

Information DISPLAY

March 2009
Vol. 25, No. 03

Official Monthly Publication of the Society for Information Display • www.informationdisplay.org

**Ultra-Low-
Power
Displays
Come in
Many Shapes
and Sizes**

- **Bistable Displays in a Retail Environment**
- **Large Outdoor Low-Power Cholesteric Displays**
- **Segmented E-Paper Display Applications**
- **A First Look at Display Week 2009**
 - **ICDM Introduces DMS Version 1**
 - **New Flexible-Display Track**



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COVER: Ultra-low-power displays come in many shapes and sizes. This month's featured articles show us how three different display technologies are being successfully applied to create digital billboards, in-store electronic pricing labels, and smart cards. In each case, the displays possess image stability – they maintain an image even after all power sources have been removed.



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Next Month in Information Display

Display Week 2009 Preview Issue

- Laser-Enabled Display Production Techniques
- SID 2009 Honors and Awards
- Display Week 2009 Preview
- *Journal of the SID* April Preview

INFORMATION DISPLAY (ISSN 0362-0972) is published eleven times a year for the Society for Information Display by Palisades Convention Management, 411 Lafayette Street, 2nd Floor, New York, NY 10003; Leonard H. Klein, President and CEO. EDITORIAL AND BUSINESS OFFICES: Jay Morreale, Editor-in-Chief, Palisades Convention Management, 411 Lafayette Street, 2nd Floor, New York, NY 10003; telephone 212/460-9700. SID HEADQUARTERS, for correspondence on subscriptions and membership: Society for Information Display, 1475 S. Bascom Ave., Ste. 114, Campbell, CA 95008; telephone 408/879-3901, fax -3833. SUBSCRIPTIONS: Information Display is distributed without charge to those qualified and to SID members as a benefit of membership (annual dues \$75.00). Subscriptions to others: U.S. & Canada: \$55.00 one year, \$7.50 single copy; elsewhere: \$85.00 one year, \$7.50 single copy. PRINTED by Sheridan Printing Company, Alpha, NJ 08865. Third-class postage paid at Easton, PA. PERMISSIONS: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of the U.S. copyright law for private use of patrons, providing a fee of \$2.00 per article is paid to the Copyright Clearance Center, 21 Congress Street, Salem, MA 01970 (reference serial code 0362-0972/09/\$1.00 + \$0.00). Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. This permission does not apply to any special reports or lists published in this magazine. For other copying, reprint or republication permission, write to Society for Information Display, 1475 S. Bascom Ave., Ste. 114, Campbell, CA 95008. Copyright © 2009 Society for Information Display. All rights reserved.

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Nowhere to Hide?

by Steven P. Atwood

It would be unrealistic for me to ignore the dreadful economic conditions we are facing in all areas of the display industry. Discouraging news seems to pour in almost every day about layoffs and cutbacks, and it seems that almost no one is immune. I cannot bear to look at the stock market and I am fearful just opening up the regular trade news.

Most recently, we learned about the truly devastating losses and subsequent job cuts at Pioneer from our friends at Insight Media (*Display Daily* 2/16/09). Pioneer's high prices for arguably superior products could not be sustained in this now very selective consumer marketplace, where the difference between good and great was just not enough to get customers to spend above average for their TVs and other entertainment devices. Certainly, all major manufacturers are battling heavy downward pressure on margins, but Pioneer apparently was not able to respond enough to keep its share in the declining overall market, making the impact much greater to its sales on a percentage basis. The result, as we can see once again, is that superior technology by itself cannot overcome the brutal forces of the marketplace.

Another company that has seen very difficult pressure on its businesses is NEC, whose industrial LCD business has also experienced dramatic reductions in sales. Therefore, we were not shocked a couple of weeks ago to hear that NEC could be planning to exit the LCD-panel business entirely. Even so, the news was sobering because a significant part of the marketplace for industrial and specialty displays relies on NEC's unique offerings, some made on trailing-edge fab lines and supported for 10 years or longer without major revisions. Companies making displays for the military, avionics, medical, and other specialty markets rely heavily on NEC and others to provide panels with long product life cycles and limited form, fit, and function changes. These markets demand that the products be certified for mission-critical reliability, that they perform under extreme environments, and that they offer intrinsic safety to protect life and limb. Any changes to the product design, including the display panel, become an expensive proposition for the developer to re-certify. However, producing these panels is relatively expensive and represents a heavy burden on NEC's operations, which must manage high-mix lower-volume products at the same time that its rivals are trimming all but their best-performing products.

Losing the panels NEC provides would have had a significant impact on revenues and jobs for many of NEC's customers and created another serious economic ripple throughout the industry. I say "would have" because, as it turns out, the news was not true and was vigorously denied by NEC officials. Still, the rumors would not die and over the next week NEC's PR team fielded numerous phone calls and angry inquiries, (see our Industry News segment further herein). During the month of February, my cell phone literally rang at least once each day with calls from media people or friends wanting to talk about the NEC rumor. I counted well over 100 e-mails on this subject alone, mostly links to numerous Web sites in Japan. The stories have finally died down, and it is not clear whether they were pure fiction or whether NEC's management did at some moment seriously consider shutting down the LCD business. In any case, the incident served as a bellwether for just how precarious things are right now, and how sensitive everyone is to each new bit of potentially bad news.

However, not all the news is bad, and I hope that in this issue you can join me in hiding from the bad news with some great technology stories, at least for a little while.

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industry news

NEC Out, Then Back In the LCD Business

After making a surprising statement to the contrary, NEC has quickly reaffirmed its commitment to the LCD business. What constitutes that business, however, depends on the NEC subsidiary in question.

It all began on January 30, 2009, when NEC Corp. released its consolidated financial results for the 9 months ending December 31, 2008. As is no surprise in a harsh economy, the company reported losses. More unsettling was the news that NEC planned to lay off approximately 20,000 workers over time. But a few words on the right-hand side of Slide 21 of the company's presentation to investors took many in the display industry by surprise. That slide, entitled "Business Portfolio Reform" showed environmental and energy-related business as growth areas, whereas "LCD-related businesses, etc.," were labeled as exiting areas.

A great deal of speculation ensued – both in the media and at companies, especially those that use NEC LCD modules for their own products. NEC was temporarily unavailable for comment. However, on February 2, the Monday immediately following the Friday announcement, the company posted a letter from NEC Display Solutions President Yoshikazu Maruyama on its Web site, reaffirming the company's commitment to the LCD-monitor and LCD-projector businesses.

That same day, NEC Display Solutions of America President Pierre Richer, in an interview with GEARlog (www.gearlog.com), stated that NEC Display was "not going anywhere." He also made the point that NEC Display's emphasis would be on making monitors that use LCD components sourced from other suppliers and that this was not a particularly new development.

What Richer's comment did not address (nor was it meant to) were possible changes over at NEC Electronics America, a subsidiary that markets and sells industrial-style active-matrix LCD modules incorporating panels that NEC does, in fact, make itself. NEC Corporate's statement had been that the company was committed to the LCD monitor and projector business. Did this mean that the module business was about to change?

In fact not. "Business as usual" was the message when *Information Display* spoke

with Omid Milani, Director of Displays for NEC Electronics America. Recent corporate statements from Japan "have no effect on what we are doing," said Milani, who went on to state that NEC Electronics will continue to produce the LCD modules that are vital to its specialized industrial, medical, and other customers. He added that the company is keenly aware of its long-term commitment in a market where these customers would find it difficult to locate similar suppliers in a timely fashion.

Asked why he thought that the statement about exiting the LCD business appeared in the earnings presentation, Milani said that he could not speak for NEC's global LCD business. "This is a \$46 billion company with over 100 subsidiaries," he said.

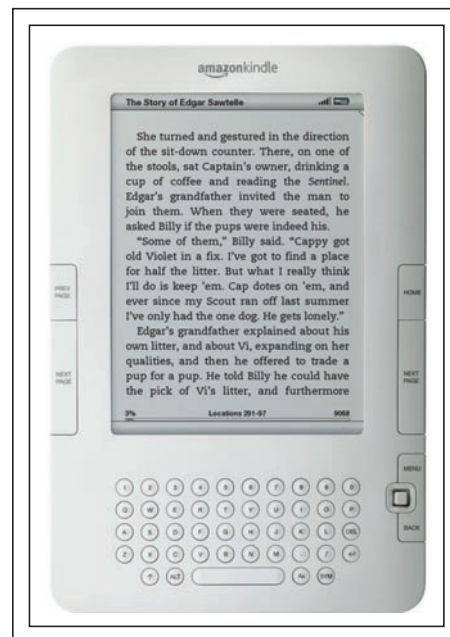
Paul Semenza, Senior Vice President for market-research-firm DisplaySearch, also believes that in the U.S., at least, NEC's display-panel business is ongoing and that any announcements of its demise were premature. "My best guess is that some internal thinking worked its way into the presentation," said Semenza. And, in fact, while he estimates that NEC's share in the LCD market worldwide is probably less than 1% overall, and may well have attracted corporate scrutiny on that account; in North America at least, NEC caters not just to end users but to those aforementioned highly specialized industrial and medical customers. "It's a decent little business for NEC," he said.

—Jenny Donelan

Kindle 2: Ultra-Thin, Ultra-Low Power

Amazon's latest version of the Kindle e-book reader continues to generate consumer excitement even in a bad economy and was selling out at \$359 a pop even before its official ship date in February 2009. The Kindle 2 is slimmer than its predecessor at just over a third of an inch. It stores 1500 titles compared to the original model's 200 and has a 25% longer battery life. According to Amazon, the new unit will enable customers to read for 4 or 5 days on only one charge with the wireless feature turned on and for more than 2 weeks with wireless turned off.

The Kindle 2's 6-in. 600 × 800 electronic-paper display, which is based on technology



Early reviewers reported that the Kindle 2's new screen offers improved text legibility and image clarity. Image courtesy of Amazon.

from E Ink Corp., now has 16 shades of gray, as compared to the original's four shades of gray. The new reader will also enable pages to turn an average of 20% faster.

Reviewers have praised the Kindle 2's revised navigational buttons (it's not as easy to inadvertently advance a page), the USB charging capability, and the new text-to-speech function (though the latter has generated a partial stir about authors' audiobook copyrights). One less popular change includes the lack of a protective cover (the original shipped with one) that must be purchased separately.

What's in store for the next Kindle, Amazon isn't saying. When asked about plans for larger screens, color versions, or other new features, the answer is that there is no answer. One thing is for sure; this little monochrome e-reader is a bright spot in a mostly dismal retail environment.

— Information Display staff

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Ultra-Low Power: Changing the Rules of the Game

by Robert Zehner

Last summer, as fuel prices across the U.S. peaked at over \$4.00 per gallon, stories about a group of auto enthusiasts known as “hypermilers” began to crop up on television and in newspapers. Rather than pursuing maximum speed or handling, hypermilers modify their driving style to achieve maximum mileage. Hypermiling techniques range from

mild (gentle acceleration and braking) to suicidal (drafting semi-trailers on the highway with the engine off), but skilled practitioners can coax 40–50 miles out of a single gallon of gasoline.

This month’s issue of *Information Display* is dedicated to ultra-low-power displays – the hypermilers of the display industry. As with their automotive equivalents, these display technologies aim to deliver an entirely different kind of high performance. It is not about frames per second; it is about pages (or prices, or ads) per battery charge.

This difference is exemplified by comparing two popular consumer devices from the past year, both of which I carry with me when I travel: Apple’s iPhone 3G and Amazon’s Kindle electronic book reader. Both have always-on cellular data capability, for when the urge strikes to surf the Web or buy the latest best-seller, but that’s where the similarity ends. The iPhone is a mini movie theatre, packing feature-length films onto its 3.5-in. backlit LCD. But, after a few hours of film, it is time for a recharge. The Kindle, on the other hand, regularly delivers 3–4 days between charges, seemingly independently of how much I read, and despite sporting a display that is over three times the size and pixel count of the iPhone. And for battery longevity, even the Kindle pales in comparison to its close competitor, the Sony PRS-505 Reader, another of my frequent traveling companions. The PRS-505 relies on USB instead of wireless for its data, allowing it to go 20 days or more between top-ups. I’m embarrassed to say that by the time the Reader’s battery is dead, I’ve often forgotten where I put the charger.

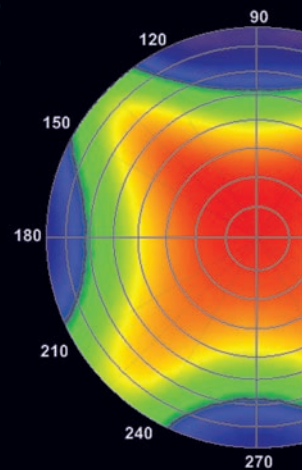
Some might point out that this is not an apples-to-apples comparison, but that is exactly the point. The hypermiling Kindle and Reader, and their electrophoretic displays, are purpose-built for immersive reading, for settling in with a book, or two, or three on a Sunday afternoon or a trans-Pacific flight. In return, at least for now, they sacrifice full-motion-video capability.

Electronic books are just one category where ultra-low power consumption confers a big advantage. This month’s featured articles show us how three different display technologies are being successfully applied to create digital billboards, in-store electronic pricing labels, and smart cards. In each case, the displays possess image stability – they maintain an image, even after all power sources have been removed. As a result, ZBD has been able to construct an in-store point-of-purchase display with a 5-year battery life, and E Ink and Epson foresee a similar battery life for a credit card with a one-time-password display. All three displays are also reflective, which means that they largely rely on ambient lighting rather than powering their own internal light source. Elimination of the backlight allows cholesteric-signage-maker Magink to cut the power required for an outdoor electronic billboard by up to 90%, when compared to LED or backlit-LCD solutions.

These ultra-low-power technologies may not be ready to replace the LCD in your living room TV. However, as the hypermilers have shown on the road, it is possible to break new ground in battery life, if you are willing to change the rules of the game.

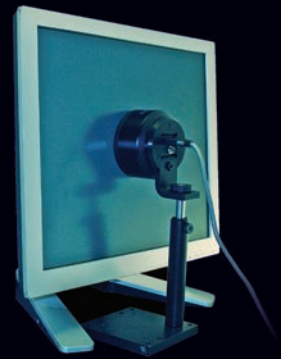
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Remember the Alamo!

by Paul Drzaic

President, Society for Information Display

There is a bit of irony in the fact that this coming May and June, SID's Display Week is being held in San Antonio, Texas. San Antonio is the home of the Alamo, which has a special place in American folklore. The Alamo is the site of a famous battle in which a number of Texian soldiers, surrounded by an overwhelming enemy force, bravely defended their garrison in the Alamo. While the soldiers fought with valor, they eventually succumbed to their attackers. Their sacrifice was subsequently used as inspiration for the Texian army in future battles, and "Remember the Alamo!" is a rallying cry remembered even today within the U.S.

A bit of history is in order. Back in 1836, Texas was a part of Mexico, but a revolution was under way. The Anglo-American residents of the territory, known as Texians, wanted Texas and surrounding territories to declare their independence from Mexico. The Mission San Antonio de Valero (also known as the Alamo), located in San Antonio de Bexar, was a site of resistance held by the Texian army leading the revolt. The Mexican general Santa Anna decided that capturing the Alamo was an important means to break the revolution and sent an army to capture the site. Although the Texians were well aware of the approaching army, they had no means to retreat with their cannons. Rather than abandon this important hardware to the Mexican army, they decided to defend the mission to the death. "To the death" is exactly what happened – despite inflicting heavy losses on the Mexican army, the Texians were greatly outnumbered and eventually were overrun. Nearly all the defenders were killed, including some famous American legends such as Jim Bowie (of the "Bowie knife") and Davy Crockett ("King of the Wild Frontier"). The Alamo was lost.

