rad; and some optically matched elements to form 2-D images for the voltage-selected slices. Five LC cells with a 4 × 4-cm aperture that were shifted 2 cm from each other composed the volumetric multilayer medium. The thickness of the LC layers was 10 μm, and the light-scattering switching on/off time was about 1 msec. The LC cells were not optimized, and liquid or anti-reflective layers were not used at this stage.

Software permitted the formation of different static and dynamic images on any LC layer, scattering light at a particular moment. A photo-camera was able to photograph a 2-D slice pattern with a short exposure time [Fig. 2(a)]. The other cells were transparent, and the image of the Kremlin can be observed through them.

In this model, layers were usually switched on and off in turn, and rather long exposure times close to the vision-persistence time permitted the visualization of all slice patterns together – similar to an entire 3-D image [Fig. 2(b)]. These slice patterns on a limited number of LC cells are not very dramatic – the slices, all ring patterns, are identical. But one can imagine a pipe which the viewer can look around and into.

Where We Are

Both of the photographs in Fig. 2 are evidence of wide-angle intensive scattering. The phenomenon's physical mechanism, as well as the technological issues already mentioned, are being investigated now. But we already believe that liquid-crystal layers can be used successfully as the volumetric medium for a real-time optoelectronic 3-D display. ■

CRTs Still Shine Brightly

Will the CRT's superb picture quality and excellent price/performance ratio allow this venerable analog display to survive in a digital age?

by Shoji Shirai

AFTER decades of dominance, the venerable cathode-ray tube (CRT) has lost its lead to liquid-crystal displays (LCDs) in the desktop-monitor market. Now LCDs and plasma-display panels (PDPs) are mounting an assault on the most important market for CRT technology: home television. These new flat-panel displays (FPDs) are thin and beautiful. Can CRTs maintain their lead in the TV market?

There is good reason to believe that CRTs will not disappear from the display shelves in consumer-electronics stores for quite a while. CRT technology has three major advantages over digital flat-panel technology that are important when viewing typical television content:

- An analog drive with high gamma value,
- A point-at-a-time display scheme, and
- Pixels not defined by physical structures.

Analog Advantages

CRTs have characteristics that make them inherently better for viewing television images. Brightness, color depth, and color accuracy all favor the CRT.

In FPDs, the relationship between the luminance and signal is essentially linear. On the other hand, the luminance is proportional to the power of the drive voltage of the CRT, which is between 2.5 and 3.0. This makes it easy to achieve a very high peak brightness without sacrificing gray scale in the dark areas of the screen. As a result, it is possible to create a bright image while still retaining details in shadowed areas.

When the TV broadcasting signal is analog, the CRT displays the signal without analog-to-digital (A/D) conversion. This allows the number of gray levels to be essentially infinite. However, when the analog signal is converted into digital data, the peak brightness and the gray levels are limited. Therefore, the CRT is better equipped to handle typical NTSC analog broadcast signals than FPDs.

For digital signals, such as those for digital broadcasting or DVD players with digital connections, both the CRT and digital displays have to deal with the same signal limitations, but the CRT still has an advantage. Digital displays are narrowing the performance gap but they still lag behind CRTs. Today, 12-bit signals are available in DVDs, but FPDs can currently handle only 7–8-bit signals. They may soon extend their range to 10 bits, but CRT technology will remain the only one capable of using 12-bit-and-higher signals. Again, the ability of the CRT to display infinite gray scale will become invaluable in the coming digital era.

Another advantage of the CRT is color accuracy, which is a function of the display's color gamut. The color gamut of TFT-LCDs have been widened by improving their backlight spectral range and color-filter characteristics. The PDP's color gamut is wider than that of the CRT, mainly because of the difference in the green-phosphor emission spectrum.

Within the color gamut, however, only the CRT can pinpoint any arbitrary position. FPDs can only address about 17 million points when using 8 bits per color. While this may seem to be a very large number, the human eye can detect an even larger number of color points. So, real color management is only possible with CRTs.

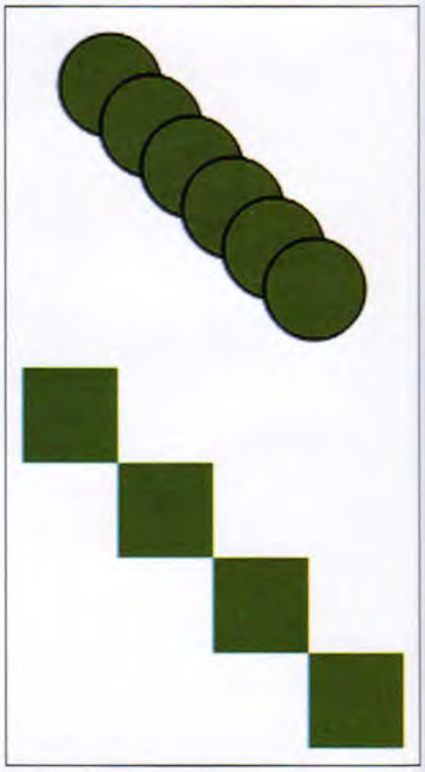


Fig. 1: Cathode-ray tubes (top) are able to create smoother diagonal lines than flat-panel displays (bottom), which have fixed pixels.

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Point-at-a-Time Display

The image of the CRT is displayed using a point-at-a-time scheme that is well suited to displaying moving images. FPDs employ a frame-at-a-time scheme, which holds the image during one frame time and causes moving images to smear.

To lessen the smearing in LCD panels, a black image can be inserted or the backlight turned off between two frames. However, this method compromises screen brightness. So, CRTs have an advantage in creating moving images that appear natural on the screen.

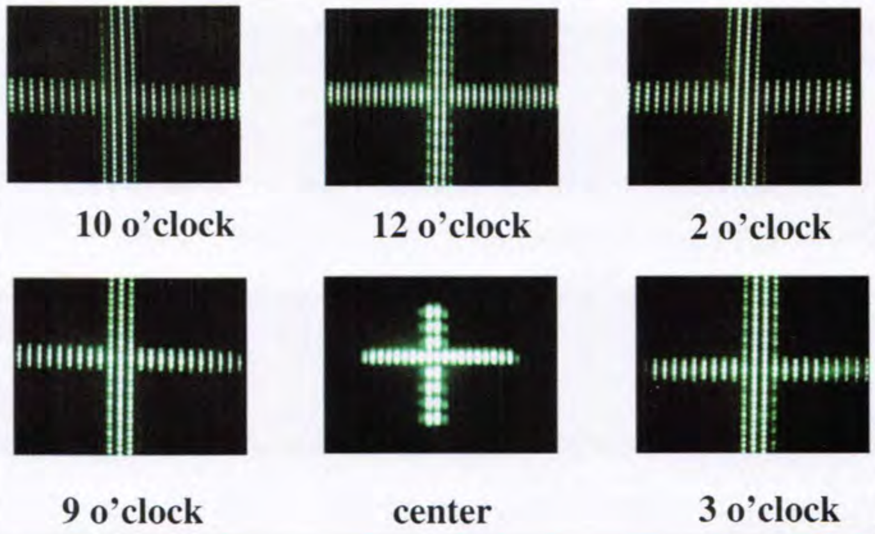
Logical – Not Physical – Pixels

In FPDs, each pixel is rigidly defined by the cell structure of the panel. This mosaic pattern makes slanting lines appear jagged and degrades the smoothness of the image. These aliasing effects decrease as the apparent pixel size gets smaller. Anti-aliasing techniques can diminish the effect, but not completely.

On the other hand, the electron beam in a CRT excites more than one phosphor dot or stripe. The structure of the dot or stripe is not the boundary of the pixel, and neighboring pixels overlap, which makes diagonal lines appear smoother than those on a digital FPD (Fig. 1).

The logical nature of CRT pixels also makes it possible to alter the size of the pixels in a given image, which is not possible in an LCD or PDP. By means of scanning velocity modulation (SVM) technology, the scanning speed is made proportional to the second derivative of the signal. SVM better defines the edge of the image, and also improves the sharpness of the image in the horizontal direction by increasing the scanning speed and reducing the pixel size in areas where the image is particularly bright. For instance, when a bright vertical line appears on a dark background, the vertical line becomes thinner so that the image is sharpened.

Logical pixels also make it easy to display images of different resolutions. If an FPD has enough pixels for HDTV, an NTSC signal must be scaled to fit that resolution. The scaling is not perfect, and some conversion artifacts are often visible. CRTs are able to display signals of varying resolution without the need for scaling, eliminating any artifacts from such conversion.



Hitachi Displays, Ltd.

***Fig. 2:** The spot size of a CRT beam is difficult to make uniform because it tends to get larger at the corners of the screen.*

Hitachi Displays, Ltd.

***Fig. 3:** In a TFT-LCD or PDP, the backlight or the light from the priming discharge cannot be shut out completely, so the dark-room contrast is less than that of a CRT.*

Still Not Perfect

For all of its many strong points, CRT technology still has some weak points that prevent it from matching digital-display performance. In many cases, these shortcomings are less noticeable in television images than they are in desktop-computer-monitor applications, and thus do not significantly diminish the appeal of CRTs.

For example, the pixels of a CRT may not be as uniform as those of a digital display. CRT pixels are defined by the electron-beam spot size. At the screen periphery, the spot size can become two or three times larger than at screen center in both the vertical and horizontal directions because of deflection defocusing (Fig. 2). The uniformity of the pixel size can be degraded substantially, especially at the screen's corners, where the deflection angle is the greatest. The dynamic-focus electron gun was developed to cancel deflection defocusing at every point on the screen. The resulting beam spot size is more consistent and is satisfactory for TV use.

The contrast of CRTs is not as good as that of FPDs. As mentioned earlier, neighboring pixels overlap each other. As a result, when there is a sharp boundary between very bright and dark areas, the electron beam spreads over into the dark area and slightly smears the boundary. This is a serious problem for computer-monitor use because it degrades black letters on a white background, which is a commonly used display scheme. The smearing and the deterioration of the contrast detract from the readability of the letters. However, for TV use, such sharp edges do not appear as frequently, and the problem is not very serious.

Halation is another problem that affects contrast. Because the CRT faceplate glass is much thicker than that of FPDs, more light scatters within the faceplate. This halation can degrade contrast performance.

Except for the very sharp edge between black and white areas and halation near the bright spot, the CRT can display a perfect black level in a dark room. At the area of the screen where there is no signal, no electron beam is emitted from the cathode and no light output can be seen from the phosphor. In this case, the dark-room contrast of the CRT is infinite. In a TFT-LCD or PDP, the backlight or the light from the priming discharge cannot be shut out completely and the dark-room contrast is not infinite (Fig. 3).

In addition, CRTs do not always produce a perfectly proportioned image. FPDs have no problem with non-linearity and distortion because all their pixels are positioned by physical structures on the panels. Errors in beam deflection can cause screen-geometry problems in CRTs, although these flaws can be controlled to some degree.

In a similar vein, CRTs also can suffer from convergence errors. In order to create a white pixel in a digital display, the panel merely has to turn on three adjacent red, green, and blue subpixels. In a CRT, the three electron beams must converge on the same point. The convergence is not successful in many instances, especially at the screen corners. To avoid convergence errors, digital convergence technology has been developed. The side electron beams around the center beam are deflected independently by the coil current, which induces a magnetic field. The screen is divided into many areas, and the optimum coil current is applied to converge the three beams in each area. If the coil current is properly optimized, the correction is quite satisfactory.

Still a Bright Idea

CRTs are still the best choice among all the other TV technologies, including LCDs and PDPs. The very structure of the CRT produces performance characteristics that give them advantages in brightness, gray scale, contrast, color, motion, and image smoothness. As long as signals of varying resolution are used, the CRT has an enormous advantage in its ability to display different resolutions without the need for scaling. Its flaws in terms of uniformity, geometry, and edge contrast are not serious when viewing typical television content.

Perhaps the biggest advantage of all, however, is cost. The price of a CRT television is about one-fifth that of digital displays of similar screen size. So, until FPDs are able to equal CRTs in terms of both overall image quality and cost, they will face a difficult challenge.

Analog CRT technology has been around for more than 100 years, and it continues to be competitive in this digital age. ■

LCoS Testing Turns Five

The manufacture of microdisplays has faced some unanticipated difficulties, but automated optical-inspection machines may hold the key to making the microdisplay industry viable.

by Lewis Collier

THE liquid-crystal–on–silicon (LCoS) industry received a great deal of attention in January 2004 when Intel demonstrated its own microdisplay chip. The industry is still in its infancy and experiencing growing pains, but LCoS technology has the potential to be a significant factor in display products, especially large-format rear-projection televisions.

As with any new industry, the manufacturing infrastructure is key to efficient production. One important element of the LCoS infrastructure is testing the panels for defects. To date, the industry has relied heavily on human inspection, but efforts to develop high-volume testing using machine vision have yielded promising results.

In 1998, DisplayCheck (DCI) began developing LCoS automated-optical-inspection (AOI) technology, working with National Instruments and Three-Five Systems (TFS), which has since spun off Brillian Corp. In this short time, most – if not all – of the current technical challenges have been met, giving machines a decided advantage over human inspection.

