DISPLAY OF THE YEAR AWARDS

Information DISPLAY

December 2000
Vol. 16, No. 12

SID

Official Monthly Publication of the Society for Information Display

The Best of 2000

- *Display of the Year Awards*
- *Plasma Displays for HDTV*
- *LEP Displays*
- *Protecting Intellectual Property*

Information DISPLAY

DECEMBER 2000
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*COVER: eMagin's OLED-on-silicon microdisplay earned the SID/*Information Display *Display of the Year Gold Award. To learn more about eMagin's display and the other five award winners, see the article beginning on page 12.*

eMagin Corp., ISE Electronics Corp., InViso, Sharp Corp., DigiLens, Inc., Toppan Printing Co.

For more on what's coming in *Information Display*, and for other news on information-display technology, check the SID Web site on the World Wide Web: **http://www.sid.org**.

Next Month in *Information Display*

New Directions
- Avionics AMLCDs
- Tiled AMLCDs
- LCoS Front-Projector Designs
- IDRC Report

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editorial

State of the Art

As is traditional here at *ID*, we celebrate the end of the year by announcing the SID/*Information Display* Display of the Year Awards (DYA) in this, our December, issue, and by giving some indication of what the Display of the Year Awards Committee (DYAC) found compelling about the winning nominees. That article begins on page 12.

Although the DYAC's choices may reflect some of the broader trends in the display industry, they are by their nature awards for specific instances of excellence in display technology, in the use of displays in products, and in the development of new materials and components for displays.

I found myself wanting to step back from individual awards, individual articles, and individual conferences we've been involved throughout the year and think about what technology and business species have sufficiently captured my attention this year so that I will be particularly interested in tracking them throughout the next. Here are some that come to mind.

- Small passive-matrix OLED prototypes have been exhibited widely over the last few months. It will be interesting to see how they are applied in cellular phones in 2001, and how quickly the market shifts to them from monochrome LCDs.
- The first appreciable shipments of LCoS microdisplays were made in the last third of 2000. Watching the extent of the developing market for rear-projection monitors and television sets using LCoS displays will be absorbing, and will be the first indication of how many of today's LCoS-microdisplay companies will be able to survive. The market for LCoS viewfinders for camcorders and still digital cameras is more predictable. Other near-to-eye (NTE) applications, including eyeglass-type displays, will probably not be significant in 2001. Significant cellular-phone and Internet-appliance applications for high-definition displays – both LCoS and direct-view – must await the roll-out of a broadband wireless Internet structure. With North America's difficulty in settling on standards, we are likely to see this in Europe and Asia first.
- Making things cheap – or, if you insist, engineering them for reduced cost – is what's needed if specific display technologies are going to reach volume markets for particular applications: PDPs for consumer television; LCDs or OLEDs for automotive instrumentation; microdisplay projectors for TV, HDTV, and computer monitors; and LCDs or OLEDs for e-books and other portable electronics (this list is not exhaustive). Serious work is under way to wring cost out in all of these areas.
- Making life easier for the Energizer bunny, or reducing power consumption, is essential if higher-quality displays are to go into hand-held devices. Some impressive reflective LCD prototypes have appeared this year. It will be interesting to see how long it takes for them to reach production, and how quickly they are adopted for high-volume products.
- Making LCDs faster is necessary if they are to be serious contenders for direct-view television. Several higher-speed LCD modes are now embodied in commercial LCD modules, and there is substantial work going on in improving the optical response time between gray levels. (It is now well understood that the traditional metric of the time it takes for a pixel to be

continued on page 32

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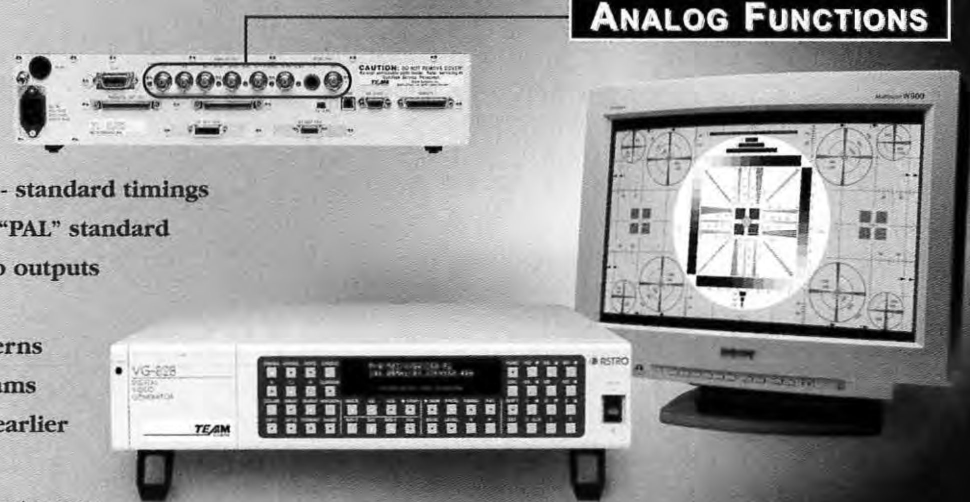

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Circle no. 2

a view from the hilltop

A Global Village ...

by Aris Silzars

"Some time ago, I returned from a visit to a foreign country." Factually, this is a correct statement. I had indeed returned to the U.S.A. from a trip to attend the International Display Manufacturing Technology Conference, IDMC 2000, in Korea. But how wrong it felt to utter such a phrase, since at no time during my visit did I feel that I was in a strange land or among "foreign" people.

From the moment I arrived at Seoul's Kimpo Airport, I could spot a few familiar faces. Yes, the crowds were large and the lines were long. But it was really no different from arriving at an airport in the U.S.A. Most of the people I didn't recognize, but several I did – just about the same as for a typical stopover in Denver or Chicago.

On arrival at the Sheraton Walker Hill Hotel, I was greeted with the sight of familiar faces everywhere. Now, for sure, this didn't feel like a "foreign" land. The warm greetings and friendly discussions made a certainty of that. There were the typical stories of delayed flights and missed plane connections. There were discussions of the latest career paths and technology developments. A few discussions turned more introspective, comparing opinions about the credibility of certain companies or individuals. Moment by moment and hour by hour, old relationships were strengthened and new ones formed.

The next several days of the technical conference were filled with the absorption of as much technical content as we could possibly sponge up – while continuing to evaluate it all in yet more small-group and individual interactions. Early on the first day, we already knew that this conference was going to be a good one. The quality of the technical papers and the attendance figures soon confirmed it.

The setting for the evening banquet was the outdoor garden court of the Sheraton Hotel. The warm late-summer evening with a clearing sky – following an earlier heavy rain – made it seem that we were indeed the recipients of Mother Nature's blessing. The winding Han River lay below us, with hills and city lights all around. In this setting, while sharing a meal with colleagues from all parts of the world, it was simply not possible to rationalize that in times past some of these friends and colleagues – based on territory or by political decree – would have been designated as enemies.

The entertainment for the evening was a selection of traditional Korean music including string instruments, a flute, singing, and a drum quartet – not all at once, but in turn. To my classical-music-trained ear the music was a fascinating and interesting blend of ancient and modern. It seemed to bridge all time and aural space. The tonality was more Western than that which I typically associate with an Oriental scale. There was, simultaneously, a simplicity and intricacy that could be appreciated on many levels. Music is the great expression of the soul of a country and a culture. Music causes the spirit to soar and emotions to surface. It becomes a great and positive unifying force among human beings everywhere.

It was in this spirit that Prof. Sungkyoo Lim moderated the evening's ceremonies. His closing remarks, expressing the unifying energy between the warm outdoor evening setting, the rousing effect of the music, the good food, and great

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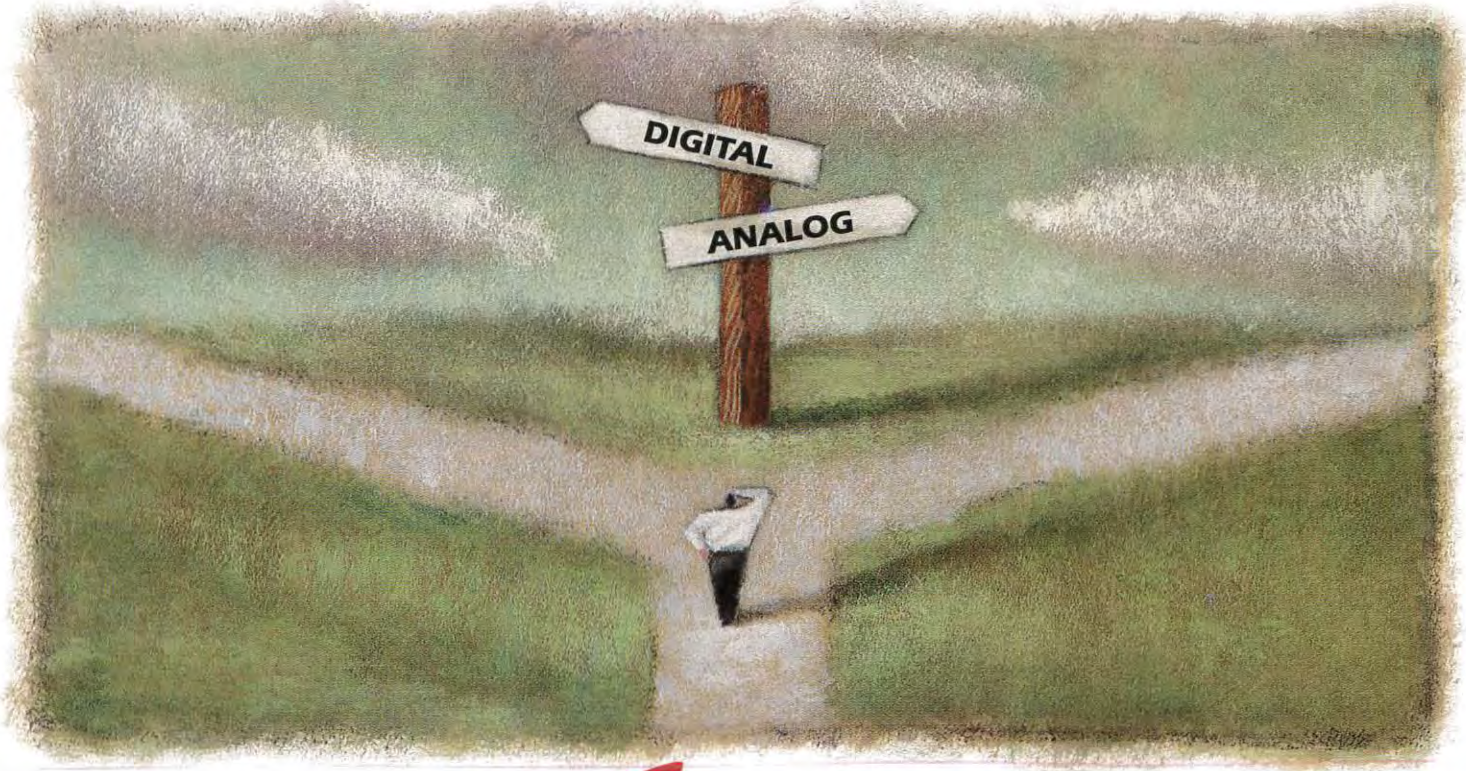

