DIGITAL SIGNAGE/DISPLAY WEEK 2010 PREVIEW ISSUE

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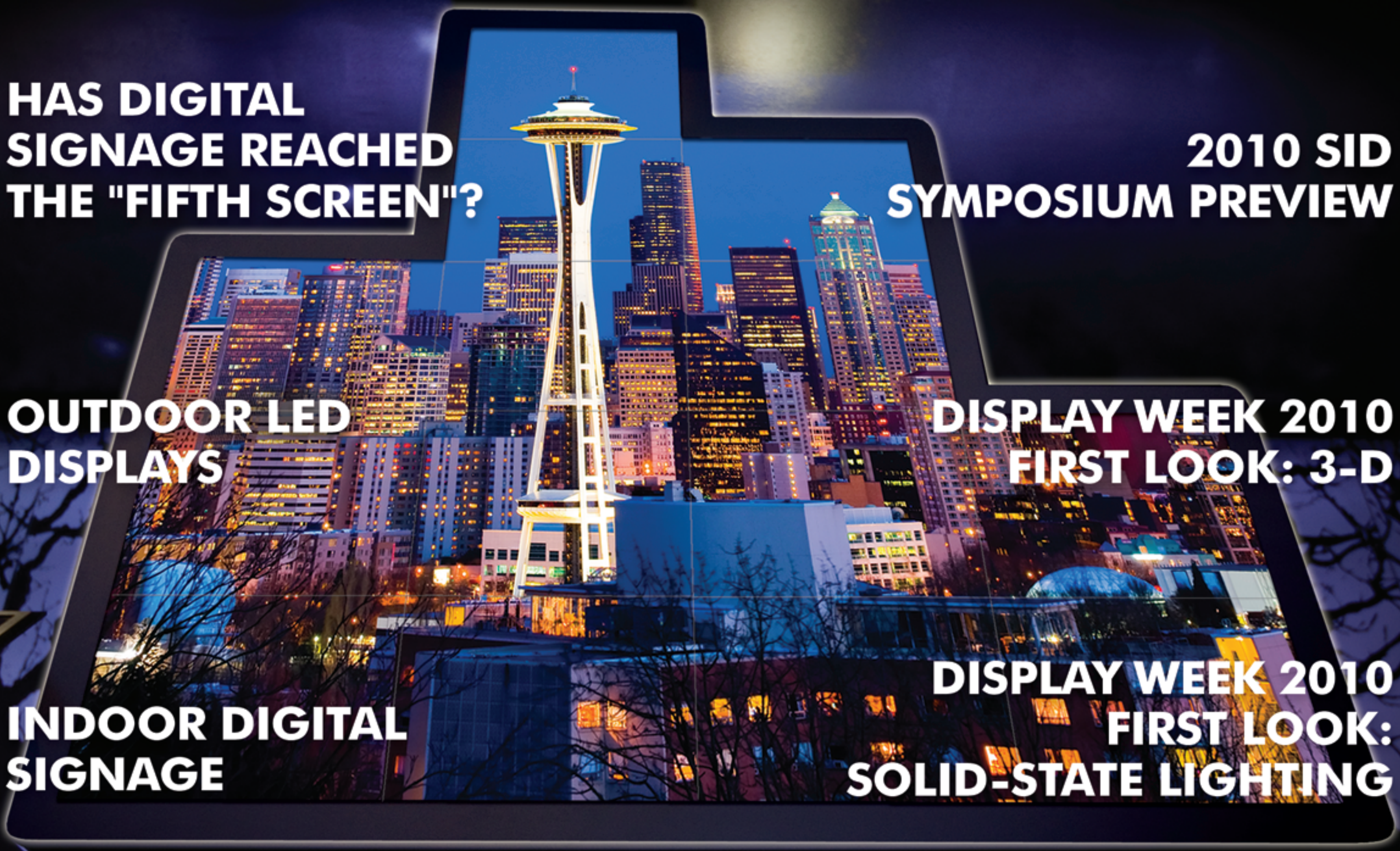
Digital Signage: The Shape of Things to Come



HAS DIGITAL SIGNAGE REACHED THE "FIFTH SCREEN"?

2010 SID SYMPOSIUM PREVIEW

OUTDOOR LED DISPLAYS

DISPLAY WEEK 2010 FIRST LOOK: 3-D

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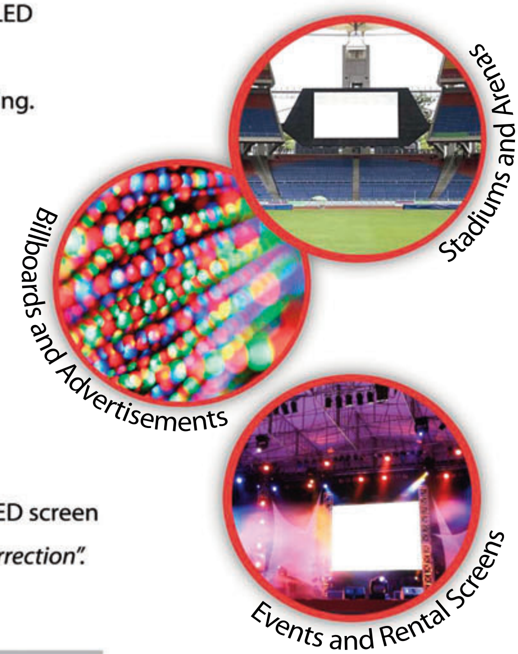

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COVER: The digital signage "skyscraper" is made up of 14 Christie® MicroTiles™ in a unique configuration that contains over 5 million uniquely addressable pixels.

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Photo courtesy of Marty Aronson, Christie Digital Systems

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Display Week 2010 Show Issue

- 2010 Display of the Year Awards
- SID 2010 Honors and Awards
- Products on Display at Display Week 2010

Plus

- Intellectual Property: Understanding Patents
- Display History: The Actuality Story
- *Journal of the SID* June Contents

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editorial

Making a Better "Back to Normal"

by Stephen Atwood

Spring is here, at least for most of us in the Northern Hemisphere, and along with the change of weather, the annual Display Week events are fast approaching. Last year at about this time, we were very apprehensive over the plummeting economy and not sure what the rest of the year would bring. But as I mentioned last fall, and many others have observed, there was a light at the end of the tunnel and it was not an oncoming train. The world economy does appear to be stabilizing and there are many pockets of economic growth showing up if you know where to look. Even the more mainstream metrics of TV sales, panel shipments, portable electronics sales, and similar indicators are all trending positive as we move into the better part of 2010. For example, given strong results in the flat-panel-TV market in 2009, and the recent positive influence of new technology such as 3-D and LED backlighting, DisplaySearch has increased its worldwide TV market forecast for 2010 by more than 10 million units, to a total of 228 million units.[1] In the mobile-phone space, Gartner, Inc., reports that despite flat growth for 2009 overall, the fourth quarter of 2009 showed an 8% uptick, and sales are expected to return to low-double-digit growth (albeit with smaller margins for vendors) in 2010.[2]

Unfortunately, what comes out of any economic crisis after the downsizing and the consolidations are finished is a new state of "normalcy" that is not always better. Many display companies have reduced their staffing levels as well as their research and marketing budgets. Generally, the work has not slowed down; instead, the people remaining find themselves ever-more burdened. Budgets for creative activities get further constrained as well. As the economy begins to recover, management teams may look at their budgets and be tempted not to backfill, but rather to take advantage of the short-term productivity gains and expense reductions that enabled them to return to higher levels of profitability faster. There is nothing wrong with this in the abstract: business is about making money, and display companies must constantly find ways to improve efficiency and streamline costs in order to stay competitive.

However, my concern is that in examining this new state of efficiency, companies may become comfortable or even invigorated by the short-term savings they have achieved. And I contend that these short-term gains can potentially translate into longer-term handicaps that stifle innovation and affect a company's ability to capture market share in the long term.

As scientists and engineers, we all know the long-term value of R&D investments, and it is easy to appreciate how cuts in this area can translate to reduced innovation, loss of market share and declining competitiveness overall. But how often do we really consider the impact of other forms of cost containment, such as reduced investment in marketing activities? In this context, I'm thinking more broadly than just tactical advertising. I'm referring to image and brand building, evangelizing technology, and positioning our companies as technology leaders, which includes investing in those activities that further the industry as a whole.

Events like DisplayWeek, for example, do much more than provide a venue for exhibits and a place for engineers to publish. Through SID, members and attendees can access one of the richest resources for education and training of the next generation of designers and scientists. The money that companies invest in this event through sponsorships and exhibits goes a long way to furthering the goals of everyone

(continued on page 37)

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The Display Side of CES

by Steve Sechrist

The Consumer Electronics Show (CES) is always a watershed event on the consumer-electronics calendar. Not only does it offer the opportunity to touch so many who flock to the sunny Las Vegas desert in the dead of Winter, it gives the industry a chance to reflect on itself. CES highlights technology successes and the unveiling of new dreams, and also exposes (through their lack of presence) those efforts that have failed to come to fruition.

This year's event was no exception, with some telling signs of things to come, such as 3D-TV, NeTVs (Internet-connected TV), the rise of LEDs in projection, and a whole new crop of e-book readers. Without question, 3-D dominated the show, with so much going on in that area that Insight Media produced a *Special Report on 3D at CES-2010.*

CES proved that there is 3-D activity at every level of the consumer and professional industries. Besides the 3-D flat-screen and projection display products, we saw activity in electronics and integrated circuits to support the formatting, distribution, and encoding of 3-D content. There was news about 2-D to 3-D conversion, 3-D cameras, and 3-D mobile devices. And most important, we saw announcements about the creation of new 3-D channels from heavyweights such as Discovery, ESPN, and DirecTV. Blu-ray 3-D standards have been agreed to, and the HDMI 1.4 specification is set to support the distribution of 3-D within the home. Multiple vendors talked about a variety of 3-D glasses to support these new TVs. And all the top TV brands announced that 3-D will be a part of their product lines in 2010 – a key message for consumers.

However, it is important to remember that this major 3-D push is coming from the companies that stand to gain the most from the phenomenon. The questions remain: will consumers actually embrace these 3-D TVs? Will they wear the glasses? Will they be willing to replace a newly purchased HDTV with a new 3-D TV? Will they pay a premium to have this 3-D capability? These questions have not yet been answered, so the future of many aspects of 3-D remains cloudy.

Going beyond the third dimension, European *On CE* editor Bob Snyder cleverly observed that while the "buzz" at the show was about 3-D TVs, the "honey" was probably in Internet-connected TVs, or NeTVs.[1] These could earn manufacturers real and immediate revenue, as supported by both the marketing numbers and the products shown at CES. For example, one DisplaySearch forecast predicted that the "Web-connected TV" market will grow from about 15 million units in 2009 to over 70 million units by 2012, with the largest market penetration in Western Europe and North America. On the other hand, a post-CES survey result from Parks Associates notes that less than 8% of U.S. broadband homes – about 5.5 million homes – are considering canceling their pay-TV subscriptions in favor of online video. That is actually down from 10% in 2009 and 11% in 2008. To be fair, this study appears to have looked at a complete conversion to Internet delivery. In reality, we suspect consumers are more likely to experiment with Internet delivery until they feel convinced they can make the switch and not lose something they want from cable, satellite, or terrestrial delivery services.

The point is, all top brands had one or more versions of NeTV at CES, all with unique nomenclature to help differentiate (or rather confuse) the consumers. But most seem to understand the idea of NetFlix and Widgets (the new substitute for channels), which empower Internet streaming directly to the TV without the use of a separate computer. This opens up a whole new delivery mechanism and changes the game for cable and satellite providers, as well as fixed-content disc suppliers handling Blu-ray and DVD distribution.

The ability to send HD content wirelessly within the home was also a pervasive theme among most major display manufacturers at CES. While not new to the show, or even some top-end sets, the wireless connectivity is becoming more robust (with 1080p/60-Hz support) and pervasive, due in part to new chips now shipping from major providers such as Amimon.

In a move to differentiate itself, Japan-based Sharp Electronics announced Quad Pixel TVs – a new technology for the company that expands the color primary set beyond the conventional RGB (red, green, blue) by introducing a new fourth (yellow) primary to the mix. While this is far from a new concept, and there is plenty of multi-primary IP out there, we think it is the first time a major CE maker is introducing it into the market as a way to differentiate its LCD products, perhaps the same way that Samsung created lots of buzz around its "LED-TV".

Display expert Ken Werner, who covered the story for Insight Media, explained that adding a yellow primary outside of the RGB triangle gives a four-sided RGBY quadrangle that contains more colors. As a result, the company now claims it can display roughly a trillion colors instead of the billion colors in a conventional RGB set.

Also visible at CES were many e-readers, including the launch of the long-awaited QUE from Plastic Logic and next-generation displays such as LG's EPH display mounted on thin, flexible stainless steel, as shown in the new Skiff device from Hearst. There was also a new production version of Pixel Qi's hybrid transflective panel shown in a private suite, and Qualcomm's MEMS display prototype in a 5-in. class size that we recently learned is ready for production and will ship by end of 2010 in a yet-to-be-named OEM vendor's e-reader.

But Insight Media analyst Pete Putman caught something even bigger brewing on the CE display horizon at CES. He mused recently in our Insight Media *Display Daily Blog* (January 18) about the "Changing of the Guard" in the industry, with some of the old-guard Japanese firms giving way to Chinese ones. Here's how Pete put it:

"Aside from all of the demos of 3-D, NeTVs, widgets, super-thin LCDs, energy conservation, wireless HD, and OLEDs, there was another significant story to be covered. That was the big-time CES appearances of Chinese CE and TV manufacturers TCL, Haier, and Hisense. This is not the first time that any of these companies have shown their wares at CES. Rather, what was truly significant was the sizes of each company's booth (enormous!) as well as the depth and breadth of their product lines."

Pete could have added Hanvon to this list, the third largest e-book reader (EBR) maker (and top seller in China), whose booth dominated the EBR Tech Zone at the show and featured dozens of new models. (We learned after the show that Hanvon sold 100,000 EBRs in China in the month of December – further proof that the market is real and exploding.)

"It wasn't hard to locate any of these booths" Pete continued; "they occupied prime

(continued on page 33)

The Future of the Fifth Screen

by Bob Rushby

Christie Digital Systems, like many companies in the display industry, has been deeply involved in exploring opportunities, developing and deploying solutions, and tracking growth in the digital-signage market, also referred to as the Digital-Out-Of-Home (DOOH) market. After all, for years most of us have been told by industry analysts that digital signage is the "next big thing" for the display industry; the so-called "fifth screen," after cinemas, television, personal computers, and handheld/mobile devices.

Yet, while growth has been steady over the past decade, and even remained positive during one of the worst economic recessions in our lifetimes, digital signage has yet to realize the rapid growth that many had been hoping for. One major factor is that a whole infrastructure has had to develop: widespread proliferation of digital signage has required much more than just a display and a wall to hang a screen on. It has needed the development of networks and network management capability, content creation tools and skills, content distribution and content management, playback solutions, and system deployment and maintenance capability not just at an individual site level, but at regional, national, and, in some cases, international scales, all focused on the unique requirements of digital signage.

Furthermore, this maturing industry has needed retailers, brands, content developers, and advertising agencies to embrace digital signage and adapt their strategies to go beyond traditional mediums such as television, radio, newspapers, magazines, and, yes, even mobile devices and the Internet. No longer does content developed for broadcast suffice for digital signage. Today, we are constantly bombarded with messages from a variety of media sources, forcing us to passively dismiss all but the most compelling display solutions and content.

At last, though, it seems many in the industry feel that we may have reached a tipping point and that the next few years will be an era of strong growth in the digital-signage market.

As you read the articles in this special issue of *Information Display* on digital signage, you will notice a recurring message – that digital-signage solutions must engage, captivate, and inform their intended audience. Today, people "tune out" poorly designed or irrelevant content and commonplace formats. Indeed, the familiar 16:9 portrait and landscape formats are quickly becoming ubiquitous and consumers are more and more simply not noticing the message. Fortunately, the display industry is responding to these needs with new and innovative solutions you will see discussed in the articles in this issue.