The Growth of Test Suites

In 2000 and 2001, Three-Five Systems outlined what were then considered to be the necessary LCoS tests. These were broken down into engineering-design and production-manufacturing tests. The goal was to distinguish which test defects could, and should, be avoided by optimizing the design from those which were truly artifacts of the manufacturing process. According to one LCoS-industry report, the original list has expanded to include 17 overall test categories.

As some predicted, however, the tests required for LCoS panels are substantially different from those required for larger flat-panel displays (FPDs). As of November 2003, we had identified and implemented 44 separate tests that were requested and are being used by the LCoS-manufacturing industry. These tests provide 135 different metrics that can be used to evaluate the performance of LCoS displays. The 44 tests can be executed using various sets of black, white, gray-scale, or color images, thus bringing the effective total number of tests to 111. These 111 tests can provide 382 metrics, 143 of which are used in parts grading, binning, and sorting. The remaining metrics can provide valuable feedback to the process line.

As the nascent LCoS industry has climbed the learning curve of this new technology, the number of necessary tests has grown, making the role of the tester very different from the one initially envisioned in order to follow the fabless model or even the model used in the LCD flat-panel arena. The small-format displays (1-in. diagonals) and pixel dimensions on the order of 10 × 10 μm have led to several test issues worth further review.

Bright and Dark Spots

When microdisplay manufacturers finally completed the first prototype cycles and had commercially ready projection units to evaluate, many new defects suddenly appeared. Of particular importance during the past 3 years was the revelation that – depending upon the overall optical-engine configuration – defects much smaller than a pixel could still be quite visible on the projected screen. This necessitated the development of "subpixel" tests that could ferret out these small spots. Five years ago, a relatively simple and fast pixel-defect algorithm was all that was envisioned.

The current standard practice is to forego the pixel test, in lieu of faster and less-expensive electrical testing at the wafer level, and concentrate instead on the optical inspection of small defects. These are often on the order of 1 or 2 μm in diameter, but software can make it easier to identify the detected bright spots (Fig. 1). Detection of these defects requires higher magnification, which in turn requires more time to inspect the entire panel. DCI is currently working on a project funded by the U.S. Display Consortium (USDC) to provide improved optics that will increase the detection of these small defects and shorten the overall test time. Evaluations of the prototype design are currently being completed; the new optics will be available at the end of the second quarter of 2004.

Brightness Uniformity

The evaluation of brightness uniformity is a prime example of the inadequacy of the existing standards for other FPDs in providing the necessary information for LCoS microdisplays. The commonly used 9-point specification for brightness uniformity generally relates to the lighting of an FPD. Microdisplays in general, and LCoS microdisplays

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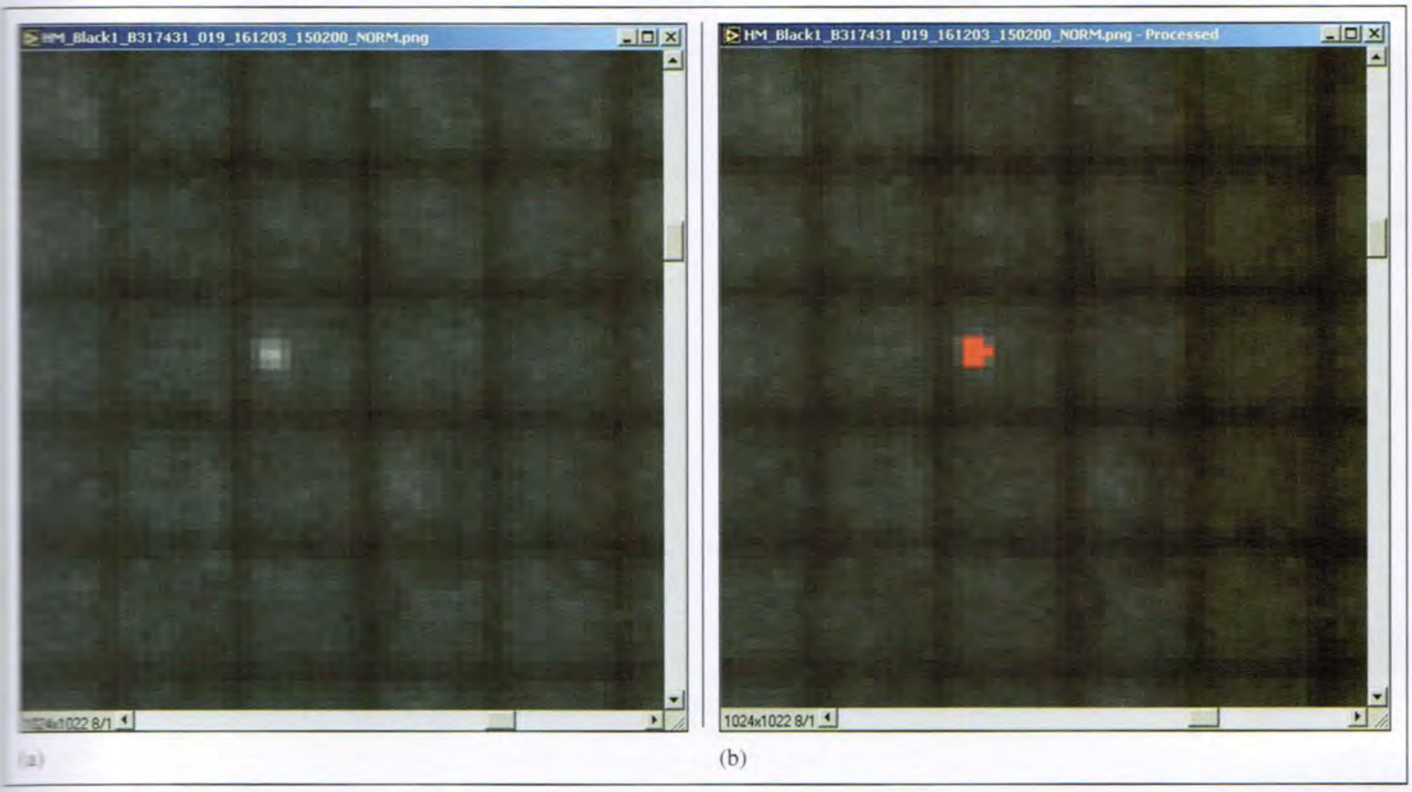


DisplayCheck

Fig. 1: (a) This image of an LCoS panel shows bright-spot defects. (b) The bright-spot defects are detected by AOI; each red square represents a region about 1 × 1 μm on the panel.

in particular, provide a myriad of opportunities for degraded brightness uniformity. Cell-gap variances and other defects can cause the display to exhibit acceptable brightness uniformity at the 50% gray level, but diverge greatly from acceptability in the black and white states. For three-panel projection systems, this can be further aggravated by mismatches in the individual panel responses.

Today's LCoS inspection systems must provide more data than just the 9-point – or even 25-point – VESA brightness uniformity measurements. The system must be capable of providing a complete gray-level map of the panel (Fig. 2). The panel shown has an overall brightness uniformity of only 56%, but measures much higher (85%) using the 9-point method.

For projection-engine manufacturers, this information is critical in determining the source of nonuniformities in the final optical-engine assembly. If the panel is uniform across its entire area and for the entire gray-level range, then the engine manufacturers must look elsewhere for the cause of the defects. Without this information, it is an expensive guessing game requiring the optical engine to be rebuilt and retested until it works. Moreover, the parts themselves may not be bad; it may be that they were not optimally matched. For the LCoS-microdisplay business to survive, this information must be available to the engine-assembly process.

Result Correlation

Understanding the results of a microdisplay test suite is the most important factor in the success of LCoS testing. There are many measurement systems available, but what do all the data mean? When one system measures panel contrasts ranging from 200 to 900, but another measurement system puts them all at 250, what is going on? When a test system measures spot defects ranging in gray-level energy from 750 to 75,000, which ones count? If a 9-point brightness uniformity always measures greater than 90%, but a full-panel brightness uniformity measures less than 70%, what is the matter? In all of these cases, and in many more, the ability of a manufacturer to correlate test results with the real world is what will allow for better process control and yield management.

Ultimately, all of the microdisplay assessments are statistical in nature. Since LCoS microdisplays are not directly viewable, the ability to correlate the test and inspection results with a volume of evidence is critical. The process follows a cycle of measurement, analysis, and revision of parameters until the statistics settle out. At the beginning of an LCoS-product life cycle, when production is measured only in multiples of ten, the manufactured parts are compared with a small set – often a single unit – of reference display devices (optical engines). This provides a very biased but useful starting point for comparing the automated assessment values, and it is the first opportunity to see the effect of the statistics of the defects. Once the product reaches the stage of sampling to customers, when hundreds of parts are produced and several reference optical engines are available, additional valuable feedback should be received that helps update the assessment criteria. Finally, when production reaches thousands of parts, the build-up process for the product should be complete and a workable set of parameters should be known. This, of course, is subject to changes in the display-manufacturing or optical-engine processes.

Business Issues

The business models of the LCoS industry have greatly affected the test solutions currently available. LCoS technology was based upon the premise of using trailing-edge complementary metal-oxide semiconductor (CMOS) fabrication technologies to develop a lower-cost alternative to the leading microdisplay panel, Texas Instruments' Digital Light Processing™ (DLP™) micromirror chips. The goal was to utilize existing technology where practical. Wafer testers, wire bonders, and any other existing pieces of infrastructure were to be used in order to get lines up and running with a minimum of capital investment. The semiconductor fabless model was often followed to minimize costs. All of these factors have affected the choice between AOI and human-vision inspection.

Machine-Vision Inspection

As predicted in 2001 and shown above, FPD test technologies cannot be used to meet LCoS AOI requirements. Therefore, DCI's technology was developed from the ground up and has been expanded as needed. None of this technology has come from other display areas. Although many commercial-off-the-shelf (COTS) components were brought into use, it was necessary to expend a great deal of time and effort to meet the needs of early adopters. Thus, the problem of creating new measurement techniques specifically for LCoS panels has been solved for the most part, but at a higher cost.

Great expense has been borne by both the equipment manufacturers in terms of R&D costs and by the early adopters of the inspection technology through high equipment costs. In 1998, the desired test capital cost per part was US\$0.25, and the expected tact times were on the order of 30 sec. The slow adoption rate of LCoS AOI – estimates from press releases indicate that fewer than 20 systems have shipped in total – has caused the capital costs to remain high and reduced the availability of process feedback data to help solve manufacturing-defect problems. While the test-equipment capital costs have decreased slightly (20–30% since 2000), the test times have lengthened because of the expanded test requirements. Thus, in 2003, the cost per part attributed to test was still well over US\$1.00. The issue of high test costs can only be resolved by increased adoption of the technology. Higher sales volumes will enable equipment suppliers to lower equipment costs and will also allow the costs to be spread over more parts.

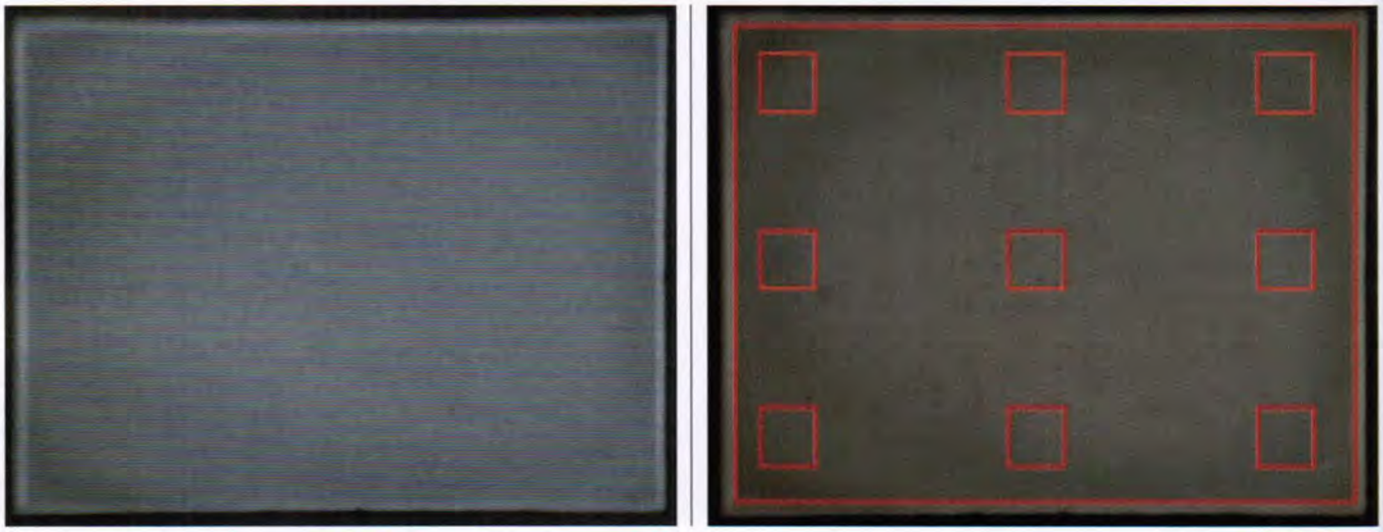
Human-Vision Inspection

Even though AOI remains expensive, what is the alternative? The only choice is to continue using human inspection, which has a number of significant disadvantages, including higher facility and labor costs and reduced accuracy and repeatability.