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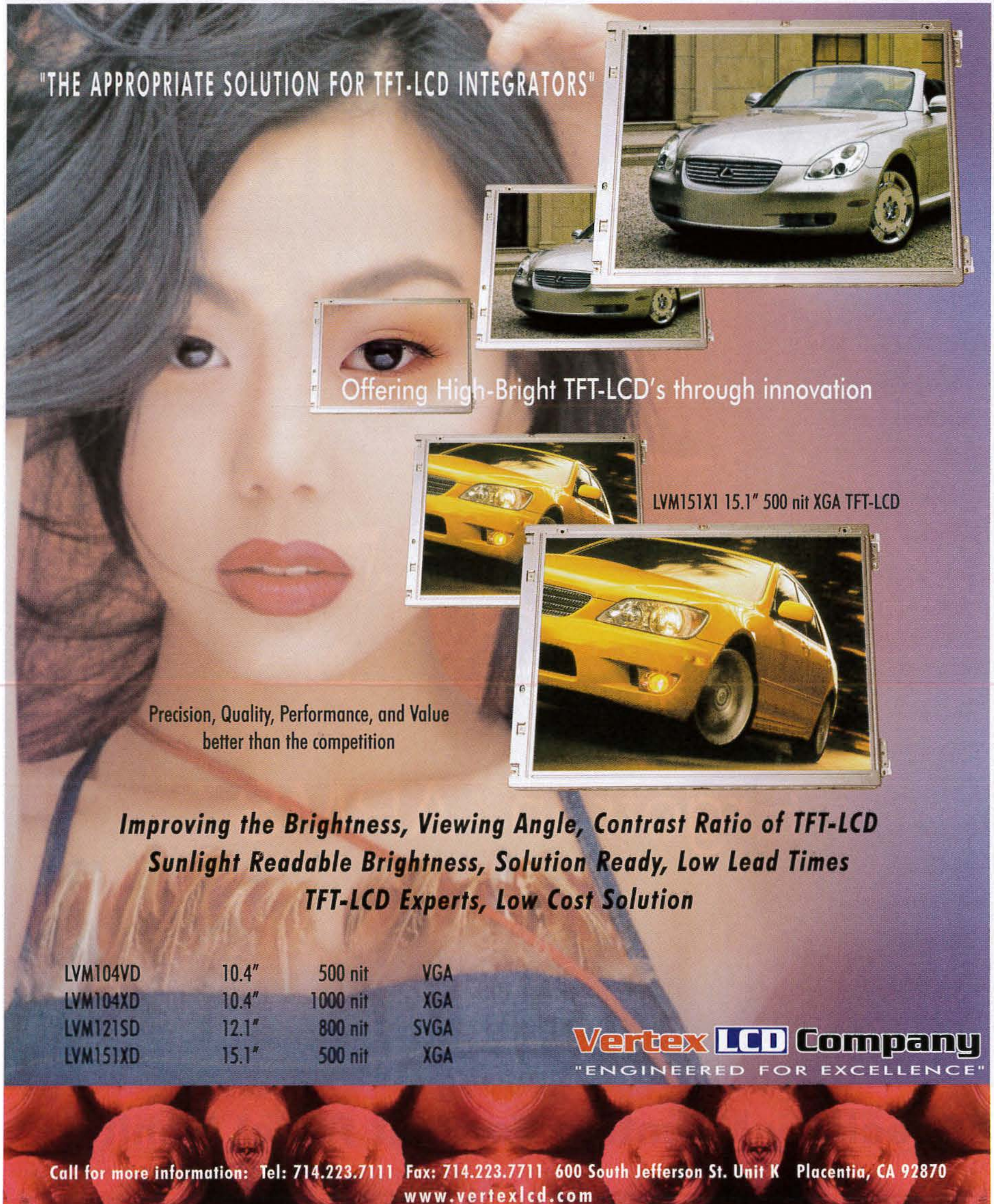
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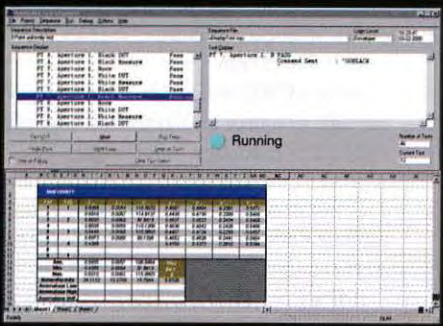

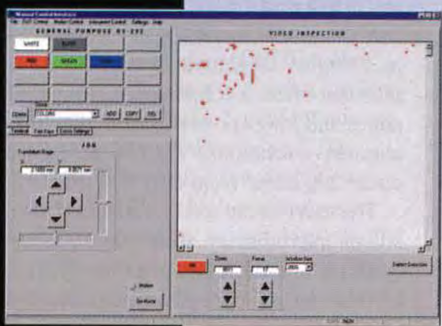

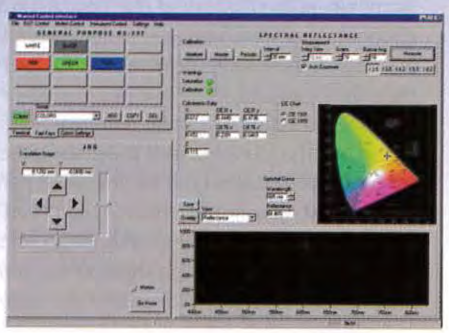

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Circle no. 9

Sixth Annual Display of the Year Awards

For the year 2000, the DYA Committee honors an OLED microdisplay, a carbon-nanotube FED module, a hand-held viewer, a rear-projection HD monitor, a digital color wheel, and a matrix filter that improves the color of LCDs.

by Ken Werner

THE recipients of the SID/*Information Display* Display of the Year Awards (DYA) are selected by an international committee consisting of leading members of the technical display community and distinguished technology journalists who cover displays (see the textbox, "2000 Display of the Year Awards Committee"). This combination ensures that the committee's deliberations are carried out with both technical sophistication and a broad perspective.

Those deliberations began in May in Long Beach, during the SID International Symposium, where the Display of the Year Awards Committee (DYAC) held its annual meeting and began discussing possible nominations for the various awards.

The submission of formal nominations began in July. Nominations are made either by committee members or by interested parties who submit their nominations to the DYAC Secretariat. The Secretariat distributes all the nominated displays and products to the committee members, who then vote for the winners.

Gold and Silver Awards are voted in three categories: Display of the Year, Display Product of the Year, and Display Material or Component of the Year. The DYAC bylaws require the committee members to consider many factors, including technical innovation, commercial significance, and likely social impact. Displays, products, components, and materials must have become commercially available either to OEMs or end users between July 1, 1999, and June 30, 2000, to be eligible for this year's awards.

***Ken Werner** is the editor of* Information Display. *The opinions expressed in this article are not necessarily those of the Publisher of* Information Display Magazine *or of the Society for Information Display.*

Display of the Year

Gold Award: eMagin's OLED-on-Silicon Microdisplay

In developing its organic light-emitting-diode (OLED) display, eMagin Corp. (East Fishkill, New York) uniquely combined two of the industry's most exciting technologies: OLEDs and display-on-silicon microdisplays. The combination of technologies results in a 0.77-in. 256-gray-level monochrome SXGA display that offers a combination of higher luminance and lower power consumption than alternative solutions. The eMagin device produces 200 cd/m^2 from only 400 mW.

This device, the world's first OLED-on-silicon microdisplay, shows the strengths of emissive microdisplays at a time when nearly all other silicon-backplane microdisplays rely on liquid-crystal or tilting-mirror technologies. Whether eMagin is pointing the way for a new industry segment, or will be left as the undisputed master of a unique niche, it has successfully pioneered a unique display technology. And the company has more in store for the future: a color version is under development.

Silver Award: ISE's Carbon-Nanotube FED Module

Japanese, Taiwanese, and Korean R&D into carbon nanotubes (CNTs) as field emitters has energized the faltering interest in FED technology. Now, ISE Electronics Corp. (Ise, Mie, Japan) has produced the first commercial product using carbon-nanotube field-emission technology.

The product is a 1-pixel 20-mm-diameter cylindrical lighting element intended to replace existing externally similar thermionic (CRT-type) lighting elements used in outdoor displays and other high-brightness applications. The nanotube lighting element replaces the thermionic cathode of the CRT lighting element with a field-emission cathode made of CNTs – fine tubes with diameters ranging from less than 1 nm to over 100 nm that are grown with carbon atoms. ISE's CNTs range from 0.5 to 50 nm.

As in a CRT device, the electrons pass through a control grid and strike a phosphor screen that produces visible light. The device is power-efficient because the cold cathode does not need to be heated as a thermionic cathode does, and the luminance exceeds 30,000 cd/m^2.

ISE's CNT FED module is exciting not only because it is the first commercial implementation of CNT technology, but because it could pave the way for new generations of FED products.

Display Product of the Year

Gold Award: InViso's eCase Hand-Held Display

InViso (Sunnyvale, California) has incorporated its OptiScape II microdisplay module in the eCase, a hand-held viewer billed as a "personal Internet companion," which can be synchronized with a PC and lets the user carry

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DISPLAY OF THE YEAR

Gold Award: eMagin's OLED-on-Silicon Microdisplay.

Silver Award: ISE's Carbon-Nanotube FED Module.

documents while on the go. This differs from PDA synchronization in that the downloaded documents can be viewed at approximately the same resolution and color depth as on a desktop monitor. The product is also offered to OEMs as a platform for incorporating their own applications.

Thanks to its OptiScape II microdisplay module, the eCase presents an SVGA 18-bit color image with a viewing angle of 34° and an eye relief of 30 mm. The effect is that of viewing a 19-in. monitor at 2.5 ft., with the image well focused across the entire field of view regardless of where (within reason) the eye is positioned relative to the display. Clearly, superior optics is a crucial part of the design.

The intelligent integration of an excellent microdisplay module into an attractive hand-held high-resolution image viewer should, in the words of one committee member, "change users' expectations for viewing graphics and high-density content on a very small display."

Silver Award: Sharp/SEL's 60-in. High-Definition Rear Projector

With the SharpVision LC-R60HDU high-definition LCD rear-projection video monitor, Sharp Corporation (Osaka, Japan) introduced the first commercial product using LCD imagers with TFTs made from continuous-grain silicon (CGS) – a high-performance variant of polycrystalline silicon developed by Sharp and its partner, Semiconductor Energy Laboratory Co., Ltd. (Atsugi-shi, Kanagawa, Japan). The high quality of CGS permits the manufacture of TFTs with an electron mobility that approaches that of single-crystal silicon. This can result in smaller transistors for higher aperture ratio and higher brightness, as well as better performance.

The imagers in the LC-R60HDU are 2.6 in. wide and project a full-color SXGA image onto the 60-in. screen with an impressive luminance of 1000 cd/m^2 and a contrast ratio of 400:1. Introduced at an MSRP of $49,995, the SharpVision set can afford to utilize premium design approaches and components at every stage, and it does. Not at all a high-volume product, its significance is in its use of a new TFT material to make a rear projector that raises the performance bar for this display category.

Display Material or Component of the Year

Gold Award: DigiLens's Application-Specific Integrated Filter™

DigiLens, Inc. (Sunnyvale, California) used a new electrically switchable Bragg grating (ESBG) technology to make an Application-Specific Integrated Filter (ASIF™) – a solid-state replacement for the mechanical color wheel used to obtain full color from a one-panel projection display. Since there is substantial interest in using one-display reflective projection engines for low-cost HDTV receivers, ASIFs are potentially important enabling components.