Some key elements to engage and captivate in digital signage are:

- The display itself needs to be interesting; either by virtue of size, unique shape, stunning picture quality, or some combination thereof.
- The display needs to be carefully blended into its design environment; it cannot simply appear as an add-on or afterthought that further clutters the space around it.
- The human factors in each environment must be carefully considered, including optimum contrast, brightness, resolution, viewing angles, *etc.*
- The content on the display needs to be spectacular – colorful, easy to read at a glance, visually appealing, and highly relevant for the intended audience.

(continued on page 39)

president's corner

Time to Move On

by Paul Drzaic
President, Society for Information Display

This will be my final President's Corner column in *Information Display*. I am nearing the end of my term as SID President and it will soon be time to pass the torch to new leadership. Before moving on, though, I'll use this opportunity to take a look at the Society for Information Display, review how the Society has evolved over the past few years, and provide a preview for some new and exciting changes that should enhance the value of SID into the future.

SID's traditional strength has been its technical symposium, which continues to be the most prestigious worldwide venue for display engineers to unveil and explain new technologies. We're not sitting still, though – we've taken several steps in our conference organization to ensure that SID is even more responsive in identifying hot new areas of technology, and delivering this content to our audience. Besides our typical coverage of topics such as liquid-crystal displays, OLED displays, and active-matrix backplanes, we have new areas of emphasis such as 3-D displays, touch interfaces, electronic paper, flexible technologies, green manufacturing, and solid-state lighting. With papers reviewed and selected by our worldwide network of volunteer experts, the SID Symposium will continue to serve as the top venue for discussion of advanced electronic-display technologies.

While this function of SID is stronger than ever, we've also recognized that the sheer size of the electronic-display industry means that economic and market factors play just as much of a role in deciding what technologies get developed as inventors' activities in the lab. The SID Business Conference, organized in collaboration with electronics market research firm DisplaySearch and the Investors Conference, in collaboration with securities and investment banking firm Cowen and Company, continue to make available critical analysis and business insight across multiple areas of the display enterprise. New for Display Week in Seattle are a series of Market Focus Conferences, organized in collaboration with electronics market research firm IMS Research. These one- and two-day conferences will take deep dives into the areas of television, touch interfaces, and lighting, providing an intensive look into the market development of these important application areas.

SID publications continue to evolve in ways designed to meet the needs of SID members and the outside world. *Information Display* continues to cover important areas of technology, but is strengthening its application-oriented content as well. We want SID to be a good home for those who use and deploy displays, as much as it is for the engineers who invent them. *ID*'s new application focus will broaden the content useful to the applications community, an important constituency for SID.

We certainly are not neglecting our technology base, though, and the *Journal of the SID* and the SID-Wiley book series continue to excel in publishing the leading papers and books on display technology. We are in the midst of a process to fully integrate *JSID* into the world of research journals, and our participation in indices such as Thomson's Web of Science and Scitopia will continue to drive the prestige of publication in our journal across multiple disciplines with a tie to electronic displays. The SID-Wiley book series is now 16 titles strong, with a wide range of topical coverage on display topics that really can't be found anywhere else. SID is proud to be able to provide these publications as a service to the greater world.

(continued on page 39)

Contrast Ratios in Outdoor LED Displays

Real-world viewing situations for LED displays in an outdoor environment are highly variable in terms of light-source intensity, light-source angle, and angle of measurement. Thus, accurate specifications can be difficult to determine.

by Ryan Hansen

THE dominant display technology used in outdoor digital signage is direct-view light-emitting-diode (LED) technology. With this technology comes a variety of interesting challenges in measuring and evaluating contrast ratio. Along with a few other key display parameters, contrast ratio is a critical component in device selection among various display technologies and manufacturers for a given application.

Most display insiders would agree that few end users truly understand the impact of contrast ratio on perceived luminosity, color depth, and picture fidelity. This realization, however, has done little to slow the contrast ratio wars raging among consumer liquid-crystal-display (LCD) TV manufacturers. Different measurement approaches combined with a variety of testing variables make it possible to publish and promote almost any contrast-ratio specification. The sky is truly the limit, especially as dynamic-contrast-ratio specifications become more common and accepted.

Consumer-display manufacturers are not alone in this regard. The LED-display industry is experiencing contrast-ratio pressure as

Fig. 1: Nearly 6000 LED modules make up this HD display at a major-league baseball field. Photo courtesy Daktronics.

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well, driven largely by the marketing push in the consumer-display market. This is especially challenging for outdoor LED displays, as end users are quick to search for a contrast-ratio specification without fully understanding the variables involved in both the testing environment and the real-world viewing of an outdoor display.

Components of Large-Screen LED Displays

In exploring this topic, it is helpful to understand that small LED modules are the basic building block of any large-screen LED display. By stacking the modules within predesigned frames, and then by stacking together those populated frames, it is possible to interconnect power and signal to produce a display of any size or resolution. For instance, the mega-high-definition (HD) display for the Kansas City Royals baseball team (Fig. 1) measures approximately 85 ft. wide by 105 ft. tall and is comprised of 36 sections containing a total of 5940 LED modules, resulting in a final resolution of 1584 × 1800 pixels.

The front-face mechanical characteristics of an LED module are the key influencers of the critical off-state measurement of the display. While designs and subtleties vary across LED-display manufactures, most major companies invest significant sums working to improve their "video-black" states across a number of areas (Fig. 2).

The louver assembly is the final overlay component of most LED modules, placed and secured after construction of the base module assembly. This assembly is the central focus regarding measured off-state luminance performance. It gets its name from the horizontal shaders that provide sunlight protection for the LED face. Generally speaking, the less sunlight reflecting directly off the display face, the higher the overall contrast ratio. In most outdoor installations, the sun is usually overhead for a large portion of the day, and manufacturers must carefully evaluate the louver design to ensure it prevents washout on the display face. Louver design is a balancing act between contrast ratio and display viewing angles.

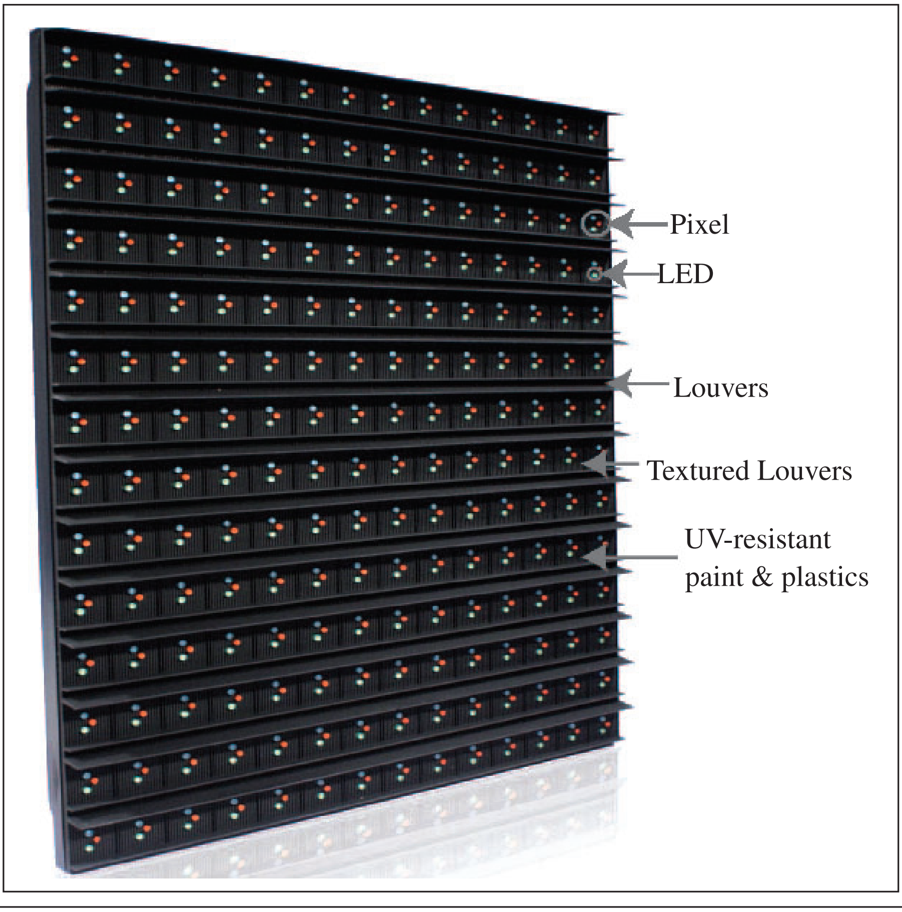

Fig. 2: This LED-display module features the louver assemblies often used to improve contrast ratio in outdoor signage. Image courtesy Daktronics.

In addition to the LED module shader design, the texturing approach across the louver assembly will affect how much ambient light is reflected back to the eye of the viewer. Generally speaking, and dependent on approach, a rougher texturing will disperse ambient light more effectively than a semi-smooth surface, creating the visual perception of a blacker off-state, thereby providing more consistent contrast across all angles of the display. In contrast, smooth finishes appear darker from the angle of incidence, theoretically allowing manufacturers to claim a higher contrast ratio. However, the same finish will produce a severe glare at the angle of reflection that can compromise side-angle viewing.

Complementing the shader design and the texturing method is the coating approach. Many, but not all, LED-display manufacturers treat the surface of their LED-module louver assemblies with an anti-reflective UV-resistant dark paint that is, again, intended to minimize light reflection from the face of the LED module. Environmental conditions also contribute to the overall contrast of a display. A seasoned display, without occasional cleaning, collects dust and dirt. Over time, this begins affecting overall contrast, making the black state appear brown in color. Methods to repel dust and dirt from displays have been introduced, but are still unproven. Other common challenges for display manufacturers and owners are the effect UV rays have on the front of the display. UV-resistant paint and plastics for the display front help to minimize this effect.

Last, the individual LEDs themselves – protruding from the face of the display by 1–3 mm – also reduce contrast performance. The amount of ambient light that is reflected from each LED depends on the size of the LED, as well as the tinting of the LED's epoxy shell. Each LED contains a small reflector cup that is intended to focus light from the package; however, it also reflects any ambient light that may enter the LED. As a result, each and every LED has the potential to detract from the overall

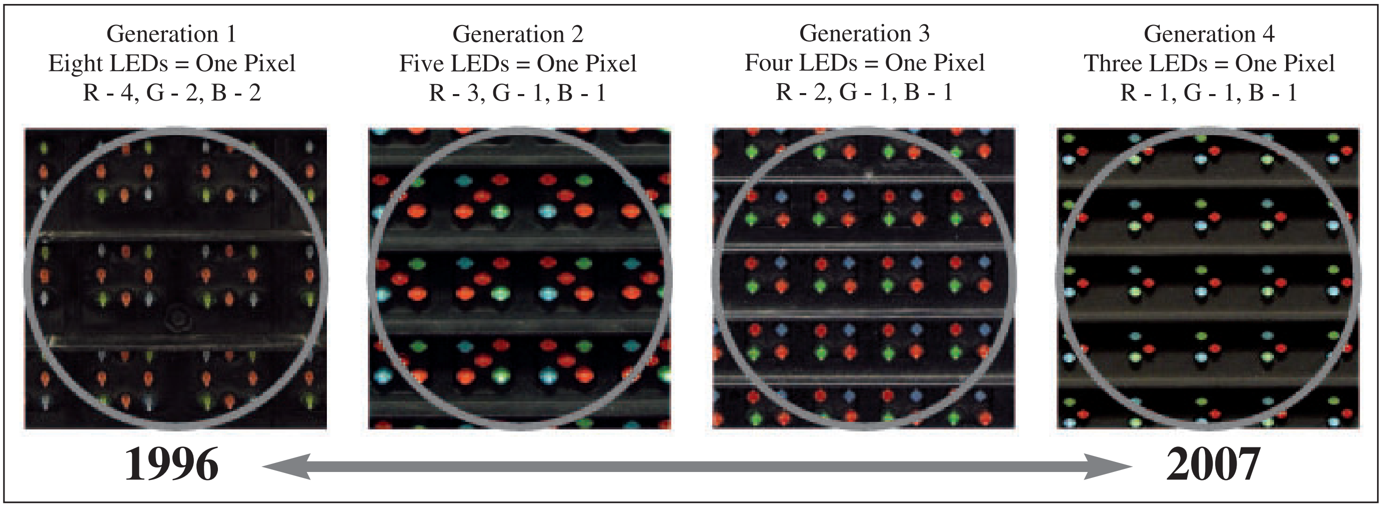

Fig. 3: Pixel layouts evolved over about a 10-year span to include fewer and fewer LEDs. Image courtesy Daktronics.

display contrast ratio. Fortunately, LED manufacturers have increased both power efficiency and luminous intensity to allow for the optimal one-red, one-green, and one-blue pixel design. Past generations of LED-display products required 12, 8, 6, and 4 LEDs per pixel to produce adequate intensity – regardless of considerations of louver design and face texturing (Fig. 3). Advances in LED technology have enabled improvements in contrast ratio.

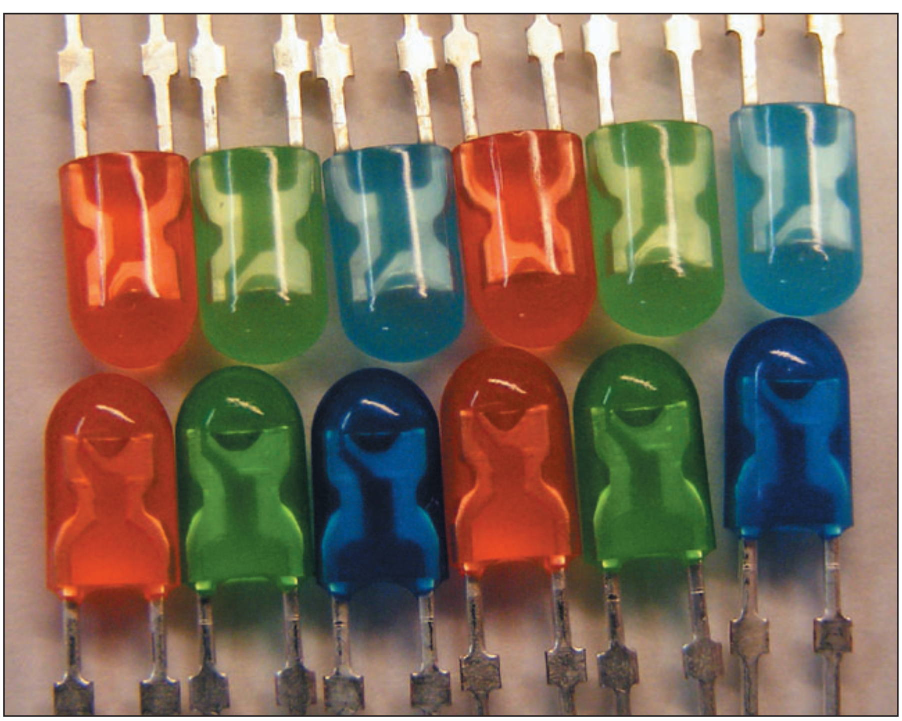

Fig. 4: There is a subtle difference between "black LEDs" (bottom row) and conventional LEDs (top).

A new marketing approach has recently appeared within the LED video industry that uses the term "black LED package" to promote improved contrast on an outdoor, lamp-style LED video display. Most red, green, and blue outdoor lamp-style LEDs have red, green, and blue tinting added to the lamp epoxy to aid in identification and improve display contrast. The "black package" LEDs simply have a little more tinting, making them slightly darker but they are not black. Because of the heavier tinting, the black LED packages do provide a modest improvement in overall display contrast, but do so at the expense of power consumption and display brightness. Figure 4 depicts the difference between standard LEDs and black LEDs.

As a side note, all contrast-enhancing methods must coordinate in a uniform manner across not only a batch of LED modules, but across all modules within a reasonable time frame. Some customer segments will routinely require matching modules 5–10 years after the initial sale. The functional lifetime of an LED video display is typically 75,000–100,000 operational hours. On the high end, that's more than 11 years of company support and contrast continuity that must be planned for from the onset of each project.

Contrast-Ratio Variables

Understanding the basic design of an outdoor LED-display module as it affects contrast ratio, it is equally useful to gain insight into the variables that affect contrast-ratio testing of such products. As noted, the contrast ratio of an outdoor large-screen LED video display is largely dependent on the module construction methods previously described: louver design, texturing, coating, and LED density.