These days, participants in most industries (including the electronic-display industry) must feel a bit like the defenders in the Alamo. Surrounded by economic enemies on all sides, with no obvious means of escape, it might seem like we are all in the fight of our lives. The forces outside the walls seem overwhelming, our options few. This is a serious time, one that tests all levels of an organization. Desperate times, indeed.

At times like these, it is worthwhile to step back and take the long view (yes, despite the current crisis, there is always a long view!). Take San Antonio as an example. Rather than break the back of the revolution, the battle of the Alamo served as a rallying cry for Texians to fight even harder. The Texian army attracted more recruits, and the "Remember the Alamo" cry inspired them for battle. The Texians won their revolution, and after a brief period as an independent state, Texas joined the United States. Today, San Antonio is the seventh largest city within the United States, with a vibrant international flavor, its famous River Walk, and yes, the Alamo, which has been preserved as a museum. So, while the defenders of the Alamo lost the battle, they laid the ground for winning the war.

The current economic crisis will end, sooner or later. When the economy begins to rebound, new technologies ready to launch will play a prominent role in that economic growth. Touch interfaces, green technology, flexible displays, and 3-D displays – all these areas will almost certainly be in high demand and will drive the profits of the future. SID in San Antonio will provide its usual high-quality mix of papers, exhibits,

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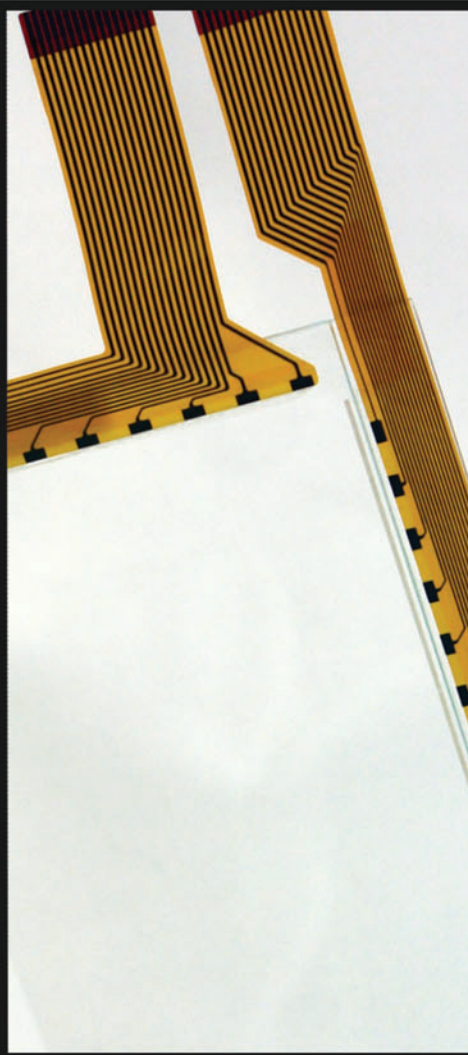
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Approaching the “Zenith”: Bistable LCDs in a Retail Environment

Previous electronic shelf-edge labels based on standard twisted-nematic segmented LCDs have allowed updates of price only. Limiting the information shown meant ultra-low-power requirements for the battery-operated displays in constant use, which in turn supported the need for low cost on the part of retailers. Bistable passive-matrix displays allow retailers to supply more information while also enabling battery options that last for years. This article discusses a bistable LCD and RF protocol designed to provide both functionality and ease of use for retailers.

by Cliff Jones

LABELING is one of the few remaining aspects of the retail arena yet to be automated. Paper labeling in a retail environment has worked for centuries, but gives the retailer limited flexibility and poor reactivity, and represents an unwanted operational cost. Many retailers would embrace a solution that can automatically update product information, pricing, and promotional content; one that responds within seconds to market opportunity and is linked directly to the stock and point-of-sale computer systems. Existing electronic shelf-edge labels (ESLs) provide only a part of the solution and are frequently limited to showing price only. Despite being electronic, these labels still require conventional paper labeling to be added for each ESL to provide the necessary product information. A matrix display would be ideal – but how is all of the required information shown on a display that both meets the right price points

for such a cost-conscious sector and copes with the need for the information to be on display 24 hours a day and 7 days a week? The answer is to use a bistable display.

The enormous potential of bistable ESLs for the retail sector has been recognized by most players by use of a bistable-display technology. In particular, reflective bistable LCD

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Fig. 1: A grating-aligned display used in a retail application.

technologies are suited to this application, not only due to their ultra-low power, but also because they can be addressed as a passive matrix. This helps the display meet the cost requirement because it avoids the need for a TFT backplane. This is true of bistable cholesteric displays (developed by Kent Displays Inc.¹), weakly anchored bistable nematics (the Binem mode from Nemoptic²), and the grating-aligned display from ZBD³ (shown in Fig. 1).

ZBD is now developing a new display technology and combining it with an ultra-low-power RF product and appropriate software to produce an integrated system. It is this bistable LCD and RF combination that is the main focus of this review.

Grating-Aligned Bistable LCD

ZBD's first approach toward using grating alignment to induce bistability in a nematic device was to employ the bi-grating to define two orthogonal directions for the liquid-crystal alignment, both within the plane of the liquid-crystal cell. Although bistability was demonstrated, there was a fundamental difficulty in that the out-of-plane electric field applied to the internal surfaces of the LCD in the usual fashion, resulting in a switching torque between the in-plane bistable states that is too low. This meant that the voltage required to operate the latch between the states was impractically high (greater than 60 V). A breakthrough was made in 1995 by Bryan-Brown, Brown, and Jones,⁴ who realized that a zenithal bistable display, one in which the bistable alignment states are between a low tilt (planar to the cell) and high tilt (parallel to the applied electric field), could operate at voltages suitably low to be readily accessed using STN drivers. This zenithal bistable surface was demonstrated in a device that used a deep monograting formed from a material that aligns the contacting liquid crystal perpendicular (i.e., homeotropic) to the local grating surface.

A simple way of visualizing how zenithal bistability arises is to consider the local alignment of the liquid-crystal director close to a deep grating surface: the grating at the groove tops and bottoms tends to favor the vertical-alignment state, whereas the side-walls of the surface will favor a horizontal state. In practice, the two states are differentiated by the presence of nematic defects; in one state, the nematic director deforms elastically around

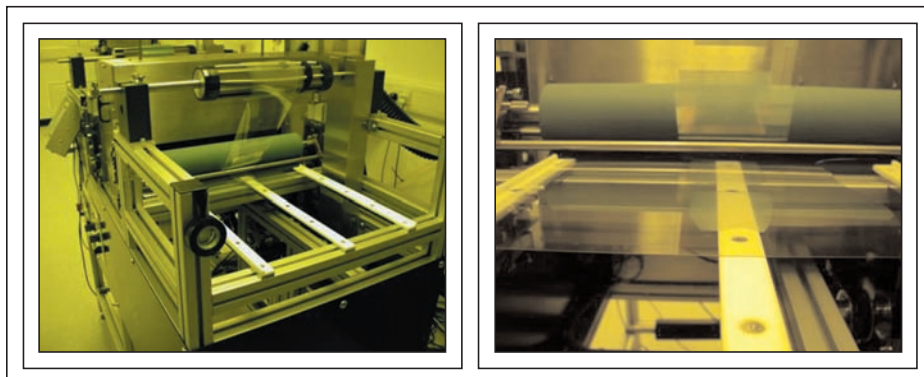


Fig. 2: The embossing process used for ZBD grating fabrication.

the grating continuously (the C-state), whereas in the other state (the D-state) this elastic deformation is reduced by forming defects (i.e., disclinations) at the top and the bottom of the grooves. Latching between the two states occurs for voltage pulses of the appropriate polarity. Negative voltages on the grating always latch to the C-state while positive voltages latch to the D-state. The latching torque arises due to the flexo-electric polarization that occurs in any nematic liquid-crystal material undergoing a splay or bend deformation. Usually, this polarization is very weak and plays only an insignificant role in conventional LCD behavior. However, in ZBDs, the deformation close to the grating is strong and localized to the top and bottom of the grooves, precisely the areas where it is needed to nucleate and annihilate the nematic defects. This means that latching can be induced with fields as low as 1.6 V/ μm (i.e., 8 V in a 5- μm -spaced display).

Achieving the Low-Cost Target

Superficially, it may appear as if incorporating grating structures to the internal surface of an LCD is a complex, unconventional, and inherently expensive process. The grating may have a pitch of between 0.6 and 1.5 μm , and have a depth-to-pitch ratio of between 0.8 and 1.2. Any offset of grating giving unnecessary photoresist between the bottom of the grooves and the ITO electrode will cause a voltage drop in the cell and potentially increased cell-to-cell variations in the operating voltage.

In practice, grating fabrication is a simple step from an LCD-manufacturing point of view, similar to the rubbing process it

replaces. The manufacturing simplicity is one of the advantages of this technology.

All production devices to date have been manufactured by Varitronix in China. ZBD and its partners produce a sheet of PET carrier film with the inverse of the required grating shape on one surface. This is then used to emboss the grating into a photopolymer (Fig. 2).

The composition of the photopolymer is designed to produce the homeotropic alignment of the liquid crystal. The embossing machinery is simply two rubber-coated rollers through which the glass and film pass. The plate is then exposed to 365-nm UV light to cure the photopolymer and the film removed, leaving a perfect replica of the grating on the LCD plate. The fidelity of the grating is maintained for a wide range of process conditions; zero-offset is achieved by ensuring that the embossing pressure and Shore hardness of the roller are kept high.

The complex part of the process is the original production of the film. This is initiated by careful mastering of a single grating structure, which is then replicated hundreds of thousands of times. Any of a number of methods can be used to create the original master grating, including contact photolithography, projection photolithography, laser scanning, or diamond cutting. Each master needs to be perfect and involves optical characterization of its uniformity and inspection for defects. However, this has negligible impact on the final cost of the grating, due to the high level of replication involved. Once completed, the master shape is copied into nickel using the standard electro-forming process used in the CD/DVD industry; although the master is destroyed in this pro-

cess, the first nickel copy can be used to produce further copies scores of times. The final step is to use the nickel to emboss the grating shape onto the film using a roll-to-roll embossing method common to the optical films industry. This film is then used by the LCD manufacturer to emboss the grating alignment layer onto one of the glass substrates of the LCD.

Once completed, the plate is used to construct a standard twisted-nematic LCD (TN-LCD), spacing the grating plate 5 μm away from a rubbed polyimide plate to give a 90° twisted structure when the grating is in the low-tilt D-state and a non-twisted hybrid-aligned state when the grating is latched into the vertical C-state (thereby forming a hybrid aligned or HAN state), as shown in Fig. 3.

The display is completed using standard polarizers, liquid-crystal material, and super-twisted-nematic (STN) drivers. It can be operated in either the normally white (NW) TN or normally black (NB) TN mode by appropriate orientation of the polarizers. Indeed, another advantage of being an LCD is that it can benefit from the use of other established components common to LCDs, such as color-filter plates, transfective polarizers, internal reflectors, and other optical elements.

A number of factors favor the ZBD device for producing low-cost displays. Of course, the fact that there is a well-defined threshold

to the bistability is ideal for line-by-line passive-matrix addressing. The simple embossing step is done with little capital expenditure and is run alongside standard TN or STN production. There are also cost savings over STN production, including the use of unpolished TN quality glass and cheaper LC materials. The additional cost of the grating film is counter-balanced by the lack of an optical compensator that would be required for an STN panel, each being of similar cost.

Achieving Optimal Device Performance

Next to cost, the ZBD device's appearance is designed to appeal to the retailer. High reflectivity, contrast ratio, and viewing angle are inherent to the design. Unlike a conventional TN, the optics are optimized for the display to be viewed without an applied field. The NW TN state has a low tilt throughout the cell, featuring high reflectivity and viewing angle, whereas the HAN state is devoid of twist and offers an exceptional black state.

Also important is the ability to display the same image content as used on a standard paper label. For this reason, the displays are typically made at 110 dpi, ensuring that the smallest text is still legible, as well as giving good response to barcode readers.

As with any of the competitive options, adding full color to the display is too expen-

sive for large-scale deployment throughout a supermarket chain. However, retailers need only a limited amount of color, for example, to highlight promotional events. This can be done very simply for negligible cost by printing a dyed area onto the glass underneath one of the polarizers (see Fig. 4).

Because the ZBD device has a high-contrast ratio (typically over 20:1), the colored area of the display can be made completely dark – essential for distinguishing between promotional offers and standard product. Figure 5 shows an alternative display option that is closer to paper-white.

Some aspects of the technology are not important in retail applications. Although operation from -20°C to +60°C has been demonstrated, the retail products work from -5°C to +45°C. Similarly, current displays take typically 0.5 sec to update a page. These limitations are largely set by the 30-V maximum operating voltage chosen. The wider temperature range and update speeds of 100 msec/page can be achieved using 40-V drivers.

Optimizing Battery Life

From the outset, the aim has been to develop a battery life for each unit of over 5 years. The ultra-low power that a bistable display offers is obvious. The display may only need to be updated two or three times each day. For a 4-in. QVGA ZBD display, each update requires less than 30 mA (including both the display and driver electronics). This corresponds to over 200,000 updates for a typical battery, which at 50 updates a day would result in a potential lifetime of over a decade (although this may be longer than the shelf-life of a typical battery). For comparison, a similarly sized STN panel would consume about 20 mA. This is similar to the ZBD current because both use similar liquid-crystal material, cell spacing, and applied voltages. However, in this case, the STN must be powered continuously, and therefore an STN panel operating from the same battery would be limited to 25 hours. In practice, of course, a high proportion of the battery energy will be consumed by the communications system.

Even if the display is not powered for the majority of the time, the communications system needs to awaken periodically to check whether an update is required. Also, to ensure dependability, the customer needs the system to be two-way: All update events must be

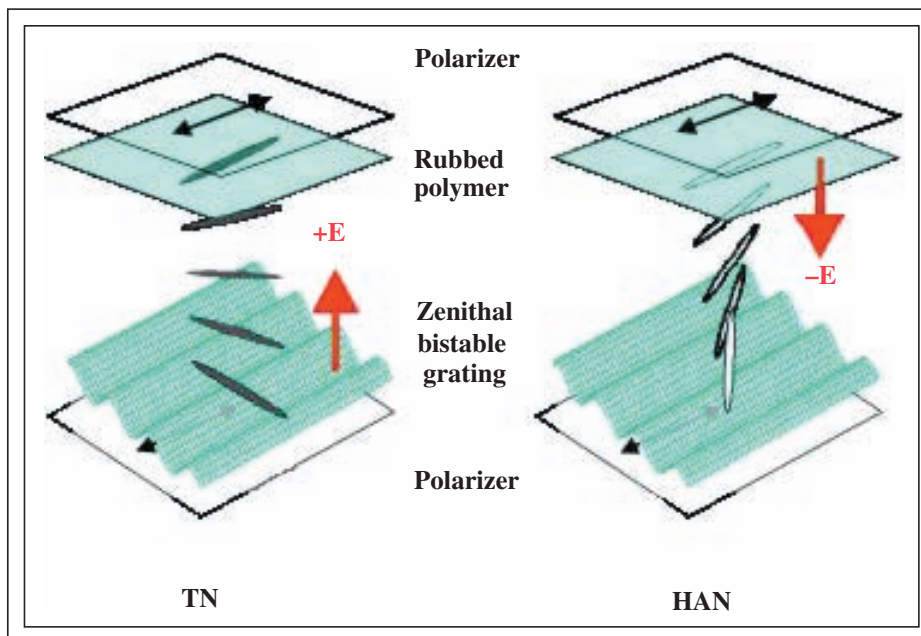


Fig. 3: Layers involved in a twisted-nematic display construction at ZBD are shown above.

acknowledged by the individual label. An RF-based communications system offers both a simple infrastructure and the bandwidth required for matrix information. Of the various options available, it is the unlicensed ISM bands (868–915 MHz) that have enabled ZBD to achieve a protocol offering ultra-low power consumption. Each wake-up also includes a synchronization signal to ensure timing is maintained between consecutive wakeups – this helps keep label costs low by minimizing the accuracy requirements on the real-time clock circuitry. The bandwidth is 25 kbps, but time-division multiplexing helps ensure the maximum efficiency of the available bandwidth. Each label has its own ID and is encoded to ensure security. Multiple channels (10 channels at 868 MHz and 60 at 915 MHz) cater to overlapping networks or multiple communicators. At each wake-up, the entire transaction (RF receive, write-image-to-memory, and transmit acknowledgement) expends approximately 40 mA. With a wake-up frequency of between 6 and 10 sec, the standby and synchronization current uses, at most, 0.1 mAh each day. Thus, each label readily achieves the target battery life of more than 5 years from two button cells when updated up to five times a day.