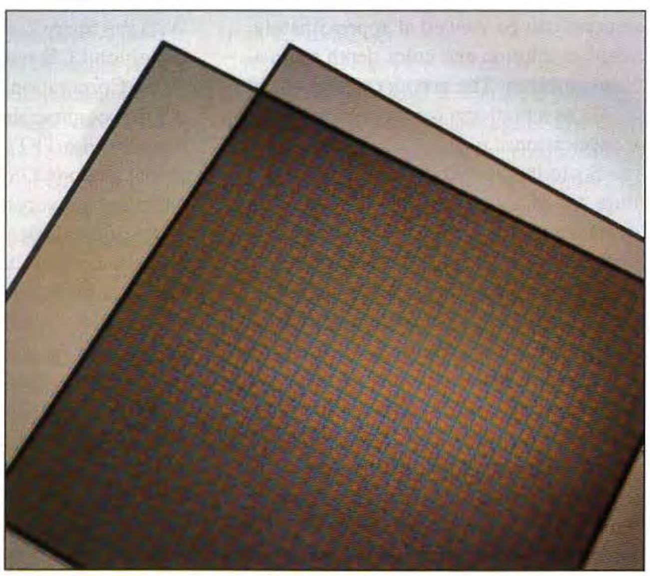
DigiLens claims an impressive list of benefits for its ASIFs, including improved black level and contrast, fast 50-μsec switching,

DISPLAY PRODUCT OF THE YEAR

Gold Award: *InViso's eCase Hand-Held Display.*

Silver Award: *Sharp/SEL's 60-in. High-Definition Rear Projector.*

DISPLAY MATERIAL OR COMPONENT OF THE YEAR



Gold Award: *DigiLens's Application-Specific Integrated Filter™.*

Silver Award: *Toppan's EBU-CF Color Filter.*

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reduced color break-up and fewer motion artifacts, and dynamic color balance. ASIFs do not have the motor noise of a color wheel, they are compact and light in weight, reduce system complexity and cost, and are reliable, says DigiLens. The ability to make "dynamic changes in color balance and saturation for different types of source signals is equivalent to changing color-wheel filters on the fly," said one committee member. ASIFs are available for use with either polarized or non-polarized light.

DigiLens has used sophisticated materials technology to make a high-performance component that promises to be low in cost and easy for system designers to use.

Silver Award: Toppan's EBU-CF Color Filter

The matrix color filter is what allows liquid-crystal displays (LCDs) to show still images and video in color, but most LCDs display many fewer colors than typical cathode-ray-tube (CRT) monitors and television sets. Toppan Printing Company (Tokyo, Japan) has eliminated that limitation with the first color filter to comply with the color-reproduction standards of the European Broadcasting Union (EBU).

The new filter features new pigments and dispersing conditions, matched to new phosphor specifications for the backlight that is used with the filter. Toppan has made the backlight specifications available to manufacturers, and has been ramping up filter production. Production capacity was over 100,000 per month in September.

Toppan has re-engineered one of the basic LCD components so that LCD television sets, DVD players, and computer monitors can, at long last, have the ability to render colors as well as their CRT-based competitors. ■

The Promise of Plasma Displays for HDTV

Innovative techniques have removed motion artifacts in the most sophisticated PDPs. Designing for cost reduction is next.

by Larry F. Weber

PLASMA DISPLAYS promise to be an attractive solution for high-definition television (HDTV) home-theater applications. Plasmaco, Inc., has developed a 60-in.-diagonal HDTV plasma-display panel (PDP) prototype (Fig. 1) which was demonstrated for the first time at the 1999 SID International Symposium, LG has developed a similar 60-in. prototype, and Samsung recently demonstrated a 63-in. prototype. Other PDPs with 42- and 50-in. diagonals are also available for HDTV.

PDPs will compete favorably with CRTs and projection displays for this attractive and growing HDTV market (Table 1). The PDP has the necessary display size and resolution for home theater, and its very wide viewing angle gives it a high-quality CRT-like image. Its slim profile offers optimal utilization of room space compared to the competing technologies. While the image quality and performance of PDPs is equal to or superior to that of CRTs and projectors, the cost of the PDP is still much too high.

HDTV Picture Quality

High picture quality requires three things: good video material, a good signal, and a good display device. The final image quality is limited by the worst of these three.

We have found that a 60-in.-diagonal display like that shown in Fig. 1 needs an HDTV signal to show its optimum image quality. An ordinary NTSC signal on this display looks poor. While motion-picture film is considerably better, it is still no substitute for a high-quality HDTV signal that was recorded with a digital HDTV camera and tape recorder. Such material is not easy to find today, but this will cease to be a problem as time goes on.

One of the major attributes of the U.S. standard for HDTV is its all-digital format. This greatly reduces noise, and the fidelity does not degrade in transit. An all-digital system also eliminates drift and mis-adjustment. The large number of pixels available in the HDTV format is quite suitable for a 60-in. display.

The display is frequently the factor limiting HDTV picture quality. The major problems are either insufficient display size or insufficient display resolution. The 60-in. PDP shown in Fig. 1 has surprised many people

Fig. 1: *Larry Weber proudly demonstrates Plasmaco's 60-in.-diagonal HDTV plasma panel in eastern New York's apple-growing country.* (Courtesy of Plasmaco. Inc.)

Larry F. Weber *is President and CEO of Plasmaco, Inc., 180 South St., Highland, NY 12528, a subsidiary of Matsushita Electric Industrial Company, Ltd.; telephone 845/883-6800, fax 845/883-6867; e-mail: larryweber@plasmaco.com. This article was adapted from the author's paper of the same title given at SID 2000 in Long Beach, California. The original paper appears in the 2000 SID International Symposium Digest of Technical Papers.*

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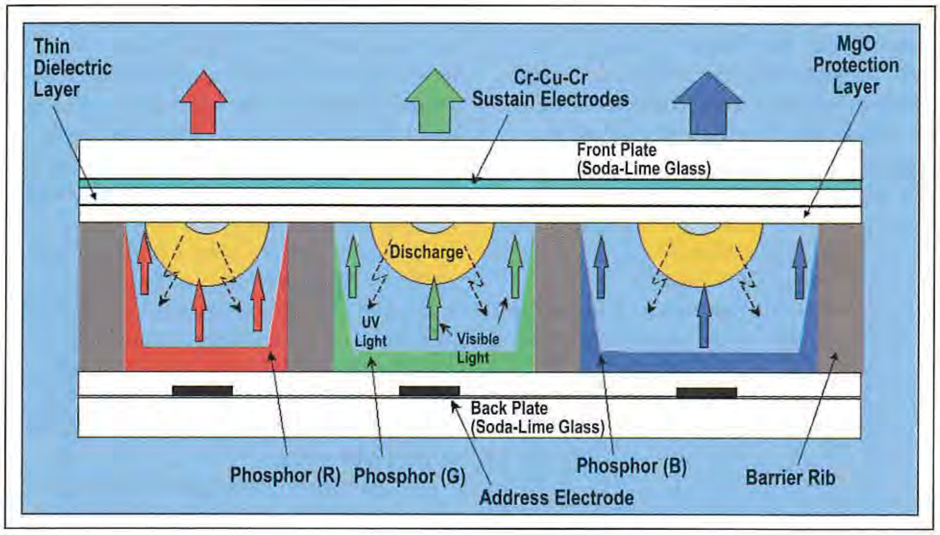


Fig. 2: An asymmetrical cell structure can overcome the tendency of PDP phosphors to exhibit low color temperatures. The larger blue subpixel allows the production of color temperatures up to 10,000K.

because it has sufficient display size and resolution to provide a truly high-quality image.

The U.S. HDTV standard includes a number of different formats, but the two most commonly discussed high-resolution formats are 1080 lines interlaced (1080i) and 720 lines progressive (720p). Both of these standards have similar picture quality, even though there seems to be a never-ending debate over which is better. The 1080i standard has an increased number of horizontal lines but at the price of interlaced scan artifacts. The 720p standard is free of these artifacts since it is progressively scanned, but, of course, it has fewer horizontal lines.

Hitting the Limit

In many HDTV displays used for home theater it is human visual acuity that limits the image quality, not the number of horizontal lines in the display. The size of the display and the pixel size must be carefully selected to avoid this visual-acuity limit.

It turns out that the (approximately) 1-mm pixel pitch of the 60-in. PDP is ideal for HDTV. This is because the visual acuity limit is about 0.35 milliradians (mrad). For the U.S. home theater, the typical distance from the viewer to the TV display is 3 m. At this 3-m distance, the 0.35-mrad limit equates to about 1 mm at the display surface. Pixels with a pitch smaller than this limit will not significantly increase the perceived resolution.

There are some interesting consequences of this visual-acuity limit. If the HDTV display has 720 horizontal lines with 1-mm pixel pitch and a 16:9 aspect ratio, then the smallest display diagonal that does not fall below the visual-acuity limit is 58 in. If the HDTV display has 1080 lines, then the minimum display diagonal is 87 in.

This means that 36-in.-diagonal CRTs are not suitable for viewing the full fidelity of any HDTV signal if the viewer is 3 m from the CRT. It also means that the extra horizontal resolution of the 1080i signal is somewhat wasted for a 60-in.-diagonal display because the 720p signal is at the visual-acuity limit. A major factor in the strongly positive viewer reaction to the 60-in. PDP shown in Fig. 1 is the close matching of the panel and pixel size to the visual-acuity limit.

Image-Quality Issues

The HDTV concept demands close attention to display image quality, and PDP designers have long struggled to improve PDP image quality to a level that is equal to or better than the CRT's. Several of these image-quality issues deserve more detailed discussion.

Digital-Signal Quality. The digital HDTV signal has many desirable attributes, such as very low noise, and it is an inherently stable medium over time. It is easy to see the difference between a purely digital HDTV signal derived from motion-picture film by noting the high level of noise from the film. This is one of the factors stimulating motion-picture producers to consider abandoning film and replacing it with digital HDTV.

To maintain high digital quality, it is important to eliminate conversion to analog over the entire data path from the camera to the eye. This requires the use of digital cameras, digital tape recorders, and digital displays. Fortunately, PDPs are inherently digital because the memory characteristics of the panel require the application of digital signals for proper control. This eliminates noise and drift. Of course, we live in an analog world, so the digital nature of the PDP also creates a number of artifact-correction issues that require specific solutions.

The panel module of Fig. 1 uses a 74.24-MHz parallel 8-bit (×3) RGB digital interface for HDTV. Data is supplied through a universal format converter that can take in 720p, 1035i, or 1080i HDTV signals. It will also take in the 768p signal from an XGA personal-computer interface *via* transition-minimized differential signaling (TMDS). The art of digital universal format conversion has advanced to the point that there are virtually no observable artifacts from the conversion process, even though there is usually a severe mismatch between the number of lines in the signal and the number of lines in the display.

High Luminance. A key feature of a high-quality display is high luminance, which is necessary for a high bright-room contrast ratio. The peak luminance of 550 cd/m^2 (without a contrast-enhancement filter) achieved by the display in Fig. 1 is reasonably high for a display of this size and resolution. This luminance is obtained through careful trade-off of the PDP sustaining and addressing times.

One well-known brightness-enhancing characteristic of the CRT – sometimes called "punch" – can also be implemented in PDPs. Punch refers to the ability to increase the luminance of small display areas to levels higher than can normally be achieved over

Table 1: Specifications for Plasmaco's 60-in. PDP

Pixel matrix	1366 × 768
Pixel pitch	0.972 × 0.972 mm
Luminance	550 cd/m^2
Contrast ratio	>500:1 (700:1 typical)
No. of colors	16.7 million
Set thickness	133 mm

larger areas. This allows a diamond ring in a dark scene, for example, to shine more brilliantly. Panasonic has developed a technology called Plasma AI which performs the punch function on PDPs. It does this by increasing the sustain frequency for images with low average luminance. This attractively increases the peak luminance of the display without increasing the peak power-supply requirement.

Color Temperature. Many customers prefer a display with a high color temperature in order to make the colors more brilliant. Unfortunately, the phosphors available for PDPs do not readily give a high color temperature without using special techniques within the device. The Plasmaco 60-in. PDP, for example, has a blue subpixel that is considerably larger than the green or the red subpixel (Fig. 2). This enhances the color temperature so that 10,000K can be achieved. We call this the Asymmetrical Cell Structure.

Dark-Room Contrast Ratio. A high-quality HDTV display needs a good dark-room contrast ratio, *i.e.*, screen contrast ratio measured in a dark room. This is because many movie directors prefer the effects of dark scenes. In home theaters, the dark-room contrast ratio is more important than the bright-room contrast ratio because prime-time viewing occurs during the evening, when ambient lighting levels are low.