For a meaningful and repeatable contrast measurement, a true dark room protected from unintended light interference is required. The three-primary components interacting with one another for contrast testing are the LED module, the measurement instrument, and the light source. Most LED-display manufacturers perform a basic on–off testing procedure with "off" being video black. However, there is little industry-wide consistency in measurement techniques. While prescribed standards exist to measure contrast ratio for some display technologies, such as the VESA FPDM (flat-panel display measurement) process, there is little conformance across the LED-display industry. Unlike the flat-panel-display measurement, the ambient light source (sun) and the measurement tool (viewer) shift over the course of the day and, in the case of a motorist or walking pedestrian, over the course of a minute. This is difficult to replicate in testing and to explain on a product specification sheet.

It should also be noted that under testing conditions it is only practical to test individual LED modules or collections of modules due to the relatively large size of the fully constructed LED video displays.

Within the testing environment, ambient lighting is provided through an artificial light source intended to reproduce a true-to-life outdoor viewing experience. Of course, it is easy to drastically impact the testing results for promotional advantage by adjusting the lighting levels (expressed in lux) within the testing environment. Virtually any decision can be justified due to the variable nature of sunlight hitting the display face. Display manufacturers currently publish outdoor specifications based on ambient lighting levels ranging from as low as 40 lux to as high as 50,000 lux.

The angle of the light source to the display module can also be manipulated to increase contrast-ratio testing results. As mentioned previously, LED modules have horizontal louvers – or light shaders – running between rows of LEDs or pixels. Increasing the angle of the light source in relation to the LED module results in more shaded area across the module face – and thus an improved black state.

Lastly, and in combination with the previously listed point, adjusting the angle of the measurement instrument to the module face will also provide display manufacturers with control of the final contrast-ratio specification. Again, this is largely possible due to the interaction between the light source and the horizontal shading louvers.

These three basic variables – light source intensity, light source angle, and measurement instrument angle – work together to produce the published contrast ratio of an LED display. Unless a test is conducted identically from display-to-display, one cannot be absolutely certain that the comparison is correct. As a result, display-manufacturers' specifications on contrast are rarely meaningful (Fig. 5).

Real-world viewing situations somewhat correspond to the testing variables of light-source intensity, light-source angle, and angle of measurement. Sky conditions will have a substantial impact on the amount of sunlight striking the display face. The time of day and time of year will impact the angle of the sun to the display face. And, lastly, the position of the viewer in front of the display face will

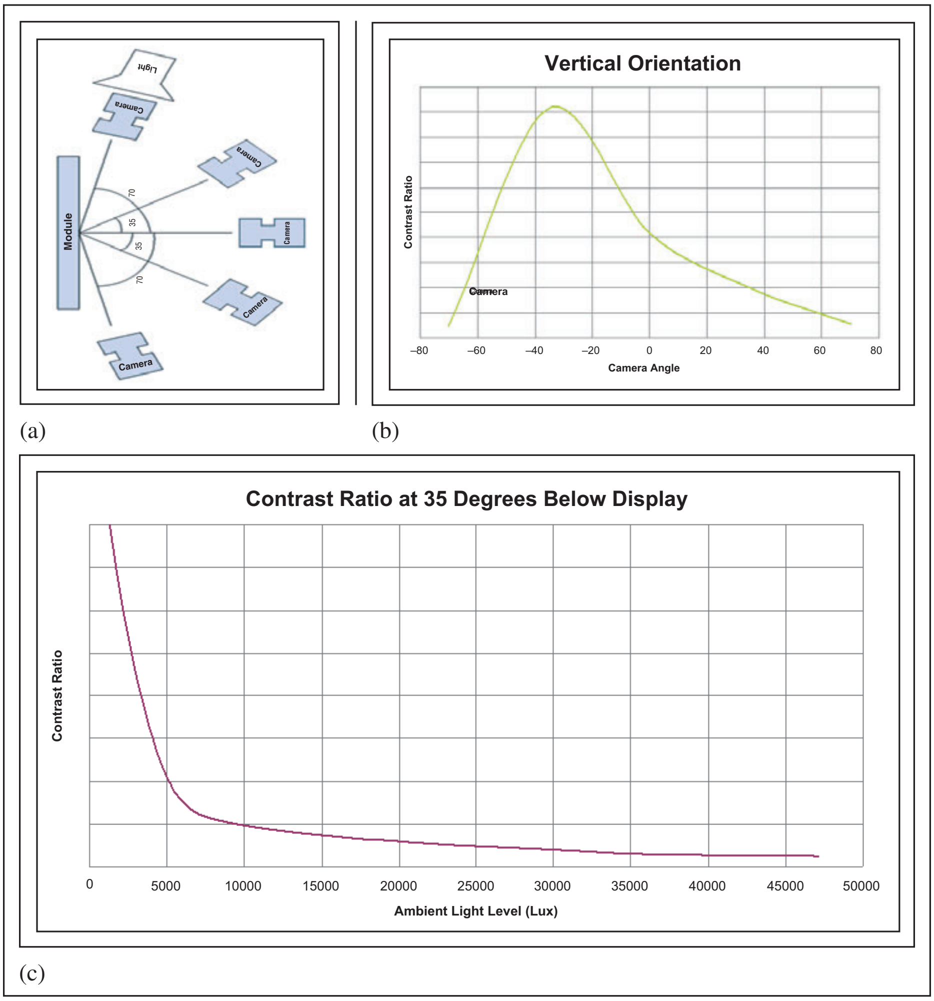

Fig. 5: *(a) This illustration shows one possible setup scenario for testing contrast on an LED module. (b) This graph shows how the contrast ratio will change relative to a fixed light-source location. This curve will change based on module design. (c) This graph shows how the contrast ratio will change at a fixed light-source and observation location based on the ambient light conditions. This curve will change based on module design.*

interact with the prior two variables to produce a contrast ratio accurate for only that specific viewing experience. This environment is substantially different from that of the indoor home theater, the birthplace of the problematic contrast-ratio war, where lighting conditions and viewing positions can be predicted with at least a modest amount of certainty.

Manufacturers of LED displays will continue to publish contrast-ratio specifications to compete for customer attention; that is the reality of the marketplace. However, the industry has a responsibility to educate customers on the variables involved. As contrast-ratio specifications climb higher, customer education becomes increasingly difficult. Given the current pace of marketing in the LED-display industry, it is likely we will see outdoor contrast specifications at 100,000:1 and beyond in the near future. However, it is highly unlikely that these numbers will be substantiated in any meaningful way. ■

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Display Technologies Evolve for Indoor Digital Signage

Effective signage needs to grab people's attention in order to convey information. In the case of digital signage, getting that attention means using the right choice of display technologies, which are constantly evolving to suit the needs of the burgeoning market.

by Don Shaw

THE indoor-digital-signage market is currently dominated by flat-panel displays that are virtually no different from the HDTVs we buy at the big-box stores and install in our living rooms at home. Indeed, flat-panel displays were the technology breakthrough that allowed the digital-signage market to begin in earnest during the late 1990s. With a high-quality displayed image, brightness of 300–700 nits, and economies of mass production alongside TV-grade panels, it is no wonder that this technology has been so successful in digital signage. However, one could now argue that flat-panel displays have become ubiquitous and easily ignored, presenting a stumbling block in an industry that needs to engage and captivate viewers. This has created an opportunity for display manufacturers to develop new technologies that can attract attention, as flat-panel displays were able to do in the past. Some of the clearest opportunities for innovation are in display sizes and shapes, but it is equally important to consider advancements in resolution, color fidelity, and brightness. Beyond these visual characteristics, it is also key to consider factors such as acceptable viewing distances, serviceability, and calibration.

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Bigger is Better

Perhaps the most obvious way to build a more exciting digital-signage display is to make it bigger than the TV in everyone's living room. In fact, liquid-crystal-display (LCD) and plasma-display-panel (PDP) manufacturers have been going down this path for several years now, with a continuing battle of one-upmanship on the trade-show floors, culminating in monolithic displays up to 150 in. on the diagonal. This is nine times the size of a more conventional 50-in. display, but also comes with orders-of-magnitude higher production costs due to manufacturing yield realities. Also, setting aside cost for the moment, there are significant challenges involved in (carefully) transporting these glass behemoths from the manufacturer, through the doors of their intended venue, and then up onto a wall or display stand. One notable success in this category is the 103-in. plasma display from Panasonic with 1080p resolution, a pixel pitch of 1.18 mm, and a weight close to 500 lbs. Somehow, Panasonic has managed to ship several thousand of these units since their commercial debut in late 2006. Figure 1 is just one example of how companies are using digital signage in new ways (in this case, as part of a giant "camera") to catch the eye of passers-by.

Displays in Arrays

Another common approach for building larger digital-signage displays is to combine several conventional flat-panel displays into an array. Everyone has seen examples of these installations at trade shows and in public spaces. They are relatively inexpensive to set up, but always need some type of custom structure to support and align them. Once installed, their most obvious drawback is the existence of large mullions between the individual display panels. Not only do these mullions provide a visual distraction, but they necessitate special care when developers are creating content and playback systems to make sure no vital messages get lost in the non-viewable or "null" display areas. It should be mentioned that reduction of bezel size among flat-panel-display manufacturers has been reasonably successful in recent years, resulting in smaller mullions, two examples of which will be discussed below. Also, as flat-panel-display technology has generally been designed to operate in isolated units, it is very difficult to achieve and maintain color and brightness uniformity across multiple units, especially as they age. As a final consideration, arrays of flat-panel displays are inherently time-consuming and labor-intensive to maintain. A typical repair involves manipulation/replacement of a large screen that is often attached to all of its neighboring units, necessitating a tear-down of a substantial portion of the array to address even single-unit failures.

Despite the difficulties of attempting to configure and maintain conventional flat-panel-display technologies in arrays, two specific efforts to address the issues are worth mentioning. One product is an adaptation of

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EDTV-resolution (852 x 480) 42-in. plasma displays, from Orion PDP Company, whereby the bezel around the screen is substantially reduced, allowing for a 4-mm seam between adjacent displays. Featuring a pixel pitch of 1.08 mm and a claimed brightness level of 1000 nits (although some parties have reported actual measurements substantially lower than this), the image quality is quite good, although newer displays feature better black levels and less glare. Furthermore, there have been numerous reports of brightness, uniformity, burn-in, and reliability issues, especially as these units age. Despite these issues and a per-unit selling price at an order of magnitude above standard 42-in. EDTV screens, Orion plasma displays have achieved a remarkable number of installations since they were first introduced in 2003; certainly due to their early-to-market advantage where no other flat-panel manufacturers had shown any interest or progress.

More recently, Samsung has introduced a 46-in. LCD panel, with a WXGA resolution (1366 x 768), that features bezels of 2.4 mm (right, bottom) and 4.3 mm (left, top), which leaves a 7.3-mm seam between adjacent displays when they are mounted in an array configuration. With a pixel pitch of 0.75 mm, a brightness of 700 nits, and visibly better contrast than the Orion plasma displays, the image quality is excellent. Interestingly enough, several other major manufacturers (NEC, Barco, Planar, *etc.*) announced their own products, with identical seam and image specifications, just after Samsung announced its offering. Selling at a lower price than the Orion plasma displays, these LCDs seem like a viable solution if the end user can accept the 7.3-mm seams, but only time will tell how the various manufacturers are able to wrap the Samsung panels with enough "tiling" technology (for mounting, uniformity, cooling, *etc.*) for success in this market.

Direct-View LED

In large venues, such as indoor sports stadiums, sunlit atriums, and concert settings, the technology of choice for signage is direct-view light-emitting-diode (LED) displays. These displays have the advantage of being able to produce extremely bright images, up to 7500 nits, and they feature vivid-color palettes. Also, because LED displays are generally made up of relatively small tiles, they are easy to configure in unusual shapes

Fig. 1: *A 103-in. plasma display appears as part of an innovative digital-signage exhibit at London Waterloo station. (Photo courtesy Panasonic UK & Ireland.)*

and look nothing like the HDTV in your living room. Originally developed for scoreboards and sunlight-viewable billboards, this outdoor technology has been adapted by numerous companies to be used indoors. Indoor usage allows the brightness to be lowered (to 1000–2000 nits) to save power and reduce cooling requirements. Also, due to the closer viewing distances, pixel pitch is typically lower than outdoor products, with 3 mm being the (very expensive) lower limit of technical feasibility, and 6–10-mm displays occupying the mainstream indoor market space. A major drawback of this technology is that these displays all become pixelated when the viewer is up close and are generally not suitable for high-resolution content unless they are very large and it can be ensured that the viewer is a sufficient distance away from the screen. A general rule for selecting LED displays is that the viewer needs to be at least 1 m back for each 1 mm in pixel pitch. It is also important to note that although this type of display will burn brightly for up to 100,000 hours, it is very difficult to maintain uniform color and brightness as the LEDs age.

Projection Displays

Conventional projection technologies, which can produce brilliant images in dark environments, are often dismissed in digital-signage applications for a number of reasons. First of all, the integrator must carefully consider how to design a projection-based solution that maintains reasonable contrast levels in the high-ambient light environments typical for digital signage, such as in retail. Another consideration is the physical space, often at a huge premium in retail and commercial settings, which needs to be allocated to satisfy line-of-sight requirements for projection-display systems. Finally, because conventional high-brightness projection systems are illuminated with lamps that only last a few thousand hours, the cost of maintenance and spares must be considered carefully, especially for 24/7 (or 16/7) digital-signage installations. Despite all of these issues, if the end user can control the ambient light levels and space is not an issue, a high-quality projector and carefully selected screen can be very cost-effective in terms of screen size. Also, the world has seen some novel examples of what can be done with special optical films on glass surfaces in conjunction with projection.

Tiled Displays

An example of another recent development in digital display technology is a product called MicroTiles from Christie Digital Systems. Designed as a series of 20-in. (diagonal) building blocks, MicroTiles can be configured in any shape and size, as shown in Fig. 2. The tiles use a direct-throw DLP rear-projection engine with solid-state LED illumination, which enables a large color gamut with no lamps to change over time. With no theoretical limit to the number of tiles in a display, MicroTiles make possible an 800-nit (calibrated) digital canvas with tiny (1 mm) seams and an unlimited number of super-fine pixels (0.57-mm pixel pitch). This product has the shape, modularity, size, and color-reproduction capabilities of direct-view LED displays, but also offers impressive image quality from any viewing distance. Furthermore, through innovative engineering and light-sensing technology, MicroTiles are the first (of hopefully many) tiled display products to feature a closed-loop calibration system, which can automatically set up and maintain brightness/color uniformity throughout the life of the display. The rated lifetime is 65,000 operating hours, and Christie claims that any service that is required on a MicroTiles display unit can be performed in less than 15 minutes by a single technician. MicroTiles are positioned at about the same price point as mainstream high-resolution indoor LED products.

Fig. 2: The MicroTiles technology allows for displays in a variety of non-uniform shapes.

New Technologies

Of course, as the display world continues to evolve over time, there will be new entrants with new technologies competing in the large-area and digital-signage display space. One new company, Prysm, recently announced a technology called Laser Phosphor Display (LPD) technology, from which it is building a product that it claims is ideal for commercial applications such as digital signage (as of this writing, Prysm had not yet published product specifications). LPD is said to use an array of modulated solid-state lasers, combined with a high-speed scanning mechanism similar to that used in CRT displays, to excite a patterned array of phosphors layered onto a rigid screen surface.

Another new entrant is Nanolumens. Using a new type of specially designed, thin-film phosphor-based electroluminescent display modules, and mounting them on a thin-polymer-film display substrate, the company claims to be able to efficiently manufacture uniformly bright (between 500 and 1000 nits) and highly scalable displays. Nanolumens has publicly demonstrated a 112-in. display unit at less than 1-in. thick that is flexible enough to wrap around curved walls and columns or roll up for easy shipping and install. However, at the time of this writing, Nanolumens had not publicly published actual product specifications.