A major benefit of the entire system is simplicity of installation. This should be contrasted with conventional ESL systems that require many routers in the ceiling of the outlet. For a large supermarket, this is both expensive and disruptive; for a smaller retailer, such systems are prohibitive. The ZBD-type system operates using a single RF transmitter that can communicate reliably with all labels in the store environment within a range that is greater than 100 m. It is interfaced directly to the existing point-of-sale infrastructure, for example, using a USB connection, and installation can be done in minutes. This helps ensure that the total cost of ownership for the labels is very low.

Conclusions

The combination of a simple bistable display technology with an ultra-low-power RF product is already proving powerful for the retail market, meeting the customer's needs for both small and large outlets. However, the application of either element or their combination is not limited to retail applications and growth in other sectors is already anticipated over the next few years.



Fig. 4: Some of the ZBD options shown at SID's Display Week 2008 included the use of area color (top left shows the display with black corners and top right with the same display and the corners latched to red).

Acknowledgments

The author wishes to thank his colleagues at ZBD, particularly David Dix and his team, for the details on the RF.

References

- ¹D.-K. Yang, J. L. West, L.-C. Chien, and J. W. Doane, *J. Appl. Phys.* **76**, 20 (1994). Kent Displays, Inc., at <http://www.kentdisplays.com/products/products.html>.

- ²I. Dozov, M. Nobili, and G. Durand, *Appl. Phys. Lett.* **70**, 1179 (1997). Nemoptic at <http://www.nemoptic.com/index.php>.

- ³J. C. Jones, *J. Soc. Info. Display* **16**/1, 143–154 (2008).

- ⁴G. P. Bryan-Brown, C. V. Brown, and J. C. Jones, U.S. Patent 6,249,332 (1995). ■



Fig. 5: ZBD's display together with LCD geometries that give a whiter light state.

Segmented Displays Enable a Variety of Smart Surfaces

Because they are ultra-thin, rugged, and flexible, high-contrast segmented electronic-paper displays can be placed in a variety of devices.

by Joanna Au and Shigeaki Kawano

ELECTRONIC-PAPER DISPLAYS (EPDs) made popular by applications such as electronic books and newspapers are also enabling a host of new applications. Not only will electronic paper using electrophoretic technology eventually become a good alternative to liquid-crystal displays (LCDs) for specific products or applications, they will help enable new products and applications, such as smart cards, and new concepts for wrist watches and display-enabled key fobs.

Electrophoretic displays made of plastic are ideal solutions in applications where a glass-based display is not viable. EPDs can endure physical stress while retaining display content with very low power requirements. EPDs, such as those based on E Ink's SURF (segmented, ultra-thin, rugged, and flexible) technology are characterized by their low-power requirements, high visibility, ruggedness, readability in sunlight, and low profile. A number of applications characterized by "more-with-less" aspects recently have become possible by using this segmented-display technology in conjunction with a

series of microcontrollers (MCUs) and drivers from Epson.

In contrast to active-matrix displays used in electronic books, which can display any image, segmented displays are low-information-content displays with a pre-determined set of images designed for a target application. Segmented displays are driven from a single wire per segment, similar to segmented alphanumeric LCDs. Possible applications include battery-powered health and capacity meters (for products involving battery life and memory storage); electronic shelf labels; hand-held data collectors; and the aforementioned wrist watches, bi-directional key fobs, and smart cards.

Having a thickness as thin as 330 μm ,¹ EPDs can fit almost anywhere. The plastic construction provides a shatterproof display with conformability and flexibility for a portable ruggedness. Displays can also be non-rectangular in shape, allowing designers to create more innovative products.

Among the first such products to highlight the benefits of EPD technology were a series of watches developed by Seiko (Fig. 1). Approximately 1000 watches were sold in 2006 as limited editions. Because of their ultra-high contrast without the need for backlighting (the display is readable even in low-ambient-light conditions), innovative curved surfaces, and low-power MCUs and EPD drivers, these products are a good example of the possibilities inherent in a fusion between EPD and semiconductor technologies.



Fig. 1: EPDs, custom IC drivers, and low-power MCUs made it possible to create an innovative design for Seiko's bracelet-style wristwatch for women. The black-and-white display runs along the exterior of the band and is capable of displaying the time in "efficiency" mode with easily recognizable numerals or in high-concept "mystery mode," as shown here. In mystery mode, the numerals appear in script in somewhat mysterious patterns. For example, the time shown here is 12:58, reading from the lower left-hand side of the display upwards (the "1" is only partially visible at the left) and right to the "8". Image courtesy of Epson.

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Power Considerations of Segmented EPDs

Calculating the power consumption for a segmented-display solution depends upon a number of variables including the size of the display, display-switching duty cycle, choice of electronics, and the use of available low-power and sleep modes.

One of the key features of EPDs that enables low-power applications is their ability to maintain an image when disconnected from a power source. Because the display only requires power while the image is changing, the usage model for the device will have an impact on the power consumed. An in-store point-of-purchase sign that updates every 2–3 sec to grab the attention of shoppers will have considerably different power requirements than an electronic shelf label that is updated once daily with a product price. To take even further advantage of the image stability, the controller chips and driver electronics can be shut down or kept in a low-power mode until the next display update.

Next, consider smart-card applications. The use of smart cards has been growing as institutions take aim at reducing the fraud that can occur with conventional credit cards. Demand for display functions has therefore emerged as the next level of improvement.

A standard six-digit seven-segmented EPD designed for smart-card applications¹ has an active area dimension of 20.3 mm × 6.1 mm. The active area defines the maximum switchable area of the display cell. An EPD consumes about 1 $\mu\text{A}/\text{cm}^2$ with a typical 240-msec pulse. Driving the entire smart-card display to white or to black with a 240-msec pulse would draw 1.24 μA at 15 V, or 18.6 μW . Using this number provides the worst-case scenario for updating the smart-card display. To derive more accurate calculations, the area for all six digits of the display is 51.0 mm². Updating only the six numbers will consume 0.51 μA of current at 15 V, or 7.65 μW of power.

One-time-password (OTP) smart cards are becoming popular because they offer an extra layer of security. These cards contain an IC that generates a continually changing checksum. The owner activates the card, usually by pressing a button, causing the current checksum to be displayed. When the user enters this checksum into a Web page or ATM terminal, the host system can verify that the user is actually in possession of the smart card at the time of the transaction. Unlike a memorized password,

the checksum is only valid for a minute or two, so a potential thief cannot gain access to the account by simply snooping on the password.

Evaluating a typical display usage model for an OTP card, the display starts off with a fully white display. When a button is pressed, a six-digit number is updated to the screen and is held there for approximately 30 sec, long enough for the user to transfer the number. After the 30 sec are completed, the numbers are erased to white and the display flashes black and then white. In this example, the whole cycle takes about 30.96 sec. Writing and erasing the six digits takes about 1.6% of the transaction cycle, and the black/white flash at the end is also 1.6% of the transaction cycle. During the remaining 96.8% of the cycle, the display draws no power. Averaged over the entire write-erase cycle, the power draw of the display alone is 0.42 μW per transaction.

Power Considerations for an EPD System

The display is only one component of the total display system. An ultra-low-power display should be matched with ultra-low-power electronics for optimal performance.

For the Seiko watches mentioned above, a dedicated EPD driver featuring low power consumption to take advantage of EPD features was developed. Drawing on accumulated LCD driver and MCU technologies, a high-voltage

process, capable of withstanding approximately 20 V, was combined and optimized with a low-leakage 20-V processor. An integrated booster circuit (DC-DC converter) was added that reduced the conventional current consumption of the power-supply circuit when active (unloaded) down to around 5 μA . By utilizing the characteristic image stability of EPDs, operating voltage and power consumption for the driver power supply could be removed when not in use. The commercialization of the EPD watch, which required frequent display switching, was enabled by these low-power-consumption technologies.

MCU, EPD driver, and real-time clock (RTC) technologies are available for the smart-card market, including a conventional 4-bit MCU² series and a recently introduced 16-bit MCU,² both featuring low power consumption. RTCs consuming just 160 nA lead the market in low power consumption, based on a newly developed low-voltage oscillator circuit. OTP cards are an example of a product that utilizes these technologies. A typical system diagram for one of these cards is shown in Fig. 2.

From the battery, 3 V of power is supplied to the MCU, RTC, and EPD driver. The MCU uses 32 kHz and 1 MHz for the clock. The EPD driver drives the six-digit display described in detail earlier. The MCU and RTC transmit data bi-directionally. The EPD

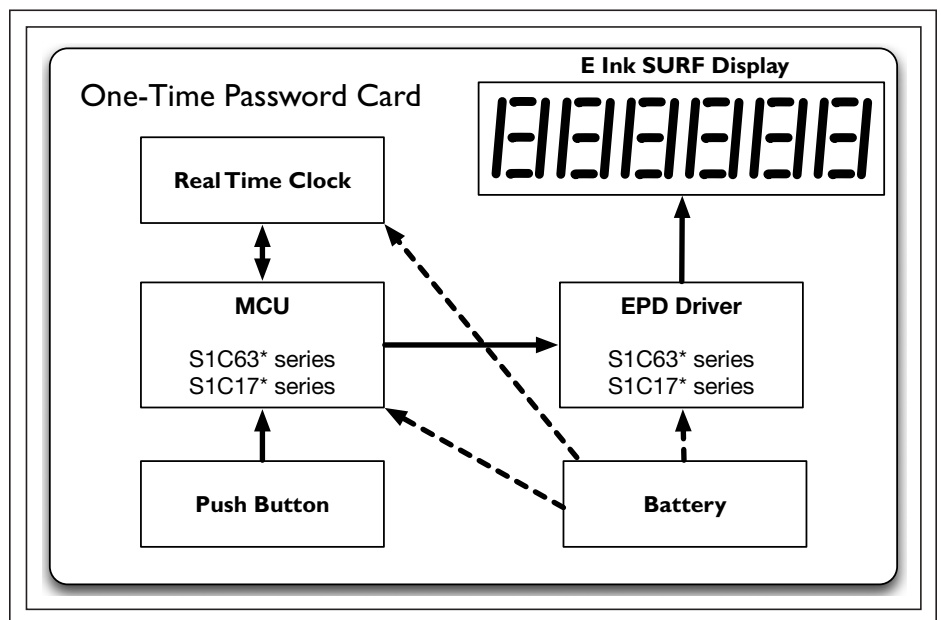


Fig. 2: A one-time-password (OTP) card diagram shows the relationship between MCU, EPD driver, and EPD. Source: Epson.

EPD applications

driver is controlled by the MCU, and input buttons connect directly to the MCU.

When the card is in use, the power consumption will be 310 nA, the sum of the MCU halt current of 150 nA and the RTC power consumption of 160 nA. By combining the MCU and the RTC on one chip, it is possible for both to share circuits, enabling a reduction in power consumption. When the password is displayed by pressing a switch (6-μA current for 300 msec), the MCU shifts to operating mode, and the 1-MHz clock starts operating to communicate with the other components. The power consumption of the MCU at this time is 600 μA. After the clock starts up, it obtains the time data from the RTC. At this time, the RTC uses 40 μA of current during transmission (about. 300 msec). The calculation and processing time for this data is taken to be 200 msec (this differs depending on the type of calculation). The power consumption when the clock is at 1 MHz is 600 μA.

Next, a 15-V power source is created using the EPD driver's DC/DC converter. The DC/DC converter is set at $3\text{ V} \times 5 = 15\text{ V}$. When starting up, charge-up consumes 30 μA for 5 msec (recommended circuit configuration for this EPD driver). The loss at start-up is 5 μA. When 15 V is applied, the display consumes 1 μA, and for the DC-DC converter power current it is five times that at 5 μA

(simplified calculation). During the transmission of the 48-bit data (about 60 μsec), 65 μA of power is consumed. For one display, data is transmitted at a minimum of three times; for white display, black display, and discharge. During the display process, white and black take 250 msec, and for all drivers at 0-V output it takes 5 msec. This information above is summarized in Table 1.

Under these conditions, the expected life of a 14-mAh battery would be 5 years if used 10 times a day (erase 10 times) and 2.5 years if used 100 times a day (erase 100 times). This combination of MCU, EPD driver, RTC, and EPD is designed to meet customer needs with respect to repeated use and battery life cycle.

In order to extend battery life indefinitely, a similar display circuit can be built for electronic-shelf-label applications utilizing IC tags, an MCU integrated with a solar-charging control circuit, and the EPD driver. The solar-charging control circuit was originally designed for use in clocks and achieves a low-power-consumption level of 150 nA in Halt mode and 3.5 μA when active (power circuit on), while easily meeting the increased power requirements of the RF-controlled clock functions. Combined with a secondary battery, the electronic shelf labels can be designed to run off ambient store light, eliminating the need to change the batteries.

Summary

There are a few drawbacks to EPD technology, including its lack of maturity in the marketplace. Electronic-paper players are few, and an ecosystem and infrastructure around EPD applications has yet to develop. LCDs, for example, have more standard drivers available to them. Presumably, this drawback will fade in time as the market develops. Other drawbacks include voltage requirements: EPDs require much higher driving voltages ($> 10\text{ V}$), even though their current requirements are very low. And last but not least, for the time being, EPDs have slower response times than other display media. However, despite these drawbacks, many of which should be overcome in the future, EPDs offer unique solutions for a variety of novel applications. With their ultra-thin, rugged, and flexible properties, segmented EPDs provide a high-contrast display that can be used on many types of devices. By choosing low-power system electronics to match the low-power features of the display, designers can realize solutions requiring both portability and long battery life.

Notes

¹Refers to E Ink SURF™ Displays.

²Refers to Epson's MCU, EPD driver, or RTC technology. ■

Table 1: One-time-password smart-card power-current consumption (typical). Operating voltage, 3 V. Source: Epson.