Dark-room contrast ratio is determined primarily by the display's lowest luminance level. Unfortunately, PDPs need a minimum intensity level for discharge priming that degrades the contrast ratio. The challenge is to reduce this minimum intensity level and still accomplish robust discharge priming for reliable addressing.

The Plasmaco 60-in. display achieves a greater than 500:1 dark-room contrast ratio by means of a special waveform [see, for example, L. F. Weber, *Asia Display '98 Digest,* 15–27 (1998)]. This technique uses slowly increasing and decreasing ramp waveforms to produce a stable positive-resistance gas discharge that can generate the necessary levels of priming without emitting very much light. This positive-resistance discharge has the added advantage of exactly establishing the subpixel wall-voltage levels so that lower-voltage address drivers can be used, which permits the use of lower-cost circuits.

Motion Artifacts. One consequence of the inherent memory characteristic of PDPs is the need to use a digital gray-scale technique that divides each video frame into a number of weighted sub-fields. A high-quality image can be achieved with a sufficient number of sub-fields, but there is a trade-off: Too many sub-fields will require too much address time, so little time will be left for the sustain operation. This will cause the panel to have low luminance. The challenge is to find the gray-scale algorithm that uses the smallest number of sub-fields that deliver minimal motion artifacts and can, at the same time, be implemented at relatively low cost.

Most of the motion artifacts show up as false contours when an object is moving across the screen, and these are most visible where the most heavily weighted sub-field changes state. They also depend on how the eye follows the moving object and how fast the object is moving, and they are especially noticeable as false contours on a moving human face.

The Plasmaco 60-in. panel uses the gray-scale method developed by I. Kawahara and

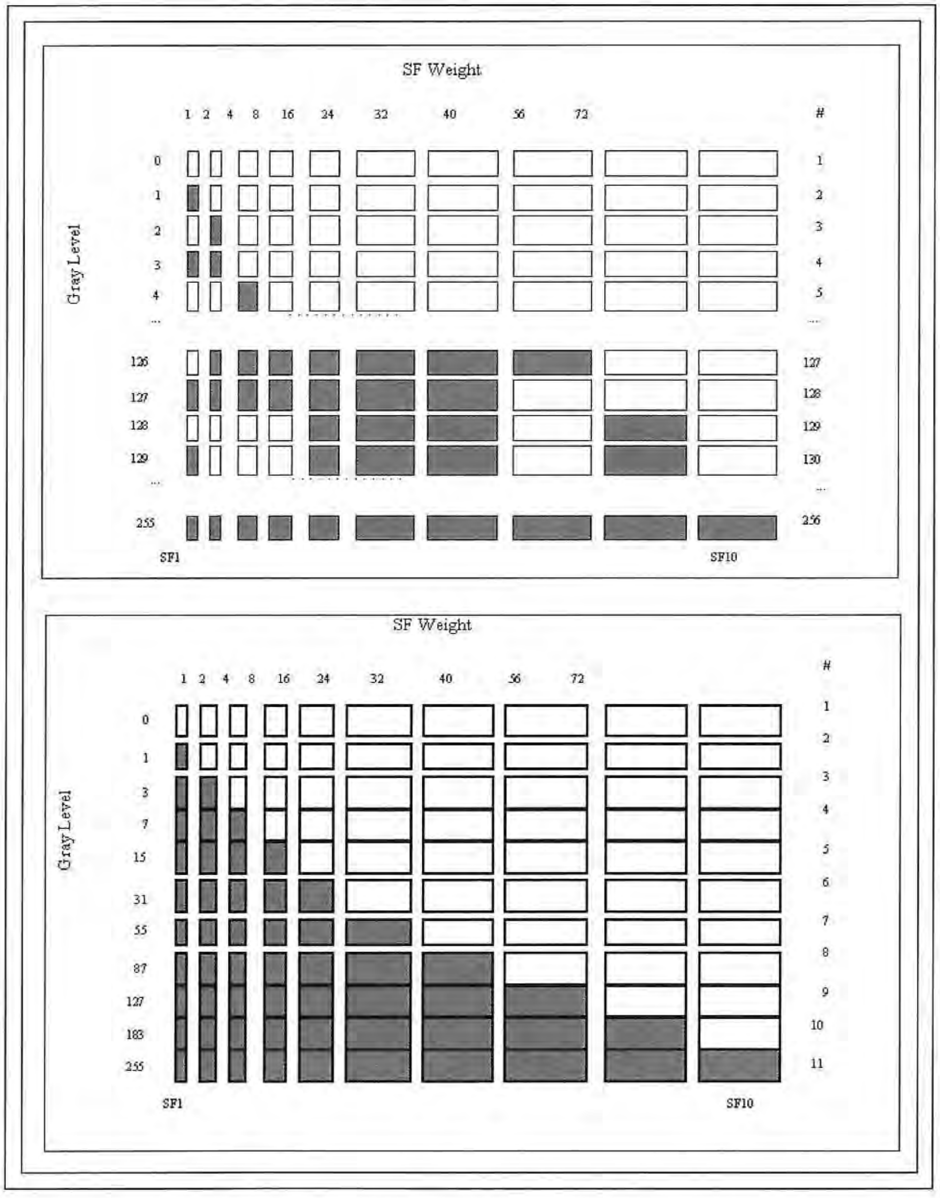


Fig. 3: *Changing from the traditional gray-scale weighting algorithm (top) to a linearly weighted sub-field sequence (bottom) permits the elimination of PDP motion artifacts.*

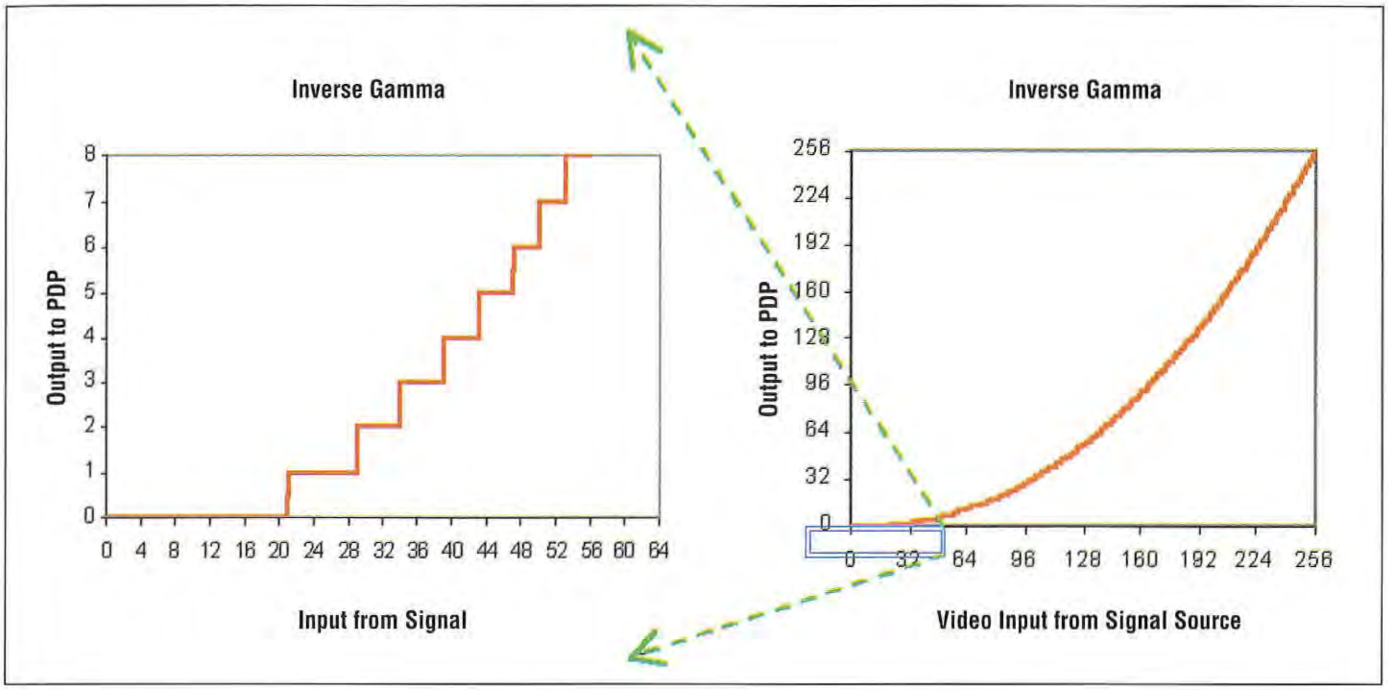


Fig. 4: *The inverse gamma look-up table needed for PDPs produces low-level contouring with 256 gray levels. Introducing spatial error-diffusion methods increases the number of low-level intensities and smooths out the inverse gamma function.*

K. Sekimoto [see *SID Intl. Symp. Digest Tech. Papers*, 166–169 (1999)] to reduce the motion artifacts in a robust and easy-to-implement way. Pioneer has developed a similar method. This technique recognizes that motion artifacts are caused by the temporal nonlinearity of the conventional gray-scale algorithm (Fig. 3, top). By using a linearly weighted sub-field sequence, all motion artifacts can be eliminated (Fig. 3, bottom).

The disadvantage of this linearly weighted sequence is that it does not allow as many intensity levels as the more common temporal nonlinear binary chop sequence. To make up for this lack of gray levels, simple spatial error-diffusion techniques are used in combination with the linearly weighted sequence.

Low-Level Contouring. Most PDPs use 8 bits for 256 gray intensities. Unfortunately, this is insufficient for the low intensity levels that movie directors are so fond of. Such low-level images will show undesirable contouring. The problem is rooted in the gamma-correction methods used to transmit signals to CRT-based displays. Unfortunately, the PDP has an inherently linear input characteristic, but HDTV signals are transmitted with gamma correction that is ideally tailored for the non-linear input characteristic of the CRT.

This gamma-correction method allows the low intensity levels to be more precisely specified by the digital code than the higher levels. The method works well for the non-linear CRT, but the inherently linear PDP requires an inverse gamma look-up table (Fig. 4). The low levels of this look-up table cause considerable contouring with only 256 linear intensities.

The solution to this low-level contouring problem is to introduce simple spatial error-diffusion methods to increase the number of low-level intensities. This smooths out the inverse gamma function. Fortunately, the human eye does not easily detect the small amount of intensity noise introduced by the error diffusion because the intensity levels are so low. But the eye easily detects the color noise at these low levels. The solution for this color noise is to use a color-killer circuit for the low-level error-diffusion bits.

Designing for Low Cost

The remaining major problem that is keeping PDPs from being used in most home theaters is cost, but there are high hopes that the cost can be substantially reduced. A number of cost-saving features have been incorporated into the 60-in. prototype.

Soda-Lime Glass. The panel uses ordinary soda-lime float-process window glass for the substrate material, which is available in high volumes at low cost. This is a significant departure from the considerably more expensive high-strain-point glasses used in most PDP products manufactured today. The disadvantage of soda-lime glass is its high propensity to distort dimensionally during high-temperature firing, which causes manufacturing difficulties when device structures require alignment. But these problems can be controlled by means of careful processing and device designs that do not rely on critical alignments.