The past year has brought about some exciting display technology innovations that will certainly contribute to the growth of the digital-signage industry. With display options that move well beyond the TV-like screen in terms of size and shape, the creative community (in advertising, retail design, and architecture alike) now has more ways than ever to captivate and engage an audience with digital signage. Beyond freedom in size and shape, we continue to see progress in resolution, brightness, color fidelity, and diminishing seams in tiled-display arrays. Furthermore, with the emergence of purpose-built signage display products across a range of technologies, manufacturers are finally starting to offer viable technical solutions for the maintenance and calibration issues long affecting large-area and tiled displays. ■

Digital Signage: Is the Business Model Finally Catching Up with the Technology?

TFT-LCD makers are looking to the digital-signage market to move production to the next and larger stage. The large-format commercial flat-panel-display market is forecast to grow, but the usage models for advertising and information dissemination via digital signage are still being worked out.

by Chris Connery

THE TERM DIGITAL SIGNAGE is now being used quite loosely in the display industry as well as in the popular press. It encompasses small electronic shelf-label liquid-crystal displays (LCDs) or electrophoretic displays, medium-sized thin-film-transistor LCDs (TFT-LCDs) used in check-out lines at grocery stores and gas pumps, poster-sized LCDs and plasma-display panels (PDPs), and billboard-sized light-emitting-diode (LED) displays. The most common use of the term digital signage over the past decade, however, has been for large-format (26-in. and larger) LCD and PDP products, and these are the focus of this article. The anticipation is that displays used in out-of-home (OOH) environments to convey dynamically changing information and advertising will be the next large-area application for flat-panel displays (FPDs) and that this application will join TVs, monitors, and notebooks as a major market for TFT-LCD technology. Many in the industry even refer to this market as "The Fifth Screen."

With TFT-LCD production under way at Gen 10 fabs, there is speculation about Gen 11 and larger lines, but that raises the question of whether such large fab lines are needed (to produce televisions at any rate) because surely there will come a point at which the average-sized FPD TV is "large enough." At that point, bigger glass substrates would simply allow for more of the same size products to be produced from one piece. The question for LCD producers is if there is a market beyond televisions that demands even larger displays and whether or not such a market is already being served by technologies that have more cost-effective scaling abilities, such as PDP, LED, and projection technologies (both rear and front). Certainly, because substrates have grown larger over the years, new applications have been discovered and have moved from smaller-sized notebook PCs to desktop monitors to TVs, with digital signage being the next logical step.

One of the most visible applications of this OOH signage is the poster-type advertising seen in airports, malls, and nearly any public space imaginable. These posters are ripe for replacement by digital technology for the following reasons: they already have pre-defined dimensions (typically 60–80+ in. diagonals); the vendors associated with these displays would seemingly profit by updating the content dynamically; and the ecosystem for this type of public-space advertising seems to be well-established. Increased production of PDP and larger LCD glass substrates planned in the near and long term seems to be helping to make this vision a reality. So, using LCD production as a template, digital signage really does seem to be poised to become the next major large-area application for FPD technology (Fig. 1).

Digital-Signage Market Is at the "Frontier" Stage

Digital signage has caught the attention of the likes of Intel, Microsoft, Cisco, H-P, and others. Intel and Microsoft are even bullish enough on the technology to be spending money on demonstrations showing the power of digital signage in retail. In 2010, these two companies have been showcasing an in-store kiosk, with elements ranging from large-sized LCDs, to touch activation and interaction, to gender and ethnicity recognition.

While such efforts are important to create awareness of the category and provide manufacturers and vendors with concepts of what might be, other vendors have already been actively participating in making this market, though still quite fragmented, a reality. Behind some of the most visible digital-signage installations are major players in the FPD market, including Samsung, Panasonic, NEC, LGE, and others. An example of what many companies in the digital-signage value chain mean when they say "digital signage" is

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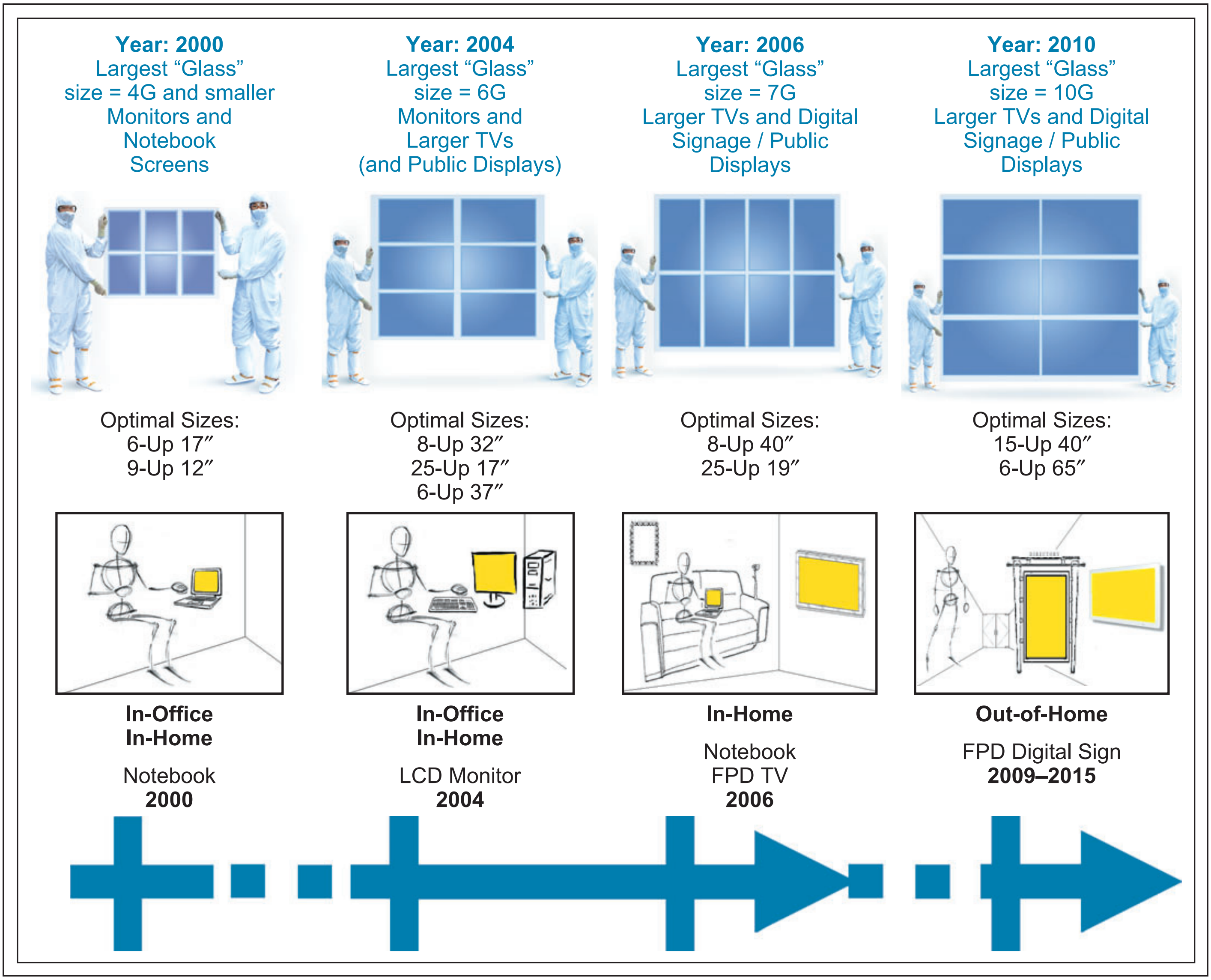

Fig. 1: *Out-of-home signage is a logical next step in LCD evolution from a production standpoint. Source: DisplaySearch and Corning Incorporated.*

the fully functional – and revenue-producing – installation at JFK airport (Fig. 2). This initiative was a collaborative effort among many players, but most notably Samsung, with its commercial-grade 70-in. LCD panels and leading OOH advertising company JCDecaux. The 40–70-in. displays not only provide a glimpse of what all airport and mall concourse signage might look like in the future, but also represent a real-life demonstration of digital signage in action. The messaging on the screens can be controlled dynamically, thus allowing JCDecaux to quickly alter a message for its advertisers, split up the messaging on the screens by time of day (called day-parting), and even tap into emergency alert systems.

The industry is also beginning to examine the OOH market beyond indoor applications and is looking outdoors, even for smaller-sized applications (compared to large LED-based billboard-type displays). Mainstream technologies such as TFT-LCD and PDP have not been considered optimal for outdoor usage due to their limited sunlight readability and sensitivity to harsh environments. However, as ruggedization improves, flat-panel manufacturers are now looking at applications including bus shelters, outdoor train platforms, or city-centric way-finding or advertising on street furniture (Fig. 3). Successful deployments of super-large-scale LED billboards can be seen throughout many major metropolitan areas across the globe, but replacements for the 65–85-in. 4–6-sheet printed poster boards used for bus shelters have been difficult to match in an electronic format that works well outdoors using flat panels. The aforementioned advances in ruggedization, as well as seamless tiling of these displays, may soon make these transitions to digital formats easier and more affordable.

Fig. 2: This signage installation at JFK Airport was created by out-of-home advertising company JCDecaux and uses 40–70-in. LCDs from Samsung. Picture property of JCDecaux.

Growth of the Large-Format Commercial Display Market

The large-format commercial display market (consisting of 26+-in. LCD and PDP products used in commercial applications) is one of the fastest-growing segments in the display industry. Just the display segment of this market is forecast to grow at a 24% compound annual growth rate (CAGR) from 2007 to 2015 and to exceed 7 billion in unit volume shipments by 2015 (Fig. 4). But this growth will not be without challenges.

The OOH Advertising Market

Much has been learned over the years in trying to reach the low-hanging fruit of digital signage – replacing Mylar poster boards in airports and malls with FPDs, for example. This segment of the OOH advertising market is dominated by large advertising companies not generally known to the FPD industry, such as Clear Channel Malls, Clear Channel Outdoor, Clear Channel Airports, CBS Outdoor, JCDecaux, and Titan Worldwide, which have all been in the OOH advertising business for decades. A close look at advertisements on the walls of any airport or mall will generally reveal the "owners" of these advertising spaces. Most of these companies have 10-year contracts on the space and make money out of selling it to their client base (typically through advertising agencies).

Even if these companies are tempted to "go digital," the investment required to replace printed posters with flat-panel displays is massive, even with FPD prices falling. Arguments abound as to how much more

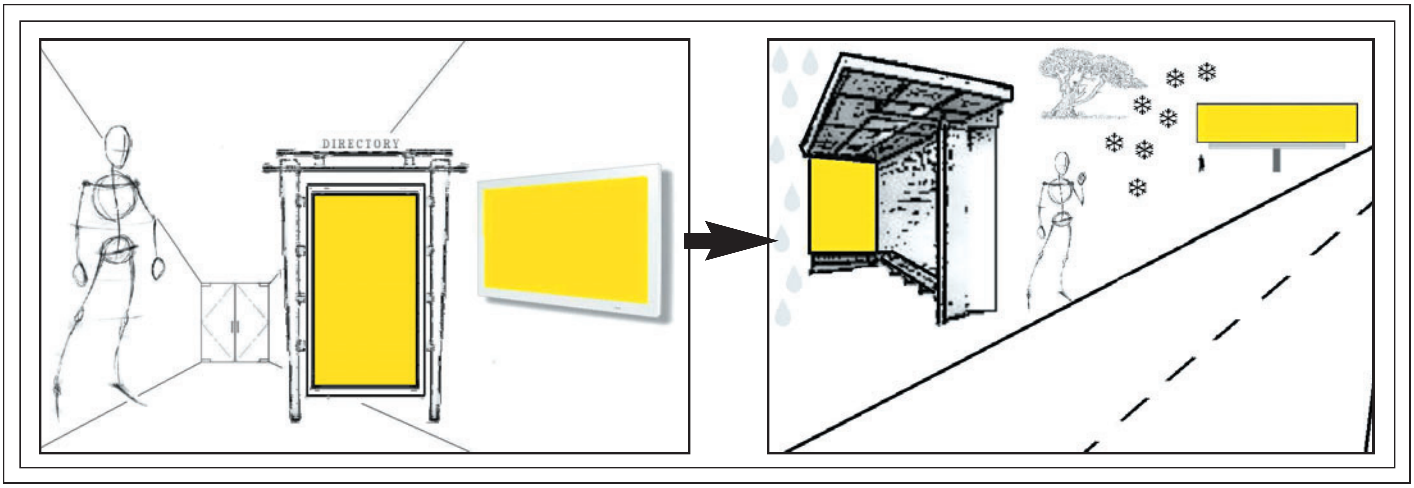

Fig. 3: Technological advances are making the movement of flat-panel signage from indoors to outdoors a greater possibility. Source: DisplaySearch.

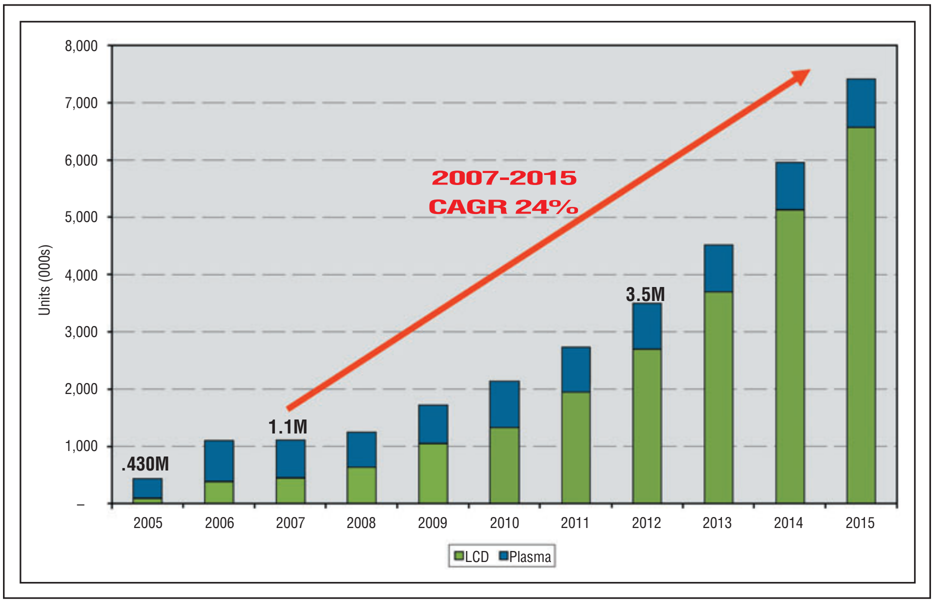

Fig. 4: The worldwide large-format commercial flat-panel-display market is forecast to grow aggressively over the next 5 years. Source: DisplaySearch Q4 '09 Quarterly FPD Public Display Shipment and Forecast Report.

these companies can make by "time slicing" their ads so that they can, for example, sell three ads on one display within a day rather than just one a week (for example, an ad for coffee in the morning, a snack at lunch time, and a dinner special in the evening). Advertising companies all have some sort of digital-signage initiative and even refer to the market as the Digital-Out-of-Home (DOOH) market. Many look favorably toward existing display technologies, especially "commercial grade" products, which are customized for harsh environments and 24 × 7 usage, but still are not convinced of the ROI involved in swapping out printed posters with digital signs. The advertising world has also not escaped the impact of the global recession, thus making it even more difficult for such companies to make the investment to go all-digital.

A further challenge for DOOH is the lack of standards and interoperability. Up until now, the digital-signage market has been the "wild west," with many companies, both big and small (but mostly small) putting up their own type of installation. If they want to attract advertisers to their network, then they need to make all advertisers aware of the existence of their network and its audience reach, in terms that the advertising community can understand. Traditional media such as radio, TV, newsprint, and magazines all have established and audited metrics for pricing and measuring audience awareness typically classified by cost-per-thousand (CPM) (not million) viewers. Such metrics are just now being defined by various digital-signage trade organizations, but have yet to become widely accepted. With so many different digital advertising networks available, certain companies have become key data aggregators, which advertising agencies can leverage to find similar DOOH installations without having to contract with each one. Forward-thinking display companies such as NEC have also launched initiatives that allow for open platforms for one network to talk to another, thus eliminating the infrastructure barrier.