Item		Card Not In Use	Card In Use											
Accumulation time (ms)		-	5	5.3	205.3	210.3	210.36	460.36	465.36	465.42	715.42	720.42	720.48	725.48
Operating time (ms)		-	5	0.3	200	5	0.06	250	5	0.06	250	5	0.06	5
Push button	on		6uA											
MCU	1MHz CR clock (Run state)		600uA						600uA			600uA		
	32kHz crystal (Run state)							25uA			25uA			25uA
	32kHz crystal (Halt mode)	0.15uA	0.15uA											
Real Time Clock	During data transmitting			40uA										
	Nomal operating	0.16uA	0.16uA											
EPD Driver	Voltage boost (from 0V to 15V)						30uA							
	During display data input						65uA			65uA			65uA	
	When EPD is not driving (no load)						5uA							
	EPD driving current consumption						5uA							

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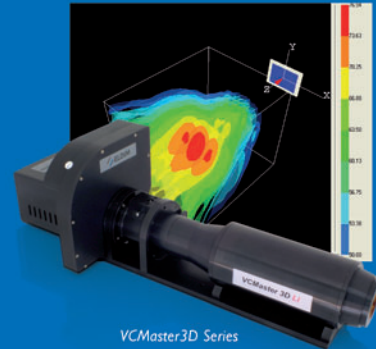
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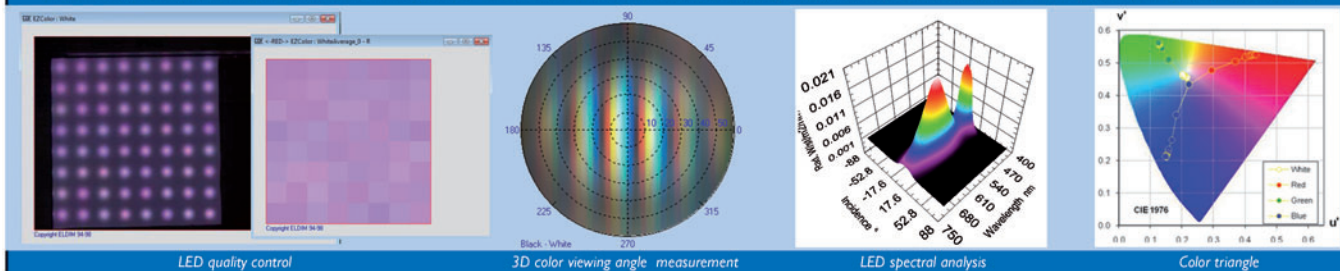


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Low-Power Large-Area Cholesteric Displays

Compared to an emissive or transmissive display, a reflective display can offer low power consumption, especially if it is also capable of utilizing low-power supporting systems. Such often forgotten systems can consume more power than the display itself.

by David Coates

LARGE-AREA DISPLAYS can be found in applications that range from showing moving images at sports stadiums to presenting a cycle of static images on outdoor billboards. They are also used as transportation and information signs. Wall displays conveying mood or ambience rather than images are also being developed. These displays can be employed outdoors or indoors and used for short- or long-range viewing; it is unlikely that any one technology or display type will suit all these diverse applications.

Light-emitting-diode (LED) displays have enjoyed success for over 10 years in some of the above applications, *e.g.*, sports stadiums, but their growth into other applications such as the outdoor-advertising market has been quite slow; this may suggest that LEDs are not universally suitable for all applications. LED displays may, for example, consume too much power for use in long-term applications or, due to the large bright area of the screen, they may be deemed overbearing and intrusive in confined indoor spaces. They may also be judged to produce too much light pollution (even though they can, in fact, be dimmed). They may also suffer image break-up if the viewing distance is quite varied, not have enough contrast and brightness in full-sunlight locations, or not meet various local regulations that dominate the static-billboard market. In such circumstances, another option is required that ideally should provide a different

set of properties that complement rather than mimic LED technology and that would be more suitable for some applications. One such option comes in the form of low-power-consumption large-area full-color reflective displays.

Cholesteric liquid-crystal displays (ChLCDs) have been used for many years and have been suggested¹ for applications that require very low power, usually in hand-held devices but also in monochromatic signs (green/black and blue/white). In these applications, to achieve a very-low-power specification and also to attain fast scan rates, the optical properties of the ChLCD are often compromised. For large-area displays, this need not be the same paradigm; the image quality may be more important, and if the display itself is not the major power user (other electronics besides the LCD are using power), then the power used by the display becomes less critical.

The key features of ChLCDs are that they are reflective and use a bistable mode of operation; thus, there is no backlight, and once an image is generated no further power is required by the display; some power may be needed to keep the system alive, but the LCD itself requires no power. Here, a distinction is made between the display, *i.e.*, the part that shows the image, and the system that drives the display.

A ChLCD operates between two stable states, a colored reflecting state (planar state) and a weakly light-scattering state (focal-conic state); between these two states many stable gray levels exist. A black absorber behind the display absorbs light that is not

reflected (*i.e.*, transmitted) by the display and provides a black color. The stable states are accessed by applying a high voltage (>30 V) which produces the transparent metastable homeotropic state which, when allowed to relax, forms the planar state, and with further lower voltage pulses the focal-conic state, or forms mixed focal-conic/planar gray levels. A single cholesteric film will typically reflect a waveband (~ 60 – 90 nm) of light; to reflect white light and achieve full-color operation, three layers (red, green, and blue) are used.

Power Requirements

By using this mode of operation, ChLCDs have been studied for use in very-low-power applications such as mobile phones. Despite the bistable nature of the display, the relatively high voltage required can counter this potential advantage of very low power, especially if the display has to be updated regularly. This has reduced the applicability of ChLCDs in many mobile applications, especially those that require frequent image updates.

However, large-area displays require the integration of other components to form a system whose power requirements as a whole must be considered; the overall power used can then be divided into three categories:

- **Power to change the image (display power):** In three-layered devices, this is in the range of 5 – 15 W/m²; it occurs only while the image change is taking place. The average power therefore depends on the time taken (defined, for example, by

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the number of displayed lines and the drive scheme) and the voltage required. Clearly, the contribution to the overall average “image change” power budget depends on how often an image change is made.

- **Power to operate the display as a whole (i.e., background or system power):**

This includes any PCs and/or controllers to capture incoming data (usually the display is connected to some outside source to download information and images), power supplies, and other electrical items involved in running the display. This is typically in the region of 350–700 W per display. In applications where the image requires very infrequent changes, most of this equipment can be shut down between image changes to reduce the power to a very low level ($<1 \text{ W/m}^2$).

- **Power to peripheral equipment such as lighting, heating, and/or cooling as required:**

This is dependent on the location of the display (indoors or outdoors), the climate (hot or cold), and specification requirements such as image refresh time, etc. The mechanical design of the system is a key feature in defining these parameters.

- Power for lighting depends on how reflective the display is, how bright the surroundings for the display are, and the design and type of lamps; typically, this is in the region of $30\text{--}100 \text{ W/m}^2$.
- Because the transmitted light is taken up by an absorber behind the display, there is a conversion of light into heat at this point; thus, some cooling is often required and can consume up to 100 W/m^2 , depending on the design of the mechanics in the display and the climate in which the display is used. Indoor displays should not require cooling.
- Heating may also be required to provide a reasonable switching time and can consume $50\text{--}250 \text{ W/m}^2$, again depending on the climate, display design, specification requirements, and drive scheme used. Indoor displays should not require heating.

Thus, when comparing the power used by large-area displays, it is important to understand which power-consuming components are included or not included in the power specifi-

cation. Displays used indoors will require much less power than those used outdoors.

When comparing reflective displays with typical values for other large-area display types, the system in which they work also has to be considered. For example, a large-area backlit LCD designed for outdoor use has to emit in the region of 2000 cd/m^2 to compete with direct sunlight² – in this mode, it uses about 2 kW/m^2 , but at night this can be much less, at about 0.5 kW/m^2 . “Background” power (PC, etc.) to run the system should be added to achieve an overall power budget that is in the region of $1.0\text{--}2.5 \text{ kW/m}^2$. The move to more efficient backlights will help reduce this power budget.

Large-area (20 m^2) outdoor LED displays (typically having a pitch of 20 mm) use in the range of $0.5\text{--}0.7 \text{ kW/m}^2$ over a 24-hour period (depending on brightness and pixel pitch). Smaller-pitch LEDs will consume significantly more power, and displays used indoors will use less power.

A bistable ChLCD cannot show video images, so like-for-like comparisons are not possible. Therefore, the power required to provide repeated changing of static images has to be considered. The reflective nature of

ChLCDs replaces the power required to handle direct sunlight by what should be a lower power requirement to illuminate the display at night.

Large-Area ChLCDs

In 2002, Magink and Mitsubishi Electric Corp. launched the first large-area outdoor ChLCDs, showing static images on displays ranging between 2 and 13 m^2 . Figure 1 shows such a display, which consists of ChLCD panels in a glass-fronted temperature-controlled box. The contrast ratio was 6–8:1 with an image refresh taking place every 7 sec and lasting for about 2 sec at 20°C . The display and background system used about 25 W/m^2 for each image change and 16 W/m^2 between image changes; overall, about 17 W/m^2 was used. The overall power consumption was dominated by heating ($100\text{--}250 \text{ W/m}^2$), cooling or air circulation ($<6 \text{ W/m}^2$), and illumination ($80\text{--}100 \text{ W/m}^2$). Overall, the display used an estimated 150 W/m^2 , but this was the first device of its kind.

Other bistable ChLCDs have been used as train timetables, indoor information displays,³ and traffic guidance signs.⁴ Displays of this type tend to be smaller and of higher resolu-



Magink Display Technologies

Fig. 1: Shown is a 2-m^2 bistable ChLCD introduced in 2002 in Mumbai, India.

cholesteric displays

tion; thus, there are more lines to address per m^2 , which uses more power. For example, AEG multicolor displays⁴ of this type consume 150 W ($\sim 70 \text{ W/m}^2$) in daylight and 750 W ($\sim 340 \text{ W/m}^2$) at night.

High-Contrast ChLCDs

Image quality is a critical issue for applications such as advertising billboards. The typical contrast ratio of $\sim 6:1$ for the bistable operation mode, while adequate for alphanumeric displays, was not good enough for full-color images. Improvements to the liquid crystal and the drive schemes resulted in a contrast of 10:1, but at the expense of a longer image refresh time.

To provide the quantum leap in image quality required for many high-end applications and also to address some other issues found in the use of ChLCDs for large areas, the contrast ratio was improved by making use of the homeotropic phase as a display state rather than as an intermediate state. Magink developed a method of doing this that has led to a high-contrast ChLCD featuring a contrast ratio of 50:1 on a pixel and, as a result, also has major impact on the color gamut, which increased in area by about 90%.

The homeotropic state is metastable and only exists while an electric field is applied across the thin film of a cholesteric liquid crystal. Thus, the display requires constant

power to maintain the areas of an image that are required to be in the homeotropic state. Some areas of an image are used in the bistable mode; thus, the display is a hybrid bistable-driven device. Consequently, more power is used by the ChLCD itself in the high-contrast mode, compared to the fully bistable mode. However, when using the high-contrast mode of operation, other features are improved that can allow power savings elsewhere. For example, the total image refresh time is very fast (currently $<170 \text{ msec}$ at 20°C and $<800 \text{ msec}$ at -10°C), which reduces the requirement for heating in very cold climates, and for indoor use (over the range of $15\text{--}50^\circ\text{C}$), video images at 60 fps can be shown. The high-contrast display can also be used in the lower-power conventional bistable mode if required; in this case, the contrast is about 15:1.

The high-contrast mode was initially used in a box similar to that used by the bistable display mode (Fig 2). It consumed about 54 W/m^2 when showing an “average” image. The power budget per image change is not relevant in this case, as the power is provided all the time and image changes cause negligible increases in power use. When video mode is used, the power consumption increases to about 107 W/m^2 . Additionally, there is the background power (approximately 500 W per display) and cooling during the sunshine

hours, which, in this design, can be up to 150 W/m^2 . In this first design, some significant heating was also provided ($150\text{--}350 \text{ W/m}^2$) but was not really required. At night, when little or no cooling is required, the lights consumed about 60 W/m^2 . Thus, on average over 24 hours, the display, depending on conditions, required over 300 W/m^2 for a 13-m^2 display (this was the largest display size available).

This system design did not take full advantage of the properties of the high-contrast mode; it used the same basic design as that used in the bistable mode of operation. By making more use of the properties of the high-contrast mode, lower overall power can be realized. For example, taking the display out of the glass-fronted box can, depending on the design, reduce the need for forced cooling (although some cooling is still currently used) and the lack of front glass reduces parasitic reflections, which leads to a further improvement in image quality, which in turn allows less lighting to be used. The fast image changes are less susceptible to low temperatures (at -10°C the image refresh time is $<1 \text{ sec}$), thus eliminating the need for heating of the display.

The first outdoor displays of this type (Fig. 3) that show high-contrast static images have no heating and require less lighting and involve an average power consumption of $110\text{--}120 \text{ W/m}^2$ (over 24 hours). Lower-



Fig. 2: Shown is a 6-m^2 high-contrast ChLCD – (a) day and (b) night views – erected in Cannes, France, in 2006.

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Fig. 3: Shown is a 20-m² high-contrast ChLCD from Pensacola, Florida, 2008.

power drive electronics, background, and lighting requirements suggest that this can be reduced to below 80 W/m² for a 20-m² outdoor static display.

Making use of these savings for indoor use (often with video images), where there is no cooling (or heating) requirement but with constant and more powerful lighting, about 120–130 W/m² is possible. Compared to equivalent LED or backlit LCDs that also show video images, the virtues of a reflective display are quite clear in terms of power savings.

Summary

Large-area outdoor reflective displays, bistable or not, can use less overall power than equivalent emissive and transmissive displays which have to deal with direct sunlight. ChLCDs can be operated in a conventional “low-power” bistable mode. However, in large-area displays, it is the system and peripherals requirements that dominate the power budget. In a high-contrast display mode that inherently uses more power than the bistable mode, the positive attributes lead

to less peripheral power being required. This leads to a reduction in power consumption. Figure 4 illustrates some typical average values mentioned here – the low-power nature of the reflective mode is readily appreciated, and when used optimally the unexpected advantage of employing a higher-power display (*i.e.*, a high-contrast ChLCD) to provide a lower-power display overall is also clear.

Acknowledgments

The author wishes to thank colleagues at Magink Display Technologies and Dr. Z. Hara at the Mitsubishi Electric Corp. for discussions and data used in this review.

References

- ¹See displays from Kent Displays Inc., which pioneered this type of device.
- ²Screen Technology Ltd. data sheets.
- ³LC TEC M1 SVGA ChLCD module.
- ⁴AEG MIS Geameleon bistable ChLCDs. ■

Outdoor Large-Area Displays Comparison of Power Use

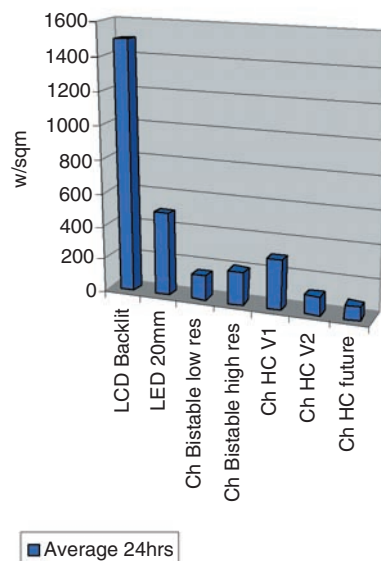


Fig. 4: Comparison of power usage in different outdoor large-area displays. Source: Coates, Magink.

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ELECTRONIC-PAPER ISSUE

Information DISPLAY January 2008 Vol. 24, No. 1

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The New York Times

Has E-Paper Finally Arrived?

