DISPLAY-ELECTRONICS ISSUE

Information DISPLAY

January 2004
Vol. 20, No. 1

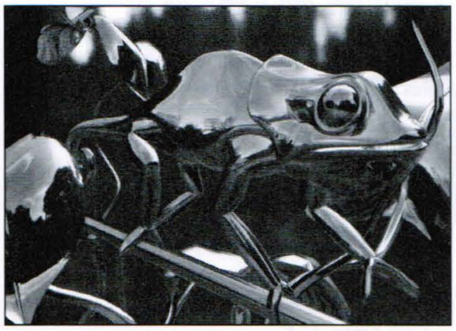
SID

Official Monthly Publication of the Society for Information Display

Cinema-Quality Images in Real Time!

- ***LCD Overdriving Technologies***
- ***Driving AMOLEDs with a-Si Backplanes***
- ***The Card that Drives the Display***
- ***Seattle to Host SID 2004***
- ***FLOWERS 2003 Report***

Modern graphics cards can draw complex, rapidly changing images in real time with cinematic quality and can even do it on multiple displays.



*n*VIDIA

Next Month in
Information Display

LCD Issue

- 100 Years of Commercial LC Materials
- Big-Screen-Display Market
- Motion Adaptive Feedforward Driving
- SMAU '03 Report
- IDRC '03 Report

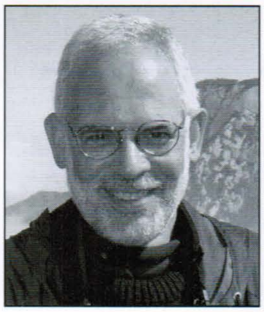
INFORMATION DISPLAY (ISSN 0362-0972) is published eleven times a year for the Society for Information Display by Palisades Convention Management, 411 Lafayette Street, 2nd Floor, New York, NY 10003; Leonard H. Klein, President and CEO. EDITORIAL AND BUSINESS OFFICES: Jay Morreale, Managing Editor, Palisades Convention Management, 411 Lafayette Street, 2nd Floor, New York, NY 10003; telephone 212/460-9700. Send manuscripts to the attention of the Editor, ID. Director of Sales: Kate Dickey, Palisades Convention Management, 411 Lafayette Street, 2nd Floor, New York, NY 10003; 212/460-9700. SID HEADQUARTERS, for correspondence on subscriptions and membership: Society for Information Display, 610 S. 2nd Street, San Jose, CA 95112; telephone 408/977-1013, fax -1531. 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 0362-0972/04/$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, 610 S. Second Street, San Jose, CA 95112.

Information DISPLAY

JANUARY 2004
VOL. 20, NO. 1

For Industry News, New Products, Forthcoming Articles, and Complete, Continually Updated Conference Calendar, see www.sid.org.

editorial



January

January. This is the month when seemingly every editorial writer on the planet – at least in countries that follow the Gregorian calendar – feels compelled to publish his or her predictions of what the new year will bring. Fortunately, my colleague David Lieberman has done this brilliantly in his "Backlight" column in this issue. (David really was brilliant: he put together the predictions of several of our more interesting industry analysts rather than hazard his own.) I recommend the column heartily.

Freed from rubbing the crystal ball myself, I can write instead about some of the articles you will read in this issue. Dick McCartney (National Semiconductor) provides a superb tutorial on LCD overdriving, or, as Dick prefers to call it, response-time compensation (RTC). RTC is the technology that is making AMLCDs fast enough to render rapidly moving video images with high quality; that is, RTC is an essential enabler for LCD TV. Dick pioneered RTC more than a decade ago, when the application was aircraft instrumentation rather than television. Important as it is, RTC is not well understood by many people in the industry. We are very pleased that Dick has written this article for *Information Display*.

This is our Display-Electronics Issue, so it may not be surprising that it contains two other articles covering aspects of display electronics. IDTech created a stir at SID 2003 by exhibiting a 20-in. active-matrix OLED driven by TFTs made from amorphous silicon. Until recently, it was believed that the relatively high-current requirements of OLED pixels would make low-temperature-polysilicon TFTs necessary. In their article appearing in this issue, IDTech's Koichi Miwa and Atsushi Tanaka explain how it is possible to use the much less expensive amorphous-silicon TFTs through the careful design of compensation circuits.