Information Portals

Digital signage is often associated with digital advertising, but other applications such as multi-use displays for mass transit, emergency-response boards, general-information points on college campuses, and electronic menu boards may offer even more growth potential in the near term, as digital-signage advertising models continue to develop. New opportunities could arise through the American Recovery and Reinvestment Act, which allotted an estimated $8.4 billion to the Department of Transportation; it is likely that a significant portion of this will be spent on IT, including electronic public displays/digital signage. In addition, the need for consumers to reduce fuel consumption and pollution means more people are leveraging mass-transit alternatives in metro areas. There are many projects with FPDs in public places on the drawing board, with proposed uses including advertising, train schedules, and homeland security in locales such as subways/train stations, ferries, or bus stops. In total, the use of digital displays in out-of-home markets, whether for information or for advertising, is on the rise worldwide. ■

Symposium Preview

Plan your visit to Display Week 2010 with an advance look at some of the most exciting developments that will be revealed in the symposium's extensive collection of display-technology sessions.

by Jenny Donelan

IT IS NEVER EASY to choose the papers that will be presented at the Society for Information Display's annual Symposium at Display Week. Nevertheless, the 13 subcommittees have done their work: this May, in Seattle, cutting-edge research, ingenious manufacturing ideas, and brilliant solutions to ongoing design problems will all be disclosed by top researchers as they share their results with the rest of the international electronic-display community at Display Week 2010.

The following is a list of session highlights by subcommittee, which includes active-matrix devices, applications, applied vision, display electronics, display manufacturing, display measurement, display systems, emissive displays, field-emission displays, flexible displays, liquid-crystal technology, OLEDs, and projection. In addition to the session topics listed here, the Society for Information Display has also designated special topics of interest for Display Week 2010. These include touch technology, green technology, 3-D, and solid-state lighting. For more on touch and green technology, see the First Look articles in the March 2010 issue of *Information Display* magazine. First Look pieces on 3-D and solid-state lighting appear in this issue.

Active-Matrix Devices: Momentum Builds for Oxide Conductors

The most exciting trend to surface in last year's active-matrix submissions was the use of oxide-semiconductor technology as a replacement for silicon-semiconductor technology. In fact, this very section began last year with the question: "Can oxide thin films substitute for silicon?" Based on this year's papers, the answer would seem to be "yes," according to subcommittee chair Roger Stewart, President, Sourland Mountain Associates.

"Everything seems to be moving toward tin-oxide," he says, citing several submissions as evidence, but, in particular, "*Highly Reliable Oxide-Semiconductor TFT for AMOLED Displays,*" by Toshiaki Arai of Sony. "Sony has made the transistors better than anything we've seen before," he says, "and they've taken it all the way into production and made displays with it. There is huge potential here." That potential, he explains, includes cheaper manufacturing costs and lower power consumption. Other papers to watch for in this area include "*Amorphous Oxide TFT Backplanes for Large-Sized AMOLED TVs,*" by Yeon Gon Mo of Samsung Mobile Display, and "*Low-Power LCD Using In-Ga-Zn-Oxide TFTs Based on Variable Frame Frequency,*" by Seiko Amamo of the Semiconductor Energy Laboratory Co., Ltd. Other papers of interest include "*A System LCD with Optical Input Function Using IR Backlight Subtraction Scheme,*" by Kohei Tanaka of Sharp, which describes a new type of low-power-consumption touch screen that uses an infrared backlight subtraction scheme suitable for integration with mobile products. "*A Novel Multi-Level Memory In-Pixel Technology for Ultra-Low-Power LTPS TFT-LCD,*" by Naoki Ueda of Sharp, explains how a high-image-quality low-power-consumption display can be developed by incorporating memory into each pixel.

Applications: Digital Signage Evolves in Many New Directions

Applications are one of the most exciting areas of display technology – where all the research, planning, and hard work come together in the form of real products. This year, popular paper topics include 3-D, solid-state lighting, and digital signage. Many of the most interesting submissions feature digital signage, including "*Technologies and Applications for Large-Sized High-Resolution Tiled-Display System,*" by Sachin Deshpande of Sharp Laboratories of America, which traces the development of the "SharpWall," a 177-in.-diagonal tiled prototype with a 10,000 x 4500-pixel resolution. Other signage papers include "*Interactive and Natural Viewing of Giga-Pixel Images on Large-Sized Tiled Displays,*" by Chang Yuan of Sharp Laboratories of America, which describes how on-screen images can be controlled by viewers' natural movements in front of the display, and Distinguished Paper "*Ultra-Low-Reflective 60-in. LCD with Uniform Moth-Eye Surface for Digital Signage,*" by Tokio Taguchi of Sharp Corp. The anti-reflection surface described in Taguchi's paper incorporates nanostructures based on certain moths' corneal structures, which are covered by sub-wavelength anti-reflection structures.

Also recommended are "*60-in. Highly Transparent See-Through Active-Matrix Display without Polarizers,*" by Eiji Satoh of

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Sharp Corp., which introduces an information display that can substitute for windows in stores and other venues, and "*Large-Area Plasma-Panel Radiation Detectors for Nuclear Medicine Imaging to the Super-Large Hadron Collider,*" by Peter Friedman of Integrated Sensors LLC, which describes a new type of radiation sensor derived from PDP technology.

Applied Vision: Human Factors and Image Quality

Many of this year's most interesting Applied Vision papers focus on image quality and human factors. Among the former are the Invited Paper "*Enhancing the Visible with the Invisible: Exploiting Near-Infrared to Advance Computational Photography and Computer Vision,*" by Sabine Susstrunk of the Swiss Federal Institute of Technology, and "*Factors Affecting Image-Quality Preferences,*" by PremNandhini Satgunam of The Schepens Eye Research Institute at Harvard Medical School. Susstrunk's paper discusses the benefits of using near-infrared (NIR) radiation images in conjunction with standard color images for certain computational photography and computer-vision tasks such as material classification and skin smoothing. Satgunam's presentation reveals the reactions of human subjects asked to state preferences with regard to enhanced video imagery. Preferences for enhancement depended on the content, and particularly on the presence or absence of human faces.

The Applied Vision sessions also feature many 3-D and solid-state-lighting–related papers this year. Both 3-D and solid-state lighting have dedicated sessions in 2010, and some of the most important papers from those sessions are discussed in the First Look articles also in this issue.

An additional Invited Paper of note is "*3-D Technology Development and the Human Factor Effect,*" by Chao-Yuan Chen of AU Optronics Corp., which examines the relationship among 3-D content, display hardware, and human factors.

Display Electronics: A Far-Ranging Support System

Last year, Display Electronics Chair Michiel A. Klompenhouwer remarked that a display had become so much more than just a panel – signal processing, interfaces, and driving technologies were just as important in terms of developing high-image-quality low-power slim-form-factor products. In 2010, this trend has continued, as demonstrated by display-electronics papers covering technologies ranging from LCDs to OLEDs to electronic paper and electronics in areas such as display drivers and interfaces, field sequencing, local dimming, and color management.

Among this year's sessions is one devoted to Multi-Primary Displays, with four papers, and one on Driving Electronic Paper, which includes the Invited Papers "*Drive Systems for Electronic-Paper Displays,*" by Ian French of Prime View International, and "*ID Document Technologies with Bendable AMOLED Displays,*" by Joerg Fischer of Bundesdruckerei GmbH.

Another paper of interest is "*A Monolithic Block-Wise Functional Light Guide for 2-D Dimming LCD Backlight,*" by K. Käläntär of Nippon Leiz, which describes a functional light-guide plate (LGP) that uses recessed V-grooves as semi-partitions between consecutive blocks to realize a backlight unit for a 2-D dimming display. The height of a groove controls the cross-talk between the blocks.

Display Manufacturing: Green Is the "Third Wave"

Green is an extremely important part of this year's symposium (see "Display Week 2010: Green Technology" in the March 2010 issue),

Display Week 2010 at a Glance

TIMETABLE	Sunday Course	Monday Sem	Monday Bus	Tuesday Symp	Tuesday Exh	Tuesday Inv	Wednesday Symp	Wednesday Exh	Wednesday Focus	Wednesday Focus	Wednesday App	Thursday Symp	Thursday Exh	Thursday Focus	Thursday Focus	Friday Symp
8:00 AM - 8:30 AM				SID Bus Mtg												
8:30 AM - 9:00 AM		Seminar 1 - 4	Business Conference	Welcome & Keynote Addresses and Business Conference							App Tut 1-2					
9:00 AM - 9:30 AM	Short Course S1 & S2						Oral Sessions 23-29	Exhibits Open/Exhibitor Forum Sessions	Market Focus Conf.: Future of TVs, Part I	Market Focus Conf.: Future of Lighting		Oral Sessions 44-50	Exhibits Open/ Exhibitor Forum Sessions	Market Focus Conf.: Future of TVs, Part II	Market Focus Conf.: Future of Touch	Oral Sessions 67-73
9:30 AM - 10:00 AM																
10:00 AM - 10:30 AM																
10:30 AM - 11:00 AM		Seminar 5 - 8		Oral Sessions 3-9	Exhibits Open/Exhibitor Forum Sessions	Investors Conference	Oral Sessions 30-35				App Tut 3-4	Oral Sessions 51-57				Oral Sessions 74-80
11:00 AM - 11:30 AM																
11:30 AM - 12:00 PM																
12:00 PM - 12:30 PM			Bus. Conf. Lunch				SID Luncheon & DYA Awards									Auth. Int.
12:30 PM - 1:00 PM																
1:00 PM - 1:30 PM																
1:30 PM - 2:00 PM		Seminar 9 - 12	Business Conference									Oral Sessions 58-64				
2:00 PM - 2:30 PM				Oral Sessions 10-15			Designated Exhibit Time									
2:30 PM - 3:00 PM																
3:00 PM - 3:30 PM	Short Course S3 & S4											Auth. Int.				
3:30 PM - 4:00 PM		Seminar 13 - 16		Oral Sessions 16-22			Oral Sessions 37-43				App Tut 5-6					
4:00 PM - 4:30 PM												Poster Session				
4:30 PM - 5:00 PM																
5:00 PM - 5:30 PM			Bus. Recept.	Auth. Int.		Inv. Recept.	Auth. Int.									
5:30 PM - 6:00 PM																
6:00 PM - 6:30 PM							Special Event					Oral Sessions 65-66				
6:30 PM - 7:00 PM																
7:00 PM - 7:30 PM																
7:30 PM - 8:00 PM				3-D Cinema Session												
8:00 PM - 8:30 PM		Awards Banquet														
8:30 PM - 9:00 PM																
9:00 PM - 9:30 PM																
9:30 PM - 10:00 PM																

and nowhere is this more apparent than in the Display Manufacturing sessions. The Invited Papers "*Green LCD Technologies,*" by Po-Lun Chen of AU Optronics Corp., and "*EcoDesign for TV Displays,*" by Cornelis Teunissen of Philips Consumer Lifestyle, both contain vital information about efforts being made in this critical area of display technology. Chen's paper discusses three "waves" in LCD development. The first was performance; the second, cost-reduction; and the third, the greening of both product and manufacturing processes. Teunissen's paper looks at the eco-challenges faced by the display industry in general and focuses on solutions that can be achieved in the area of TVs in particular.

Another paper of interest is "*A Novel Approach to Make Flexible Active-Matrix Displays,*" by Jang Lin Chen of ITRI, which discusses how a TFT backplane was successfully developed with a polyimide (PI) substrate and a novel de-bonding technology.

Display Measurement: Critical Measurements for 3-D

This year, Display Measurement features oral sessions in two vital and timely areas: 3-D and Contrast and Motion Artifacts. 3-D is of course a hot technology at Display Week this year, and cross-talk between left- and right-eye imagery that degrades the stereoscopic effect is what Display Measurements' Chair Stephen Atwood describes as "a fundamentally critical concern" for stereoscopic displays. "The principle challenge is finding ways to measure stereoscopic displays in terms of things that matter," he says. Three display-measurement papers that aim to do just that are "*Crosstalk Simulation for Polarization-Switching 3-D LCD,*" by Youngji Ko of Samsung Electronics Co., Ltd., "*Crosstalk Suppression by Image Processing in 3-D Displays,*" by Yu-Cheng Chang of National Chiao Tung University, and "*Crosstalk Evaluation of Shutter-Type Stereoscopic 3-D Displays,*" by Cheng-Cheng Pan of Chi Mei Optoelectronics Corp.

A companion session, notes Atwood, similarly investigates autostereoscopic (3-D with no glasses) display measurements. Of particular interest here is "*Characterization of 3-D Image Quality of Autostereoscopic Displays: Proposal of Interocular 3-D Purity,*" in which Tsutomu Horikoshi of NTT DOCOMO proposes the concept of "interocular 3-D purity" to indicate the image quality of autostereoscopic displays.

Another paper of interest is "*Proposal of Evaluation Method for Local-Dimming Backlights,*" by Hideki Ichioka of Sharp Corp., which explains a defect named "halo" that is specific to displays with local-dimming backlights, and proposes a method to evaluate the defect.

Display Systems: HUDs, HMDs, and More

3-D was the big news in last year's Display Systems track – so much so that for 2010, 3-D has its own dedicated sessions. This year, with 10 sessions covering not only 3-D, green technology, and solid-state lighting in joint sessions, but HMDs (head-mounted displays) and HUDs (head-up displays), LED backlighting, and novel and emerging display technologies, the Display Systems track has a great deal going on.

In the HMDs and HUDs session, the Invited Papers "*Modern Cockpit Displays and Concepts,*" by Jean-Noel Perbet of THALES Avionics, and "*Head-Mounted Display: Optical Design,*" by Jannick Rolland of the University of Rochester, cover, respectively, a human-centered cockpit system designed to improve overall safety, and a new design for an HMD.

Other papers of note are Distinguished Paper "*Control of Subjective Depth on 3-D Displays by a Quantified Monocular Depth Cue,*" by Shuichi Takahashi of Sony Corp., which considers the architecture and effectiveness of new algorithms that handle the subjective depth of 3-D displays, and "*LED Backlighting for LCD TVs,*" by Winfried Schwedler of Osram Opto Semiconductor, which provides an overview of the issues surrounding the fast-growing market for LED-backlit LCD TVs.

Emissive Displays: Plasma Prevails

"Plasma displays continue to be a growing application area and the papers in this area dominate EMD," says Emissive Displays Chair Gerrit Oversluizen from Philips Research Laboratories. "A lot of research is aimed at continuing the decrease in power consumption that is particularly relevant for large screen sizes. These developments go hand in hand with less material use; *i.e.*, an increasingly green technology." On the technical side, he notes, this impetus involves increasing the xenon content of the gas mixture and implementing protective layer improvements as well as electronics and driving adaptations.

He also observes that "plasma displays are starting to explore 3-D applications. Plasma-display technology, with its relatively fast response time, appears rather suited for this application." Consequently, a paper not to be missed is "*Development of High-Performance Panel and High-Speed 3-D Driving Technology for the World's First Full-HD 3-D Plasma Displays*," by Mitsuhiro Ishizuka of Panasonic

Other papers to watch for are "*Very Sensitive Measurement Method of Plasma-Display Exoemission*," an Invited Paper by Larry Weber, and "*A Consideration of Excitation and De-excitation Process of MgO Protective Layer,*" by Hiroshi Kajiyama of Hiroshima University, which discusses the dynamics of trapped electrons and holes in the protective layers of ACPDPs, which are important to an understanding of the electron emission mechanism.

Field-Emission Displays

Field-emission-display (FED) color-TV projects, once a focus for many display companies, are no longer much in evidence at Display Week, but this year's submissions show ongoing FED research in a number of promising areas. Among these submissions are the Invited Paper "*Full-Color Quantum Dot Display,*" by Byoung Lyong Choi of Samsung Electronics Co., Ltd., which discusses advanced pattering methods for large-area full-color quantum-dot displays and Distinguished Paper "*Switching of Carbon-Nanotube Emitters with Integrated MOSFETs,*" by Kyu Chang Park of Kyung Hee University, which provides an investigation of the use of metal-oxide-semiconductor field-effect transistors (MOSFETs) for stabilizing and controlling emission currents.

Another paper of interest is "*Fabrication and Properties of Planar-Gate-Type Triode with CNT Emitters for Backlight Units,*" by Yong Zhang of Fuzhou University," which presents a description of how a planar-gate-type triode with CNT emitters was fabricated with photolithography, wet etching, and electrophoresis deposition.