- Electrodynamics: Unlocking Color in E-Paper
- E-Paper Manufacturing
- Electronic Papers: Past, Present, and Future
- Early Days of LCD Research and Development
- Journal of the SID January Preview

ICDM Special Session: A Visionary Standard

The new guidelines contained in the Display Measurements Standard (DMS) developed by SID's International Committee for Display Metrology (ICDM) are designed to flexibly address the pace of change in the display industry by using a common language rather than specific tests. And those guidelines will grow with technology. "We anticipate that this will be a living document," says Joe Miseli, Chair of the ICDM.

by Jenny Donelan

METROLOGY AND HEROISM are not words that often show up in the same sentence, but in the case of SID's International Committee for Display Metrology (ICDM), the pairing is apt. Over the last decade, the members of the committee have labored, for the most part, without compensation, and, in addition to their day jobs at different companies throughout the world, to create a comprehensive metrology standard for evaluating displays. Though it might not sound especially heroic to ensure that all display measurements are made on the same baseline for fair and honest comparisons, this was a difficult and complicated task that no power-that-be ever mandated. A group of visionaries simply knew that displays were sometimes being measured with error and bias and set about to put that situation to rights.

The fruit of their labors, a 400+ page book that will be available for the first time at Display Week 2009, is unlikely to turn heads in the same way as, for example, an OLED television or a flexible display that can be worn as a bracelet. But its long-term impact may be just as great. The Display Measurements Standard (DMS), Version 1, is also noteworthy because it is the first standard ever to be sponsored by the Society for Information Display. And the ICDM is the first

standards-development committee ever to exist within SID.

The *Display Measurements Standard (Version 1)*, on sale at Display Week, consists of a 400+ page book and a DVD containing extras such as test patterns for multiple resolutions. Included in the book will be descriptions for measuring performance for all types

of displays – LCD, PDP, OLED, projection, 3-D, flexible, and even CRT. There will also be a technical section, a metrology section, and many different references and guides, including glossaries and tables. "The scope of this is boundless – it is not limited to any type of display or state of development of display," says Joe Miseli, Senior Staff Engineer for

6.4 SAMPLED FLUX FROM WHITE

ALIAS: Light Output

DESCRIPTION: We calculate the luminous flux from a front projector by use of sampled illuminance measurements of a white full screen and the area of the projected image so that the influence of white primaries (white image fields and/or white subpixels) can be included. **Unit:** lumen (lm). **Symbol:** Φ_W .

APPLICATION: Front projectors.

SETUP: The following icons are defined in Section 3.7 for any standard setup details:



OTHER SETUP CONDITIONS: The illuminance measurements must be made in a room where the stray light is ignorable or can be accounted for as a correction.

Patterns needed: (1) SET01S50 as in Figure 1, (2) AT02P to locate the centers of the 3x3 array of equal rectangles that defines the measurement grid (Figure 2), (3) FW or a full-screen white pattern. A video generator that uses the native resolution of the projector is strongly recommended.

PROCEDURE: Select the mode of operation of the projector to be measured. For each mode selected perform the following steps:



Figure 1. Pattern (SET01S50) to set up the front-projector.

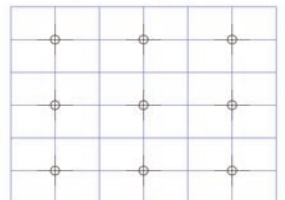


Figure 2. Pattern (AT02P) to determine detector positions.

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A sample page from the Display Measurements Standard, Version 1. Included in the book will be descriptions for measuring the performance of all types of displays.

Displays at Sun Microsystems and Chair of the ICDM. The Standard is also designed to be accessible to anyone involved with displays. "It can be used by manufacturers, OEMs, and even end users," says Miseli. In order to ensure consistency of style and clarity of language for the project, all content is being overseen by a single editor, Ed Kelley, Senior Scientist for Display Metrology at NIST, who is the ICDM Editor-in-Chief.

What the Standard will not do is describe what constitutes good or bad image quality. Rather, it will ensure accuracy in measurement of the image quality by describing methods for measurements so that results produce accurate numbers. The emphasis is on proper methodology and reducing ambiguity through a clear and common language.

Answering a Need

One of the driving forces behind the creation of the ICDM was the dearth of a common language for the evaluation of displays. Though there was the VESA (Video Electronics Standards Association) FPDM2 (Flat Panel Display Measurement) standard, devel-

oped by many of the parties now involved in the ICDM, the FPDM2 standard was last updated in 2001. "Displays have been changing so quickly that standards have not kept up," says Miseli. The new guidelines are designed to address the pace of change flexibly by using a common language rather than specific tests. And those guidelines will grow with technology. "We anticipate that this will be a living document," says Miseli.

Another driving force was that measurements for certain aspects of display performance are notoriously easy to manipulate. This made it easy for manufacturers to engage in what is commonly called "specsmanship." Therefore, chief among the goals of the Standard were, in the words of the committee, "to establish standard setup and testing conditions to assure accuracy in testing and work to eliminate such 'wiggle room,' so that those

ICDM: Where and When

Special Session: Focus on the ICDM

The session, consisting of five 10-minute presentations and a 30-minute panel discussion, takes place Wednesday, June 3, from 10:40 am to 12:00 pm in Room 214A/B of the Henry B. Gonzalez Convention Center.

Featured papers include:

- **"Gamma and Gray-Scale Measuring Methods for ICDM Standards"**
Don Gyou Lee, LG Display Co., Ltd., Kyungbuk-do, Korea
- **"3-D Stereo-Display Standards"**
Adi Abileah, Planar Systems, Inc., Beaverton, OR, USA
- **"Projectors and Front-Projection-Screen Measurements"**
Michael Rudd, THX Ltd., San Rafael, CA, USA
- **"Luminance and Contrast"**
Jens Jorgen Jensen, Delta, Hoersholm, Denmark
- **"Viewing-Angle Measurement Methods"**
Thierry Leroux, ELDIM S.A., Saint Clair, France

INTERNATIONAL COMMITTEE FOR DISPLAY METROLOGY

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SOCIETY FOR INFORMATION DISPLAY
Definitions and Standards Committee
International Committee on Display Metrology
(ICDM)

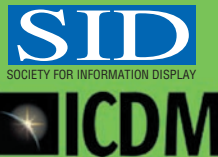


DISPLAY MEASUREMENTS STANDARD

VERSION 1.0

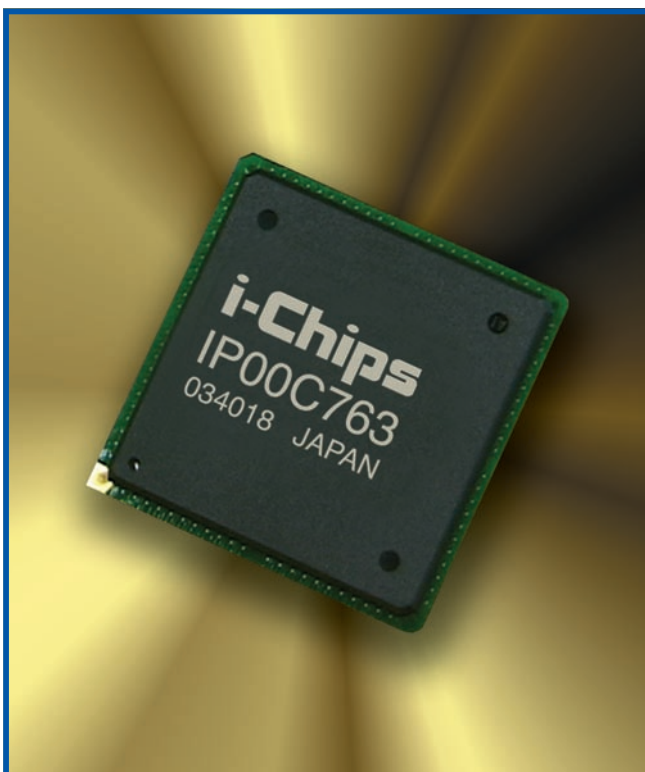
June 1, 2009

Abstract: This document consists of standard measurement procedures to quantify electronic display characteristics and qualities. However, it is also a document that discusses display metrology or the science of display measurements in that it reveals some of the problems associated with making display measurements, contains diagnostics to reveal those problems, and offers solutions to these measurement difficulties. In general, we avoid setting any performance criteria or performance minima. The hope is to serve standards organizations that wish to minimize the amount of space dedicated to measurement descriptions and make reference to this document instead. Consider the measurements in this document to be a buffet from which the desired reference methods can be selected depending upon the needs of the user.



NOTE: This document is in the public domain and may be used freely. However, we do ask that appropriate references be made when you incorporate any of its content in another document or work.

The Display Measurements Standard, Version 1, will be available for sale at Display Week 2009 in San Antonio, Texas. A DVD containing extras such as test patterns for multiple resolutions is included in the price of the 400+ page book.



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Display Week 2009

who test displays cannot skew conditions in order to demonstrate favorable results.”

The experts who came together to address this situation hail from a wide range of fields relating to displays, including display metrology, color science, vision science, human factors, display engineering, physics, and many others. The ICDM now has more than 150 active members. Many of them have been working together in various capacities toward a unified display standard for a number of years, but the ICDM was officially founded in 2007.

Visitors to Display Week 2009 will have several opportunities to buy, view, and learn about the new Standard. It will be on sale at the SID Membership Booth, and a special ICDM session will feature presentations on different aspects of metrology — and, in a way, on a bunch of visionaries quietly making history.

Presentation: Introducing the ICDM

Standards Chair Joe Miseli will present “Introduction to the ICDM Display Measurements Standard” as part of the Display Measurements Methods and Standards session scheduled for Wednesday, June 3 from 9:00 to 10:20 am in Room 214A/B of the Henry B. Gonzalez Convention Center in San Antonio, Texas.

Visit the ICDM Web site at www.icdm-sid.org. ■



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Flexible Displays Come into Their Own at Display Week 2009

For the first time, the Society for Information Display has designated official sessions for flexible-display papers at Display Week. This year, there are seven sessions devoted exclusively to flexible-display technology: Flexible Display Components, Flexible-Display Manufacturing (a joint session with manufacturing), Flexible Active-Matrix Backplanes, Organic TFTs, e-Paper, Emerging Active-Matrix Technologies (a joint session with Active-Matrix Devices), and Flexible AMOLEDs.

by Jenny Donelan

INTEREST IN FLEXIBLE DISPLAYS has been steadily growing within the industry; while on the outside, end users are becoming intrigued as well. So, as the research papers in this area proliferate, flexible-display products are also being developed that have the potential to exercise considerable consumer appeal. Among these, for example, are flexible e-books, cell-phone skins that can be programmed to change colors, and flexible OLED displays – all topics that will be presented at Display Week 2009.

“It is a relatively hot area,” says Flexible Displays Subcommittee Chair David Morton from the Army Research Laboratory. Even in a sluggish economy, he notes, “We did a little better this year than last in terms of paper submissions.” For this reason, and because the technology has developed a momentum of its own, flexible displays will have their own dedicated sessions at Display Week 2009 for the first time. “There have always been papers that address flexible displays” says Morton, “but some would go to electronic paper and some would go to OLEDs.” If you

wanted to follow flexible displays you had to be a well-prepared session hopper.

Now, however, that SID has created an official destination for flexible-display papers, it will be much easier to follow the technol-

ogy. This year, there are seven sessions devoted to flexible displays: Flexible Display Components, Flexible Display Manufacturing (a joint session with manufacturing), Flexible Active-Matrix Backplanes, Organic TFTs,



A flexible OLED display developed by Universal Display Corp. and LG Display represents just one of the technologies currently under development for potential military and commercial applications. Image courtesy of UDC.

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e-Paper, Emerging Active-Matrix Technologies (a joint session with Active-Matrix Devices), and Flexible AMOLEDs. There is also a keynote address from Plastic Logic on flexible e-books – a paper originally scheduled for the above manufacturing session, notes Morton.

Highlights

One of the standout topics this year is the commercialization of flexible e-books, which will be covered in the joint session with manufacturing. Now that the Kindle and other e-readers have stirred public interest, the potential for flexible media seems greater than ever. Papers on this topic are “Flexible e-Books” by Ian French from Prime View International and “Rollable Displays: From Concept to Manufacturing” by Edzer Huitema from Polymer Vision, Ltd. “The key here is that these companies are working on flexible e-books and at some level claim to have products available in the coming year,” says Morton. “So, one thrust of this session will be lightweight, rugged, flexible e-books for newspapers.” Another will be the advent of this technology into other types of lightweight, rugged, zero-power displays.

Advances in flexible OLED displays will be another area of focus at this year’s symposium. Chief among these advances is the ability to put devices on plastic rather than steel or other metals. “The question then is how long will they last?” says Morton, noting that encapsulation is therefore also an important topic, but one that not many papers addressed this year. One of those flexible OLED papers to watch for is from Dong Un Jin of Samsung SDI Corp. titled “World’s Largest (6.5 in.) Flexible Full-Color Top-Emission AMOLED Display on Plastic Film and Its Bending Properties.” Another related presentation of interest will be “Active-Matrix PHOLED Displays on Temporary Bonded Polyethylene Naphthalate Substrates with 180°C a-Si:H TFTs” by Douglas Loy from the Flexible Display Center at Arizona State University.

An additional highlight, which does not have high-resolution aspects but is bound to appeal to consumers – especially teenagers – are programmable cell-phone skins that can change color, which will be covered in “Flexible Electronic Skin Displays” by Erica Montbach from Kent Displays. “This is not necessarily a highlight in terms of content, but they will sell a lot of them,” says Morton.



An Hitachi mobile phone features a flexible display from E Ink on its cover. Image courtesy of E Ink.

Featured Papers

The aforementioned flexible OLED paper from Samsung discusses how AMOLEDs are uniquely suited to flexible displays and describes the fabrication of a (relatively) large, full-color flexible display based on this technology.

Critical elements of a-Si technology on plastic for AMOLED applications is the subject of “Amorphous-Si TFTs with 100-Year Lifetimes in a Clear Plastic Compatible Process for AMOLEDs” by James C. Sturm from Princeton University.

Semiconducting nanofibers help achieve excellent charge properties in low-cost large-area flexible organic thin-film transistors, as described in “Organic TFTs Based on Semiconducting Nanofibers Embedded in Insulating Polymer” by Kilwon Cho from the Pohang University of Science and Technology.

“A Reliable Flexible OLED Display with an OTFT Backplane Manufactured Using a Scalable Process” will be presented by Mao Katsuhara from Sony Corp. The paper

describes how the Sony team developed a full-color top-emission AMOLED display using a scalable, lift-off, and shadow-mask-free process.

Trends in Flexible Displays

Now that flexible displays have a category of their own at Display Week, what’s next on the horizon? Advances in flexible OLED displays will definitely be an area to continue watching, according to Morton. He also notes that he has been seeing some worthwhile student papers and that interesting work is in fact coming out of academia in general.

“When you look at flexible displays, there are still so many areas to work on, such as barrier films, organic TFTs ... even the mechanical stuff, the ability [of the material] to survive the actual flexing.” Flexible displays, in other words, offer more uncharted territory than, say, LCDs, which have been around longer. “There are still going to be advancements made in LCDs, but it is a lot harder to find something unique to do your Ph.D. on,” he says. ■

Journal of the SOCIETY FOR INFORMATION DISPLAY

A preview of some of the most interesting papers appearing in the
March 2009 issue of the *Journal of the SID*.