The labor costs of human inspection are obvious. What may be less obvious are the capital costs. In the case of near-to-eye devices, human inspection has been shown to be an effective solution for fairly low-cost viewing stations. For projection devices, however, the costs add up quickly for human inspection because of the necessary projection test systems, cleanroom factory area, labor expenses, and the time costs, including both setup and test times.

Space is also a major part of the cost equation. A DCI LCoS production system requires less than one-quarter of the space required for a human-inspection projection station. Given that this is performed in a Class 10,000 or better cleanroom, the facility costs are significant, and a human requiring four times as much space can make a financial difference.

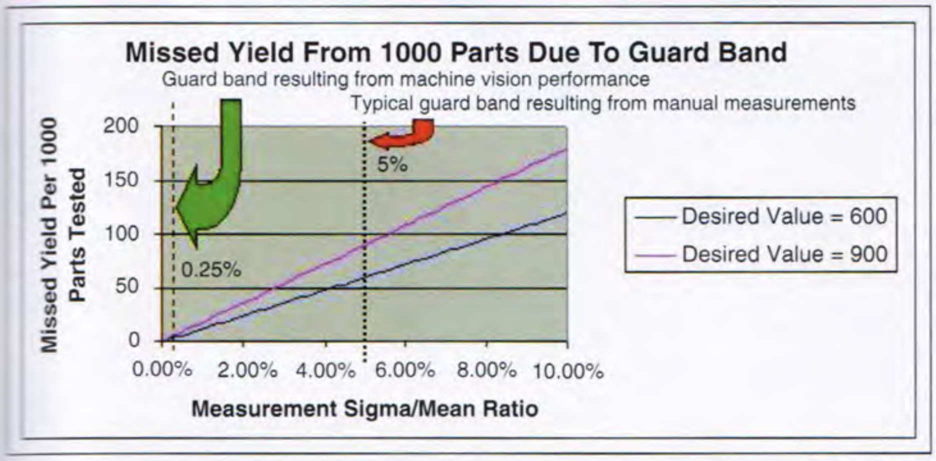
AOI does not eliminate but does reduce labor costs. A single operator can easily manage four AOI systems, but human inspection



(a) (b)

DisplayChec

Fig. 2: (a) This brightness-uniformity image shows an entire 1024 × 768-pixel LCoS panel. (b) The same panel with 9-point and entire-panel brightness-uniformity locations displayed shows how the use of fewer data points can fail to measure noticeable lack of brightness uniformity.



DisplayCheck

Fig. 3: Yield loss is greatly reduced if inspection measurement accuracy can be increased.

requires at least one person per station. In many cases, extra personnel are required to help assist in the loading and alignment of the panels into the projector test setup.

The machine-vision equipment also provides automated data collection that further reduces additional labor requirements for manual data entry. Even though the capital investment for AOI equipment may be large, the total-cost-of-ownership analysis can show that it may cost less in the long run.

Inspection Effects on Yields

One additional cost of human-vision inspection that must be included is the cost of lost revenue due to the necessary guard band. The repeatability of a measurement will dictate how close to the specified parameter a threshold can be set so that all manufactured parts meet the specification.

For example, consider the contrast ratio (CR) of a panel. If the variance for the given metric is greater in one system than another, then the measured value may be further away from the tested panel's actual value. Since all devices must exceed the specified contrast, a higher measurement uncertainty requires that a higher guard band be established to ensure that all parts meet the specification.

Consider yield loss as a function of measurement error (Fig. 3). This error is represented as the ratio of the measurement sigma to the measurement mean. The graph shows two loss lines, one for an expected CR of 600 and the other for 900. As shown, a sigma/mean ratio (SMR) of less than 3% can lead to the loss of 50 of each 1000 parts tested when the expected CR is 900. This means that 50 of each 1000 parts will actually be good enough to meet the 900:1 CR requirement, but must be excluded from shipment in order to ensure that no parts of less than 900:1 are shipped.

For LCoS equipment that typically achieves an SMR of 0.25% for the contrast measurement, the guard band would be very close to the specified limit; therefore, only a few parts out of each thousand would be classified as bad when, in fact, they did meet the specification. A 5% SMR is considered the benchmark for repeatability for human inspection, yet leads to a 10% yield loss when the desired CR is 1000:1. In the vertically aligned nematic (VAN) mode, the expected CR can increase to 3000:1, so the yield losses of higher-contrast parts may reach 20% for human inspection *vs.* about 1% for machine-vision inspection. At these levels of loss, human inspection may require expensive retesting to help reduce the losses.

Small-Defect Detection

A final example of the limits of human inspection is in the resolution of small defects, both bright and dark spots. With machine vision, these are measured as energy with a variance of only a few percent. Humans cannot resolve fine spots of energy with the repeatability that comes close to that of AOI. Thus, the potential exists for a large number of panels to be misjudged using human inspection. As optical engines evolve, market demands can raise the reference-level requirements. When the customer starts rejecting too many panels, the human-inspection test costs can increase dramatically because of the significantly longer testing time per panel and the over-rejection of panels that needed to ensure lower return rates. With machine vision, requirement changes are handled with a simple increase in a digital value correlated with the customer requirements.

Machines for the Long Run

Even though the capital investment for AOI equipment may be large, the total-cost-of-ownership analysis may show that it is less expensive over time. Provided that these systems are adopted in sufficient quantity soon enough to reduce the capital costs significantly, machine inspection can play an important role in the development of the LCoS industry. New challenges will arise, but the infrastructure seems to be in place to meet any reasonable obstacle. As production volumes increase, the correlation between measurements and optical-engine results will achieve the necessary statistical basis to ensure continued improvement in both the manufacturing process and the quality of the final display product. ■

conference report

IDW Celebrates Its 10th Anniversary with Record-Breaking Attendance

Highlights of IDW '03 included a competition between the champions of different LC modes for television, a phosphorescent OLED on a flexible substrate, and progress in flexible LCDs.

by Ken Werner

THE International Display Workshops (IDW), held December 3–5, 2003, drew approximately 1500 registrants to Fukuoka, a major port city on Kyushu, the southernmost island of Japan. The attendance, a record for the conference, was 250 more than last year's total and substantially exceeded the organizers' expectations, said Organizing Committee Executive Chair Takeo Sugiura of Toppan Printing. The conference was held in the Fukuoka International Congress Center (Fig. 1).

Referring to Fukuoka's reputation as an entertainment and cultural center, Sugiura welcomed attendees in his opening remarks by encouraging them to "enjoy Fukuoka, but not too much." General Chair Tatsuo Uchida (Tohoku University) observed that this was the first time since the conference's inauguration in 1994 that an IDW has been held anywhere other than the island of Honshu, the main island of Japan. Program Chair Kouji Suzuki (Toshiba) said that 449 technical papers had been accepted for presentation at the conference, which makes IDW the world's largest technical display conference devoted to information display, as measured by number of papers.

Keynote on CNTs

The Keynote Address, "Toward Industrial Application of Carbon Nanotubes," was given

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

Ken Werner

Fig. 1: *IDW 2003 was held at the Fukuoka International Congress Center in Fukuoka, a major port on Kyushu, Japan's southernmost island.*

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by Sumio Iijima of Meijo University, who was introduced by Suzuki as the discoverer of carbon nanotubes (CNTs). There has been substantial interest in using CNTs as emitters in field-emission displays, but Iijima made a point of focusing on the discovery of CNTs and some other applications. The discovery was made accidentally during research on fullerene using high-resolution electron microscopy, which was essential for seeing nanostructural details such as CNTs. As a result, there were few researchers in the world who were in a position to discover CNTs, Iijima said.

Among the non-display applications of CNTs and their interesting cousins, carbon nanohorns, are gas-absorption materials, bio-recognition, and drug-delivery systems. It is possible to insert a single molecule into a carbon nanohorn and perform spectroscopy on that single molecule.

LCD Television

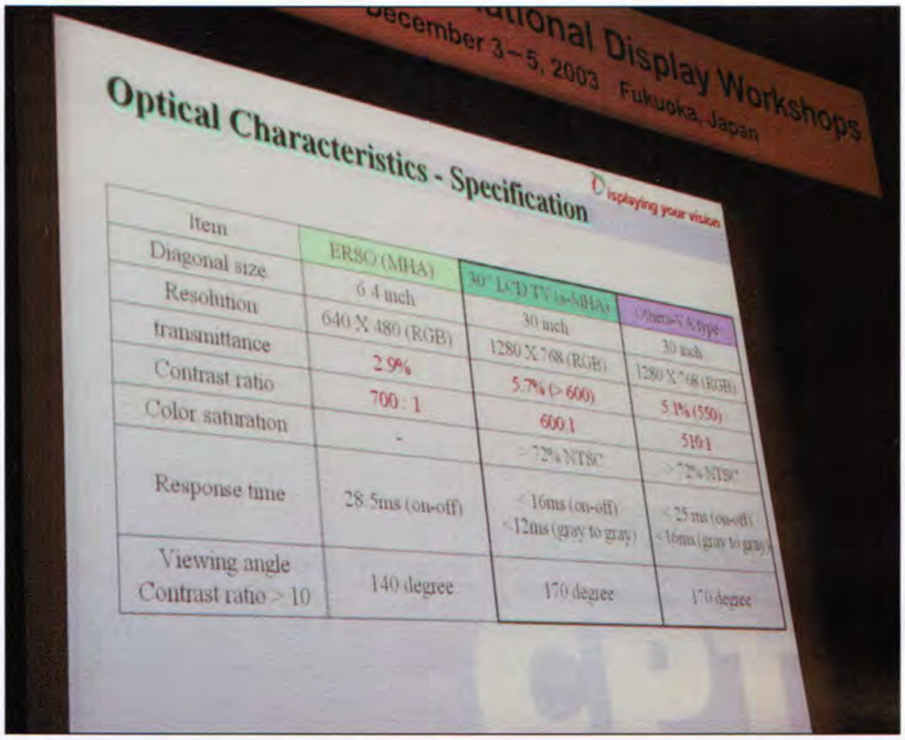
The LC-TV Technologies session, the best attended of the technical sessions, immediately followed the Keynote Session. Featured presentations from Sharp, LG.Philips LCD, and Chunghwa Picture Tubes (CPT) filled the Main Hall at the Fukuoka International Congress Center. Among other things, the three papers set forth each company's case for the superiority of its chosen cell design for large-screen LCD TV.

Hiroshi Take of Sharp made the case for his company's ASV mode, which is one of the vertically aligned modes. He said that ASV delivers good to excellent performance in uniformity, color shift, viewing angle, image persistence, contrast, and response time, with substantial weakness only in transmissivity.

Hyun-Chul Choi made LG.Philips LCD's case for the superiority of Super-IPS technology as a wide-viewing-angle mode for TV applications. Choi said that S-IPS maintains color fidelity at extreme viewing angles much better than the MVA and PVA vertically aligned modes, and also offers much better viewability of dark images. He said that contrast ratio, the traditional metric for specifying viewing angle, is the same for S-IPS and MVA, but color fidelity is much better with S-IPS. He documented this claim with photographs that LG.Philips LCD has shown widely in the past. It was therefore LG.Philips LCD's task, he said, to come up with metrics that actually reflect what viewers see, and he came up with several of them, including uniformity of gamma with viewing angle. The gamma of a measured IPS display changed only 0.4% as viewing angle changed from 0 to 60°, while the comparable VA gamma change was 48%, he said.

Although S-IPS has very good viewing angles horizontally and vertically, they are not as good on the diagonal. Choi said LG.Philips LCD is developing a variant they call True Wide (TW) IPS that improves the diagonal viewing angle substantially, and he made the following claim about TW-IPS: "I dare to say to you that IPS is CRT-like!"

Ruby Chuen-ru Lee described Chunghwa Picture Tubes' LCD-TV VA technology called Multidomain Homeotropic Alignment (MHA), which was developed by the Electronic Research & Service Organization (ERSO), a division of Taiwan's Industrial Technology Research Institute (ITRI). CPT's optimized version, Super MHA, permits a larger aperture ratio and a luminance of 600 nits. An optimized film allows a contrast ratio of 600:1, with viewing angles maximized on the diagonal instead of vertically and horizontally. The response time is 12 msec (gray to gray), and Lee claimed better transmittance, contrast ratio, and response time than other vertically aligned approaches (Fig. 2).



Ken Werner

Fig. 2: *Chunghwa Picture Tubes claimed that its s-MHA LC mode has better transmittance, contrast ratio, and response time than other vertically aligned approaches.*

All of the manufacturers were using some version of feedforward driving in addition to their cell designs to obtain total gray-to-gray switching times down to 16 msec or less, thus minimizing motion smear. LG.Philips LCD and CPT specifically credited Mitsubishi, which invented the technology and continues to develop it. Choi of LG.Philips LCD congratulated fellow IPS user Hitachi on its black-data-insertion approach, which is another step toward smear-free LCD TVs.