Flexible Displays: Color Comes Closer

In 2009, due to the ever-increasing number of flex-related submissions, Flexible Displays had its own dedicated sessions for the first time. This year, the submissions relating to electronic paper, flexible-display manufacturing, and flexible backplanes have continued to

Symposium at a Glance

2010 Display Week Symposium at a Glance – Washington State Convention and Trade Center

Day	Times	Ballroom 6B	Ballroom 6C	Ballroom 6E	Room 608-610	Room 611-612	Room 615-617	Room 618-620	Times
Tuesday, May 25	8:00 – 10:20	SID Business Meeting and Keynote Session (Ballroom 6E)							8:00 – 10:20
Tuesday, May 25	10:50 – 12:10	3 Polarization-Based Stereoscopic Displays (Joint with Projection)	4 Active-Matrix Integration	5 OLED Fundamentals	6 Display Drivers and Interfaces	7 Blue-Phase Devices I	8 Image Quality	9 Green Technologies in Display Manufacturing (Joint with Manufacturing)	10:50 – 12:10
Tuesday, May 25	2:00 – 3:20	10 Crosstalk in Stereoscopic Displays (Joint with Measurement)		11 OLED Devices I	12 Color Sequential (Joint with Systems)	13 Blue-Phase Devices II	14 Contrast and Sharpness	15 Low-Power e-Paper & Other Bistable Displays (Joint with Liquid-Crystal)	2:00 – 3:20
Tuesday, May 25	3:40 – 5:00	16 Autostereoscopic Displays (Joint with Systems)	17 TFT Processing	18 OLED Devices II	19 Multi-Primary Displays	20 Cholesteric Displays	21 Field-Emission Displays and Emitters	22 Novel Power Reduction Techniques	3:40 – 5:00
Tuesday, May 25	5:00 – 6:00	Author Interviews (Exhibit Hall)							5:00 – 6:00
Wednesday, May 26	9:00 – 10:20	23 Autostereoscopic Display Measurements	24 Novel Pixel Design	25 OLED Devices III	26 Driving Electronic Paper	27- Ferroelectric Liquid-Crystal Devices	28 Emissive Displays	29 Power-Saving Device Designs (Joint with Systems)	9:00 – 10:20
Wednesday, May 26	10:40 – 12:00	30 2-D/3-D Switching for Autostereoscopic Displays	31 Touch-Technology Development	32 OLED Material I	33 Electronic Paper I	34 IPS Technology	35 Exo-Emission		10:40 – 12:00
Wednesday, May 26	2:00 – 3:30	Designated Exhibit Time (Exhibit Hall)							2:00 – 3:30
Wednesday, May 26	3:30 – 4:50	37 Human Factors of 3-D Displays (Joint with Applied Vision)	38 Multi-Touch Systems and Developments	39 OLED Material II	40 Electronic Paper II	41 Liquid-Crystal Alignment	42 PDP TV	43 Technologies in Active-Matrix Devices (Joint with Active-Matrix)	3:30 – 4:50
Wednesday, May 26	5:00 – 6:00	Author Interviews (Exhibit Hall)							5:00 – 6:00
Thursday, May 27	9:00 – 10:20	44 Volumetric and Integral Imaging (Joint with Systems)	45 Display-Embedded Touch Solutions	46 OLED Manufacturing (Joint with Manufacturing)	47 Flexible OLEDs (Joint with OLEDs)	48 VA-Mode LCDs I	49 Protective Layer	50 Measuring Contrast and Motion Artifacts	9:00 – 10:20
Thursday, May 27	10:40 – 12:00	51 3-D TV and 3-D Video	52 OLEDs for Lighting Applications (Joint with OLEDs)	53 AMOLEDs I	54 Flexible-Display Manufacturing I (Joint with Manufacturing)	55 VA-Mode LCDs II	56 Novel and Emerging Display Technologies	57 HMDs and HUDs	10:40 – 12:00
Thursday, May 27	1:30 – 2:50	58 Novel 3-D Displays (Joint with Systems)	59 Solid-State Lighting (Joint with Applications)	60 AMOLEDs II	61 Flexible Backplanes I	62 Nanostructure Enhanced Liquid- Crystal Devices	63 Display Manufacturing: Reflective Technologies	64 Novel Near-to-Eye and Heads-up Displays	1:30 – 2:50
Thursday, May 27	3:00 – 4:00	Author Interviews (Exhibit Hall)							3:00 – 4:00
Thursday, May 27	4:00 – 5:20		65 Projection Lighting (Joint with Projection)						4:00 – 5:20
Thursday, May 27	4:00 – 8:00	Poster Session (Exhibit Hall)							4:00 – 7:00
Thursday, May 27	5:40 – 7:00		66 Lighting Materials and Applications (Joint with Emissive)						5:40 – 7:00
Friday, May 28	9:00 – 10:20	67 High Dynamic Range (Joint with Electronics)	68 Lighting Design (Joint with Systems)	69 Oxide TFTs I	70 Flexible-Display Manufacturing II (Joint with Flexible)	71 Projection Components	72 Display Manufacturing: Testing	73 Emerging Display Applications	9:00 – 10:20
Friday, May 28	10:40 – 12:00	74 LED Backlighting	75 Displays and Lighting Technologies (Joint with Applied Vision)	76 Oxide TFTs II	77 Flexible Backplanes II	78 Mobile Projection	79 Display Manufacturing: Processing	80 Digital Signage	10:40 – 12:00
Friday, May 28	12:00 – 1:00	Author Interviews (Exhibit Hall)							12:00 – 1:00

TECHNOLOGY TRACKS KEY

3-D	Active-Matrix Device	Applications	Applied Vision	Electronics	Emissive
FEDs	Flexible	Green	Lighting	Liquid-Crystal	Manufacturing
Measurement	OLEDs	Projection	Display Systems	Touch	

roll in. Several offerings outline new types of e-readers, and at least five tackle perhaps the hottest of flexible-display issues: color. Papers on color include "Large-Sized Full-Color eReader Displays Based on Electro-wetting," by Johan Feenstra of Liquavista BV, "*Flexible Electrofluidic Displays Using Brilliantly Colored Pigments,*" by Kenneth Dean of Gamma Dynamics, "*4.8-in. QVGA Color Reflective AMPDLCD Driven by Printed OFETs,*" by Joo Young Kim of Samsung Electronics Co., "*Research of Various Mode Color PDLC Structures for Flexible Reflective Display,*" by Jae-eun Jang of Samsung Advanced Institute of Technology, and the Invited Paper "*Dyed Polymeric Microparticles for Color Rendering in Electrophoretic Displays*" by Mark Goulding of Merck Chemicals, Ltd. Goulding's presentation will describe how, when formulated as colloidal dispersions in low dielectric media, a range of dyed polymeric microparticles with tunable size, charge, and color can be developed that is suitable for use in full-color or monochrome electrophoretic displays.

Other papers of interest include "*ZnO TFTs and Circuits on Flexible Polymeric Substrates by Low-Temperature PEALD*," by Thomas Jackson of Penn State University, which reports on the use of a novel, weak-oxidant plasma-enhanced atomic-layer-deposition (PEALD) process at 200°C to fabricate stable, high-mobility ZnO TFTs and fast circuits on glass and polyimide substrates. "*High-Performance Organic-Inorganic Hybrid Plastic Substrate for Flexible Displays and Electronics*," by Jia-Ming Liu of ITRI, reports on an inorganic dominated silica/polyimide (PI) hybrid film that has been successfully developed for the fabrication of flexible AMOLEDs.

Liquid-Crystal Technology: Greener, Better Optical Performance, Lower Cost

Liquid-crystal technology is mature and well-established, according to Chair Birendra Bahadur of Rockwell Collins. It is the standard by which other display technologies must be measured and is, though continuously improving, not in a time of great transition. "The only evolutionary topic in LCT is blue-phase LCDs," says Bahadur. Accordingly, a Distinguished Student Paper that symposium goers should be sure to check out is "*Low-Voltage Blue-Phase LCDs with Patterned Electrodes,*" by Linghui Rao of the University of Central Florida, which outlines an approach that would enable blue-phase LCDs to be driven by a-Si TFTs.

While other changes to LCDs are incremental, they are not inconsequential, particularly at a time when both governments and consumers are demanding greener products. "Displays are becoming greener and more environmentally friendly," says Badahur. "Newer LCDs are cutting the power consumption, weight, and cost substantially." One example of advances in this area is the recommended paper, "*Development of Low Haze VA Compensation TAC Film and Proposal of Compensation Film Arrangement for Improving CR in VA Panel,*" by Eiichiro Aminaka of FUJIFILM, which aims at enabling high-contrast ratio, low-power-consumption LCDs. Last, Badahur continues, viewing angle, color gamut, and video performance are better than ever. "And, LCDs are becoming cheaper and more affordable, even to consumers in very-low-income parts of the world."

Other papers of interest include "*The World's First Photoaligned LCD Technology Applied to Gen 10 Factory,*" by Koichi Miyachi of Sharp, which describes a factory procedure that improves the transmittance, contrast ratio, and response time of LCD TVs. "*A Novel Hole-Induced Vertical-Alignment LC Mode with Superior Transmittance,*" by Yong Kyu Jang of Samsung Electronics, outlines a new liquid-crystal mode, refered to as the Hole-Induced Vertical-Alignment (Hi-VA) mode, which uses a via hole of an organic layer on a TFT substrate to achieve multi-domain alignment.

OLEDs: Moving Beyond Mobile Phones

"This year, we're seeing OLEDs deployed in more non-conventional and unique applications, beyond just mobile devices/TVs," says Eric Forsythe, new OLED subcommittee chair. The technology is starting to mature to a point where we can start building demonstrators and go beyond conceptual drawings into actual applications. There's also a strong green story because of OLEDs' low power consumption. In all, OLEDs open up new design spaces and opportunities, such as the foldable applications and ultimately flexible and rollable ones. From a manufacturing perspective, one of the reasons that folks push hard on OLEDs is the potential for low-cost manufacturing, provided that some technical hurdles are overcome."

One of the papers to look for, according to Forsythe, is Distinguished Paper "*LTPS-Based Transparent AMOLED,*" by Young Woo Song of Samsung. Transparent-display technology might be used for, among other applications, store windows, personal navigation devices with augmented reality, and automobile displays mounted in windshields. Says Forsythe," Samsung has fabricated a nice-looking display for a notebook PC that is reasonably transparent (38%) and will be demonstrating both the technical results and the actual display itself. This should create a lot of buzz." Another strong paper is "*The High Performance Scalable Display with Passive OLEDs,*" by Nobuo Terazaki of Mitsubishi Electric Corp., which discusses the development of large-area OLED displays for billboards and other signage. "This is just another example of how we're looking at OLEDs for non-conventional applications beyond mobile and television."

Another recommended paper is "*A New Seamless Foldable OLED Display Composed of Multi Display Panels,*" by HongShik Shim of the Samsung Advanced Institute of Technology, which describes the creation of a foldout display (for larger viewing area) for mobile devices and similar applications.

Projection Displays: Large and Small

Projection submissions for 2010 cover a gamut of technologies: stereoscopic projection displays, solid-state lighting, mobile projection, and projection components. One of the most significant offerings in this area is the Invited Paper "*The Physics and Commercialization of Dual Paraboloid Reflectors for Projection Systems,*" by Kenneth Li of Wavien, Inc., which discusses how dual paraboloid reflectors (DPRs) work as imaging devices, as well as the advantages of DPRs.

Other papers of interest include Invited Paper "*High-Resolution Microdisplays for Pico-Projectors,*" by Karl Guttag of Syndiant, which outlines how higher-resolution microdisplays have been developed by using liquid crystal on silicon (LCOS) combined with a distributed memory and digital processing. The Invited Paper "*Speckle Suppression by Means of Ferroelectric LC Cell,*" by Igor N. Kompanets of Lebedev Physical Institute of RAS, discusses how unwanted speckle-noise can be eliminated.

Come Get Inspired

Last year, touch, solid-state lighting, 3-D, and green technology came to the front as exciting new areas of display technology.

Consquently, SID has added new sessions in these areas. But great discoveries and advances are taking place everywhere in the display industry. The Symposium is an excellent place to learn about new manufacturing processes and materials that could give your business the edge it needs. You might just discover something completely invaluable and unexpected. Come get inspired at Display Week 2010. ■

Solid-State Lighting Will Shine at Display Week

For the first time in the history of Display Week, the Society for Information Display has designated official sessions for solid-state lighting. They are OLEDs for Lighting Applications, Solid-State Lighting, Projection Lighting, Lighting Materials and Applications, Lighting Design, and Displays and Lighting Technologies.

by Jenny Donelan

FROM the technically inaccurate but highly effective "LED TVs" moniker used to promote LED–backlit LCD TVs at major stores, to the energy-efficient and often colorful home and industrial lighting applications that use OLEDs and LEDs, solid-state lighting is a technology that cannot be ignored. Both LEDs and OLEDs are solid-state semiconductor devices that are generally more durable than conventional incandescent or fluorescent light sources. They also show promise in terms of efficacy and lifetime and do not contain mercury, thus offering environmental benefits.

In recent years, LEDs have increasingly been used as the backlight source for LCDs. In this capacity, in two-dimensional arrays, they offer local dimming, which can be used to adjust the amount of light energy needed in each region of the display to provide the best image contrast, as well as to reduce total energy needs – something on everyone's minds these days with the latest generation of large-area TVs. Even when not used as two-dimensional arrays, LEDs provide advantages as backlights by virtue of their increased luminous efficiency over cold-cathode fluorescent lamps (CCFLs) as well as their small form factor and wider operating-temperature range. Similarly, LEDs offer inherent advantages over both incandescent and compact fluorescent (CF) bulbs for general-lighting environments, where they are much more energy efficient than filament lamps and much less affected by ambient and operating temperature than CF lamps.

Also on the horizon for lighting and displays are OLEDs, which for display applications are inherently attractive as self-emitting arrays that can be made at the same or even higher pixel densities as LCDs. Companies that have already introduced OLED display products include Sony, Panasonic, Samsung, and LG. OLEDs are also just starting to be deployed as architectural light sources, where they offer an array of benefits similar to LEDs along with the ability to define shapes and forms more easily.

This year, as solid-state backlighting becomes increasingly sophisticated, and solid-state-lighting manufacturers are busily developing new applications for their technology, the Society for Information Display found it appropriate to devote sessions to solid-state lighting. The 2010 technical symposium includes six sessions that cover a range of solid-state-lighting topics, from general illumination to projection to backlighting, and more. "It was important for SID to create a lighting committee to bring new ideas about light sources, technologies, and related devices and systems into our community," says Dr. Kälil Käläntär, this year's Solid-State-Lighting Program Vice-Chair.

Trends and Highlights

In basic terms, the big challenges in solid-state lighting are generating light and then extracting the light from that source, according to Käläntär. "Color rendering, efficiency, and light extraction are the issues we face in both LED and OLED development. In the case of LEDs, making a line or surface from the point source without losing energy is the big challenge. For OLEDs, it is shaping the light." Several of this year's papers take an overview of progress in solid-state lighting. Two to watch for are the invited papers, "On the Recent Progress of LED Lighting in Japan" by Toshiba Lighting and Technology Corp.'s Kiyoshi Nishimura, and "The Many Roles of Illumination in Information Display," by Lorne Whitehead of the University of British Columbia.

Another area to check out is projection, a technology that has greatly benefited from solid-state lighting, which has allowed devices to become smaller and provide better imagery. A full session has been designated for Projection Lighting, which includes presentations on laser-based projectors as well as the paper "High-Brightness LED-Based Projector with NTSC 120% Wide Color Gamut."

Obviously, LED backlighting and OLEDs will be important topics at Display Week 2010, and visitors should not miss the invited papers "Remote Phosphor for Future LED Backlights and Lighting Applications" by Wen-Chi Chang of KISmart and "Highly Efficent White Top-Emission PIN OLEDs for Displays and Lighting" by Jan Birnstock of Novaled AG.

Papers that examine how developments in solid-state lighting for displays have been

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leveraged for more general applications include "LED Drivers: From Displays to General Lighting" by Michael Kretzmer of Endicott Research Group, and the invited paper "LEDs: From Displays to Lighting" by Dragan Sekulovski of Philips Research Europe. Sekulovski's presentation will provide an overview of problems in temporal control and spatial-light-distribution perception with regard to both displays and general lighting.