To obtain access to these articles on-line, please go to www.sid.org

Edited by Aris Silzars

Bi-directional OLED microdisplay for interactive see-through HMDs: Study toward integration of eye-tracking and informational facilities

Uwe Vogel

Daniel Kreye (SID Member)

Bernd Richter, Gerd Bunk

Sven Reckziegel, Rigo Herold

Michael Scholles, Michael Törker

Christiane Grillberger

Jörg Amelung, Sven-Thomas Graupner

Sebastian Pannasch, Michael Heubner,

Boris Velichkovsky

Fraunhofer Institute for
Photonic Microsystems

Abstract — First prototypes of bi-directional OLED microdisplay devices that combine both display and camera functionality on a single CMOS chip (OLED-on-CMOS) have been designed. The major goal of this integration is to provide capabilities for eye-tracking in see-through HMDs to achieve gaze-based human–display interaction, *e.g.*, in augmented-reality applications. The development of the prototype was accompanied by user studies with a simulated bi-directional microdisplay consisting of a commercially available eye-tracker and a see-through HMD. These tests were aimed at providing basic minimum requirements in terms of temporal and spatial resolution of an eye-tracker to be implemented within the prototype, as well as to evaluate ergonomics of an appropriate user-interface design. A description of the current state of the hardware architecture and design aspects for bi-directional OLED microdisplays are also presented.



FIGURE 3 — Mock-up system consisting of a microdisplay and a head-mounted eye-tracker simulating the bi-directional see-through HMD.

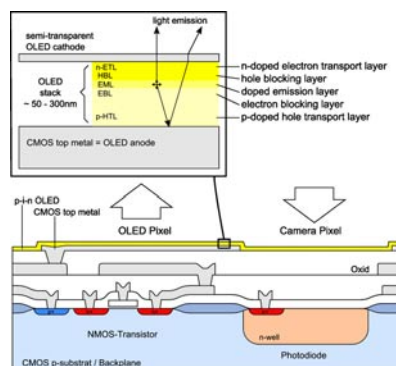


FIGURE 6 — Detailed view of the used OLED structure sandwiched between metal electrodes (top) and a cross-sectional view of a CMOS device with an integrated OLED illustrate the functionality of a bi-directional OLED microdisplay (bottom).

A full-color eyewear display using planar waveguides with reflection volume holograms

Hiroshi Mukawa (SID Member)
Katsuyuki Akutsu (SID Member)
Ikuo Matsumura
Satoshi Nakano
Takuji Yoshida
Mieko Kuwahara
Kazuma Aiki

Sony Corp.

Abstract — A full-color eyewear display with over 85% see-through transmittance with a 16° horizontal field of view was developed. Very low color crosstalk, less than 0.008 $\Delta u'v'$ uniformity, and 120% NTSC color gamut were achieved. Waveguides with two in- and out-coupling reflection volume hologram elements enabled a simple configuration that has an optical engine beside the user's temples. The reflection volume hologram elements used on the waveguides realized a small thickness of 1.4 mm for each waveguide, and an out-coupling reflection volume hologram used as an optical combiner contributed a high see-through transmittance of 85% due to its wavelength selectivity. However, there are technical challenges in achieving a reasonable screen size and quality color images with optics that utilize holographic waveguides because holograms have large chromatic dispersions compared to conventional optical elements such as lenses and mirrors. Approaches to overcome these issues are described.

Figure 1 illustrates the basic structure of the holographic planar waveguide of the eyewear display. The waveguide has an in-coupling and an out-coupling reflection volume hologram which have exactly the same fringe pattern and a mirror symmetrically positioned. Reflection volume holograms were employed because their diffraction bandwidths are much smaller than those of transmission holograms and could potentially enlarge the field of view of the eyewear displays. Each of these holograms has red, green, and blue hologram layers to transmit full-color images through the waveguide.

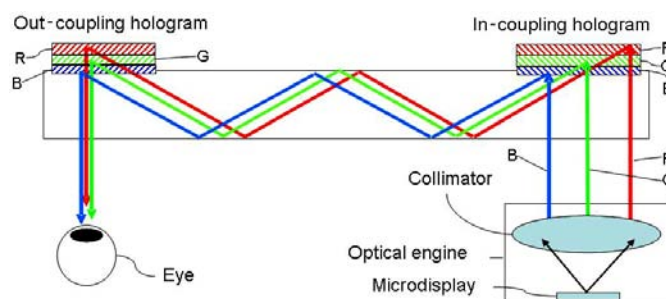


FIGURE 1 — A basic structure of a holographic planar waveguide of the eyewear display.

RGB-to-RGBW conversion with current limiting for OLED displays

Michael E. Miller (SID Member)
Michael J. Murdoch

Eastman Kodak Co.

Abstract — Organic-light-emitting-diode (OLED) displays employing white-light-emitting OLEDs in combination with RGBW color filters can demand high peak currents to present images with bright, highly saturated colors. Image-processing methods that take advantage of a very highly efficient white subpixel in addition to filtered RGB subpixels to reduce the peak current and power of these displays are described. The image-quality impact of these algorithms are explored to develop a final image-processing algorithm.



FIGURE 2 — A pictorial example of the effect of the RGB-limiting algorithm with RGB values limited to 1.0, 0.67, 0.33, and 0.0 with a threshold of 0.75.

Motion-adaptive alternate gamma drive for flicker-free motion-blur reduction in 100/120-Hz LCD TV

Taesung Kim (SID Member)
Bo Ye
Chung Phan Vu
Nikhil Balram (SID Senior Member)
Hugo Steemers

Marvell Semiconductor

Abstract — LCD motion blur is a well-known phenomenon, and several approaches have been developed to address it. This includes very-high-performance approaches based on motion-compensated frame-rate conversion (MC-FRC) and very-low-cost approaches based on impulsive driving. Impulsive-driving schemes are attractive because of their low cost, but suffer from two significant issues – loss of luminance and large-area flicker. A new impulsive-driving approach using motion-adaptive alternate gamma driving (MA-AGD), which removes motion blur and preserves the original luminance level without causing large-area flicker, is proposed.

While MC-FRC (motion-compensated frame-rate conversion) technology has been rapidly adopted as an ultimate solution for better motion performance, impulsive-driving technology, despite its simple and cheap implementation, has always been in the research mode due to its side effects. Flicker and luminance loss are two major drawbacks of impulsive-driving technologies, keeping them from being commercialized. In terms of luminance loss, there is a way to compensate the light loss by applying alternate gamma drive (AGD), which makes one frame darker to give the impulsive effect and another frame brighter to compensate for it by making the average brightness level even. However, flicker is almost impossible to eliminate completely because its generation principle conflicts with impulsive driving.

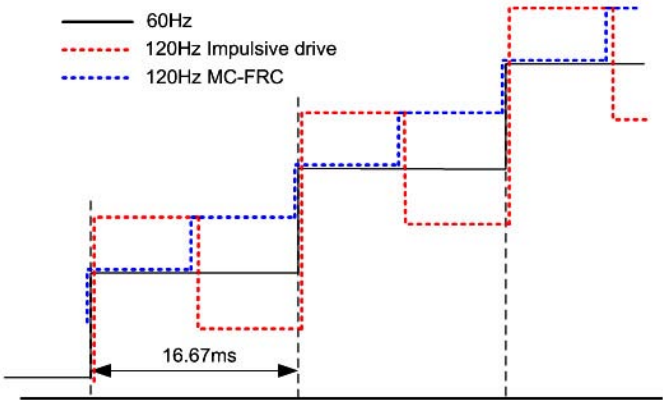


FIGURE 1 —The luminance variation of each driving scheme. (a) Native response of liquid-crystal molecules. (b) Boosted response by RTC.

A 12-bit segmented resistor–capacitor digital-to-analog converter for a display driver IC of a large TFT-LCD panel system

Seongjong Yoo (SID Member)
Yongjoo Song
Jiwoon Jung
Myunghye Lee

Samsung Electronics Co., Ltd.

Abstract — A 12-bit segmented R–C DAC to support a linear gamma curve has been proposed and fabricated in a 720-channel LCD source driver with a 16-V 1-poly 3-metal high-voltage CMOS process. The proposed DAC has a global resistor string and sample-and-hold buffers. A MSB voltage selected by the upper 6 bits of input data and a LSB voltage selected by the lower 6 bits of input data are summed by using a sample-and-hold operation with offset cancellation in the proposed DAC. The measured DNL was less than 0.3 LSB, and the output voltage deviation was less than 3 mV in all gray levels. Although two sample-and-hold buffers were adopted to operate alternatively, the die size was as small as 24.9 mm², which was only an 8.3% increase compared to that of a conventional 8-bit 720-channel source driver. Because of its good performance with small area, the proposed DAC can be a good low-cost solution for a 10-bit TV system.

TABLE 1 — Chip summary.

Process	16-V 1P3M high-voltage CMOS
Operating Voltage	15.0-V (Analog), 3.3-V (Logic)
DAC Dynamic Range	6.0 V
Number of Channel	720
Chip Size	15,200 x 1640 μm
Resolution	12 bits
Output Latency	one horizontal line display time
Application	10-bit 40/46-in HD FHD LCD Panel (1366 x 768, 1920 x 1080)

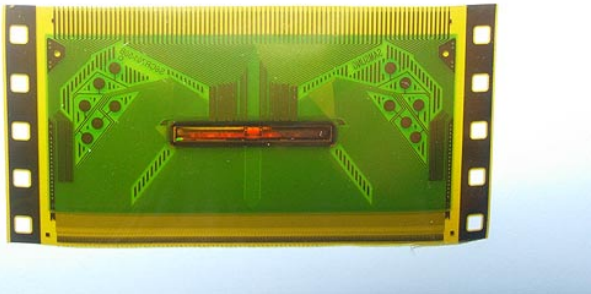


FIGURE 13 — Die photo with COF package.

Color-breakup suppression and low-power consumption by using the Stencil-FSC method in field-sequential LCDs

Fang-Cheng Lin (SID Student Member)
Yi-Pai Huang (SID Member)
Ching-Ming Wei (SID Student Member)
Han-Ping D. Shieh (SID Fellow)

National Chiao Tung University

Abstract — Field-sequential color (FSC) is a potential technique for low-power liquid-crystal displays (LCDs). However, it still experiences a serious visual artifact, color break-up (CBU), which degrades image quality. Consequently, the “Stencil Field-Sequential-Color (Stencil-FSC)” method, which applies local color-backlight-dimming technology at a 240-Hz field rate to FSC-LCDs, is proposed. Using the Stencil-FSC method not only suppressed CBU efficiently but also enhanced the image contrast ratio by using low average power consumption. After backlight signal optimization, the Stencil-FSC method was demonstrated on a 32-in. FSC-LCD and effectively suppressed the CBU, which resulted in more than a 27,000:1 dynamic contrast ratio and less than 40-W average power consumption.

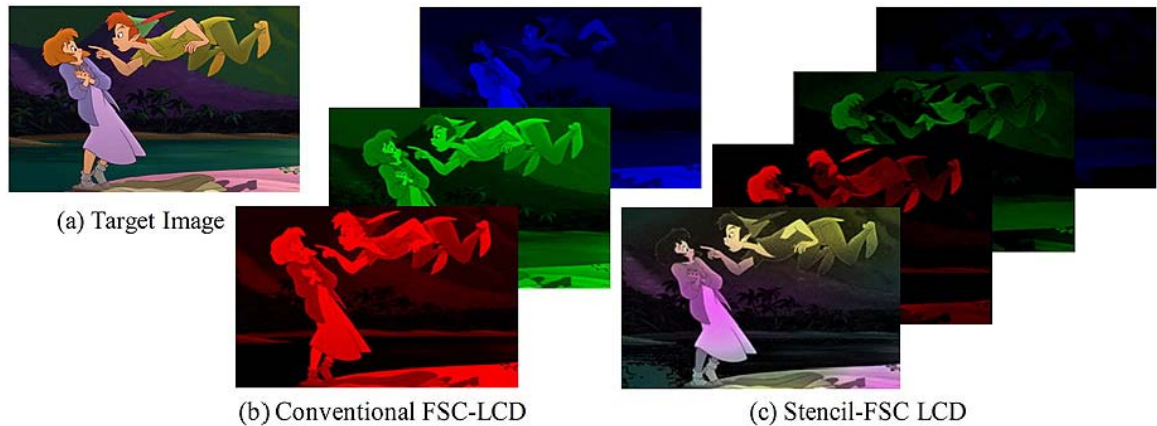


FIGURE 1 — (a) Target image_ *Peter Pan* (©Disney), each sub-frame image using the (b) conventional FSC-LCD and (c) Stencil-FSC method.

Evaluation of moving-line contrast degradation without motion

Michael E. Becker (SID Member)
Display-Metrology & Systems

Abstract — A method for evaluation of the contrast of moving step-grating patterns under smooth-pursuit eye-tracking conditions without imaging data acquisition and image analysis is introduced. *Periodic optical responses* of the display to a set of simple driving signals have been recorded at a fixed location, and the luminance vs. time data has been evaluated to obtain two types of contrast for characterization of the dynamical performance of the display under test: the *frame-convoluted contrast* and the *frame-integrated contrast*. The relation of this characterization with respect to *modulation transfer functions* from *impulse responses* and to the *dynamic modulation transfer function* from sine-gratings is explained and discussed. The approach described here provides a detailed and comprehensive characterization of the dynamical properties of electronic displays, including both extreme cases of *step-response* and *impulse-response* with quantities that are related to visual perception. With this type of evaluation, the visual resolution of displays can be described by the same characteristics in the static and the dynamic case. The method is attractive due to limited instrumental efforts and the transparent method of evaluation.

Visual targets with initially sharp edges moving across certain electronic-display screens (e.g., LCDs and PDPs) are often perceived as blurred by human observers. This is caused by the hold-type characteristics of the temporal response of the display and by integration of the human visual system while smoothly following the movement of the target (i.e., *smooth-pursuit eye tracking*, *SPET*). Increased LCD response times, especially when switching between intermediate levels of gray, further deteriorate the visual quality of moving objects and thus contribute to motion blur, but they are not the actual cause.

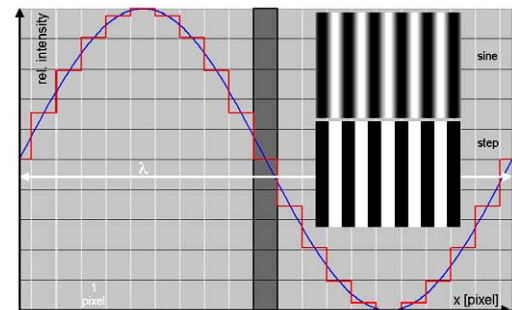


FIGURE 1 — Intensity profile (i.e., intensity vs. DUT pixel) of sine and step gratings shown in the inserts. The sine grating with wavelength λ is approximated by a series of steps. The step-grating has a minimum wavelength λ of two pixel (one pixel for each optical state).

LCD motion-blur estimation using different measurement methods

Sylvain Tourancheau (SID Member)
Kjell Brunnström (SID Member)
Börje Andrén (SID Member)
Patrick Le Callet

University of Nantes

Abstract — The primary goal of this study was to find a measurement method for motion blur which is easy to carry out and gives results that can be reproduced from one lab to another. This method should be able to also take into account methods for reduction of motion blur such as backlight flashing. Two methods have been compared. The first method uses a high-speed camera that permits us to directly picture the blurred-edge profile. The second one exploits the mathematical analysis of the motion-blur formation to construct the blurred-edge profile from the temporal step response. Measurement results and method proposals are given and discussed.

Four recent monitor displays have been tested in this work. They were all TFT AMLCDs with a refresh frequency of 60 Hz, with different types of panel, sizes, and resolutions as depicted in Table 1. In the following, they are identified with letters from A to D. Both C and D were using backlight flashing (BF). The response time given by the manufacturers is also mentioned.