In a late-news paper, "A TFT-LCD with Image-Capture Function Using LTPS Technology," Takashi Nakamura and his colleagues from Toshiba Matsushita Display (TMD) provided more technical details on the image-capture display first shown at SID 2003 in Baltimore, and announced that the current version can capture images in color (the SID 2003 version only captured images in shades of gray).

This display allows the user to lay a document such as a business card or photograph on the display surface; with the push of a button, the system then acts as an office scanner (without moving parts) and records the image. Nakamura revealed that the image-sensing device at each pixel location, which was kept secret at SID 2003, is a photodiode – not a resistive or capacitive device. An amplifier in each pixel sensor circuit overcomes the low photo current typical of these diodes. Nakamura showed a video in which a color image was captured and then displayed in color on the same image-capture display that recorded the image.

In the Q&A session, a member of the audience asked what the display's pixel aperture ratio was, given the fact that the pixel electronics is in the same plane as the display TFTs. Nakamura answered that a 70% aperture for a 3.5-in. display is possible.

Electrophoretic Displays

In a subsequent session, Guofu Zhou and his colleagues from Philips Research Labs, E-Ink Corp., and Philips Mobile Display Systems presented "Driving Schemes for Active-Matrix Electrophoretic Displays." E-Ink and Philips have been collaborating for some time on the active addressing of microencapsulated electrophoretic (MEP) displays. Early EP displays (EPDs) of the 1980s used charged particles of a single charge (and color) that moved through a colored fluid under the influence of an electric field. The viewer saw either the color of the particles or the color of the fluid. E-Ink uses two colored particles each with a different charge. Studying this type of display has given rise to the development of novel driving schemes, Zhou said.

First, the optical state of an MEP display, unlike that of an LCD, depends on the polari[ty] of the drive signal instead of just magnitude. Second, the particle displacement (and the change in optical state) of these displays is proportional to the time integral of the applie[d] voltage, which the authors call the voltage impulse. Third, the voltage pulse needed to reach a particular final optical state depends strongly on the initial optical state. These di[s]plays typically require voltages of ±15 V.

Where Is Thunder Contained?

The Saga Forum, an adjunct to the annual Plasma Display Technical Meeting, was held at Takeo Hot Spring, Saga Prefecture, Japan, on December 6, 2003, immediately following the International Display Workshops that concluded the previous day in Fukuoka, an hour away by train on Japan Rail's Kyushu Line.

The Saga Forum turned out to be more than a technical meeting. In addition to its being a forum for papers and discussions on plasma displays, it was a gathering of the PDP clan to honor one of its central figures: Heiju Uchiike, currently Professor of Electrical and Electronic Engineering at Saga University, and previously (for 30 years) Professor of Electronics at Hiroshima University.

In addition to making the key discovery that magnesium oxide is the most desirable dielectric material for the protective layer in ACPDPs, Uchiike has trained several generations of PDP designers and engineers, and has been a close friend and colleague of many others. One of his students was Tsutae Shinoda, whose work in the development of large-screen color PDPs helped make them a commercial reality and who has incidentally made Fujitsu Hitachi Plasma (FHP) Display a leading supplier of PDPs.

Tsutae Shinoda, Larry Weber, Roger Johnson, and many other leaders of the plasma community were in the room when Prof. Uchiike made his introductory remarks.

Roger Johnson (ITL and SAIC), who had been a graduate student with Larry Weber in the research group of Gene Slottow and Don Bitzer, the inventors of the plasma display, gave an illustrated history of PDPs entitled "ACPDPs: Past, Present, and Future." One of the photographs is a famous one: Donald Wedding's daughter standing by a monochrome plasma display approximately 1.5 m on the diagonal. Johnson noted that the circulation of this photo revived interest in PDPs among executives at some major Japanese electronics companies, and was therefore crucial to the subsequent development of plasma displays.

Johnson challenged the assembled company to think beyond the immediate challenges facing PDPs to the promise of large, flexible displays, which Johnson called electronic-display fabric (EDF). Plasma EDF could be made using two approaches: hollow-core microfibers, which Shinoda pioneered at Fujitsu in the relatively early days of PDP development, and hollow-core microspheres, which Johnson worked on at SAIC. Such displays can be connected in the z-direction, said Johnson, so they do not have to be tiled on edge like LCDs or traditional PDPs.

Another speaker, who asked that his name not be used, was passionate in saying he believed LCD manufacturers were not being straightforward in making the claim that LCDs have a lifetime of 60,000 hours, substantially more than PDPs. This, he said, is the lifetime of the backlight unit (BLU), not the display, and the lifetime rating is determined at a lower luminance than that actually used, and is determined with the BLU continuously on. Switching the TV set (and the BLU) off and on will further shorten the lifetime. As the speaker's company has measured it, the actual BLU lifetime is 20,000 hours, which is no better than the lifetime of a PDP.

Jin Jang (Kyung Hee University, Seoul, Korea) discussed the status of the Korean AMLCD and OLED industries because, as moderator Larry Weber said, "we should understand our competition." Xiaolin Yan (TCL) predicted that "the PDP market in China will grow at a staggering rate, climbing to 1.6 million units in 2007 (the Olympic Games will be held in China in 2008)." He also commented that many aspects of PDP-TV production have already been localized in China, with more to come.

At the banquet following the Saga Forum, "Sleeping Tapir" (the pen name for N. Awaji of Fujitsu Laboratories) presented a senryu – a type of 17-syllable poem – he called "Where is Thunder Contained?" In plasma displays, of course.

These characteristics have some interesting ramifications for the display electronics. Among these are (1) the higher voltage requires a TFT structure with two TFTs placed in series, (2) the drive signal must be determined from the difference between the desired state and the previous one, and (3) the need for positive and negative drive voltages motivated the development of a dedicated source.

The new drive scheme is being used in a 6-in. SVGA display prototype for e-books and similar applications. The display has a pixel density of 160 ppi, a reflectance of 36%, a contrast ratio of 9:1, and a viewing angle is 180°. In this prototype, there are four gray levels – black, white, and two intermediate levels of gray – because the module incorporates tri-level data drivers. With only +15, 0, and -15 V available, the only way to vary the impulse is to vary the length of the applied pulse.

In the Q&A session, *Information Display* asked, "Since gray levels have positive and negative particles intermixed, are the gray levels stable?" Zhou said, yes, "the intermediate states are as stable as the extreme states." "How do you do that?" Zhou replied, "That's difficult to answer, but they do it."

Vladimir Chigrinov (Hong Kong University of Science and Technology) asked, "Do you have problems with agglomeration?" Zhou, after some explanation of the meaning of agglomeration as being the clumping together of particles, which was a problem in early EPDs, said, "No, there are no problems. They have found ways to avoid it." Chigrinov asked for details about the techniques used to avoid agglomeration, but Zhou would not say any more about them.

SiPix Imaging has previously discussed its Microcup® technology for the roll-to-roll fabrication of EPDs. At IDW, Jerry Chung and his SiPix colleagues discussed techniques for obtaining gray scale and color rendition in these displays. Eight or more gray levels have been achieved with pulse-width and pulse-amplitude modulation and a passive matrix. The maximum voltage is approximately 30 V. The gray levels are stable when power is removed from the display. The company has also made an active-matrix EPD prototype. A color RGB display can be made with white charged particles and an appropriately colored dielectric solvent. Chung said that, on the basis of simulations, they believe such a display should have a wider color gamut than other reflective displays.

The session moderator asked which applications did SiPix see for its active-matrix displays and for its passive-matrix display. Chung answered that active-matrix-display applications such as e-books require faster updating in the vicinity of 200 msec. Passive-matrix EPDs are good for information boards that are infrequently updated.

Flexible Displays

S. Tokito and his colleagues from NHK Science & Technical Research Laboratories presented their paper "Flexible Color OLED Display Based on Phosphorescent Polymers" to a packed room. Tokito began by saying, "The day before yesterday, terrestrial digital broadcasting started in Japan." He was referring to news that had blanketed Japanese TV stations and newspapers. The DTT service was initiated in three cities – Tokyo, Nagoya, and Osaka – with a roll-out to other areas by 2011, at which time analog terrestrial broadcasting will be terminated. Tokito was only one of several IDW speakers who included this event into their talks – all happily.

The focus of Tokito's talk was a 3.6-in. flexible color passive-matrix OLED-display prototype with 64 × 64 pixels. It is hard to pattern RGB subpixels on a plastic substrate because of its dimensional instability. The strategy for circumventing the problem was to use an efficient white OLED in conjunction with RGB color filters. The white light was obtained by using a combination of red and blue phosphorescent polymers for the emissive layer of the OLED. A luminous efficiency of 5.2 lm/W was achieved at a luminance of 100 cd/m^2 – the highest efficiency reported for a polymer OLED so far, said Tokito.

In "High Resolution TFT Display on Transparent Plastic Substrate," Jin Jang (Advanced Display Research Center, Kyung Hee University, Seoul, Korea) surveyed the various technologies for fabricating TFTs on flexible substrates, including amorphous silicon, polysilicon, and organic materials, specifically pentacene. The Center has done extensive work on all of these technologies, and Jang was able to provide experimental results on the uniformity and characteristics of TFTs on plastic made with the various techniques. A member of the audience asked which TFT material Jang preferred. Jang said, "We have a very high-quality polymer substrate and we can choose our material, but high-quality polymer substrates are hard to come by. In

Ken Werner

Fig. 3: *At the low-keyed exhibition, Hitachi showed its 32-in. WOOO LCD TV based on its black-data-insertion approach, which produces pictures remarkably free of motion smear.*

Ken Werner

Fig. 4: Aomori Prefecture was promoting its previously announced concept for a "Crystal Valley" in the prefecture, including R&D zones, FPD industrial zones, and a foreign access zone in Hachinohe Port. The prefecture's exhibit included a new 6-in. VGA field-sequential OCB-LCD color display sporting an "Aomori Create" logo.

that case, amorphous silicon could be a useful stopgap.

Sigurd Wagner and colleagues from Princeton and Harvard Universities presented a clear and informative tutorial overview entitled "Flexible and Deformable Silicon Thin-Film-Transistor Backplanes." Among their conclusions were that

- Amorphous-silicon TFTs continue to operate during and after elastic deformation, and fail electrically only when they fracture.
- The two most important practical measures for making TFT circuits flexible are to ensure strong adhesion across interfaces, without local defects, and to passivate surfaces that are susceptible to cracking.
- In deformable and stretchable backplanes, the required deformation may exceed the critical strain on the TFTs. Then, the TFT circuits can be placed on rigid islands that divert most of the deformation to the plastic or elastic substrate.

Exhibits

IDW traditionally contains a relatively small, informal exhibition, and this year was no exception. In the exhibit area, Hitachi showed an impressive 32-in. WOOO LCD TV based on its black-data-insertion approach (Fig. 3), and LG.Philips LCD showed its 55-in. S-IPS LCD TV. When the 55-in. was introduced in late October, it was the world's largest LCD. That was how it was still being described on the poster in LG.Philips LCD's booth, but Samsung had just introduced a 57-in. prototype to reclaim the record.

Aomori Prefecture was promoting its previously announced concept for a "Crystal Valley" in the prefecture, including R&D zones, FPD industrial zones, and a foreign access zone in Hachinohe Port. The prefecture's exhibit included a new field-sequential OCB-LCD color display sporting an "Aomori Create" logo (Fig. 4). Optically compensated bend (OCB) LCDs are often associated with Tatsuo Uchida of Tohoku University, who is Research Director for the Crystal Valley Plan.

Some attendees were surprised to find a sizeable booth sporting the logo of Candescent Technologies, the once high-flying developer of FEDs. There is still a small staff at Candescent, and one of the staff members was promoting the licensing of the company's extensive patent portfolio.

IDW is one of the most important technical-display meetings in the annual calendar, with lots of high-level business going on just out of sight. IDW '04 will take place December 8–10, 2004, at the Niigata Convention Center in Niigata, Japan. ■

Products on Display at SID 2004

Some of the products on display at North America's largest electronic-display exhibition are previewed.

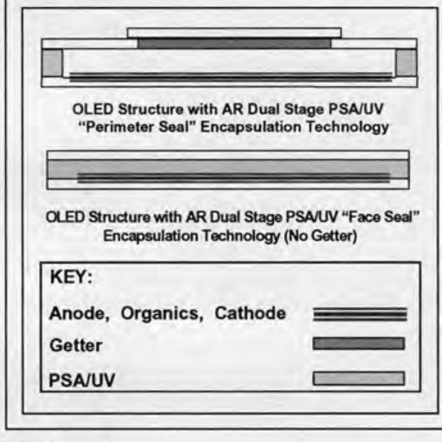
by The Editorial Staff

THE SID 2004 *International Symposium, Seminar & Exhibition will be held at the Washington State Convention and Trade Center in Seattle, Washington, the week of May 23. For 3 days, May 25–27, leading manufacturers will present the latest displays, display components, and display systems. To give you a preview of the show, we invited the exhibitors to highlight their offerings. The following is based on their responses.*

ADHESIVES RESEARCH
Glen Rock, PA 717/235-7979
www.adhesivesresearch.com
Booth 832

Optically clear PSA-coated products

Adhesives Research will be offering custom-engineered ARclear® optically clear PSA-coated products for bonding backlights, polarizers, filters, and retarders, and holographic, anti-reflective, and hard-coated films for touch screens, large and small LCDs, flat-panel displays, plasma displays, and flat-screen CRTs. Also available are dual-stage transformable adhesives for encapsulation of rigid and flexible LCDs, OLEDs, electronic paper, and other display technologies. Applied from a carrier film and exposed to an external trigger, these adhesives undergo a transformation in physical/chemical properties to obtain mechanical strength and chemical resistance. These products should enable the display industry to encapsulate more efficiently, while offering several key processing advantages: availablility in roll form; facilitates roll-to-roll processing; remains flexible after cure; cures with UV light (no heat cure); very low-outgassing/shrinkage; and may eliminate the need for desiccant. ISO 9001:2000 certified.