No Transparent Electrodes. All current PDP products use transparent ITO or SnO_2 electrodes in parallel with high-conductivity opaque metal bus bars (Fig. 5). This two-electrode approach adds unnecessary cost and alignment complexity to the design. The prototype uses a novel all-opaque metal-electrode design, which we call the "fence electrode" (Fig. 6) [see W. Schindler, *IDW '99 Proceed-*

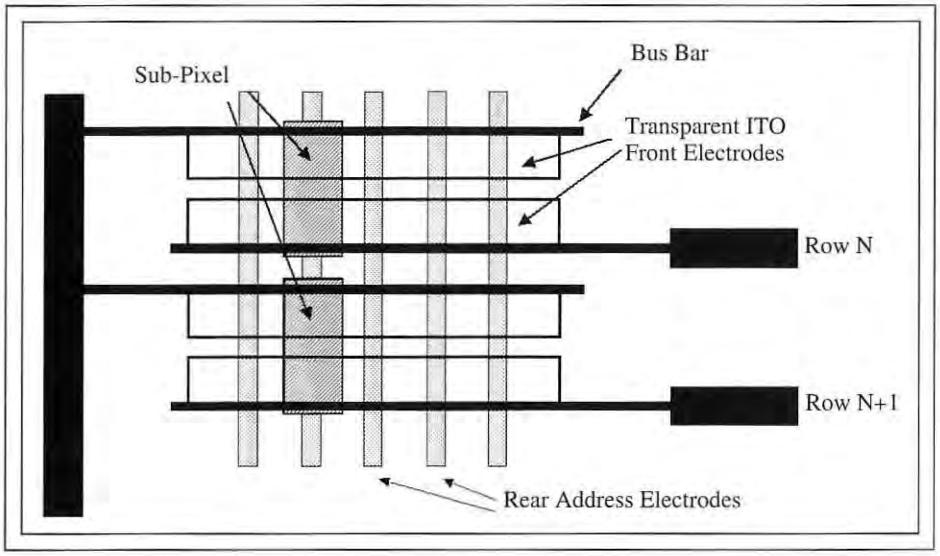


Fig. 5: Today's production PDPs use transparent electrodes and opaque metal bus bars.

ings, 735–738 (1999)]. In this approach, each front-plate electrode is composed of three narrow opaque electrodes that allow light to pass easily around them. This approach also provides a large discharge area and capacitance similar to that of the transparent electrode's. These fence electrodes are made by the well-established Cr-Cu-Cr electrode manufacturing process developed over 20 years ago by IBM. Small vertical shorting bars are added to increase yield by reducing the problem of open electrodes. The fence-electrode structure eliminates the need for expensive transparent electrodes.

Single-Scan Addressing. A third low-cost feature incorporated in the prototype is the use of single-scan addressing for an XGA display. This has the advantage of reducing the number of data address drivers by a factor of 2 over dual-scan designs. While single-scan addressing is common in VGA PDP products with 480 lines, the 768 lines of an XGA display are usually achieved by using dual-scan.

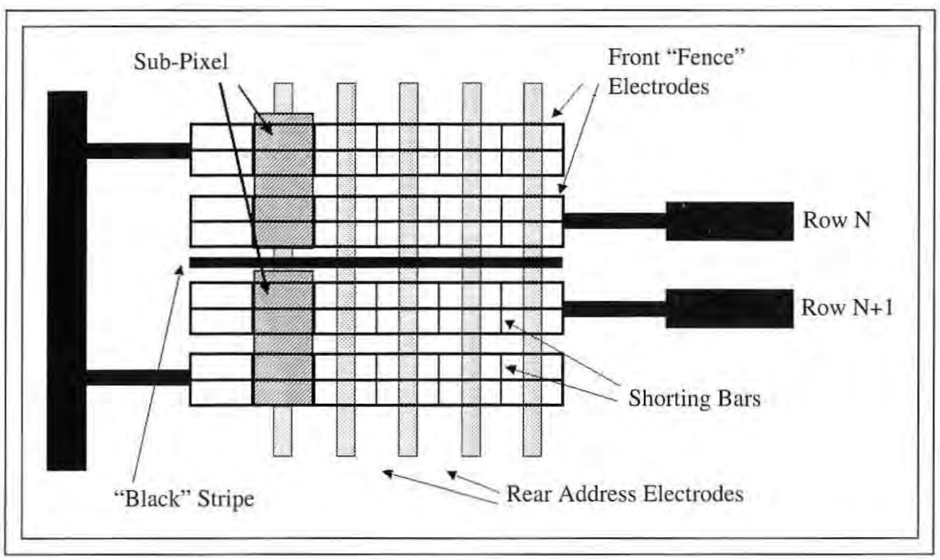


Fig. 6: The "fence electrodes" used in Plasmaco's 60-in. prototype eliminate transparent electrodes, thus reducing costs.

The fundamental problem is that the increased number of horizontal lines requires more precious address time during the fixed frame time. To get this extra time without resorting to dual-scan addressing there are only two options. The first is to increase the total address time, but this has the undesirable side effect of reducing the amount of time for sustaining the panel, which results in decreased luminance.

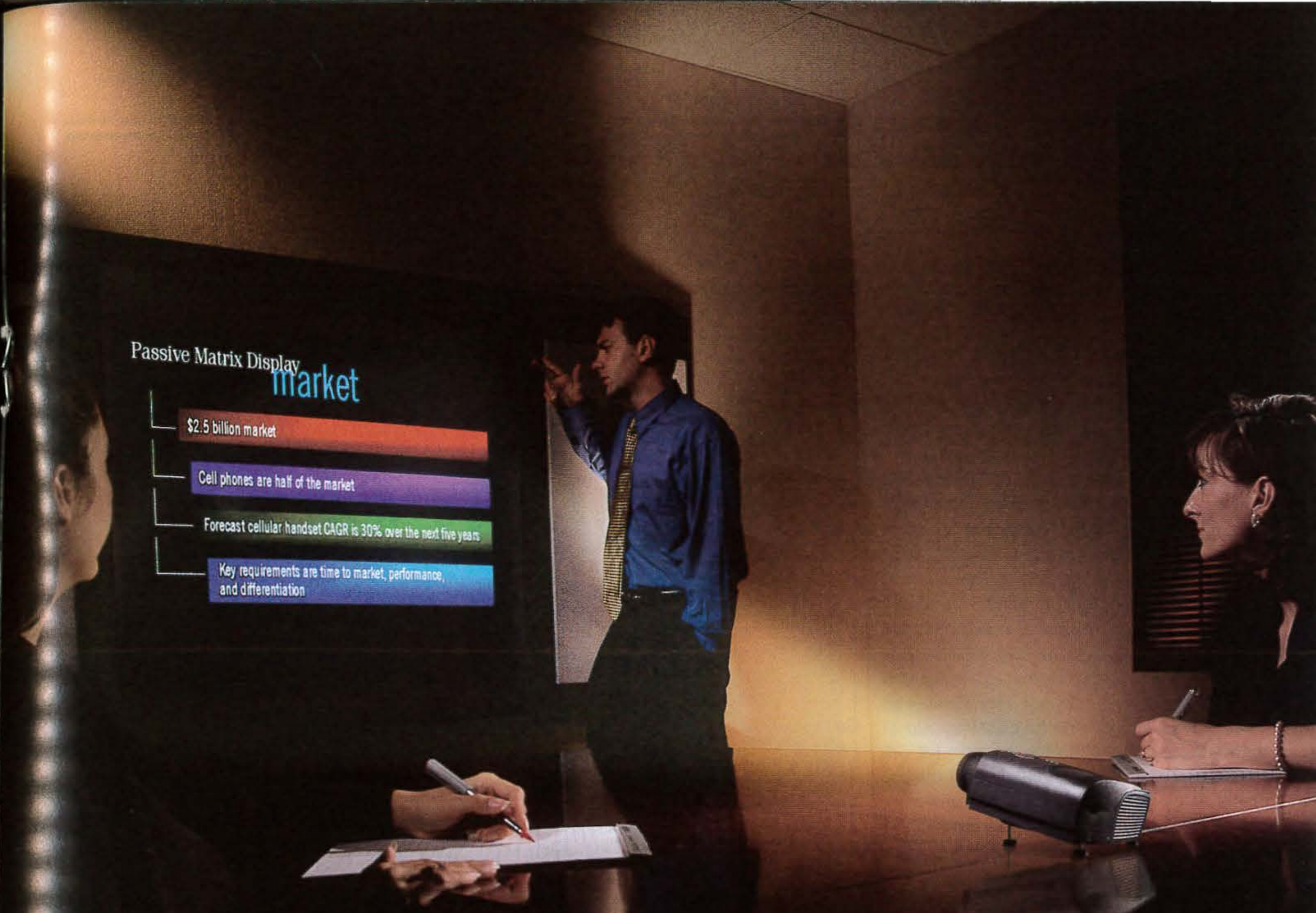
The second possibility is to reduce the amount of time necessary to address a single line. The prototype uses the second approach, and obtains a single-line address period of only 1.5 μsec. The challenge is to achieve this short address period while maintaining reliable addressing.

The use of single-scan addressing not only reduces the data driver costs but also reduces panel costs because dual-scan requires a critical alignment between the front and back plates of the panel. A single-scan design does not require any critical alignment, which allows the much lower-cost soda-lime glass to be used.

Where Are We Now?

PDP technology shows great promise for meeting the demands for home-theater HDTV displays. The overwhelming response of the public to the HDTV images on the 60-in. PDP demonstrates that its image quality has risen to the necessary level.

What remains to be accomplished is reducing the cost of this technology. This will occur as PDP manufacturing capacity and technology advance. In the interim, PDPs will enjoy a happy coexistence with projection and CRT HDTVs as the high-performance alternative. ■



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Circle no. 10

Light-Emitting-Polymer Displays

OLEDs can be made with small-molecule or polymer materials. Small molecules were first to market, but LEPs have some competitive advantages.

by Karl Heeks

ORGANIC light-emitting diodes (OLEDs) are potentially very attractive for commercial exploitation as a flat-panel-display technology because of their low power consumption, wide viewing angle, fast response time, and compact and lightweight construction. OLEDs are based on either Eastman Kodak's small-molecule light-emitting-diode (SMLED) film technology or Cambridge Display Technology's (CDT's) conjugated polymer light-emitting-diode (PLED) technology.[1,2]

SMLEDs

SMLED technology is more mature than PLED technology, and Kodak has licensed several companies, including Pioneer, Sanyo Electric, and Ritek Corp. Pioneer was the first company to enter the marketplace in 1997 with a 256 × 64-pixel monochrome display, which was followed by a segmented color-matrix display for an automotive stereo system. More recently, efforts have been focused on the fabrication of full-color displays capable of video output.

There have been three main approaches to fabricating full-color SMLED displays. The first uses an array of white SMLED pixels coupled to an array of traditional color filters.[3] The second approach utilizes blue SMLEDs as light sources with fluorescent color arrays as a color-changing medium to achieve RGB.[4] The third is the direct approach of patterned SMLED RGB emitter arrays.[5]

The first two approaches to color are undesirable because they entail a substantial loss of display efficiency, either from absorption in the color filters or from reported poor quantum efficiencies in the fluorescent materials. Furthermore, these two approaches increase the complexity of device manufacture. The direct-patterning approach offers the best route to enhance color purity and display efficiency. To directly pattern the RGB emitters, Pioneer used a shadow-mask technique.