Those of us who work primarily with standard business software are likely to take graphics cards (and embedded chips) for granted, but my teen-aged son likes to tell me that this attitude is a sign of intellectual decline and poor character. Indeed, gamers know very well that the ongoing technological battle (primarily between *n*VIDIA and ATI) to produce the most advanced video card is a heated one. The goal is nothing less than cinema-quality computer graphics rendered in real time. (Matrox makes cards of this class, too, but is seemingly more interested in the professional market.) *n*VIDIA's Tony Tamasi describes what a high-end video card has to do these days, and what we can expect in the very near future.

There is also a report on FLOWERS 2003, the display conference sponsored by the Russian, Belorussian, and Ukrainian Chapters of the Society for Information Display. This conference has a unique character, which (I hope) the report conveys. The conference certainly had technical, commercial, and cultural content that is not to be found elsewhere.

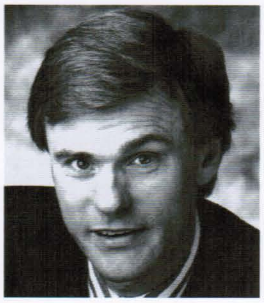
Finally, some of us are already beginning to think about the next SID International Symposium, Seminar, and Exhibition being held this year in Seattle May 23–28. This issue of *ID* is going to press before the content of SID 2004 is established, but we can certainly tell you a bit about the exciting city in which it

continued on page 38

Information
DISPLAY

Editor: Kenneth I. Werner
Managing Editor: Jay Morreale
Administrative Editor: Dian Mecca
Administrative Assistant: Ralph Nadell
Contributing Editors: David Lieberman, Bryan Norris, Alfred Poor, Joe Hallett, Patrick Dunn, Stephen Atwood
Advertising Manager: Jay Morreale
Sales Manager: Kate Dickie

my turn



Welcome to the DVI Follies!

by Peter H. Putman, CTS

If we are to believe the trade and consumer press, the new Digital Visual Interface (DVI) connection standard is simply the best thing since chopped liver. But is it?

I recently conducted a multi-product review of several plasma and LCD monitors. As part of that test, I fed a variety of PC and digital video signals to those monitors equipped with DVI inputs, just to see how well they would "talk" to my DVI signal sources – a Samsung SIRT-165 ATSC set-top receiver and an *n*VIDIA GeForce4 TI 200 AGP display card.

Of the six monitors in my review, four were equipped with DVI inputs. One was a big-screen TFT-LCD design (NEC–Mitsubishi's 40-in. LCD4000 with 1280 × 768 resolution), while the plasma offerings came from V, Inc. (Vizio P4 46-in. 852 × 480 PDP with built-in TV tuner), Philips (32FD9954 32-in. 852 × 1024 PDP with built-in TV tuner), and NEC (PS42VP4 42-in. 853 × 480 PDP monitor).

One of the supposed advantages of a DVI connection is that it is "plug and play" for the end user. So how did the review monitors behave in that regard?

In my tests, the Philips, Vizio, and NEC–Mitsubishi monitors had varying degrees of success with basic PC DVI rates (800 × 600, 1024 × 768, 1280 × 768, 1280 × 1024) from the *n*VIDIA card and DTV signals from the Samsung tuner. Some test signals would come up correctly sized, and others would be compressed or completely misidentified.

The Vizio P4, a plasma TV that does not re-scale higher-resolution PC signals to fit its 852 × 480 matrix, had a hard time identifying several DVI signals correctly, labeling 1280 × 720/60 as "1280 × 1024, Out Of Range," identifying a subsequent "true" 1280 × 1024/60 signal as "1360 × 768," and labeling a 1360 × 768 signal as "1280 × 1024."

In fact, many of the RGB and HDTV test signals I connected to this monitor triggered an "Out Of Range" on-screen message while simultaneously displaying just fine, although severely overscanned and cropped.