TABLE 1 — Specifications of displays under test. L_{max} is the luminance of white, and RT is the response-time value given by the manufacturers.

Id	Type	Size (in.)	Resolution	L_{max} (cd/m ²)	RT (msec)	Notes
A	IPS	20	1600 × 1200	300	8	
B	TN	24	1920 × 1200	400	5	
C	IPS	26	1920 × 1200	500	5	Backlight
D	IPS	30	2560 × 1600	370	5	Backlight

Evaluation of motion performance on scanning-backlight LCDs

Wen Song (SID Student Member)
Kees Teunissen (SID Member)
Xiaohua Li (SID Member)
Yuning Zhang (SID Student Member)
Ingrid Heynderickx (SID Fellow)

Southeast University

Abstract — The scanning-backlight technique to improve the motion performance of LCDs is introduced. This technique, however, has some drawbacks such as double edges and color aberration, which may become visible in moving patterns. A method combining accurate measurements of temporal luminance transitions with the simulation of human-eye tracking and spatiotemporal integration is used to model the motion-induced profile of an edge moving on a scanning-backlight LCD-TV panel that exhibits the two drawbacks mentioned above. The model results are validated with a perception experiment including different refresh rates, and a high correspondence is found between the simulated apparent edge and the one that is perceived during actual motion. Apart from the motion-induced edge blur, the perception of a moving line or square-wave grating can also be predicted by the same method starting from the temporal impulse and frame-sequential response curves, respectively. Motion-induced image degradation is evaluated for both a scanning- and continuous-backlight mode based on three different characteristics: edge blur, line spreading, and modulation depth of square-wave grating. The results indicate that the scanning-backlight mode results in better motion performance.

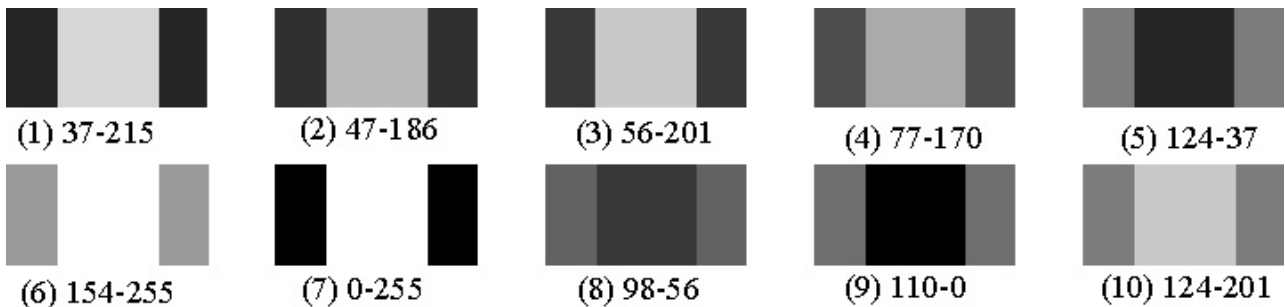


FIGURE 4 — The ten stimuli used in the perception experiment.

High-pixel-rate grating-light-valve laser projector

Hiroki Kikuchi (SID Member)
Shigeki Hashimoto, Shinichiro Tajiri
Tsuneo Hayashi, Yutaka Sugawara
Michio Oka, Yoshiyuki Akiyama
Akira Nakamura
Naoya Eguchi (SID Member)

Sony Corp.

The main concept behind the speckle reduction is to introduce the averaging of independent speckle patterns within the human eye's temporal and spatial resolutions. The averaging of N independent speckle patterns suppresses the measured speckle contrast by a factor of $1/\sqrt{N}$. To maximize the effect of speckle reduction, the projector was designed to introduce the following diversities in speckle patterns: (a) Polarization diversity. (b) Diversity by line scan. (c) Wavelength diversity. (d) Temporal variation diversity.

Abstract — A high-pixel-rate high-contrast (30,000:1) wide-color-gamut grating-light-valve laser projector is reported. A new optical engine enabling high-frame-rate (240 Hz) scan projection is employed. Panoramic wide-angle-scan projection with a 64:9 aspect ratio was also developed. Speckle noise is eliminated using a simple but highly efficient technique. The optical throughput efficiency of the grating-light-valve laser projector is reviewed.



FIGURE 1 — The GLV laser projector demonstrated at 2005 World Exposition, held in Aichi, Japan. The screen size is 50 × 10 m. Twelve 5000-lm laser projectors were used.

Efficient and compact green laser for micro-projector applications

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Steven J. Gregorski
Dragan Pikula
Satish C. Chaparala
David A. S. Loeber (SID Member)
Jacques Gollier (SID Member)
Joan D. Gregorski
Martin Hempstead
Yukihiro Ozeki, Yoshiaki Hata
Kazuhiro Shibatani
Fumio Nagai, Nobuyoshi Mori
Yukinobu Nakabayashi
Naoki Mitsugi, Satoshi Nakano

Corning Incorporated

This green-laser module is a small-form-factor implementation of the frequency-doubled architecture using the SIDM-based adaptive optics. The optical components, including the DBR laser and SHG, are assembled on a ceramic base that provides electrical interconnections. The high-temperature co-fired ceramic material provides a low-cost base on which the optical components are integrated. The multi-layered ceramic offers the options for running traces between the layers for high-speed electrical interconnection.

Abstract — Efficient and compact green lasers are keystone components for micro-projector applications in mobile devices. An architecture that consists of an infrared-producing DBR (distributed Bragg reflector) laser with a frequency-doubling crystal is used to synthesize a green laser that has high electrical-to-optical conversion efficiency and can be modulated at speeds required for scanner-based projectors. The design and performance of a green-laser package that uses adaptive optics to overcome the challenge of maintaining alignment between the waveguides of the DBR laser and the frequency-doubling crystal over temperature and lifetime is described. The adaptive optics technology that is employed uses the piezo-based smooth impact drive mechanism (SIDM) actuators that offer a very small step size and a range of travel adequate for the alignment operation. The laser is shown to be compact (0.7 cm³ in volume) and capable of a wall-plug efficiency approaching 10% (at 100-mW green power). It was demonstrated that the adaptive optics enables operation over a wide temperature range (10–60°C) and provides the capability for low-cost assembly of the device.

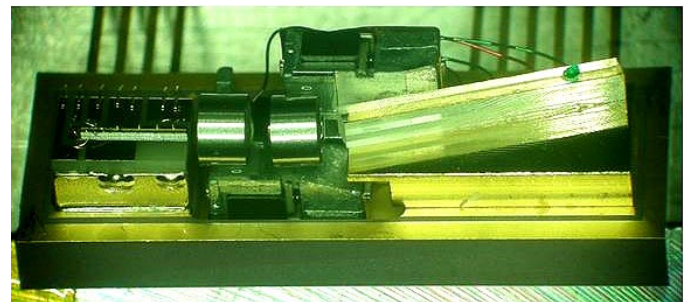


FIGURE 4 — Illustration of the layout of components inside a green-laser package. The SHG is mechanically angled.

Charge carriers and triplets in OLED devices studied by electrically detected electron paramagnetic resonance

Thomas D. Pawlik (SID Member)

Marina E. Kondakova (SID Member)

David J. Giesen (SID Member)

Joseph C. Deaton (SID Member)

Denis Y. Kondakov (SID Member)

Eastman Kodak Co.

The chemical identity of the triplet is reflected in its characteristic EPR spectrum. This enables us to identify the location of the recombination zone in an OLED device. Furthermore, the triplet distribution among the constituents in a mixed layer and the effects of blocking layers can be studied. The fundamental understanding about the extent of the recombination zone in various OLED architectures helps us design the devices with improved performance.

Abstract — Organic light-emitting diodes (OLEDs) were investigated by an electron paramagnetic resonance (EPR) technique that uses the effective device conductance as the detection channel. This technique enables us to identify and study charge carriers and triplet excitons with high sensitivity. By using a series of model devices, it was demonstrated that this type of spectroscopy provides information regarding triplet energy transfer and the location of the recombination zone. The fundamental understanding about the extent of the recombination zone in various OLED architectures helps in the design of devices with improved performance.

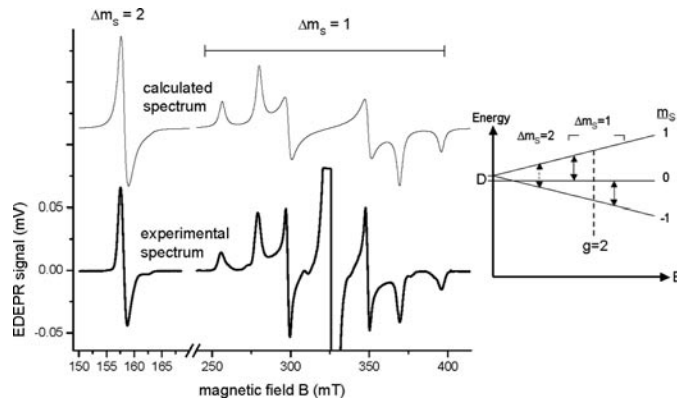


FIGURE 1 — Experimental EDEPR spectrum (bottom trace) and calculated triplet spectrum (top trace) of an OLED device of the structure ITO | CFx | NPB (75 nm) | TBADN (40 nm) | ALQ (35 nm) | LiF | Al, measured at 15 K. The schematic energy level diagram of a triplet as a function of an applied magnetic field is shown on the right side. The $\Delta m_s = 1$ and $\Delta m_s = 2$ EPR transitions are indicated by arrows.

Effect of geometrical characteristics of a scribing wheel on the bending strength of LCD glass substrates

Y. S. Liao

G. M. Yang

Y. S. Hsu

National Taiwan University

Abstract — Scribing followed by a breaking method has often been applied to separate the individual liquid-crystal-display (LCD) glass panels from the mother cells. In some special occasions, especially for compact mobile devices, the bending strength of the glass substrates after breakage is the most important concern. In this study, the effect of the geometrical characteristics of the scribing wheel on the bending strength of LCD glass substrates was investigated. A volume-crack effective coefficient was defined to estimate the effect of different geometrical characteristics of the scribing wheels. It was found that there is a strong correlation between the bending strength and the coefficient before chipping appears as the scribing load is increased. Thus, the coefficient can be used for the assessment of the geometrical effect of scribing wheels on the bending strength of glass substrates.

The four-bar bending test as shown in Fig. 4 was used to estimate the effect of the geometrical characteristics of the scribing wheels on the bending strength of the active-matrix liquid-crystal display (AMLCD) glass substrates. The bending force can be obtained by directly measuring the bending stress during the four-bar bending test. Under the conditions for the same glass-sample size and same fixture, the relationship between the bending force and bending strength will be linear.

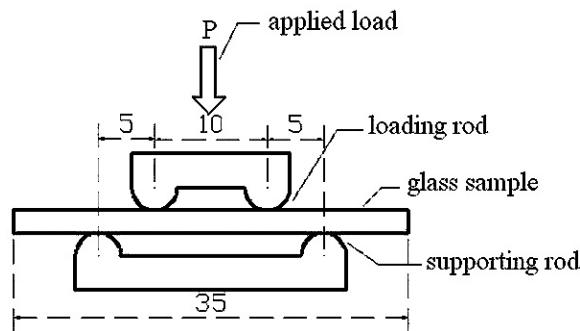


FIGURE 4 — Schematic illustration of a four-bar bending test device. All of the units are in mm.

Direct observation of the electrical activity of coincidence-site lattice boundaries in location-controlled silicon islands using scanning spread resistance microscopy

Nobuyuki Matsuki
Ryoichi Ishihara
Kees Beenakker

Delft University of Technology

Abstract — Scanning spread resistance microscopy (SSRM) was used to investigate the electrical activity of coincidence-site lattice (CSL) boundaries in location-controlled silicon islands fabricated using the μ -Czochralski (μ -CZ) process. Using SSRM, the electrical activity of random and $\Sigma 3$ and $\Sigma 9$ CSL boundaries, which are determined by electron backscattered diffraction (EBSD) analysis, were observed. Quantitative evaluation of the microscopic current mapping by SSRM revealed that $\Sigma 3$ and $\Sigma 9$ CSL boundaries, of which most of them are coherent, have much less electrical activity than the random grain boundaries. Some of the $\Sigma 3$ and $\Sigma 9$ CLS boundaries seemed to be incoherent, while the number of such incoherent CSL boundaries are very much limited according to previous TEM investigation and showed increased activities; however, their activities are still lower than that of the random boundaries.

Crystal-line growth in the μ -CZ process is illustrated schematically in Fig. 1. A significant reduction in the number of random boundaries in the channel region resulted in attaining a field-effect mobility of 597 $\text{cm}^2/\text{V}\cdot\text{sec}$ on average. The mobility decreased by approximately 10% when the coincidence-site-lattice (CSL) boundary was perpendicular to the channel. Although the influence of the CSL boundaries is much less than that of random boundaries, it is very important to investigate their electrical properties because they inhibit further improvement of TFT performance.

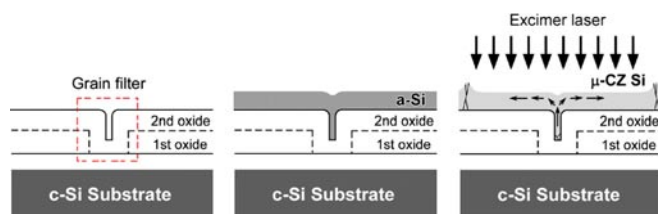


FIGURE 1 — Schematic description of the μ -CZ process. (a) Formation of the grain filter. (b) Deposition of amorphous silicon. (c) Excimer-laser annealing and crystallization.

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editorial

continued from page 2

I'm proud this month to introduce three great articles about the latest innovations in ultra-low-power LC and electrophoretic displays, solicited and edited by our Guest Editor Rob Zehner from E Ink Corp.

If you have not seen electronic shelf tags in your area yet, I'm betting you will soon. Dr. Cliff Jones from ZBD Displays Limited introduces us to new technology for making bi-stable ultra-low-power LCDs that can display relatively high total information content entirely on embedded batteries that can last for years. It may not be sexy, but the total market for these displays is almost beyond counting and the value model for retailers is very compelling. This is an application that is getting very close to having its solution at the ready. If it enables a business advantage for even a few retailers, it could become virtually pervasive almost overnight.

Meanwhile, if larger sizes are your interest, the article on large-area cholesteric displays by David Coates of Magink will certainly get your attention. David reveals the latest efforts in making very large billboard and stadium-sized displays based on bi-stable cholesteric technology, the stuff that groups like Kent Displays has been researching and demonstrating for decades now. I must admit, this was not on my radar and I was really surprised to see how much effort was being invested in this direction. I thought LEDs would own the space for a long time, but now I think we have a competition.

Our third feature on the latest advances in electrophoretic display technology is co-written by Joanna Au of E Ink and Kawano Shigeaki of Epson Corp. and shows us some whimsical applications as well as a very promising and practical enabling influence on smart-card technology. Electrophoretic technology has received a lot of much-deserved attention lately, and the future looks very bright for those that have stuck it out for so long, including our respected and very diligent colleagues at E Ink.

So, while there may not be any way to totally escape the bad news, there are places to hide, at least temporarily, and inspiration to be found. Despite the hard times, innovation is still alive and well in the display world. ■

president's corner

continued from page 6

and tutorials; as well as the business conference and networking opportunities – part of the regular cycle of the electronic-display industry. You can also be sure that the technologies that will lead us out of the current economic downturn will be on view during Display Week. Can you afford not to be on top of some really important developments?