At the SID International Symposium in May 1999, Pioneer demonstrated a prototype full-color 5.2-in. QVGA passively driven SMLED display that used a highly accurate mask-moving system to directly pattern the 320(×3) × 240 pixels to an effective pixel size of 0.33 × 0.33 mm. In October 1999, Kodak and Sanyo demonstrated a high-quality 2.4-in.-diagonal active-matrix full-color SMLED display, again using shadow masking to directly pattern the RGB emitters. This display successfully integrated Kodak's small-

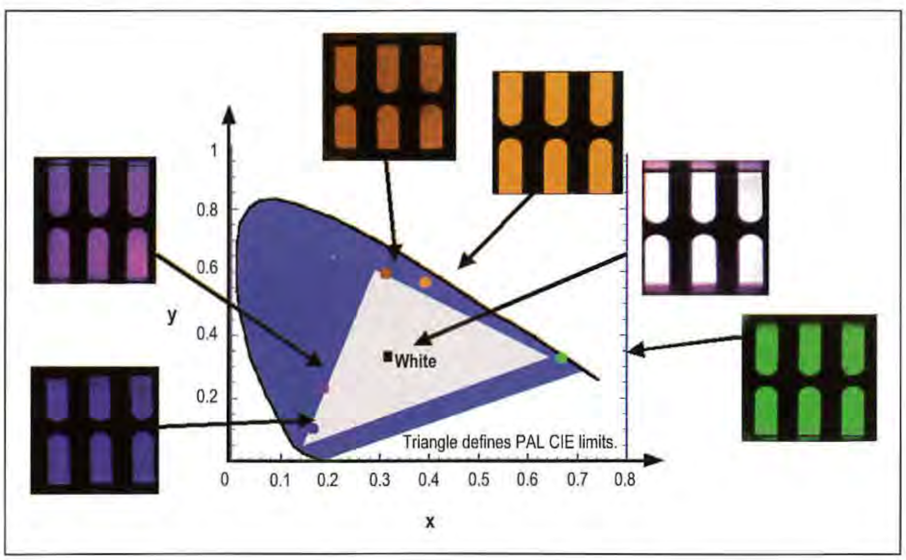

Fig. 1: *PLED materials can produce a wide variety of colors, including a red, green, and blue that come very close to the primary colors required for full-gamut PAL television.*

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The author thanks Jeremy Burroughes, Carl Towns, Julian Carter, and colleagues from CDT; and T. Shimoda, S. Miyashita, and colleagues from Seiko-Epson Corp.

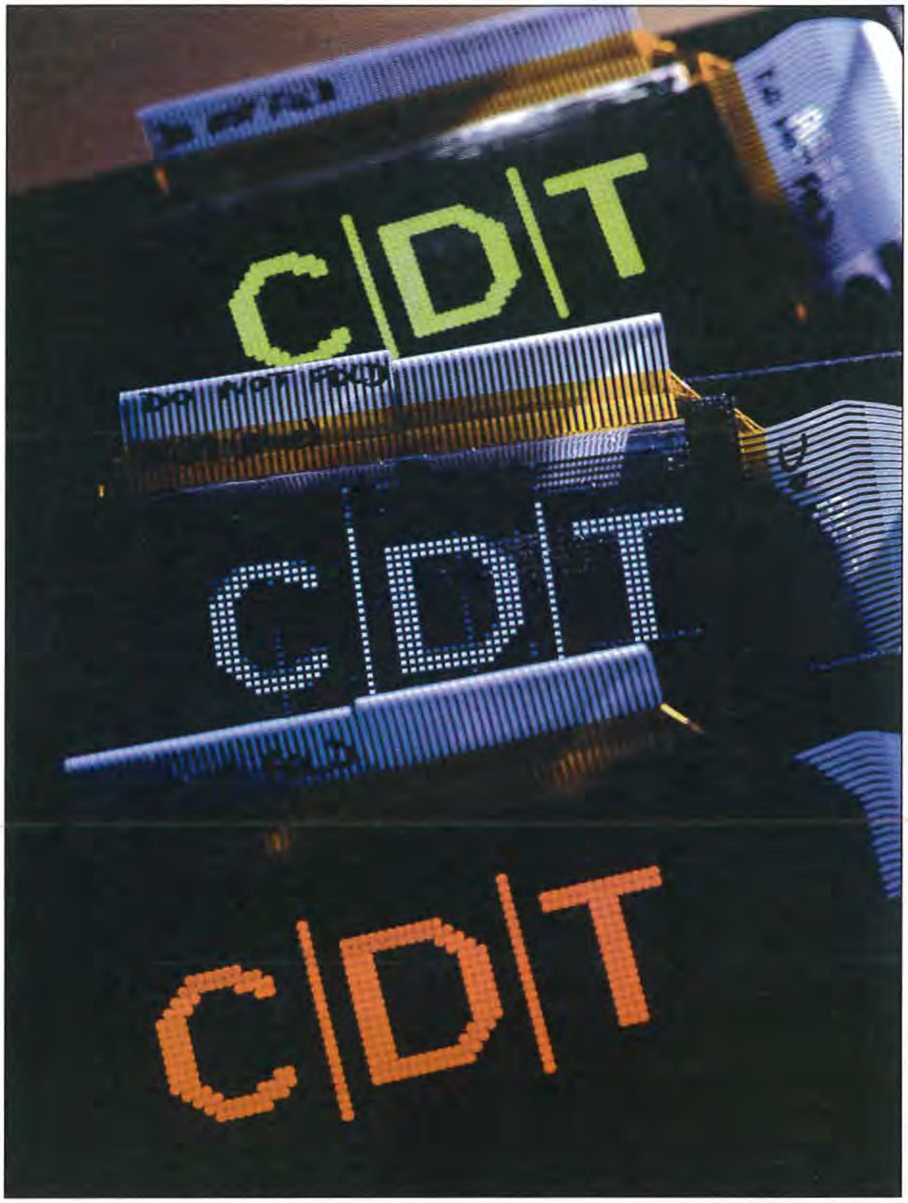

Fig. 2: *A polymer system for passive-matrix displays has recently been introduced that features high luminance at low voltage, a flat cd/A curve, high efficiency, a long lifetime, and a stable voltage/time characteristic.*

molecule technology with Sanyo's low-temperature-polysilicon (LTPS) technology and aroused a lot of interest in the flat-panel-display (FPD) community, in part because the display's response time and viewing angle are superior to that of an LCD's.

In normal graphics mode (150-cd/m^2 peak luminance), the display is reported to use 400 mW of power, which is half that of an equivalent LCD measured under similar conditions. Efficiency improvements for red and blue will produce further reductions in power consumption for this type of display. The characteristic qualities of these displays – high brightness, thinness, and low power consumption – make them attractive for consumer products such as PDAs, videophones, and other hand-held imaging devices.

At SID 2000, the Kodak/Sanyo collaboration unveiled an impressive 5.5-in. QVGA full-color LTPS TFT display that is expected to find applications in PDAs and automotive navigation systems. Kodak/Sanyo expect to establish a manufacturing process that will make displays available in 2001.

But there remains a significant technological challenge to using the shadow-mask approach in patterning at high resolutions over areas much beyond that needed for a 5-in. display. This results from problems of dimensional control of the patterned features related to thermal effects and mask sagging. NEC has developed a technique for stepping a small mask to pattern large areas at high resolution, but this limits throughput and may not be a satisfactory approach for volume manufacturing. Unless there is a breakthrough in this area, it may restrict SMLEDs to small- and medium-sized color displays.

PLEDs

Cambridge Display Technology has licensed its polymer-based technology to Philips, Seiko-Epson, Delta Electronics, and others. The progress made in PLEDs has been particularly impressive recently. Philips Research Laboratories has developed devices using poly(p-phenylene vinylene) – PPV – derivatives as the emissive material. These materials, synthesized by Aventis Research and Technologies, show extrapolated lifetimes greater than 20,000 hours (red-orange emission) and luminous efficiencies in excess of 16 lm/W (green emission). The early applications for these polymeric systems will be backlights and monochrome matrix displays. At CDT, we have concentrated on developing polyarylene systems that have been prepared by Suzuki cross-coupling. The performance of these systems is excellent in terms of color, efficiency, and lifetime. A variety of colors is available, including a red, green, and blue that come very close to the primary colors required for PAL television (Fig. 1). The efficiency, luminance, and lifetime of devices incorporating these primaries, as well as yellow, are summarized in Table 1.

One of the attractive features of PLEDs is their very simple device architecture. A basic device comprises

1. An anode, which is usually ITO on a glass or plastic substrate.
2. Two thin polymer layers, one of which is a polymer hole-conducting layer –

Table 1: Summary of LEP performance

Color	Efficiency at 100 cd/m^2 (lm/W)	Brightness at 5.5 V (cd/m^2)	Lifetime at 80°C (hours) (normalized to 50% from 100 cd/m^2)
Red	2.15	2000	4400 (extrapolates to ~100,000 at RT)
Green	18	10,000	>800
Blue	1.5	1000	1900 (RT, extrapolated)
Yellow	21	100,000	900

Source: Cambridge Display Technology

usually a film of polyethylene dioxythiophene polystyrene sulphonate (PEDT/PSS) made by Bayer AG and deposited from aqueous solution.

3. A conjugated-polymer emissive layer.
4. A cathode system – a low-work-function metal typically capped with aluminum – that is deposited *via* physical vapor deposition (PVD).

The device is then encapsulated to prevent the ingress of water and oxygen.

Initial work on PLEDs, as for SMLEDs, concentrated on monochrome applications. In these devices, the two polymer layers were deposited by spin coating, so it was necessary to optimize the rheological properties of the EL polymer solutions for this deposition process. For dot-matrix applications, it was also necessary to optimize the electronic properties of the EL polymer, depending on whether the display would be driven by an active or a passive matrix. One of the first technology demonstrators was a 2-in.-diagonal high-resolution (800 × 236) monochrome PLED display driven by LTPS TFTs.[6]

For active-matrix drive schemes, where the pixels are on throughout the frame, the LEP material needs to be tuned so that its peak luminous efficiency occurs close to the normal operating luminance of 100–150 cd/m^2 and to ensure that it is suitably stable. The requirements for an ideal polymer system for passive-matrix displays used in portable applications would, however, be different.

The system would need to be capable of very high luminance at low voltage, have a flat cd/A curve, be very efficient, have long lifetime, and have a stable voltage/time characteristic. If the required drive voltage is sufficiently low, then low-voltage drive chips may be used. This results in lower power consumption and a reduction in the module cost.

We have recently produced such a polymer system. The yellow emitter (CIE 0.45, 0.54) turns on at less than 2 V, and the average voltages required to achieve luminances of 100, 1000, and 100,000 cd/m^2 are 2.1, 2.4, and 5.5 V, respectively (Fig. 2).

AM-LEP Displays with Ink Jets

In order to make a full-color light-emitting-polymer (LEP) display, one must form an array of patterned RGB LEP emitters that define the device pixels. This is non-trivial because it is difficult to integrate conventional patterning techniques such as spin coating and photolithography (which may cause severe damage to the LEPs) to achieve the resolution necessary for full-color displays.

Workers at Seiko-Epson and CDT have developed an ink-jet printing process that can directly pattern both the charge-conducting and emissive polymer layers on large-area substrates with high resolution and at low cost. An additional advantage of this technique is that it reduces the amount of polymer wastage. (Spin coating is extremely wasteful of material, but in ink-jet printing the required volume of ink is deposited directly, with only minimal wastage associated with flushing the ink-jet printer heads.)

CDT

Fig. 3: Cambridge Display Technology and Seiko-Epson have recently demonstrated a 2.5-in. full-color 16-gray-level active-matrix ink-jetted display.

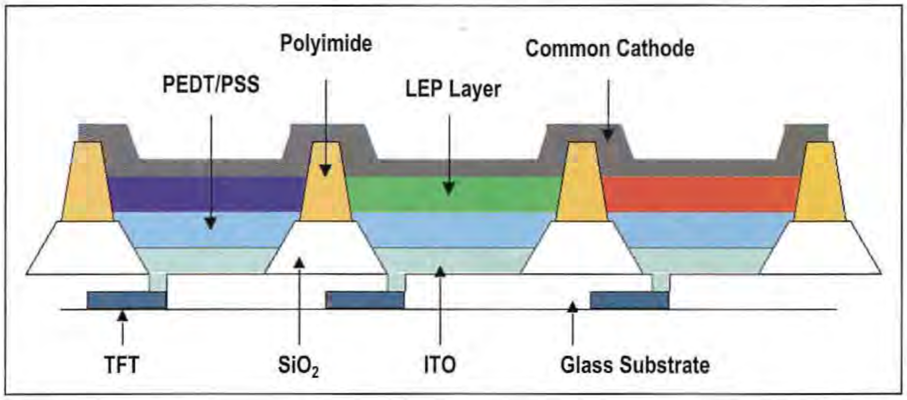

Fig. 4: *This cross-sectional schematic view of the full-color ink-jetted display shown in Fig. 3 illustrates the vertical structures, consisting of SiO_2 and polyimide pillars, atop the TFT substrate.*

The ink-jet printing process requires a modification to the ink-jet heads on a conventional commercial machine to make them compatible with the solvents in the LEP inks. The rheological properties of LEP inks and charge-transport solutions must be modified so that they may be successfully deposited by ink-jetting.