Last but not least, two papers in the joint session (with Applied Vision) Displays and Lighting Technologies examine lighting in terms of human factors. "Is Brighter Always Better? The Effects of Display and Ambient Luminance on Preferences for Digital Signage" by Pearl Guterman of York University in Toronto reports on the responses of observers asked to rate natural images while luminance and ambient lighting varied. "Evaluation of Human Reactions on Displays with LED Backlight and a Technical Concept of a Circadian Effective Display" by Oliver Stefani of Fraunhofer IAO compares the effects of LED *vs*. CCFL backlit displays on humans.

Don't Be Left in the Dark

To find out the surprising answers to the questions posed in the above two papers, be sure to attend these and the other solid-state-lighting sessions at this year's symposium. The lighting industry as a whole is in a state of rapid change, and this affects the display industry on many levels. "Solid-state light sources have changed the LCD backlight from a static and passive role to a dynamic and active one," says Käläntär. And in terms of more general-lighting applications, he continues, technologists would do well to think beyond the current lighting infrastructure in order to put the current and next-generation of solid-state lighting to best possible use. ■

3-D Goes Deep at Display Week 2010

In recent years, Display Week has featured special sessions to demonstrate 3-D. For 2010, with the technology clearly on the commercial horizon, the Society for Information Display has designated dedicated sessions for 3-D papers. The 2010 technical program will feature nine sessions on 3-D technology: Polarization-Based Stereoscopic Projection Displays, Crosstalk in Stereoscopic Displays, Autostereoscopic Displays, Autostereoscopic-Display Measurements, 2-D/3-D Switching for Autostereoscopic Displays, Human Factors of 3-D Displays, Volumetric and Integral Imaging, 3-D TV and 3-D Video, and Novel 3-D Displays.

by Jenny Donelan

WHILE 3-D display technology is far from new – Victorian-era stereoscopes and the 3-D horror/fantasy films of the early 1950s come to mind – the technology's recent momentum is something new indeed. The question of whether to see a new animated film in the 3-D or "regular" version is now commonplace in many parts of the world. According to the Associated Press, 20 movies were released in 3-D in 2009, as compared to eight in 2008; and 3-D cinema screens in the U.S. and Canada more than doubled from 1514 to 3548. Although 3-D films amounted to only 4% of the 558 films released last year, they accounted for 11% of the total box office.[1] Smaller screen makers are eager to catch part of the action as well. 3-D TVs were much in evidence at the Consumer Electronics show in Las Vegas earlier this year, and many manufacturers have announced new 3-D products, with retail giants such as Best Buy and Wal-Mart either selling or announcing plans to sell 3-D TVs later this year[2] (see Fig. 1 for a recent example from LG).

The above market activity, at least in the case of cinema, represents a resolution of the "chicken or egg" conundrum common to many technologies before they gain traction: A 3-D display is only as good as its content. Display manufacturers desired a critical mass of high-quality 3-D content prior to committing significant resources to 3-D display products, while content creators wanted consumers to have easy access to compelling 3-D

***Fig. 1:** LG is just one of many TV manufacturers that have announced 3-D models in recent months. Shown above is the LX9500, launched in Korea in March 2010 and scheduled for distribution in Europe and North America in May 2010. (Image courtesy LG.)*

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displays before prioritizing development of stereoscopic content. Now, notes Brian Schowengerdt, SID Technical Program Vice-Chair for 3-D and a Senior Research Scientist in the Department of Mechanical Engineering at the University of Washington, the industry is reaching the point at which display developers are beginning to feel confident that there will be enough 3-D content to drive the market, and vice versa. 3-D cinema system developer RealD was instrumental in building confidence in both theater owners and content creators that there would be strong bilateral ramp-up, while prominent figures such as director James Cameron have provided high-profile examples for filmmakers, he notes. The recent surge in 3-D filmmaking has in turn created a critical mass of content that is being used to seed the home-entertainment market. In the home 3-D arena, many major manufacturers (Samsung, Sony, and LG) have started moving toward (or are already) producing 3-D TVs. Sony has come out in the most public way, announcing that 3-D will be a major focus across the company, spanning many product platforms (TV, gaming, and video capture).[3]

3-D Sessions

For the above reasons, and due to the high volume of 3-D-related paper submissions, SID has added a dedicated 3-D session track to this year's symposium. "For the past few years, we had been noting an increase in the number of 3-D related papers," says Schowengerdt. Anyone following 3-D who wanted to track down all those papers, however, faced a challenge; they were not in any one session or place. "3-D displays really cut across all the topical areas," says Schowengerdt. In fact, out of this year's nine 3-D sessions, seven are joint sessions, with projection, display measurement, applied vision, and other areas.

Trends: 3-D TVs and Autostereoscopic Displays

Not surprisingly, one of the main trends for papers at this year's symposium is 3-D TV development. There is a session completely devoted to 3-D TV and 3-D Video, for example. Two papers to watch for here, according to Schowengerdt, are "Novel Simultaneous Emission Driving Scheme for Crosstalk-Free 3-D AMOLED TV" from Baek-Woon Lee of Samsung Mobile Display, and "New 240-Hz Driving Method for Full-HD and High-Quality 3-D LCD TV" by Dae Sik Kim of Samsung Electronics Co. In the video realm, "An Ultra-Low-Cost 2-D/3-D Video Conversion System" by Chao-Chung Cheng of National Taiwan University and "3-D Video Framework Design for FVV Realization" are also important papers.

Another major topic that will be addressed from several directions at SID is autostereoscopic displays. Even though consumers have proved surprisingly willing to don special glasses in order to see moves such as *Avatar* in 3-D, for example, the urge to make this eyewear obsolete is strong. "The 'Holy Grail' is a high-fidelity, compelling 3-D display that does not require glasses," says Schowengerdt.

Three papers that will examine the trend of developing a directional backlight for glasses-free viewing are "Backlight for View-Sequential Autostereoscopic 3-D" from Adrian Travis of Microsoft, and "Directional Backlight Lightguide Considerations for Full Resolution Autosterescopic 3-D Displays" and "Directional Backlight Timing Requirements for Full-Resolution Autostereoscopic 3-D Displays," both from John Schultz of 3M. These papers are of note for a couple of reasons, says Schowengerdt. First, the latter two represent 3M's recent strong investment into 3-D. Second, all three represent efforts toward steering images to the right and left eye using the backlight rather than using a lenticular array over the screen. This enables the full resolution of the panel to be used.

Also of interest is "Prototyping of Glasses-Free Table-Style 3-D Display for Tabletop Tasks" by Shunsuke Yoshida of the National Institute of Information and Communications Technology in Japan. The paper explores the special considerations necessary when embedding a 3-D display in a horizontal tabletop surface, rather than orienting it vertically it on a wall or stand. The novel display is an inversed cone that is recessed into a round table around which viewers can sit. The overall shape and display optics enable each viewer to see a correct stereoscopic view.

Other issues to notice are the development of standards for measuring and creating 3-D video and displays, as well as solutions for the ongoing challenge of eliminating crosstalk between the left- and right-eye images, which degrades the stereoscopic effect.

Special 3-D Cinema Event

The SID symposium will cover the above-mentioned technical aspects of 3-D displays and much more, but it's important to remember that the technology's evolution has been inextricably tied to entertainment since its inception. In order to honor this association, this year's Display Week will feature a special 3-D Cinema Event on Tuesday evening, May 25. 3-D film shorts will be exhibited stereoscopically on a special 30-ft. silver screen along with featured talks by 3-D filmmakers and other members of this rapidly growing industry.

References

[1]"3-D boosts box office worldwide to record $30 bln," http://news.yahoo.com/s/ap/20100311/ap_en_mo/us_box_office_year_end

[2] "Wal-Mart to Carry 3-D TVs in Select Stores," http://www.homemediamagazine.com/wal-mart/wal-mart-carry-3d-tvs-select-stores-18846.

[3]http://www.sony.net/united/3D/ ■

continued from page 3

real estate surrounding the massive Samsung and Sharp exhibits, space that was formerly taken by three Japanese CE power players made conspicuous by their absence – Pioneer, Sanyo, and Hitachi. What happened to them?"

Well, most of us already know that Pioneer, now out of large-format displays, was relegated to North Hall with the audio crowd. Sanyo merged with Panasonic, so there was no Sanyo booth, and Hitachi offered no public explanation for why it was not present at CES this year.

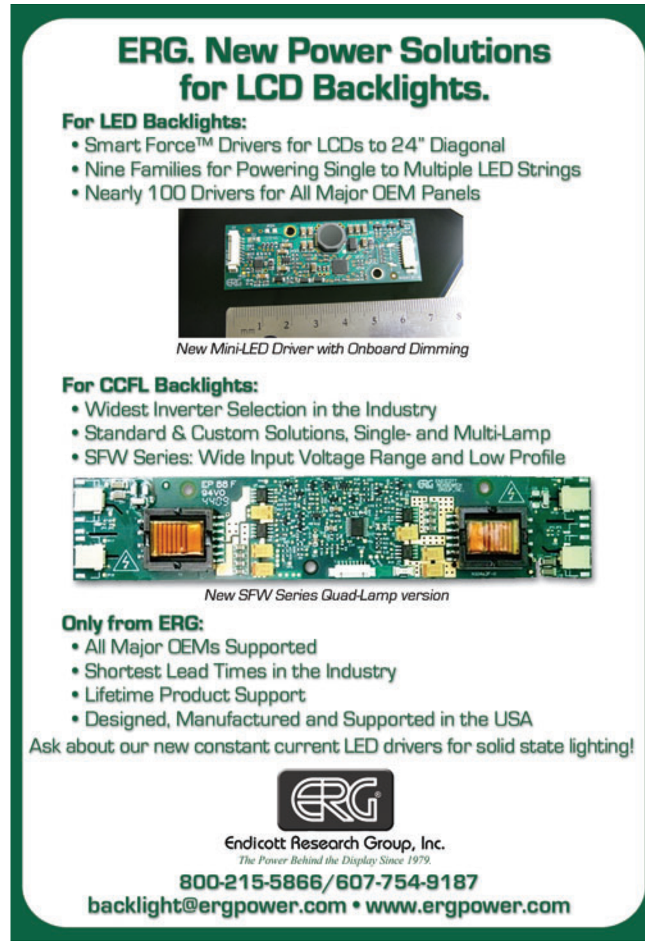
What else didn't we see at CES? There wasn't any word about new OLED TVs (there were several prototypes, including 3-D, but no commercialization announcements). We did not hear anything from AsusTek and its long-rumored dual-screen (color) EBR.

So, the old guard in consumer electronics is seeing new challenges from mainland Chinese brands, while upstart brands like Vizio are using aggressive pricing models to shake things up with entrenched TV brands. But similar to the years that have passed before it, 2010 opened with a large, loud, and, yes, impressive CES with new technology, hopes, and dreams of capturing the mind share (and market share) of consumers everywhere. But technology aside, are things really that much different from years past? We would say yes! For even though today 3-D dominates the display technology horizon, perhaps the same way HDTV did just a few years back, the discussion itself is beginning to shift from pixels, speeds, and feeds to something more exciting. Our content, connectivity, and mobility options are exploding with the opening of the Internet, and new devices to capture, create, and display this knowledge – right into the living room and beyond.

References

[1]http://on-ce.net/index.php?option=com_content&task= view&id=359& Itemid=45 ■

***Steve Sechrist** is an analyst with Insight Media. He can be reached at steve@insightmedia.info.*



See Us at Display Week 2010 in Seattle Booth 341

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Journal of the
SOCIETY FOR INFORMATION DISPLAY

**The following papers appear in the May 2010 (Vol. 18/5) issue of *JSID*.
For a preview of the papers go to sid.org/jsid.html.**

continued from page 2

in our industry as well as building the image of the supporting companies. Essentially all of the leaders in today's display community showcased their new technologies at one time or another through SID events, and in doing so achieved a very high level of visibility and respect in their mainstream marketplaces. That is money well spent.

Just as I cannot imagine the Society of Automotive Engineers (SAE) surviving without the support of all the major automakers, I cannot imagine the future of SID without the generous and enabling support of all the major display companies. I also do not think it is wise for any display company to trim its marketing budget too far today, at a time when competition for the best differentiating IP and the brightest engineering talent has never been greater. What better way to ensure the success of your company than to invest in the things that make your technical leadership stronger and more efficient than ever before?

I sincerely hope that as we shake off the last 18 months of economic challenges, we do not get too focused on the short term and that we all make the effort to preserve the things that were working for us before the new "normal" came upon us.

So look at re-funding the long-term marketing and sponsorship activities at your company as soon as you can for all the reasons I have described above. It is a worthwhile investment in your industry as well as your own business.

This month we present to you our April issue, which combines the theme of Digital Signage with our annual Display Week preview. Our guest editor, Bob Rushby from Christie Digital Systems, has assembled some great articles for us that address many of the fundamental technical advancements in the field of digital signage. In the first Frontline Technology article, "Contrast Ratios in Outdoor LED Displays," author Ryan Hansen explains how designers are using innovative techniques to improve the sunlight viewability of LED-based outdoor signs. At a slightly higher level, author Don Shaw takes us through the many recent evolutions in digital-signage technology in his article, "Display Technologies Evolve for Indoor Digital Signage." Last, guest-editor Rushby offers a great thumbnail view of the state of the field in his Guest Editorial, where he introduces us to the term "fifth screen."

Chris Connery from DisplaySearch provides our monthly Display Marketplace feature, "Digital Signage: Is the Business Model Finally Catching Up with the Technology?" and includes several examples of real leading-edge but fully viable installations and new concepts that have the potential to be financially successful as well as technically exciting.

Because this is also our last issue of *ID* before Display Week 2010, we wanted to give you as much information as possible about all the great things coming up at next month's event. You can find a nice overview of new paper sessions on Solid-State Lighting and 3-D technology, as well as previews of all the major topical sessions in the Symposium. Last, but not least, we feature reviews of two new and important display industry books: *Transflective Liquid Crystal Displays,* by Zhibing Ge and Shin-Tson Wu, and *Liquid Crystal Displays: Addressing Schemes and Electro-Optical Effects*, 2nd edition, by Ernst Lueder.

So, as you sit back and enjoy another month of *Information Display* magazine, I hope you are looking forward to your upcoming trip to Seattle to join the rest of us at Display Week 2010 as well as looking at a promising business future. I hope you can influence your company not to embrace the new "normal" too closely and to look for creative ways to invest back into the industry as much as possible.

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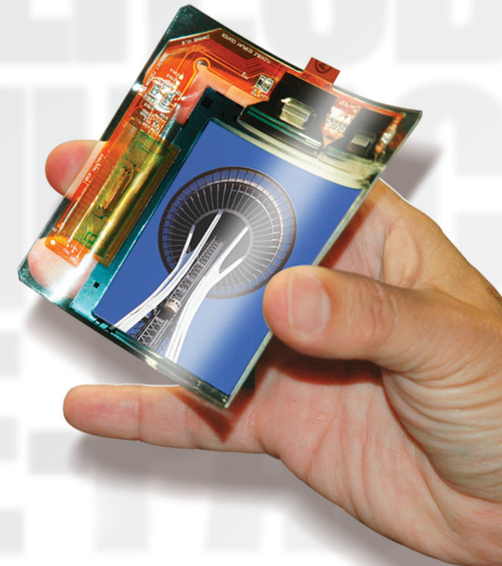
[1] http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/100223_lcdtv_tvs_to_exceed_180_million_units_in_2010.asp

[2] http://www.gartner.com/it/page.jsp?id=1306513. ■



DISPLAY
WEEK
SID

guest editorial

continued from page 4

- The well thought-out use of interactive and responsive display solutions to attract attention, improve message targeting, increase consumer dwell time, and improve message retention in measurable, quantitative ways is imperative.
- And, of course, digital-signage solutions must be affordable, robust, installable, and maintainable in often challenging and unforgiving environments.