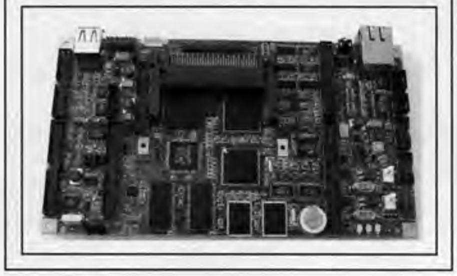


Circle no. 1

APPLIED DATA SYSTEMS
Columbia, MA 301/490-4007
www.applieddata.net
Booth 117

Graphics-rich embedded RISC platform

Applied Data Systems' VGX is an innovative graphics-rich embedded RISC platform that delivers breakthrough multimedia capability for the newly emerging digital multimedia environment and is engineered to fulfill the most challenging video-intensive applications while still maintaining a compact 4 × 7-in. package. VGX features Silicon Motion's SM501 graphics accelerator, providing an embedded platform with 24-bit color or up to SXGA, dual display with a CRT/TV encoder, video input/NTSC/PAL with scaling, and an LVDS interface. Combined with a separate power supply, the VGX is one of the most durable, robust products designed for the graphics-rich ruggedized requirements for convergence devices and other mobile multimedia devices requiring the broadest range of performance and functionality.

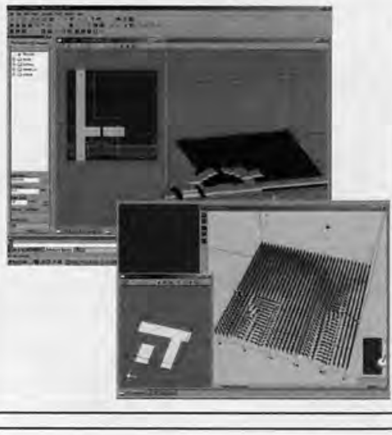


Circle no. 2

AUTRONIC-MELCHERS GmbH
Karlsruhe, Germany +49-721-9626-445
www.autronic-melchers.com
German Pavilion Booth 1509-4

Display-modeling software

autronic-Melchers has extended their DIMOS modeling software into the third dimension. The software features full 3-D OpenGL visualization of the 873-D editing process, development of a 3-D model



Circle no. 3

0362-0972/05/2004-062$1.00 + .00 © SID 2004

of TFT displays or other displays with masks similar to that in the development process, a finite-element approach, and algorithms for modeling dynamic deformation. The software is embedded into the DIMOS 2.0 framework.

AZORES CORP.

Wilmington, MA 978/657-7270
www.azorescorp.com
Booth 1113

Panel printers

The Model 5200 PanelPrinter™ System from Azores Corp. provides advanced photolithography for large-area-substrate applications that require 0.8–4.0-m resolution. Fully integrated subsystems provide manufacturers with maximum performance and flexibility. They include a high-fidelity projection lens and illumination system, a precision X-Y stage, an automated substrate alignment system, an automated reticle handling and storage system, and a sophisticated suite of metrology sensors. The system features a variety of lenses to meet the needs of active-matrix LCD, FED, OLED, and polysilicon applications; real-time magnification adjustment for more-accurate layer-to-layer registration; and real-time auto-focus measurement and compensation for increased utilization and throughput.

Circle no. 4

BEKAERT SPECIALTY FILMS

San Diego, CA 858/614-1211
www.bsf.com
Booth 975

Transparent conductive film for plasma displays

Bekaert Films will feature Screenlite®, a transparent conductive film sputtered in a webcoater on a flexible (PET) substrate specifically designed for plasma-display-panel applications. The films includes ultra-low resistance for excellent EMI shielding, high visible transmission with minimal color shifting both in reflectance as well as in transmission, strong corrosion resistance, European design and manufacturing, and films available for Class A and Class B filters.

Circle no. 5

BRILLIAN CORP.

Tempe, AZ 602/389-8888
www.brilliancorp.com/home.html
Booth 231

Gen 2 microdisplay chipset

Brillian Corp. will demonstrate its latest LCoS® Gen II 1920 × 1200 microdisplay chipset, the BR1920HC2, in their large-format 65-in. 1080p HDTV prototype. Their patented UltraContrast microdisplay technology, coupled with a three-panel optical architecture, provides contrast ratios exceeding 2000:1 for crisp bright images, a high pixel fill factor of >93% providing smooth non-pixelated imagery; fast response times of <10 msec enabling exceptional video reproduction without artifacts, and an analog drive architecture with uniformity correction for smooth gray-scale performance. The BR1920HC2 microdisplays will be sampling in Q3' 04.

Circle no. 6

CAMBRIDGE DISPLAY TECHNOLOGY (CDT)

Cambridge, U.K. +44-1223-723-586
www.cdtltd.co.uk
Booth 1404

Ink-jet-printed PLED

Cambridge Display Technology will demonstrate a full-color active-matrix light-emitting diode (PLED) printed by using ink-jet-printing technology. The process takes advantage of the solution-processible nature of PLED systems, and points the way to significantly lower production costs for display manufacturers. Also on exhibit will be ink-jet-printing equipment and many other examples of PLED technology.

Circle no. 7

CAMBRIDGE FLAT PROJECTION DISPLAYS

Fenstanton Cambs, U.K. +44-1480-462-234
www.camfpd.com
Booth 638

Wedge® displays

Cambridge Flat Projection Displays will demonstrate Wedge® projection technology that allows for the projection within a flat screen, combining all the benefits of a flat-panel display plus projection's great flexibility and scalability. Their 14-in. Wedge display prototype shows how the technology offers daylight-visible marginless form-flexible displays that can also be made transparent, vandal resistant, or curved. Further attractions are the system's reversibility (turning it into a camera) and its delivery of collimated light (useful for backlights). The technology remains in development with image quality improving rapidly and routes to manufacture becoming better understood.

Circle no. 8

CORESIX PRECISION GLASS

Newport News, VA 757/888-0898
www.coresix.com
Booth 1310

Glass wafer substrates

Coresix Precision Glass is a supplier of high-quality glass wafer substrates to the display-market worldwide. Edging, polishing, and cleaning processes are used to create unsurpassed surface quality and cleanliness in every wafer produced. The versatility of the system provides options in orientation marking (flats, notches, and dimples) and edge profiles (radius ground, 45°, and 35°). In-house capability to process nearly any format of material from standard sheet glass (1737®, soda lime, Borofloat®, Eagle 2000®) to block material (fused silica, BK7®, filter glass) is available. Regardless of the specifications, the highest level of quality and cleanliness available in the market today is provided.

Circle no. 9

CORNING DISPLAY TECHNOLOGIES

Corning, NY 607/974-8183
www.corning.com/displaytechnologies
Booth 134

Gen 6 glass

Corning LCD glass substrates for advanced displays are currently available in sizes up to Gen 6, with Gen 7 planned for introduction in the second half of 2004. Experiencing dynamic growth, the display industry has migrated from Gen 4 to 7 in roughly 4 years, compared to 10 years for Gen 1 to 4 migration. Large-sized substrates allow for dramatic economies of scale for manufacturers, leading to more affordable notebook computers, LCD desktop monitors, and LCD-TVs.

Circle no. 10

CYRO INDUSTRIES

Rockaway, NJ 973/442-6000
www.cyro.com
Booth 123

Anti-reflective acrylic sheet

Medical-equipment OEMs can reduce glare and promote easy viewing of information-display screens with ACTYLITE® anti-reflective acrylic sheet from CYRO Industries. This sheet product is an ideal glazing material for optical displays, improving screen clarity with more than 97% light transmission. Half the weight of glass, the sheet cuts glare to less than 2% total light reflectance, allowing displays to be easily viewed from any angle regardless of lighting conditions. The anti-reflective sheet helps provide doctors, medical technicians, and nursing staff with sharp easy-to-view displays.

Circle no. 11

DONTECH

Doylestown, PA 215/348-5010
www.dontechinc.com
Booth 965

Filter, coatings, and display enhancements

Custom optical and EMI/RFI filters for display enhancement, VARgard™ antireflective films, custom anti-reflective and conductive coatings, night-vision filters, hot mirrors, dichroic filters, glass and plastic laminations, fine wire meshes, and transparent heaters for low-temperature environments. Dontech provides display and touch-screen enhancement services *via* film laminations, optical bonding, and bezel integration.
Circle no. 12

DOOSAN DND CO.

Danwon-Ku, Ansan-City, Korea +82-31-599-2421
www.drvacuum.com/index.php
Booth 1028

OLED pilot-production system

Doosan DND's OLED Pilot System, applied to small-molecule and polymer OLED fabrication processes, is a OLED mass production system cluster-type system that treats all the processes from substrate input to encapsulation. System specifications include substrate sizes of 300 × 350 mm and 370 × 470 mm, a deposition uniformity of ±5%, and a mask alignment accuracy of under ±100 µm.

Circle no. 13

DR. SCHENK OF AMERICA LLC
Woodbury, MN 651/730-4090
www.drschenk.com
German Pavilion Booth 1409-5

Flat-panel inspection system

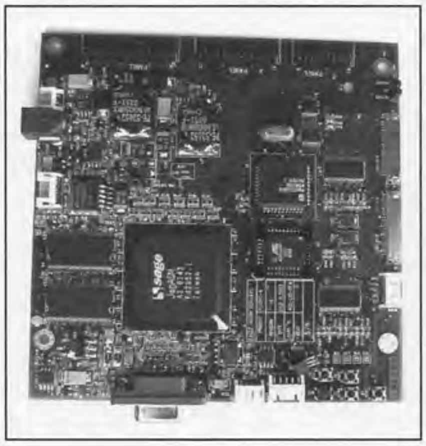
Dr. Schenk of America will feature the flat-panel inspection system Chess, based on high-resolution cameras using proprietary pattern elimination technology. Chess is a modular optical system capable of inspecting all panel sizes and types, including glass substrates, coated glass, color filters, OLED structures, array structures, light-guide plates, and rear-projection screens. A variety of resolution ranges is provided in order to accommodate customer-specific manufacturing and inspection environments. Chess inspection scanners are either fully integrated into automated production lines or are available as stand-alone systems with integrated handling for batch and prototype production, as well as for R&D laboratory use.

Circle no. 14

EAGLE VISION DISPLAYS
Santa Clara, CA 408/748-1545 x21
www.evdisplays.com
Booth 633

Flat-panel-display controller board

Eagle Vision Displays will feature FLIGHT, a flat-panel-display controller board built around a high-performance scaler technology, which enables the display of analog RGB signals on TFT-LCDs and other flat-panel displays. It provides all the electronics necessary to drive flat panels up to a resolution of 1600 × 1200 (UXGA). It can scale up as well scale down input signals to the display resolution. A high level of integration on the board enables it to drive both TTL as well as LVDS displays. It employs a powerful interpolation technique for image scaling.



Circle no. 15

EARTHLCD
San Juan Capistrano, CA 949/248-2333 x223
www.EarthLCD.com
Booth 518

ARM development kit

EarthLCD will launch the new MDK-002 mARMalade ARM 720 Development Kit, an ARM processor SBC featuring the Sharp LH79520 75-MHz 32-bit ARM 720T, assembled as a development kit with a Panasonic 7.8-in. flat-panel color STN touch-screen LCD.

Circle no. 16

ENDICOTT RESEARCH GROUP
Endicott, NY 607/754-9187
www.ergpower.com
Booth 421

Inverter with closed-loop current control

The new DMW Series inverter from Endicott Research Group provides closed-loop current control over a wide input voltage range (8–18 Vdc), monitoring the lamp current to maintain consistent brightness, regardless of any variations in input voltage. Designed for LCDs backlit by two cold-cathode fluorescent lamps (CCFLs), it provides a high-efficiency solution with a combined power of up to 16 W. Ideal for applications run from an unregulated input voltage source or power supply, such as battery-powered equipment, DMW Series inverters are designed to meet all of the LCD manufacturers' specifications and have the on-board features display design engineers are looking for. In critical applications, the inverters will always light the display with a consistent brightness, even with fluctuations in the input voltage.