Another challenge has been the registration of ink-jet drops to the substrate, but a reliable method of drop registration has been developed by pre-patterning suitable well structures and modifying the surface energies.

CDT/Seiko-Epson recently demonstrated a 2.5-in. full-color 16-gray-level active-matrix display (Fig. 3). The vertical structures on top of the TFT substrate consist of insulating SiO_2 and polyimide pillars (Fig. 4). The SiO_2 prevents shorting between the cathode and ITO at the pixel edge, and the polyimide creates the wells into which the ink is deposited.

The LEP inks were based on poly(dialkylfluorene) derivatives, which were chosen for their high luminescence efficiency in blue, green, and red. The device structure has a common cathode which has been developed to efficiently inject electrons into the LUMO – lowest unoccupied molecular orbital, which is the equivalent of the conduction band in inorganic semiconductors – level of the three polymer emitters, as well as be sufficiently stable for product applications.

The display is 200 × 150 pixels, with each pixel comprising nine subpixels (three per primary). The subpixels are circular and 28 μm in diameter on a 70-μm pitch. This display is based on LTPS active-matrix technology, and it uses a digital drive scheme based on temporal and spatial dither to achieve the 16 gray levels per color. Philips Research is also using the ink-jet-printing approach as a way to realize full-color PLED displays, and recently demonstrated a two-color passive-matrix display with 64 × 96 pixels at a pitch of 600 m.[7]

With the demonstration of a high-quality high-resolution color active-matrix PLED display using ink-jet printing, the next step becomes the integration of this innovative technique into a PLED manufacturing line. The ink-jet process is fully compatible with volume manufacturing and is not expected to be a bottleneck in the process flow for these displays. Ink-jet printing is also fully compatible with very large substrate sizes, for which, in active-matrix applications, the display size will almost certainly be dictated by the ability to fabricate large arrays of TFTs. The integration of ink-jet printing and web-coating manufacturing is expected to enable the fabrication of low-cost PLEDs on plastic substrates. Since LEP is inherently a plastic-based technology, it is one of the few mainstream technologies well suited to making formable and flexible displays.[8]

Concluding Remarks

SMLED displays are now in the marketplace, and recent demonstrations by Kodak/Sanyo have brought the benefits of this emissive technology to the display community at large. LEPs offer several advantages over small molecules associated with LEP's intrinsic characteristics of thermal stability, solution processability, and simple device architectures. These characteristics offer the potential for a cheaper manufacturing route. The addition of ink-jet printing for patterning these materials offers the possibility of increased display resolution and panel size for full-color displays.

PLEDs are not yet in the marketplace, and the coming months will see the first manufacturing capabilities coming on line. There is a growing need for a high-quality video display for mobile applications that is lightweight, emissive, full-color, and low in power consumption. Companies such as CDT and Seiko-Epson are working towards the commercial availability of a product with these characteristics. Over time, we anticipate that this light-emitting plastic technology will have the necessary characteristics and cost advantages to penetrate other display markets, and that it will have some unique properties that will open up new market segments.

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Protecting Intellectual Property in the Electronic-Display Industry

Traditional patents are one way to protect intellectual property, but they may not be the best way.

by Richard L. Fink, Kelly K. Kordzik, Song K. Jung, and Zvi Yaniv

INTELLECTUAL-PROPERTY (IP) issues have been, and continue to be, a subject of great importance for all involved in the display industry. The presence and enforcement of IP laws is the major form of protecting the large investments in developing new products and technologies.

Patents, copyrights, trademarks, and trade secrets are all forms of IP protection. Almost all countries have laws for some form of IP protection. Most of these laws are similar, but they do differ in a few small but very important details. Furthermore, the laws in the U.S. are changing. In this article, some relevant IP issues concerning the display industry, especially in the U.S., will be discussed.

Patent *vs.* Trade Secret

In a small laboratory at Company X, a bright engineer makes a discovery that will improve a display technology under development. The engineer diligently documents the discovery in a bound lab book, obtains signatures of co-workers who witnessed the discovery, and submits the proper invention disclosure to management. Now, the question is how should Company X protect this invention that it has made significant investments to produce. The answer depends on many factors.

To protect the invention, Company X has two major alternatives: patent the invention or hold it as a trade secret. A patent is essentially a deal struck with the Federal Government to provide a monopoly on the discovery in exchange for dissemination of the idea to the public. A trade secret is confidential information held tightly within the company.

Can One Get a Patent?

To obtain a patent, the invention must be novel. If someone else has previously made the same discovery and disclosed it publicly in a publication, then a patent can not be obtained. Even if a patent is awarded, later discovery of prior art can render the patent worthless.

In all countries except for the United States, this precludes the inventor and Company X from publicly disclosing the invention prior to submitting the application. In this sense, disclosure is very broad: it can include public use, sale in the marketplace, or publication. With some possible minor exceptions, the U.S. is alone in allowing submission of patent applications after public disclosure by the inventor, but only within 1 year of disclosure.

For a "mature" technology such as the CRT, finding relevant prior art can prove difficult. Invention of the CRT is credited to Karl Ferdinand Braun from a paper published in 1897 (Fig. 1). The archive of patent and technical literature is extensive. If prior art is discovered, Company X may still want to hold the discovery as a trade secret, depending on the application.

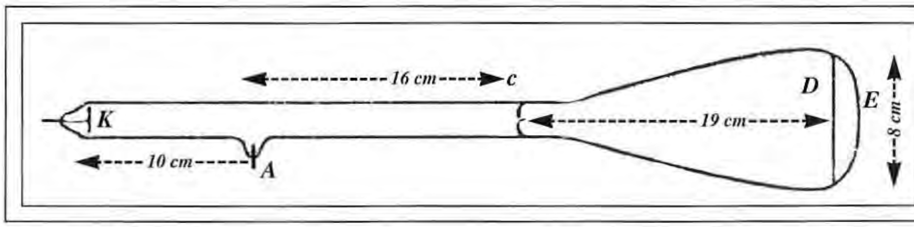

Fig. 1: Even though the basic technology is over 100 years old, a healthy level of intellectual property is being generated in an effort to maintain CRT market share over competing technologies. Shown here is a photograph of the first page of Karl Ferdinand Braun's original paper, "Ueber ein Verfahren zur Demonstration und zum Studium des zeitlichen Verlaufes variabler Strome," published in Annalen der Physik und Chemie *in 1897.* (Used by permission of Peter A. Keller.)

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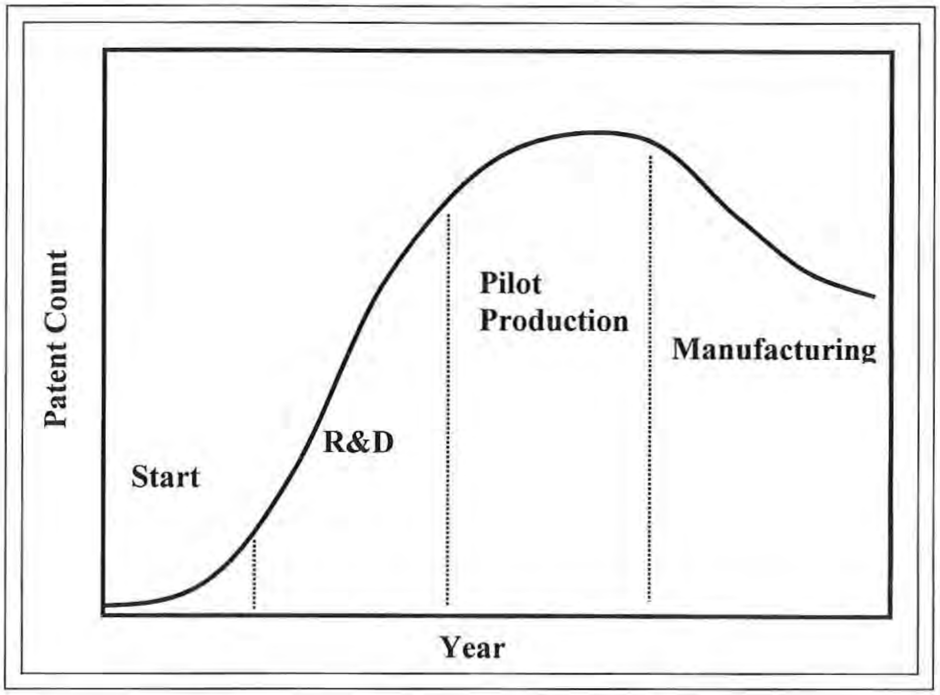

Fig. 2: Patent activity increases until product manufacturing begins and then falls off as the technology matures.

Will a Patent Be Worth the Effort?

Whether or not Company X decides to patent its discovery depends on the company's nature, the character of its IP, and the existence of prior art. If the company is an R&D house that makes its money from selling licenses to technology, then the answer is clear: patent the invention. If the company is a manufacturing house, then the decision is complicated.

Typically, if the discovery is something that can be detected or measured – such as a novel material, architecture, or assembly – then the discovery should be patented. If the discovery is of a process – such as a more efficient manufacturing procedure – then the decision will likely be to hold the discovery as a trade secret. Patent infringement of a manufacturing process is difficult to detect because it is not likely to be evident in the end product. Furthermore, it may be easy for competitors to design around the invention by making minor changes to the discovered process if it is patented.

There are other issues that influence the decision to patent a discovery, including problems with the U.S. patent system. The first problem is that it typically takes 2–3 years to obtain an issued and enforceable patent. Consequently, if Company X begins manufacturing and selling the invention during that interim period, the company is at the mercy of infringers. If a product – such as software – has a short life cycle, it may be obsolete by the time the patent is issued.

The second problem with patent protection is the expense, not only for obtaining the patent but also for patent litigation, which averages in the six-figure range. Obviously, this is a serious hindrance to individual inventors and small companies, where innovation is often the most creative. To help ease this burden, the U.S patent law was changed 5 years ago.

Lowering the First Hurdle

Those who seek patent protection for their inventions are often surprised at how expensive it is to prepare and prosecute a patent application to an issued patent. The various fees required by the U.S. Patent and Trademark Office (USPTO), the patent attorney, and a draftsman can typically range between $3000 and $15,000, depending upon the complexity of the invention. As noted above, for individuals and start-up companies, it is often difficult to justify such an investment.

On June 8, 1995, an alternative to the traditional patenting process became available as a result of the Uruguay Round Amendments Act (URAA). Among other things, the legislation provided that a patent term begins on the date of issue but ends 20 years from the filing date (with some exceptions) and that a *provisional* patent application may be filed with a lower filing fee and less stringent requirements as to its content. Essentially, a provisional patent application may be filed with an enabling description of the invention and any required drawings along with the fee, which is considerably lower than the filing fee required for a "non-provisional" or "regular" patent application.

The main ingredient not required in a provisional patent application is the "claims," which in a "regular" patent application sets forth what the inventor asserts to be his or her "invention." The significance of not including the claims is that a great deal of time and money can be saved. Since the claims are often difficult to draft and since they should be drafted by a registered patent attorney, there can be a significant savings in attorneys' fees. The total fee for preparing and filing a provisional patent application can be less than $1000 for simple mechanical inventions.