While the Philips, Vizio, and NEC–Mitsubishi monitors were content with 480p and 720p DVI signals, the LCD4000 subsequently choked on a 1920 × 1080i/30 signal from my Samsung tuner. It was also unhappy with a 1280 × 1024 signal source. Only the unassuming Philips plasma TV was able to handle all of the PC and DTV DVI sources without complaint.

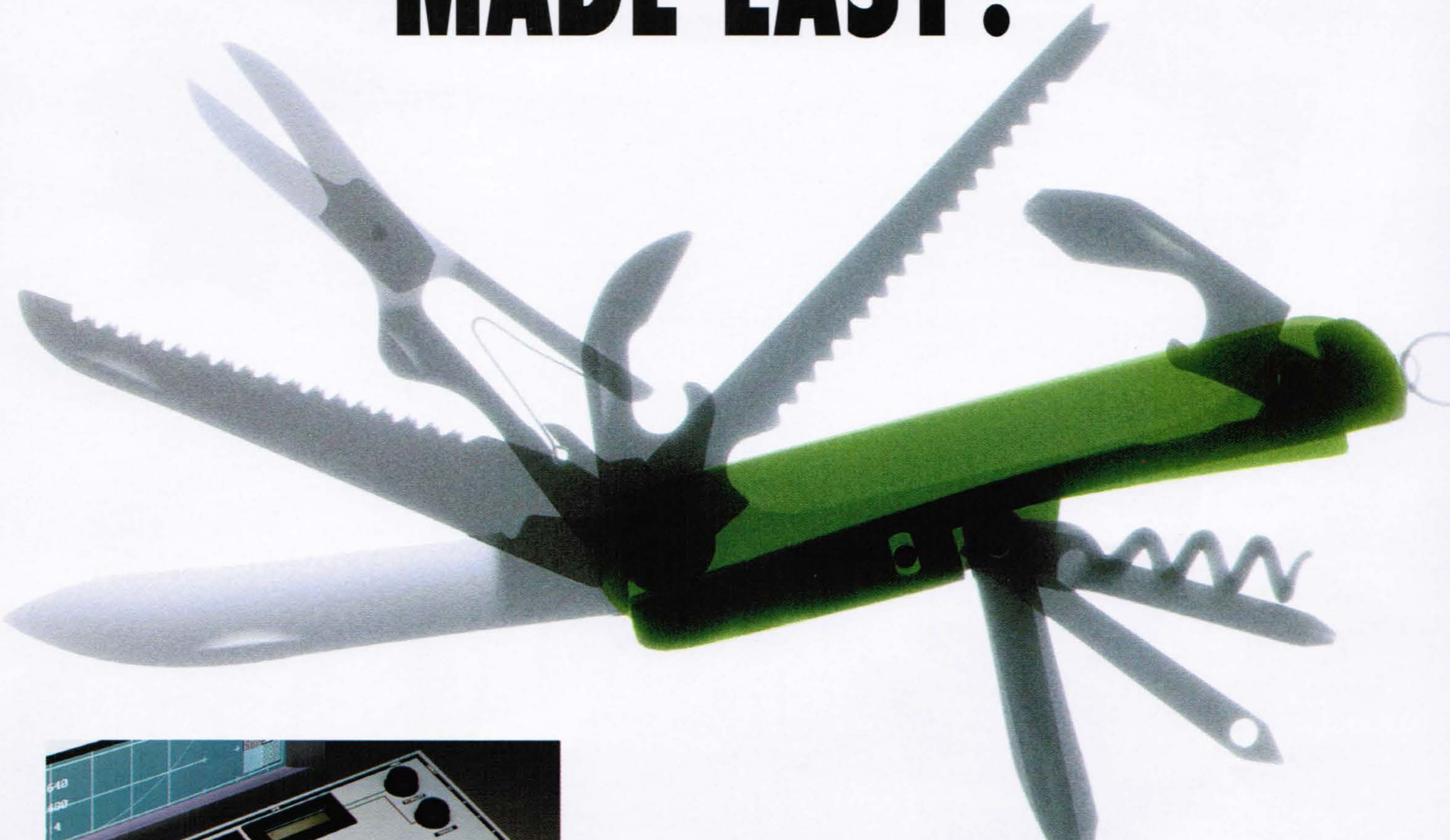
Confronted with 720p and 1080i DVI test signals from the Samsung tuner, NEC's PS42VP4 plasma monitor simply remained dark and identified these signals as "Illegal." (In speaking with NEC, I determined that might be due to the lack of support for High Definition Copy Protection (HDCP) on the PS42VP4, which is really a product intended for the professional and industrial marketplace.)