Circle no. 17

ERGOTRON
Saint Paul, MN 651/681-7684
www.ergotron.com
Booth 863

Adjustable arm for flat-panel monitors

Ergotron will introduce the Neo-Flex™ Arm, a value-priced adjustable arm for flat-panel monitors. This sleek, streamlined arm provides 8 in. of vertical movement, allowing a monitor to be positioned anywhere. Patent-pending technology provides 180° right/left monitor tilt, up to 180° up/down monitor tilt, 360° monitor portrait/landscape rotation, and 360° arm side-to-side rotation. It's ideal for office and home settings, especially for situations where multiple persons use the same monitor. Because it clamps to the back of the desk, it also frees up desk space.

Circle no. 18

EUROPTEC AG
Oftringen, Switzerland +41-62-788-77-98
www.EuropTec.com
Booth 1133

Transparent glass covers for displays

EuropTec will feature transparent glass covers (*e.g.*, laminated glass and hardened glass) for displays, providing mechanical protection as well as performing shielding functions (anti-static, anti-reflective, electromagnetic shielding, color corrections, *etc.*). Typical applications include displays and public-information terminals, POS terminals, ATM machines, *etc.* EuropTec has developed a very elaborate laminated multilayered system to meet the stringent standards in terms of transparency, anti-reflective properties, and resistance to physical force.

Circle no. 19

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS
Dresden, Germany +49-351-8823-238
www.ipms.fraunhofer.de
Booth 1633

Second-Generation OLED modules

The Fraunhofer Institute for Photonic Microsystems will present the first customized second-generation OLED modules fabricated from the first vertical in-line production system for OLEDs on 300 × 400-mm substrates.

Circle no. 20

GENNUM CORP.
Burlington, Ontario, Canada 905/632-2999
www.gennum.com
Booth 119

Dual-channel image processor

Gennum Corp. will feature the GF9350, a 10-bit dual-channel image processor that sets new benchmarks in image quality by integrating Gennum's Visual Excellence Processing™ (VXP™) set of broadcast-quality technologies within a single device. The GF9350's uncompromised dual-channel processing capabilities and extensive feature set enable new applications in the high-quality display market. Also featured will be the GS8000 Long Reach™ TMDS Extender that automatically restores DVI/HDMI signals, allowing for extended-cable-length performance.

Circle no. 21

GLOBAL LIGHTING TECHNOLOGIES
Brecksville, OH 440-922-4584
info@glthome.com
Booth 1120, 1122

Molded light guides for cell-phone backlighting

New MicroLens™ molded white LED light guides from Global Lighting Technologies provide bright, efficient, cost-effective backlighting solution for Gen 3 cellular phones. Designed to meet the exacting demands of the full-color displays used in Gen 3 cellular phones, these light guides provide enhanced brightness (as high as 10,000 nits), crisper color, extreme thinness (as low as 0.65 mm), lower power consumption, and more-efficient use of white LEDs, making it possible to reduce the overall number of LEDs used per backlight. GLT's patented SolidState™ technology enables mechanical holding features to be designed into the backlight, and

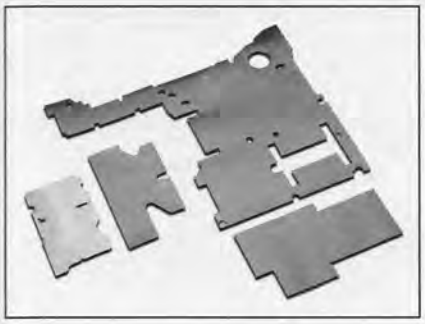
MicroLens™ technology permits the LEDs to be attached directly to a flex circuit and molded into the backlight.

Circle no. 22

GRAFTECH INTERNATIONAL
Cleveland, OH 216/676-2256
Booth 1622

eGraf® SpreaderShield™

Graftech will feature the eGraf® SpreaderShield™, a thermal-based solution solving today's high-temperature heat problems. The graphite-based thermal solution can be combined with plastics, metal, or elastomers in the finished components, and it distributes heat evenly in two dimensions, eliminating "hot spots" while simultaneously reducing touch temperature in the third dimension. Custom-designed thermal properties are tailorable up to 500 W/mK. Available with adhesive backing for simple "peel and stick" use, they are suited where lightweight is critical and space for a cooling solution is limited. Typical applications include laptop computers, flat-panel displays, digital video cameras, cellular phones, and PDAs.



Circle no. 23

i-CHIPS TECHNOLOGY
Santa Clara, CA 408/844-0530
www.i-chipstech.com
Booth 442

SXGA/UXGA display processor

The new IP00C716 display processor from i-Chips Technology is a highly integrated image-processing device that covers a wide range of applications. It has the ability to convert any input image format up to 230 Mpixels/sec to a totally different output timing and resolution. It can work equally well with both interlaced video signals and progressive-scan formats. The IP00C716 can generate typical output resolutions such as SXGA, UXGA, and 1080p in either digital RGB or YUV format. It has a sophisticated 10-bit scaling filter to ensure superior image quality for all types of conversions. The IP00C716 is ideal for applications involving high-resolution displays. It is supported by an evaluation board, schematics, and software settings.

Circle no. 24

INSTEC
Boulder, CO 303/444-4608 x207
www.instec.com
Booth 1302

OLED-display lifetime testing

Instec will introduce the TP10S, a low-cost temperature-controlled stage for the lifetime test of OLED displays. Ten actively driven samples can be tested simultaneously with independent temperature controls. The temperature range of the stage is from –20 to +80°C. An N_2 (or other gas) purge input for testing samples is provided with the stage. Another new product introduced by Instec at SID 2004 will be the WinLC station which measures parameters such as voltage holding ratio, ion density, dielectric constants, and elastic constants through automated LCD testing. The WinLC is equipped with two independent high-voltage arbitrary wave-function generators (up to ±400 V) and four independent data-acquisition scopes.

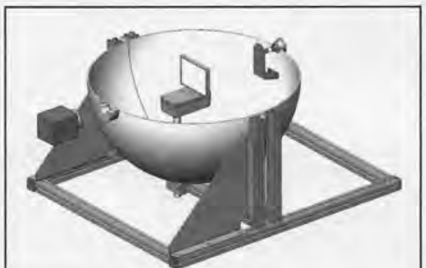
Please send new product releases or news items to Information Display, c/o Palisades Convention Management, 411 Lafayette Street, 2nd Floor, New York, NY 10003.

Circle no. 25

INSTRUMENT SYSTEMS
Ottawa, Ontario, Canada 613/729-0614
www.displaytesting.com
Booth 311

Integrating sphere for FPD contrast measurements

Instrument Systems will feature integrating sphere systems that greatly simplify and produce more reproducible results than alternative contrast-measurement techniques. Errors resulting from alignment inconsistencies and nonuniform illumination of the displays can be largely eliminated. Flat-panel-display laboratories will find the 20-in. sphere well suited for testing displays up to 8 in. on the diagonal. Larger spheres are available up to 80 in. in diameter. A graduated rotational center mount enables straightforward alignment of the display and measuring photometer (see diagram, top hemisphere has been removed to show interior).



Circle no. 26

INTELICOAT TECHNOLOGIES
South Hadley, MA 413/539-5172
www.intelicoat.com
Booth 1232

StratFX hardcoat films

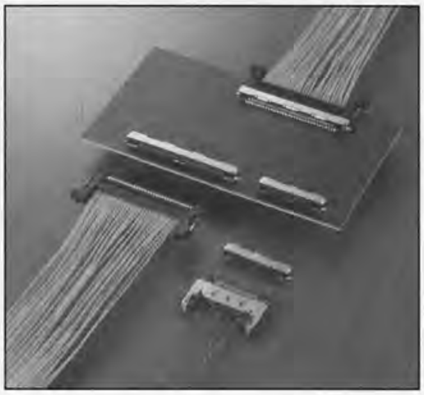
For touch screens, pen-entry devices, and other front-surface protective applications, StratFX hardcoats offer exceptional clarity and outstanding scratch, abrasion, and chemical resistance. Available with clear and anti-glare versions, these two-sided products are specially formulated to receive thin-film coatings. Permanent markers wipe clean. They are available in widths up to 60-in.

Circle no. 27

JAE ELECTRONICS
Irvine, CA 1-800-JAE-PART
www.jae-connector.com
Booth 1027

Connectors and cable assemblies

JAE Electronics will feature the FI-E Series connectors and cable assemblies for digital-TV internal wiring. This new series is specifically designed with the electrical and mechanical features necessary to best support the transmission of low-voltage differential signaling (LVDS) within digital devices. The FI-E is a robust series that uses a blind mating guide and locking mechanism to ensure complete and secure mating. It has a low profile and fine pitch to keep size to a minimum and it works with twisted-pair and fine-coax cables. This series is ideal for LCD, plasma, and projection digital TVs, as well as other products utilizing LVDS.



Circle no. 28

Circle no. 29

JKL COMPONENTS CORP.
Pacoima, CA 818/869-0019
www.jkllamps.com/
Booth 938

LCD-module lamp assemblies

JKL Components Corp. has launched the Highnit line of products to address high-brightness LCD modules. This new product line offers multi-rail assemblies that increase the brightness up to 300% of standard luminance. If used with enhancement films, the Highnit multiple lamp rails can increase the LCD module intensity an additional 40%. The Highnit lamps use a RGB phosphor to provide the ultimate enhancement for color LCDs. They have extremely stable electrical and optical characteristics and are vibration and shock resistant to more than 100 Gs. These high reliability assemblies have a lifetime of up to 50,000 hours.

Circle no. 30

JDS UNIPHASE
Santa Rosa, CA 707/525-7669
www.ocli.com
Booth 326

Light engines for microdisplay rear-projection TVs

JDS Uniphase will display DefiniTV™ light engines for microdisplay rear-projection televisions (RPTV). DefiniTV light engines for DLP and LCoS RPTV offer excellent performance in the critical areas of contrast, brightness, and color stability over time. The DefiniTV architecture provides a high-brightness high-contrast high-uniformity image that enables a significant increase in screen diagonal without large increases in required screen gain. The DefiniTV light engine is an ideal solution for 16:9 high-resolution (1080p and 720p) RPTVs with screen diagonals from 42 to 67 in. DefiniTV light engines can be customized to accommodate a wide range of contrast specifications, color points, and lumen output levels.

KEITHLEY INSTRUMENTS
Solon, OH 440/542-8106
www.keithley.com/main.jsp
Booth 1308

Nanotechnology software toolkit

Keithley's Nanotechnology Toolkit speeds and simplifies the characterization of nanoscale materials and devices. Designed exclusively for use with the Model 4200 Semiconductor Characterization System, the Toolkit offers the capabilities researchers need to create powerful nanotech R&D software applications. It includes 16 interactive test modules (ITMs) for characterizing the seven most common nanodevice structures, including carbon-nanotube-based devices, transistors, molecular wires, and other components relevant to display technologies. These ITMs leverage the Model 4200-SCS's intuitive Windows®-based GUI, minimizing the system-specific training needed and allowing users to start acquiring data quickly. The system's sub-femtoamp measurement resolution allows characterizing extremely low level signals with confidence.

Circle no. 31

KEYTEC
Richardson, TX 972/234-8617
www.magictouch.com
Booth 1108

Touch-interactive capability

Circle no. 32

Keytec's Magic View Touch provides touch-interactive capability without having to physically touch the screen. The mouse cursor is controlled by a laser pointer; click, double click, drag, *etc.* There is no limit to screen size, and it can be used on a projection screen, plasma display, LCD, or CRT monitor.

KRISTEL DISPLAYS
Saint Charles, IL 630/443-1290
www.kristel.com
Booth 736

Industrial monitors

Kristel Displays will feature industrial and OEM active-matrix color LCD monitors available in sizes ranging from 10.4 to 19 in. in both open frame and enclosed designs. The units are certified UL, CSA, TUV, and CE where applicable.

Circle no. 33

KURT J. LESKER CO.
Clairton, PA 412/233-4200
www.lesker.com
Booth 317

New OLED sources

The Kurt J. Lesker Co. has participated with DARPA/USDC to develop linear-configuration evaporation/sublimation sources for OLED-display manufacture. The large-area deposition source (LADS) will be available in 300-mm substrate-width capability and will be scalable, with 600-mm capability to follow. In comparison to typical point sources, the LADS deposits low-temperature OLED/molecular materials with superior coverage, uniformity (>90%), material utilization efficiency (~70%), overall rate, and film quality. The source has been characterized *via* AFM in the growth of AlQ_3 at rates from 0.5 to 20+ Å/sec.

Circle no. 34

LAMBDA RESEARCH CORP.
Littleton, MA 978/489-0766
www.lambdares.com
Booth 113

Photorealism product

Lambda Research will feature TracePro, the first truly visual 3-D optical analysis and design program. This new photorealistic rendering product is an add-on software tool to show the lit appearance of almost any display system before prototyping. The photorealistic rendering feature uses LightWorks®, licensed from LightWork Design, to achieve realistic renderings of lightpipes, front and backlights, LED illumination, and any bulb- or lamp-lit scene. This new feature has a full range of rendering technology to fulfill the needs of users during all stages of the design process, from quick pre-visualization images to advanced high-quality photorealistic renderings including the lit appearance of illumination sources.