But that's not the whole story. There are also disadvantages in filing a provisional patent application. First, a provisional patent application is not examined by the USPTO and can never be issued as a patent on its own. It is basically effective for obtaining a filing date. This filing date can be relied upon by a subsequently filed "regular" patent application as a priority date for proving that the invention was "invented" at least as early as that filing date. Since the U.S. patent system grants patents to the person "first to invent" an invention, having such a provable date can be quite valuable. It may also be useful if foreign applications are being considered where patents are granted to the "first to file" an invention.

A second disadvantage in filing a provisional patent application is that it only *defers* (up to 1 year) the need to file a "regular" patent application, claiming priority to the filing date of the provisional patent application, in order to eventually obtain an *issued* patent. (Only an issued patent enables its owner to preclude others from practicing the claimed invention.) Therefore, although the initial expense for filing a provisional patent application is lower than that of a "regular" patent application, the problem of the higher costs associated with the "regular" patent application will eventually have to be confronted if an issued patent is still desired.

Along with deferring the cost of a "regular" patent application, filing a provisional patent application and deferring the filing of the "regular" patent application also defers the USPTO's examination of the application and the resulting issuance of a patent. As discussed above, this also defers the patent protection afforded by an issued patent.

If a patent-application filing date is needed on short notice, and there is insufficient time to prepare a "regular" patent application, then a provisional patent application provides an alternative solution. Additionally, if money is tight and time is needed to determine if an invention will succeed as a marketable property, then deferring the greater costs associated with a "regular" patent application by filing a provisional patent application is an option to consider.

Do I Want to Keep a Secret?

Trade-secret protection is essentially a creation of contract law, enforceable in state courts. A company's protection is only as strong as (1) the standard internal procedures for maintaining trade secrets, (2) the language in the confidentiality agreements, and (3) a willingness to police and enforce violations in court. Trade-secret protection is a significant hindrance to innovation because it involves an attempt to stifle the dissemination of knowledge. It is the opposite of what is desired in the scientific community: freely available knowledge. Those working in emerging technologies often favor patents as a means of advancing the field and increasing acceptance.

Patent Activity as a Measure of Strength

The classical view is that patent activity varies as a technology passes through the various stages of its life cycle (Fig. 2). Specifically, patent activity increases until product manufacturing begins and then falls off as the technology matures. Interestingly, liquid-crystal-display (LCD) technology shows signs of active development, even though LCDs have been on the market for 15 years (Fig. 3). The figure shows a steady increase in patent activity for Patent Class 349 (Liquid-Crystal Cells, Elements, and Systems). The drop-off in 1999 is within the noise of the data. Class 349 is a broad class and includes many subclasses of LC technology. Clearly, as certain LC technologies mature, others are being developed to overcome old barriers in a continuous effort to improve performance and lower manufacturing costs.

More detailed statistics by class, subclass, and company assignment can identify who is doing what within a specific class and subclass. Knowing that a competitor has a significant number of patents in a certain class may indicate a new strategic direction that could affect one's own strategy. Custom reports of patent activity are available for a nominal cost from the USPTO.

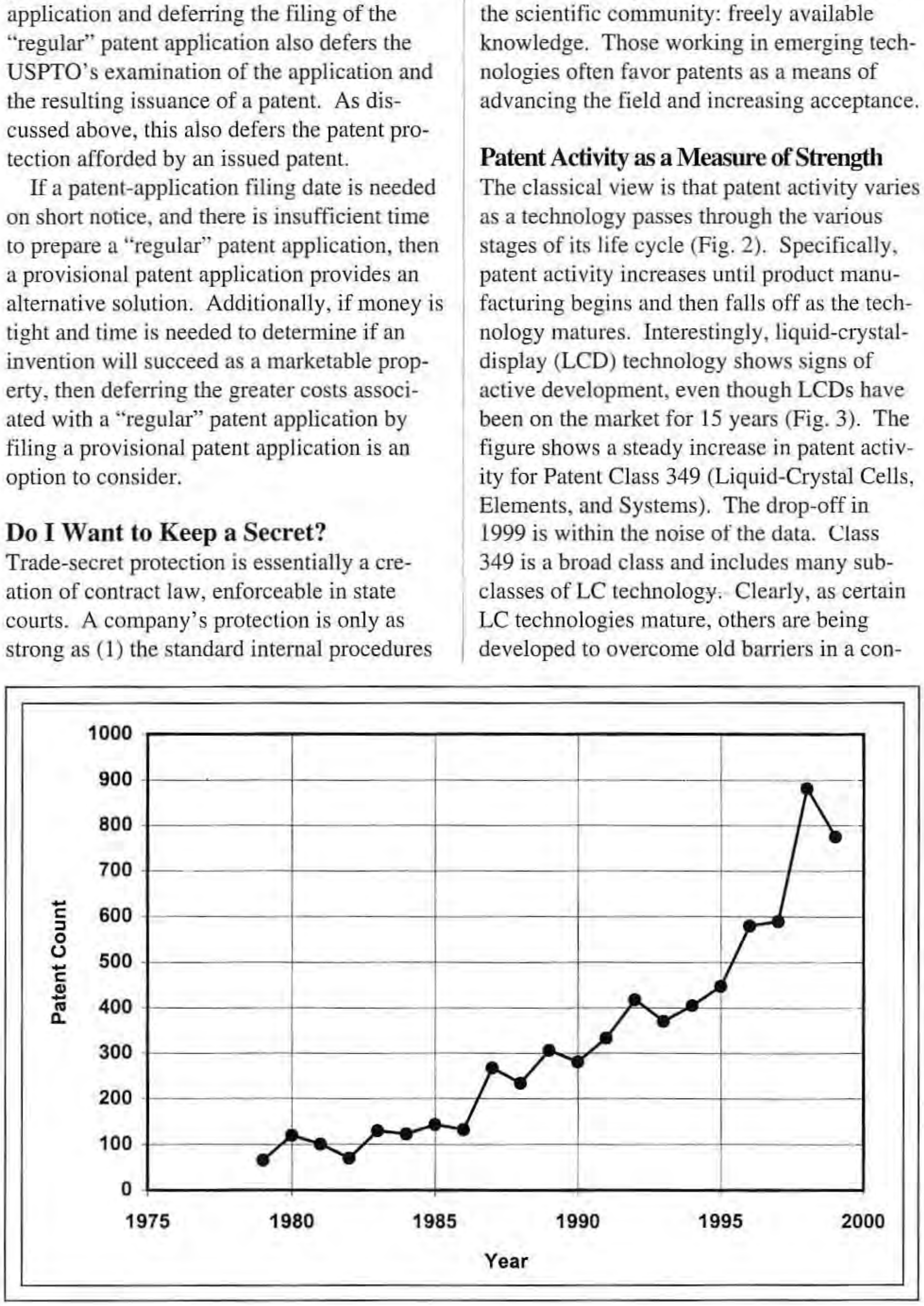

Fig. 3: *The patent activity of Patent Class 349 (Liquid-Crystal Cells, Elements, and Systems) shows a steady increase. Although LCDs have been on the market for 15 years, patent activity is still strong.* (Data from USPTO.)

Summary

The decision to patent a discovery or to hold it as a trade secret should be given serious and prompt consideration. Long-range and international implications must also be included in the decision. Patent activity within a technology class is a measure of the strength of the technology and can influence company strategy.

There are many other issues that are equally important, including enforcement and licensing strategies, international protection, and portfolio management.[1] In this discussion, we have only presented a single perspective here, that from the point of view of U.S. law. Quite different perspectives are required in countries such as Japan, where manufacturing and product export command a higher strategic importance. IP issues are complicated and demand discussion from differing perspectives. These issues are presented and discussed at the annual Symposium on Flat Panel Display Intellectual Property Issues held in Austin, Texas, each spring.

References

[1]For more information on enforcement, see Zvi Yaniv, "Strategic Analysis and Enforcement of Intellectual Property in the Flat Panel Display Industry in North America," in the proceedings of Intertech's 2nd Annual Display Industry Conference, October 2000 (to be published). ■

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turned on from full black to full white plus the time it takes to turn it off again is not adequate for characterizing an LCD's ability to handle video without smearing.)

- Materials and approaches for making and packaging pixel-switching transistors are booming – and not only in research laboratories. Amorphous silicon dominates, of course, but low-temperature-polysilicon (LTPS) TFT-LCDs are available in quantity, continuous-grain silicon (CGS) is now in a commercial HDTV monitor, organic transistors are getting closer to being a practical production technology, Kopin makes its single-crystal-silicon–on–glass transistors in quantity, and Alien is packaging single-crystal transistors in tiny blocks about 300 nm on a side and is distributing them across the backplanes of small plastic displays.

There is much more, but I'll stop here. This has been a technically exciting, as well as prosperous, year in the display industry. May 2001 bring us more of the same, and may the holiday season that many of us celebrate at this time of year remind us that our technologies glow most brightly when they are used to enhance the dignity, well-being, happiness, and mutual understanding of our fellow human beings.

– KIW

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

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conversation, for me captured the full measure of why we gather together – to build lasting relationships that cannot be built any other way.

Now, before you conclude that I am a gushing sentimentalist, one who clearly does not appreciate the new world of electronic communications and the value of the Internet, let me suggest something I think is at work here that is creating a change of historic proportions – and, yes, it is something to do with the Internet.

Communications, thanks to the Internet, is becoming instantaneous, location-independent, and virtually free. That means we can reach anyone, anywhere in the world, at any time. Therefore, without much thought at all, our sphere of influence and sphere of communications are broadening to cover the globe.

How do we decide with whom of the six billion residents of this planet we should communicate? After all, most of us can't manage more than a few hundred "serious" relationships at any one time. Clearly, we do it based on common interests for business or personal reasons. What is so important about this is that new groupings of individuals are forming based on something other than geography. Think about the future impact of this. For centuries, we have organized ourselves into cultures, tribes, societies, states, kingdoms, fiefdoms, empires, and countries, all based on geographical boundaries. Borders were the walls between these entities and the people were contained within them.

But now? The European economic boundaries have already mostly disappeared. And in the future? Groupings by geographic region will make little sense. With worldwide communications and a global economy, what is there to protect? What is the value of a piece of land except as a place for one's residence or a business location? Neighbors become all those people worldwide with whom we communicate and exchange ideas. The new "countries" will be based on common interests or economic associations. However, we may each belong to several of them. This has to be a scary thought for our tradition-bound leaders and politicians. How do you "rule" a group of people when you can't even figure out who they are or where they are? For this reason, I am sure that geographically based government entities will survive for many years to come. However, they will have less and less influence on the operation of world society and the world economy. We will be driven by our interests and our ability to form those relationships that are most meaningful for us. They will span the globe. And that is also why we are likely to travel more rather than less in the coming years. The relationships we build through electronic media eventually demand to be strengthened by personal contact. Just as the electronic office created more paper instead of less, the Information Society will create a greater need for worldwide personal contacts, not less. The more we communicate, the more we will want to get to know each other even better. In my opinion, this is a good thing.

As I often travel long distances, through many time zones, my awareness grows that this earth is a finite resource, a finite place, and all that we have to work with. For now, there is no other. This global village is ours to develop and to enjoy. But, we must appreciate its limitations. The Information Society that we are helping to facilitate with our display activities will most certainly help to do that.

You will be reading this column during the December holiday season, and the members of the international display community will be celebrating that season from the perspectives of many cultural traditions. Please allow me to thank each and every one of you for the many great activities that you have allowed me to participate in during this past year, for your tremendous support of our Society, and for the many important contributions you have made to our successful year. May this season give all of us the wisdom to appreciate the wonders of this world and continue on the path to make it an ever better place for each of us. This is our global village – our home.

Should you wish to express your thoughts to me on this topic or others, you may reach me by e-mail at president@sid.org or silzars@attglobal.net, by fax at 425/557-8983, by telephone at 425/557-8850, or by mail at 22513 S.E. 47th Place, Issaquah, WA 98029. ■

Aris Silzars is President of SID and lives on a hilltop in Issaquah, Washington.

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