So, while "Remember SID in San Antonio" is unlikely to attain the popularity of "Remember the Alamo," I would not be surprised if the events in May and June will be setting the stage for future successes. You might even think about stopping by the Alamo to get some inspiration. I will; maybe I'll see you there! ■

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LCD Pioneer George Heilmeier Named to National Inventors Hall of Fame



George Heilmeier

new electro-optic effects in liquid crystals at RCA Laboratories and ushered in the first liquid-crystal displays (LCDs) based on what he termed the dynamic scattering mode (DSM).

Heilmeier was born in 1936 in Philadelphia, Pennsylvania. He earned his bachelor's degree with honors in electrical engineering from the University of Pennsylvania and two master's degrees and a Ph.D from Princeton University. As a Ph.D student, Heilmeier worked part-time at RCA Laboratories. After becoming interested in organic semiconduc-

tors, he focused his thesis in that field, then began conducting research on the electro-optic effects of liquid crystals that would eventually lead to the first LCDs.

After heading an RCA Laboratories research division, Heilmeier became a White House Fellow and a Special Assistant to the Secretary of Defense. He then became Assistant Director of Defense Research and Engineering for Electronics and Computer Science. In 1975, he was named Director of the Defense Advanced Research Projects Agency (DARPA). At DARPA, Heilmeier contributed to the first stealth aircraft and other major military initiatives such as artificial intelligence.

In 1977, he returned to industry as the Senior Vice President and Chief Technical Officer for Texas Instruments and later as Chairman and CEO of Bellcore Corp., which was formed out of AT&T's Bell Labs after the divestiture. He retired in 1997.

Heilmeier is also known for drafting "Heilmeier's Catechism," a series of questions to answer when developing research proposals and business plans. Numerous versions exist on the Internet. The following is representative:

- What are you trying to do? Articulate your objectives using absolutely no jargon.

- How is it done today and what are the limits of current practice?
- What's new in your approach and why do you think it will be successful?
- Who cares? If you're successful, what difference will it make? What are the risks and the payoffs?
- How much will it cost? How long will it take?
- What are the mid-term and final "exams" to check for success?

Source: <http://www.cs.ucsd.edu/~ddahlstr/misc/heilmeier.html>.

In celebration of the 50th anniversary of the integrated circuit, the National Inventors Hall of Fame chose this year to honor 15 individuals whose advances enabled or related to integrated-circuit technology. In addition to Heilmeier, the roster includes Jean Hoerni, who developed the manufacturing process for modern integrated circuits, and Alfred Cho, who developed a process used in creating devices such as the lasers used in CD and DVD players and drives. The 2009 induction ceremony will be held on May 2 in Mountain View, California.

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Official Housing Request Form: Society for Information Display (SID-2009)

San Antonio, TX May 31 – June 5, 2009



The official housing closing date is May 1st, 2009. If you have not made reservations by this date, contact Globetrotter Travel, and every effort will be made to secure accommodations for you.

Fill out this form completely and mail or fax to:

Globetrotter Travel
18121 Georgia Avenue
Suite 104

Olney, Maryland USA 20832-1437

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Email
sid@globetrottermgmt.com



Online Reservations and Hotel Maps/Descriptions
www.globetrottermgmt.com/sid

Hotel	Single	Double
1) Marriott Rivercenter (Headquarter)	\$214	\$214
2) Grand Hyatt	\$214	\$214
3) Marriott Riverwalk	\$214	\$214

Current Tax of 16.75% not included in room rates (tax rate subject to change without notice).

All hotel requests must be accompanied by a completed SID hotel agreement. Agreement may be found with the hotel rules and restriction section of the website.

All reservations require a first nights deposit when paying by credit card and full payment when paying by check or bank wire. Checks should be made out in US funds payable to Globetrotter Travel. Wire Transfers of Money now require an additional \$50 non-refundable, non-applicable bank processing fee.

Contact Information:

Name: _____

Company: _____

Address: _____

Address: _____

City _____ St _____ ZIP _____

Country _____

Phone: _____

Fax: _____

E-Mail _____

Exhibitor ☐ Attendee ☐

Occupant Information: (Each line represents 1 room unless otherwise specified)

Preferred Hotel Choice: (1) _____ (2) _____ (3) _____

Smoking Y/N	Number of People	Number of Beds	Name(s) of Occupant(s)	Arrival Date	Departure Date

Special Requests (please circle): Roll-a-way Handicapped Accessible Other _____

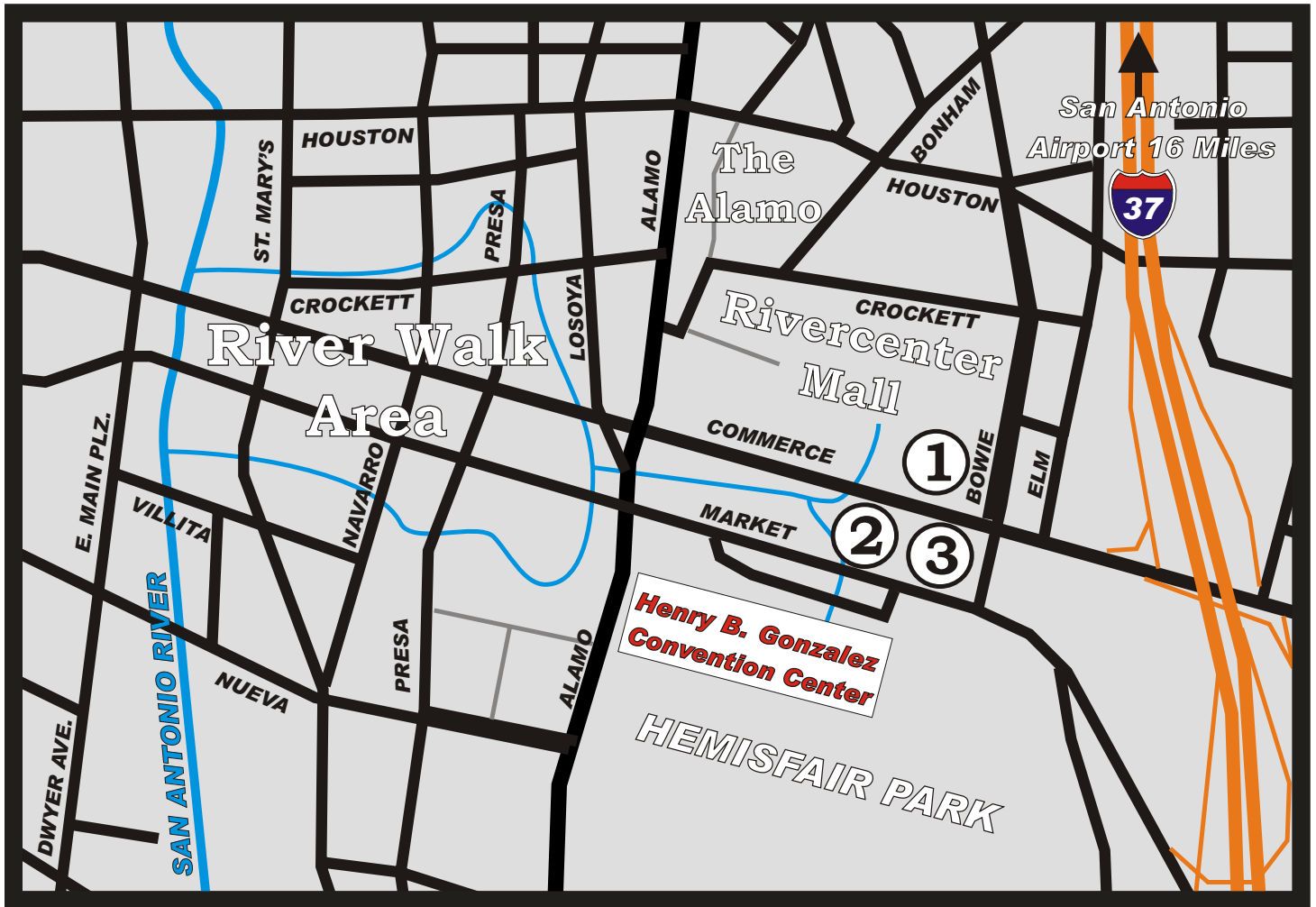
Credit Card Number: _____ Exp Date: _____

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Cardholder's Signature: _____

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SOCIETY FOR INFORMATION DISPLAY 2009



- ① **Marriott Rivercenter**
- ② **Grand Hyatt**
- ③ **Marriott Riverwalk**

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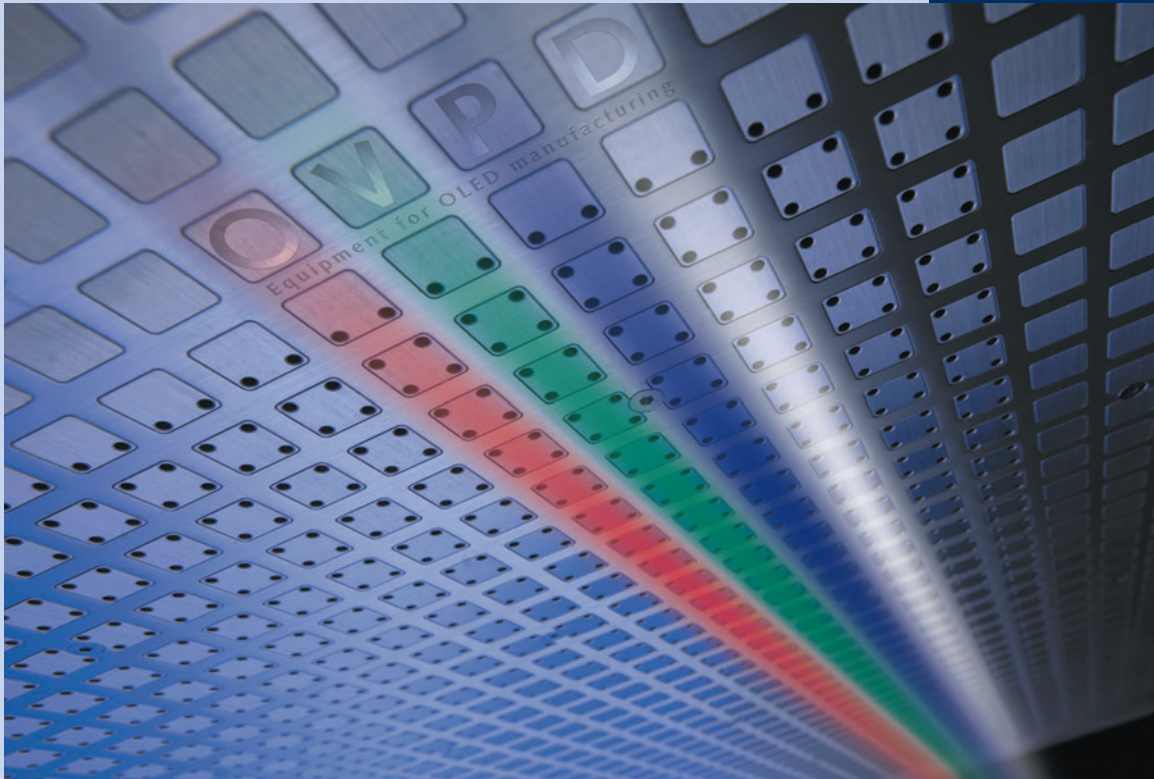
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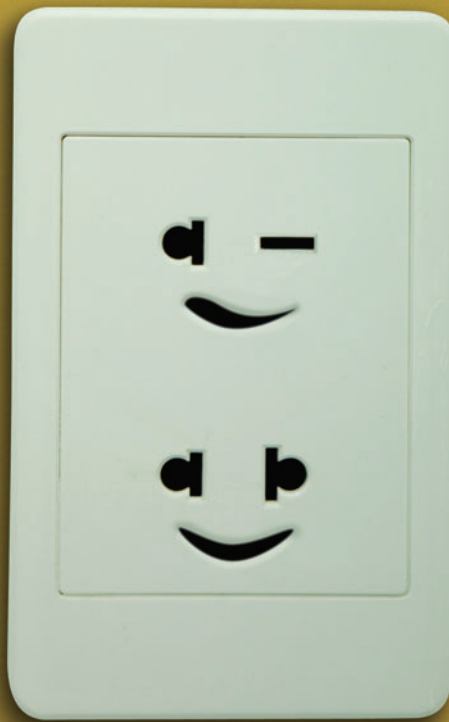
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PROFESSIONAL INFORMATION

1. Are you professionally involved with information displays, display manufacturing equipment/materials, or display applications?

110 ☐ Yes 111 ☐ No

2. What is your principal job function? (check one)

- 210 ☐ General /Corporate /Financial
211 ☐ Design, Development Engineering
212 ☐ Engineering Systems (Evaluation, OC, Stds.)
213 ☐ Basic Research
214 ☐ Manufacturing /Production
215 ☐ Purchasing /Procurement
216 ☐ Marketing /Sales
217 ☐ Advertising /Public Relations
218 ☐ Consulting
219 ☐ College or University Education
220 ☐ Other (please be specific)

3. What is the organization's primary end product or service? (check one)

- 310 ☐ Cathode-ray Tubes
311 ☐ Electroluminescent Displays
312 ☐ Field-emission Displays
313 ☐ Liquid-crystal Displays & Modules
314 ☐ Plasma Display Panels
315 ☐ Displays (Other)
316 ☐ Display Components, Hardware, Subassemblies
317 ☐ Display Manufacturing Equipment, Materials, Services
318 ☐ Printing /Reproduction / Facsimile Equipment
319 ☐ Color Services /Systems
320 ☐ Communications Systems / Equipment
321 ☐ Computer Monitors /Peripherals
322 ☐ Computers
323 ☐ Consulting Services, Technical
324 ☐ Consulting Services, Management /Marketing
325 ☐ Education
326 ☐ Industrial Controls, Systems, Equipment, Robotics

- 327 ☐ Medical Imaging /Electronic Equipment
328 ☐ Military /Air, Space, Ground Support /Avionics
329 ☐ Navigation & Guidance Equipment /Systems
330 ☐ Oceanography & Support Equipment
331 ☐ Office & Business Machines
332 ☐ Television Systems /Broadcast Equipment
333 ☐ Television Receivers, Consumer Electronics, Appliances
334 ☐ Test, Measurement, & Instrumentation Equipment
335 ☐ Transportation, Commercial Signage
336 ☐ Other (please be specific)

4. What is your purchasing influence?

- 410 ☐ I make the final decision.
411 ☐ I strongly influence the final decision.
412 ☐ I specify products/services that we need.
413 ☐ I do not make purchasing decisions.

5. What is your highest degree?

- 510 ☐ A.A., A.S., or equivalent
511 ☐ B.A., B.S., or equivalent
512 ☐ M.A., M.S., or equivalent
513 ☐ Ph.D. or equivalent

6. What is the subject area of your highest degree?

- 610 ☐ Electrical /Electronics Engineering
611 ☐ Engineering, other
612 ☐ Computer /Information Science
613 ☐ Chemistry
614 ☐ Materials Science
615 ☐ Physics
616 ☐ Management /Marketing
617 ☐ Other (please be specific)

7. Please check the publications that you receive personally addressed to you by mail (check all that apply):

- 710 ☐ *EE Times*
711 ☐ *Electronic Design News*
712 ☐ *Solid State Technology*
713 ☐ *Laser Focus World*
714 ☐ *IEEE Spectrum*

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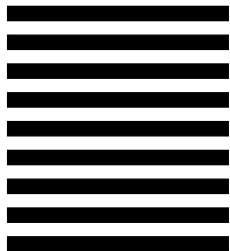
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