Circle no. 35

LANDMARK TECHNOLOGY
San Jose, CA 408/434-9302
www.landmarktek.com
Booth 318

e-Windows display

Landmark Technology will be feature the e-Windows tiling system. e-Windows is a 47-in. display system consisting of six LCDs stacked in a 3 × 2 configuration. e-Windows offers an effective resolution of 3840 × 2048 and emits a screen brightness of 1200 nits. The true-to-life images shown on e-Windows are so bright, crisp, and clear that they

are reminiscent of the real-life images seen out of a real window. This high-resolution display system is perfect for digital signage, information presentation systems, and advertising applications.
Circle no. 36

MAIN TAPE CO.
Cranbury, NJ 609/395-1704
www.maintape.com
Booth 1314

Protective films

The Main Tape Co. will feature KleenTape, a new line of products to meet the growing worldwide demand for flat-panel displays. All KleenTape products are custom developed to match the characteristics of the optical films used in the new LCD television screens, PDAs, desktop computer monitors, notebook PCs, GPS navigation units, cellular phones, and portable DVDs. KleenTape 4434 is designed to protect the diffuser films during manufacturing, converting, and transportation. KT 4434 laminates easily to the coated PET surface, removes easily without staining, uses water-based adhesives, and is translucent to allow ease of inspection.

Circle no. 37

MERITEC
Painesville, OH 442/354-2100
www.meritec.com
Booth 516

Cabling solutions

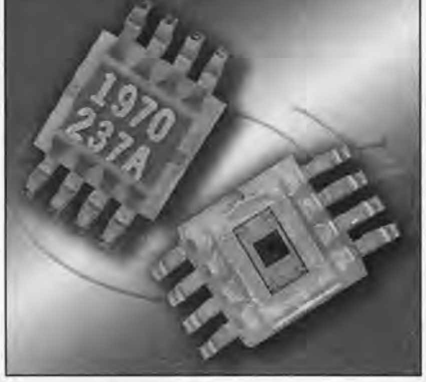
Meritec will feature its all new 4X and 12X Infiniband cabling solutions that feature direct attach for unequalled signal integrity, equalized circuitry for long-length signal integrity, innovative latch mechanism, and angled egress for tight packaging.

Circle no. 38

MICROSEMI CORP.
Irvine, CA 949/221-7112
www.microsemi.com/
Booth 874

Visible-light sensor

Microsemi will feature the LX190™, a visible-light sensor that automatically controls the brightness of flat-panel displays, emulating the spectral response of the human eye. Accuracy is fast and smooth, making viewers unaware as the display adjusts to fluctuations in ambient light. Applications include PDAs, notebook PCs, LCD TVs, tablet PCs, mobile phones, and digital cameras, based on either fluorescent lamps or LEDs. The LX190 can extend the life of LCD lighting components and lengthen battery operation in portable products.

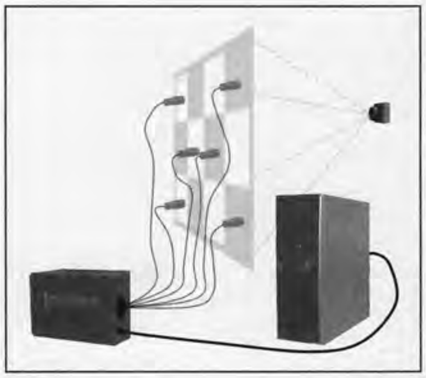


Circle no. 39

MICROVISION
Auburn, CA 530/888-8344
www.microvsn.com
Booth 107

Display-measurement systems

Microvision will introduce its latest automated display testing systems, the SS300X series. This new series improves performance with a Windows XP software platform, seamless test sequencing, higher speed positioning systems, and increased travel positioning systems to accommodate large projection and plasma displays and includes new features such as an automatic gray-scale transition-time measurement for LCDs. Microvision will also introduce its newest addition, the SS350X (pictured below). The SS350X system is a multiplexed spectrometer measuring multiple points on any size projection system "with either the projection screen in place or without the screen." These accurate luminance and color measurements will dramatically reduce testing time and are excellent for production applications.

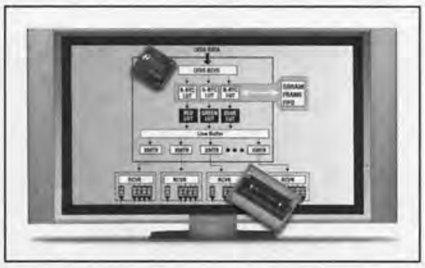


Circle no. 40

NATIONAL SEMICONDUCTOR CORP.
Santa Clara, CA 408/721-2652
www.national.com
Booth 1121

High-performance TFT-LCD driver

National Semiconductor will feature its new PPDS (Point-to-Point Differential Signaling) technology that provides the features required for the LCD-TV market. This solution was built from the ground up with the needs of the LCD-TV manufacturer in mind and combines a physical-layer interface with high-level protocol to create an efficient interface that reduces the overall required PCB size. The PPDS architecture is capable of delivering more than 1 billion colors to the display (true 30-bit color) and is designed to drive very large panels (up to 90 in.) at high resolutions (1920 × 1080). This chipset includes a timing controller and a column driver for a complete system solution that drives high-performance TFT-LCD panels.



Circle no. 41

NEMOPTIC

Magny les Hameaux Yvelines, France
+33-13-930-7250
www.nemoptic.com
Booth 944

Bistable 32-gray-scale display

Nemoptic will feature its recently introduced bistable 32-gray-scale version of its BiNem® technology. The gray-scale control is obtained by voltage modulation. The LCD cell does not require any specific modification compared to the monochrome BiNem® b/w display. The analog nature of the gray-scale control enables the generation of even more gray levels, which opens the way to full-color displays.

Circle no. 42

NTERA

Dublin, Ireland +353-121-3700
www.ntera.com
Booth 1503

NanoChromics™ displays

NTera will feature its commercially available NanoChromics display technology, which offers unrivalled appearance, performance, and cost effectiveness over existing LCD and other display technologies. NanoChromics displays provide ink-on-paper readability offering unrivalled optical performance, paper-white or crystal-clear backgrounds giving it more than four times the reflectivity and contrast of an LCD, bistable characteristics dramatically reducing power consumption, 1-V dc low-voltage operation, and cost-effective manufacturing. NanoChromics displays are manufactured using existing LCD-manufacturing processes and are ideal for use in a wide range of direct drive, flexible, and high-resolution active-matrix display applications in both monochrome and color.

Circle no. 43

NXT

London, U.K. +44-207-3434-768
www.nxtsound.com
Booth 868

LaVie S laptops

Circle no. 44

NEC has developed NXT SoundVu-enabled laptops, with a revolutionary screen that doubles as a loudspeaker. The NEC LaVie S laptops demonstrate perfect synchronicity of sound and moving image thanks to NXT's SoundVu technology. NXT SoundVu technology allows a visual display to double as an almost zero-footprint loudspeaker which removes the need for conventional loudspeakers, giving display product manufacturers added design flexibility and an easy space-saving means of producing sound, without compromising on quality.

OPTREX AMERICA

Plymouth, MI 734/416-8500
www.optrex.com
Booth 332

VGA TFT-LCDs

Optrex America will be introducing its new 6.5-in.-diagonal color VGA TFT-LCD that offers significant new performance enhancements. The T-51750 module offers an ultraslim outline, outstanding front-of screen performance, and economical COG construction. It features a luminance of 400 nits with a 300:1 contrast ratio, low power consumption (4.8 W), AGLR (anti-glare, low-reflectance) coating, and reverse-scan capability. It measures a compact 158.0 mm (W) x 120.36 mm (H) x 7.0 mm (11.55 mm, including component height), and is supplied with two-field-replaceable CCFL backlights. It provides a high-performance, rugged, and economical solution for a wide range of non-PC applications requiring a mid-size flat-panel display.

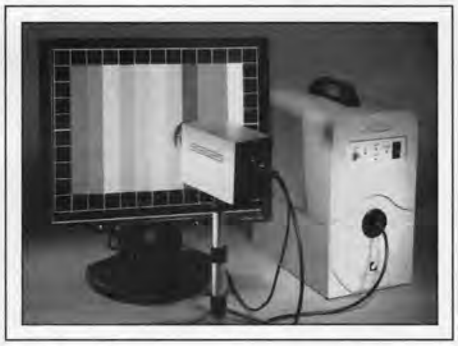
Circle no. 45

OPTRONIC LABORATORIES

Orlando, FL 407/422-3171
www.olinet.com
Booth 776

Display-measurement system

Optronic Laboratories' OL 770-DMS, comprised of the OL 770 High-Speed Test and Measurement System and the new OL 610 CCD Imaging Telescope, offers a complete solution for display-measurement requirements. The OL 770 is available in UV-VIS-NIR wavelength ranges, capable of 25+ spectral scans per second with USB interface, and equipped with Windows®-based software, yet is portable and lightweight. The OL 610 has a wavelength range from 360 to 1100 nm and is available in 0.5 and 1.0 fields of view. With the OL 770-DMS, accurate color, luminance, and spectral information are rendered instantly at the click of a button. On-screen real-time video shows exactly what is being measured, and an image of the measurement scene can be captured and stored with each spectral scan.

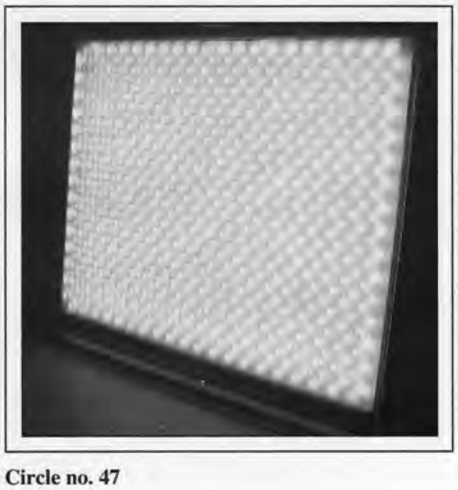


Circle no. 46

OSRAM SYLVANIA
Danvers, MA 978/750-2404
www.sylvania.com
Booth 1403

PLANON® flat-light-source technology

The next-generation xenon excimer discharge flat-panel lighting system is being introduced by OSRAM. The new OSRAM PLANON® mercury-free long-life light source extends the existing PLANON product line by allowing scalability to larger sizes, accommodating newer larger display dimensions. PLANON is now available in panel diagonals between 10.4 and 21.3 in. for industrial and medical applications and up to 32 in. for LCD-TV backlighting modules. With high surface brightness, bare lamp luminance uniformity > 80%, life of 100,000 hours MTTH, and 8000K color temperature, PLANON delivers benefits far outweighing old-technology CCFL systems.



Circle no. 47

OTSUKA ELECTRONICS CO.
Osaka Japan +81-72-855-8554
www.photal.co.jp
Booth 1432

Moving-picture response-time measurement

Otsuka Electronics will introduce the MPRT-1000, a moving-picture response-time measurement system which can accurately quantify motion display quality by processing the captured image with a fully automatic eye-tracking CCD camera, making simultaneous motion with moving pictures on LCD monitors, LCD TVs, and other display devices. Featured with an unique hardware configuration and user friendly software, the moving picture response time of various flat-panel displays can be measured instantly and correctly. Standardization activity in VESA is under progress.

Circle no. 48

PORTRAIT DISPLAYS
Pleasanton, CA 925/227-2700
www.portrait.com
Booth 510

Display software

Portrait Displays will showcase the following software for the display industry: Pivot® software, the leading screen rotation software for on-the-fly viewing in portrait or landscape orientations; Liquid View® software, on-the-fly scaling of the user interface, icons, menus, *etc.*, without altering the resolution of the display; Liquid Surf™ software, an Internet Explorer browser toolbar that improves on-the-fly viewing and enhances productivity; Liquid Color™ software, patent-pending color calibration that establishes Gamma 2.2 sRGB color; Display Tune® software, a new technology introduced this year that utilizes DDC/CI bidirectional display communication.

Circle 49

QUANTUM DATA
Elgin, IL 847/888-0450
www.quantumdata.com
Booth 101

802 Series generator

Quantum Data will be exhibiting the new 802 serie HDMI option and complete suit of test functions associated with this new interface. The 802BT wil also be shown with the HDMI analyzer, a tool to evaluate TMDS outputs and cable integrity. The versatility of the 802 Series generator will also be shown as other configurations of the product will b displayed, including TV output options, DVI, and HDTV outputs. The 802 Series is more than a signal/pattern generator. Tests are provided that give the user immediate feedback on the performance o their display functions, including EDID, Info-Frames, pixel replication, and many other tests.
Circle no. 50

SID '05
Boston, Massachusetts
May 22–27, 2005

RADIANT IMAGING
Duvall, WA 425/844-0152
www.radimg.com
Booth 416

New fast measurement cameras

Radiant Imaging's new PM-1400 Fast Cameras utilize a USB 2.0 interface to deliver quick and accurate measurements of luminance, illuminance, and chromaticity on LCDs, plasma screens (PDPs), OLEDs, CRTs, and automotive and avionic display clusters, as well as display components such as backlights and polarizers. Coupled with ProMetric 8.0 software, which provides a suite of powerful image analysis and chromaticity measurement capabilities, Radiant Imaging offers the most-comprehensive integrated solutions for production-line display metrology and display R&D.