For this issue, we have rounded up a stellar group of authors with a broad range of business credentials in the digital-signage industry. I sincerely hope you enjoy reading this issue as much as I have enjoyed being guest editor and that it gives you new insight into this exciting industry. ■

***Bob Rushby** is Chief Technology Officer at Christie Digital Systems. He can be reached at bob.rushby@christiedigital.com or at 519/744-8005.*

president's corner

continued from page 6

We have a number of other initiatives under way: new services and content available to SID members through our Web site; membership campaigns planned for Japan, Korea, and China; closer cooperation with sister display societies; and support for strengthening our chapter-level activities. All of these efforts, and more, are aimed at promoting the interests of our members, the companies, laboratories, and universities they work for, and the electronic-display industry as a whole. There are more reasons than ever for people who are interested in electronic displays to join SID. It's been my honor and privilege to do my part in helping SID expand its capabilities during my time as President. Of course, there are large numbers of volunteers and sponsors who provide the true lifeblood of SID, and through their efforts, the Society is able to provide the high-quality information and services that it does. My heartfelt thanks go out to all volunteers and sponsors.

The next SID President will be Munisamy Anandan, and he'll be writing the next President's Corner to appear in *Information Display*. Anand is a display-industry consultant with particular expertise in display lighting and has been playing important roles within SID for over 10 years. Please join me in wishing him good luck and in pledging your support for SID's next chapter. ■

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book reviews

Liquid Crystal Displays: Addressing Schemes and Electro-Optical Effects

2nd edition
by Ernst Lueder
© 2010, John Wiley & Sons, Ltd,

Reviewed by Ian Underwood

The SID-Wiley Display Technology series continues to evolve. I have grown accustomed to having a subset of these works on my office bookshelf for those rather frequent occasions when they are helpful. These books have become a comfortable part of my professional world, just like my calculator and my multi-tool. And that, I think, is the point. To quote series editor Tony Lowe: "The SID-Wiley Series is intended to explain the latest developments in information-display technology at a professional level." I might also append "… for practicing engineers, display developers, display users, and newcomers to the field." I have also found the books to be useful in teaching display technology to undergraduate and postgraduate students, as they elucidate physical principles, explain many engineering subtleties, and, in so far as is possible in a book, describe recent advances in the topic.

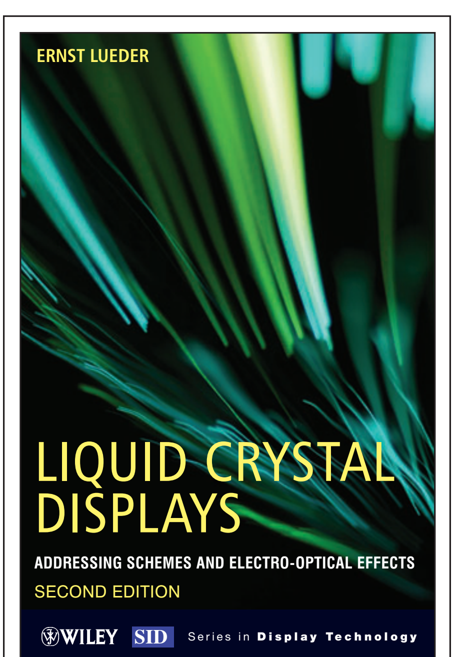
The first edition of *Liquid Crystal Displays: Addressing Schemes and Electro-optical Effects* by Ernst Lueder, published in 2001, was an excellent book. In terms of breadth it covered both electronic addressing schemes and electro-optical effects in a detailed and balanced manner. For good measure, it added chapters on assembly, projection, plastic substrates, and layer printing. In terms of depth, it spanned from principles to current practice, covering both at an appropriate and comfortable level. Finally, it entered a space that was ripe for this style of coverage and filled a prevailing gap quite neatly.

In the intervening nine years, two relevant things have happened – the field has advanced and the competition, *i.e.*, the number of books covering overlapping and related fields, has increased. So, what does the new edition offer?

The author's approach has been to insert whole sections of new material to cover significant advances. New topics covered in impressive detail include MVA (multi-domain vertically aligned) cells, electronic addressing of VA-LCDs, and light-emitting-diode (LED) backlights. These advances contribute to improved display performance in key areas such as color, contrast, viewing angle, power consumption, and switching time, which are important for modern, high-performance LCDs. The transfer of fabricated AMLCDs to a flexible substrate is also described, and the treatment of ink-jet printing and its application in LCD manufacture has been greatly expanded. The recent emergence of practical blue-phase LCs is introduced briefly.

The remainder of the original text and diagrams has been almost completely unchanged. While this is perfectly acceptable for topics such as "Descriptions of Polarization" and "Propagation of Light," I am disappointed that almost 10 years of technological advances in topics such as IPS (in-plane-switching), amorphous and polysilicon technology and addressing, LCOS (liquid crystal on silicon), LC-based projectors, and flexible substrates have been neglected. Other books in the series will presumably supply much of the missing information.

In summary, the second edition of *Liquid Crystal Displays* is a very useful book and a recommended purchase. It is almost up there with the first edition, but not quite because the update is not sufficiently thorough. The new sections are appropriate, worthwhile, and timely, but they make some of the remaining material look, by contrast, in need of a refresh.



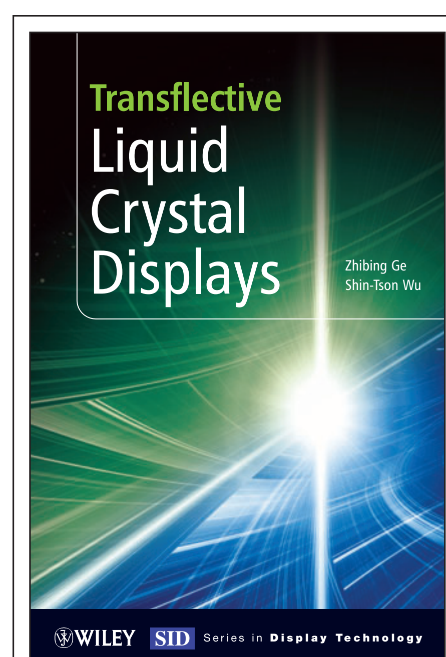
***Ian Underwood** helped establish MicroPix Technologies (now Forth Dimension Displays) and co-founded MicroEmissive Displays. He is currently Professor of Electronic Displays at the University of Edinburgh and is an Associate Editor of the* Journal of the SID.

Transflective Liquid Crystal Displays

by Zhibing Ge and Shin-Tson Wu
© 2010, John Wiley & Sons, Ltd

Reviewed by Terry Scheffer

Coming from backgrounds rich in both science and engineering, Zhibing Ge and Shin-Tson Wu have written a thought-provoking book that will appeal to display researchers and engineers alike. The work is geared toward transflective displays used in mobile devices, but covers much more than the title suggests, including fundamental continuum and optical equations that are used in simulation programs, as well as practical descriptions of state-of-the art transmissive LCDs. It also provides numerous examples for transflective modes, and explains the challenge of configuring the transmissive and reflective sections to produce similar gamma curves and wide viewing angles, while still being simple enough to be manufacturable.



Today, most transflective mobile LCDs either use the (TN) twisted-nematic mode with a transflective sheet laminated on the rear polarizer or the dual-gap ECB (electrically controlled birefringence) mode. Despite their popularity, there are shortcomings to these designs, which the authors examine throughout the book.

The first chapter, "Device Concept of Transflective Liquid Crystal Displays," introduces the concepts with a detailed description of thin-film-transistor (TFT) LCDs using TN, ECB, IPS (in-plane switching), FFS (fringe-field switching), VAN (vertically aligned nematic), HAN (hybrid aligned nematic), and OCB (optically compensated bend) modes. These modes are returned to in later chapters, with discussions of their adaption to transflective displays. With similar energy, the authors provide detailed descriptions of compensation films, reflectors, polarizers, and backlights.

The authors then discuss the basics of the continuum equations and Maxwell's equations that are needed to compute an LCD's director field, optical properties, and response times. There is a lot here to interest those who are curious about the methods used in their commercial LCD simulation software packages. And all of it will be of intense interest to those contemplating writing their own simulation programs, perhaps using commercial software such as MATLAB. The authors also explain the basics of transflective LCDs for mobile applications, breaking them down into four main categories: (1) dual-cell-gap method, (2) dual-gamma-curve method, (3) dual-field method, and (4) dual-alignment method. Detailed examples with simulated and measured results are provided for each category, along with their merits and demerits, and always with an eye on cost and manufacturability.

A detailed tutorial on the Poincaré sphere is included. As the authors point out, the Poincaré sphere is a natural way to visualize the evolution of the state of polarization as light passes through the liquid-crystal layer and compensation films. Here, the authors take special pains to show how the Poincaré-sphere approach can be applied to obliquely incident light to help researchers intuitively understand ways to widen the viewing angle. The remainder of this section offers examples of using this method to minimize light leakage at oblique viewing angles in transmission and reflection.

The chapter on "Wide View Transflective LCDs" is perhaps the most interesting in the book because it gathers the information presented in the earlier chapters to design transflective displays based on MVA (multidomain vertical alignment), IPS, FFS, and ECB, as well as hybrids of these that can fall into any one of the four basic transflective categories listed above. The reader is advised to proceed slowly here, as there is much to consider as each new design is revealed. The authors compare the performances of the diverse designs in terms of gamma response in the T and R sections at both a normal incidence and at oblique viewing, response times, and color shifts. They point out how small modifications can result in major improvements. The authors also present designs that might be considered exotic today, such as the incorporation of an internal wire-grid polarizer or an in-cell retarder. These materials, however, could very well become mainstream as these technologies mature.

A section on "Color Sequential Mobile LCDs" briefly explores the exciting possibilities of field-sequential color, with its promise of higher efficiency, higher resolution, and wider color gamut than RGB color-filter displays. However, to do this the LC must be able to switch much faster than in a conventional LCD. This is because the time needed for scanning data into the display, the LC response time, and backlight flashing time must all fit within the color subframe time of 5.56 msec for a 60-Hz frame refresh rate or even faster to minimize color break up. The LC response time needs to be less than ~2 msec; the authors consider the TN mode with a cell cap of 1.6 μm and LC with $\Delta n \sim 0.30$ as well as a 4.2-μm pi-cell, which both satisfy this speed requirement. As one can imagine, because ambient light is generally continuous and unsynchronized to the display, the reflective portion of a color-sequential transflective LCD must necessarily show monochrome and not color. In the final example of this chapter, the authors disclose a clever hybrid scheme to achieve color where color filters are used only on the reflective portion.

The final chapter, "Technological Perspective" offers a realistic account of the outdoor readability of transflective displays and the contrast ratios that can be expected due to the effect of surface reflections coming both from a direct light source, such as the sun, and from diffuse ambient sources. Anti-reflective and anti-glare coatings are essential here. The authors also cover touch-screen applications, which have special requirements for transflective displays.

Because of the rapid technological progress that will undoubtedly be made in this field, this book belongs on every LCD researcher's and engineer's bookshelf to be referred to again and again. References to published works are also plentiful. ■

***Terry Scheffer** is an LCD technical consultant living in Hilo, Hawaii.*

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SID HOUSING GUIDELINES

In order to keep facility fees down, the Society for Information Display arranges contracts that combine rental of convention facilities and guarantee of a certain number of hotel room-nights at convention hotels. SID Symposium participants can help keep registration fees down this year and in the future by registering and staying in hotels listed in the SID registration information. Nevertheless, in response to the current economic situation, SID has relaxed its deadlines for hotel reservations to provide its attendees flexibility in scheduling their participation.

IMPORTANT DATES

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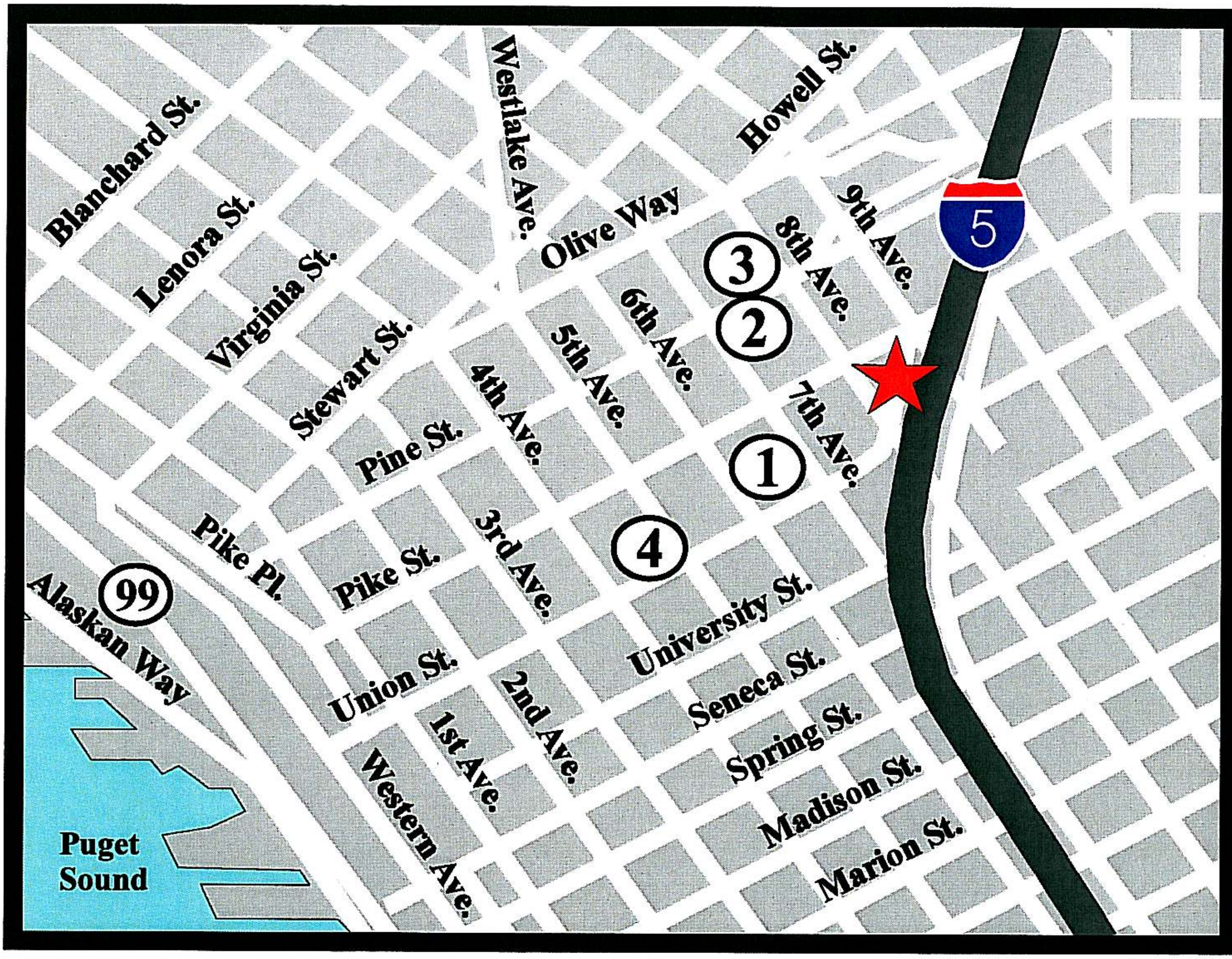

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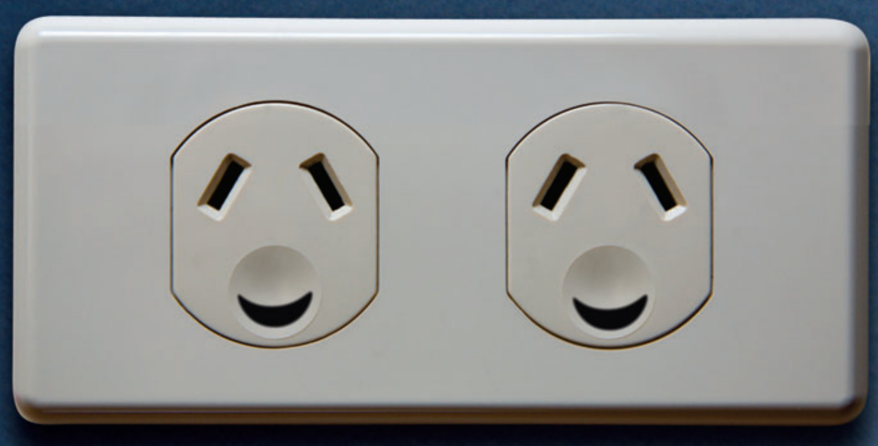

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