Circle no. 51

SOLOMON SYSTECH
Pak Shek Kok, Hong Kong +852-2207-1560
www.solomon-systech.com
Booth 732

Single-chip driver IC for color OLEDs/PLEDs

Solomon Systech will feature the SSD1338, a single-chip driver IC with a controller for 262k-color OLED/PLED displays of 132RGB × 132 with a two-smart-icon-line dot matrix. It also supports 96RGB × 96 and 130RGB × 130 OLEDs in COF packages. With a maximum 16-V driving output, up to 200-A segment source current support, an internal dc-dc booster controller, an embedded 316-kbit SRAM display buffer, and a –40 to 85°C operating temperature range, it enables OLED/PLED panels to display fast moving images and perform high brightness and contrast with low power consumption for many advance mobile devices such as Gen 3 mobile phones, smart PDAs, and digital still cameras.

Circle no. 52

SOUTHWALL TECHNOLOGIES
Palo Alto, CA 650/962-9115
www.southwall.com
Booth 536

Advanced film coatings

Southwall Technologies designs and produces technologically advanced thin-film coatings that selectively absorb, reflect, or transmit light, enhancing or enabling electronic-display products. Southwall's roll-to-roll manufacturing technology provides global customers with high-performance thin films in a flexible, easily integrated package. Display products include anti-reflective film for enhanced visibility, conductive film for EMI/IR shielding, and silver reflective films for optical mirrors. Products are specifically designed to increase the performance of CRT, LCD, PTV, PDP touch panels, and other electronic displays.

Circle no. 53

TANNAS ELECTRONIC DISPLAYS
Orange, CA 714/633-7874
www.tannas.com
Booth 143

Resized LCDs

Tannas Electronic Displays (TED), using its patented Tannas-Sized™ LCD process, continues to make all sizes of LCDs, from 1 × 3 to 7 × 17 in. and in all avionics sizes. Customers are invited to submit unique size requests for prototyping. Symbolic Displays, Inc., is a licensee with manufacturing capability using the Tannas-Sized™ LCD process. SDI specializes in the engineering design and manufacturing of custom lighted products and services in support of man-machine interface for military and commercial aerospace hardware. A Sharp 5-in. LCD resized to 3 × 3 in. and laminated on both sides with AR, EMI, and heater filter glass survives temperatures from –65 to 100°C in boiling water in repeated cycles.

Circle no. 54

THREE-FIVE SYSTEMS
Tempe, AZ 602/389-8929
www.tfsc.com
Booth 232

New dual displays

Three-Five Systems' new 1.8-in. dual-display module incorporates a 128 × 160 TFT primary display and a 96 × 64 secondary display. The ultra-thin profile of this new display will allow cellular-phone manufacturers to satisfy their customers' demands for thinner, lighter flip phones. Display brightness is a key factor when selecting a display that must vividly show graphic images and alphanumeric data. The TFT cell is manufactured using high-aperture panel technology, high-transmittance color filters, and high-transmission polarizers. The result is a clear and extremely bright main display.

Circle no. 55

TLC INTERNATIONAL
Phoenix, AZ 602/866-8208
www.tlcinternational.com
Booth 315

Gen-3 glass cutter

trade-show preview

TLC International will feature, for the sixth consecutive year, the TLC Phoenix-600® high-accuracy mechanical rectilinear/shapes glass cutter. The Gen-3 model will be on display. Built to cut single sheet or laminated substrates, and circular, curvilinear, and rectilinear parts, this machine sets the standard for clean, quick, easy singulation for FPD, microdisplay, and photonics products. TLC's unique rotating cutting head incorporates a CCD camera for quick target setup/alignment and onstage measurement/inspection. Key features include auto-calibration wheel placement accuracy, 100% repeatability, off-the-self electronics, and low price.

Circle no. 56

USHIO AMERICA
Cypress, CA 714/229-3141
www.UshioTPD.com
Booth 417

Excimer lamp system

Ushio America will introduce the new CiMAX Excimer Lamp System for display manufacturing. The CiMAX Excimer Lamp System uniformly illuminates any substrate up to 300 mm with powerful 172-nm photons. It is twenty times faster than UV/ozone treatment and much safer than oxygen plasma on sensitive films. Ideal for OLEDs, the CiMAX Excimer Lamp System will clean and treat ITO layers in one quick step.

Circle no. 57

VASTVIEW TECHNOLOGY
Hsinchu, Taiwan +886-3-563-7473
www.vastview.com.tw
Booth 520

Image and color engine

VastView Technology will feature NICE™ (Natural Image and Color Engine), a serial patent-protected IC that is a low-cost solution to high image quality, helping customers to achieve the best image quality possible. NICETM features 1.073 billion natural colors, gradational edge enhancement, smooth flesh tones, color tracking and de-color tracking, local detail recovery, overdriving, and a cost-effective solution to high image quality.

Circle no. 58

WAVEFRONT TECHNOLOGY
Paramount, CA 562/634-0434
www.wft.bz
Booth 414

Slanted tailored micro-diffuser

Wavefront Technology mass produces roll-to-roll tailored micro-diffusers (TMD) using proprietary low-cost replication methods. In addition to offering the standard circular and elliptical TMDs, Wavefront Technology has introduced the slanted tailored micro-diffuser (STMD) that performs by utilizing input light on-axis and outputs the light at a predetermined off-axis angle. The STMD is available as a custom product to meet the ever-changing requirements. WFT also offers roll-to-roll or large flat-panel replication of micro-structured optical films containing prismatic, diffractive, micro-lens, or moth-eye features.

Circle no. 59

WINTEK ELECTRO-OPTICS CORP.
Ann Arbor, MI 734/477-5480
www.wintek.com.tw
Booth 1421

2.3-in. QCIF+ 262K-color AMOLEDs

Wintek Electro-Optics Corp. will introduce its newly developed 2.3-in. QCIF+ 176 × RGB × 240) 262K-color active-matrix organic light-emitting-diode (OLED) display. This 2.3-in. AMOLED display has many advantages such as simple structure, high brightness, high contrast, wide viewing angle, fast response time, low-voltage operation, and highly saturated colors. AMOLED displays are ideal for Gens 2 and 3 mobile-phone motion-picture applications. Specifications include a pixel pitch of 0.066 × RGB × 0.198 mm, a diagonal size of 2.3 in., a brightness of 300 cd/m^2, an aperture ratio of 38%, and a contrast ratio of 500:1.

Circle no. 60

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ZEMAX DEVELOPMENT CORP.
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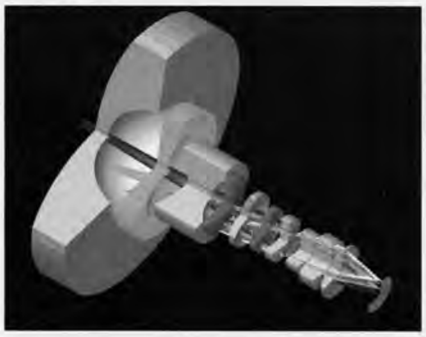

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Circle no. 62 ■

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The shift to TV-sized panels is having an interesting side effect, Semenza noted. "In the near term, all of this experimentation is pulling production away from monitor and notebook supply, creating upward pressure on prices and benefiting the panel makers. The pendulum will swing back, however."

Chuck McLaughlin of the McLaughlin Consulting Group offered a 2004 perspective on rear-projection TVs (RPTVs). "Rear-projection TV has 2 years to carve out market share before big, cheap flat-panel AMLCD screens flood the market," he said. "If the integrators and branders do not make a move to convince consumers that RPTV is the value solution during 2004, then PDP and AMLCD big screens will take over in 2005+."

McLaughlin believes that RPTV sales "will peak at 5–6 million sets annually, and little will be spent on promoting them or on new technologies. All the big bets are on flat panels," he said, and added that the TV market will be do or die for LCoS microdisplays. "If LCoS is not part of the RPTV solution, then their cause is lost," he said, "leaving them stuck in the near-to-eye market."

As for the LCD *vs.* PDP face-off, judgments vary widely on the relative pluses and minuses of these technologies, and each camp has its true believers certain that one of the two will ultimately emerge supreme. But given that both technologies will continue to evolve their capabilities, a look at one brief slice of time will not necessarily indicate the ultimate story.

As for potential new contenders, time will also tell if they will have an impact – and at what stage of the unfolding story. So, too, for one of the other big displays stories of today: electronic paper. I can't wait to see how that one turns out! ■

***David Lieberman** is a veteran display journalist living in Massachusetts; e-mail: davidlieberm@earthlink.net.*

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forcing viewers to deal with the conflict of eye focus and convergence. And 3-D displays are more expensive.

Finally, what about wearable personal displays? Will their time finally come? Certainly, there are strong features and benefits for personal displays that respond to market pull. Full-color video performance is routine. Prices of microdisplays and optics continue to plummet. High-definition microdisplay modules for projectors are now less than $100. Low-definition viewfinder modules range from $10 to $20 each. The marriage of microdisplays with new LED lamps can improve performance and lower power consumption. Personal displays have the potential to make high-definition imaging available anytime, anywhere, in a highly portable, wearable package.

But to capitalize on these strong fundamentals, developers must face the real challenge of personal displays: fit and styling. One size does not fit all. Vision correction must be incorporated. Styling needs to match fashionable corrective or sports eyewear. Easy on and off and comfort are critical.

The personal-display developers of the 90s crashed and burned, unable to put together compelling solutions. But technology moves forward and demand for portable full-color video grows. My bet is that personal displays can be the Next Big Thing. Check back in a decade. ■

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backlight

A Story with No End – Yet

by David Lieberman

There are perhaps a handful of "big" display stories that unfold slowly out in the real world at any one point in time, stories that represent a real shakeup of the status quo. One such story of the past was that of the portable computer in the early and mid-1980s.

First, of course, there were small CRTs, but then EL displays got into the game and then PDPs. Meanwhile, LCDs crept up gradually among them, growing from two-line displays, to four, 16, 32, and on up until they could handle a full page of text. The flat panels obsoleted the CRTs pretty quickly, then PDPs and LCDs went head on – EL having been relegated to niches by its high price. The two competed for a while, with LCDs offering a big power edge and PDPs offering better aesthetics. But then LCDs came through with full-color displays and the game was over. Portable computers have since belonged to the LCD.

The flat-panel TV is probably the most obvious big display story today and clearly one of the most interesting. Where once there were only CRT-based rear projectors, there are now a number of alternatives, with still others on the way. PDPs have been out there for a while now, along with projectors and tiled displays. More recently, LCDs have gotten into the game in serious fashion, and some new rear-projection designs based on microdisplays have come through with excellent displays. Waiting to emerge from the wings, perhaps, are a few other alternatives such as thick-dielectric EL and a number of second-generation FED technologies.

How will things turn out? I haven't a clue. In any case, the question depends on the time frame involved. The story will evolve in discrete and discernable stages: The scenario in 2020 is likely to be much different from that of 2010, which in turn should differ markedly from that of today.

"I think 2004 will be dominated by the LCD-television market," said Paul Semenza of iSuppli/Stanford Resources. "Two trends are converging. First, many TFT-LCD makers have decided that the TV market is more attractive than making panels for monitors or notebooks. This is driven by the intense price competition coupled with high capital costs, in a technology for which there are numerous suppliers of like product – the definition of a commodity, albeit a very high-value one."

LCD makers, Semenza said, believe that "by moving quickly to produce panels for TVs, they can carve out a role in a less-crowded space, and one in which margins are higher."

As for the second trend, "There now appears to be the feeling that anyone can be a TV maker," said Semenza, "and new entrants are coming from the ranks of monitor makers, PC OEMs, and heretofore unknown ODMs, some of whom are partnering with major brand owners, and some of those have not been in the TV business in decades."

Both of these trends, Semenza said, "are moving so swiftly that one can see a big bubble developing, which will be popped through market forces that will drive down margins and through the marketing costs of doing business in the consumer-electronics channel. But for 2004, there may be enough room for many different players to experiment in this market."

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June 9–12, 2004 Taipei, Taiwan

24th International Display Research Conference (Asia Display 2004). Contact: SID HQ, 408/977-1013, fax -1531, e-mail: www.sid.org.
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Advanced Display Technologies Symposium (FLOWERS 2004). Contact: Prof. A. Smirov, +375-17-2398858, fax -2398486, e-mail: smirov@gw.bsuir.unibel.by.
September 7–10, 2004 Minsk, Belarus

EL2004 International Conference and Workshop. Contact: Adrian Kitai, McMaster University, e-mail: el2004@mcmaster.ca.
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September 20–24, 2004 New Orleans, LA

PC Expo/Techxny 2004. Contact: CMP Media LLC, 1-888-234-9476, e-mail: www.techxny.com.
October 3–7, 2004 New York, NY

The Americas First Display Engineering and Applications Conference (ADEAC 2004). Contact: Mark Goldfarb, PCM, 212/460-8090 x202, fax -5460, e-mail: mgoldfarb@pcm411.com.
October 25–27, 2004 Ft. Worth, TX

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