Another LCD monitor in my review was withdrawn when it was discovered that one and only one DVI rate (1280 × 720) would reliably work with that monitor, which had wide-VGA native resolution. On this product, 800 × 600, 1024 × 768, and 1280 × 1024 signals just would not cut the mustard. In fact, hot-switching the *n*VIDIA card's output resolution while connected to this LCD

continued on page 37

Society for Information Display
610 S. 2nd Street
San Jose, CA 95112
408/977-1013, fax -1531
e-mail: office@sid.org
http://www.sid.org

MULTIMEDIA MADE EASY!



Introducing the 802R Multimedia Video Test Generator

- DTV–all formats
- DVI single or dual-link option
- HDCP production keys
- Built-in HDCP Go-No-Go test on any image or multiple images
- RGB up to 400 MHz
- TV option supporting NTSC, PAL, NTSC-J, NTSC-433, PAL-60
- 300 or optional 400 MHz analog pixel rates
- LVDS option up to 224 MHz
- 24-bit lookup table
- Built-in White Balance adjust using the low-cost CS-1 probe

Combine 400 MHz analog, DVI, and TV in the very same multipurpose generator. You can test the largest medical and graphics displays, too, using 4K x 4K x 8 video memory. Or, even copy one generator to many others using a standard memory card.

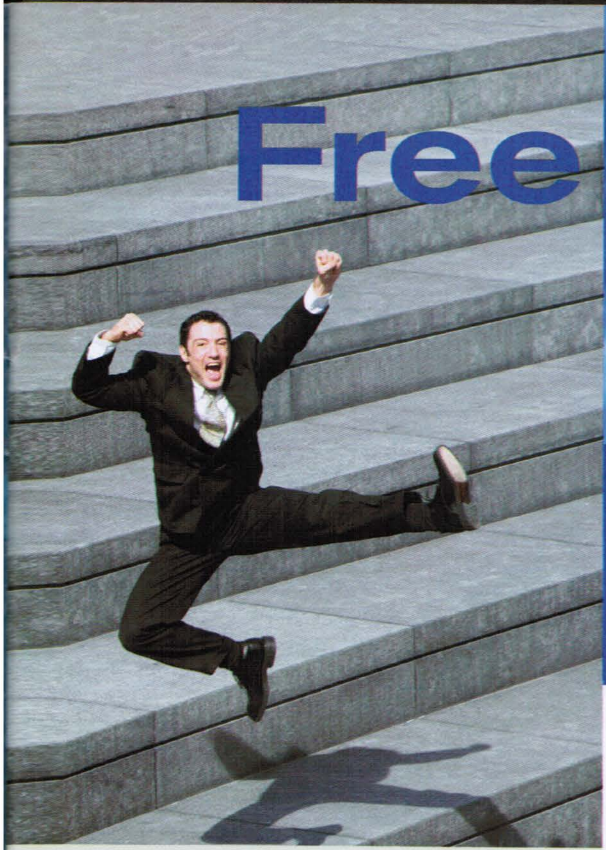
Choose from all these options at a price that makes choosing the 802R very easy. Just contact us. Never before has one video test generator done so very much…for so very little.

The Art of Technology

QUANTUMDATA

2111 Big Timber Road, Elgin, IL 60123
Phone: 847..888.0450 Fax: 847..888.2802
sales@quantumdata.com
www.quantumdata.com

Circle no. 3



Free the LCD from its video cable!

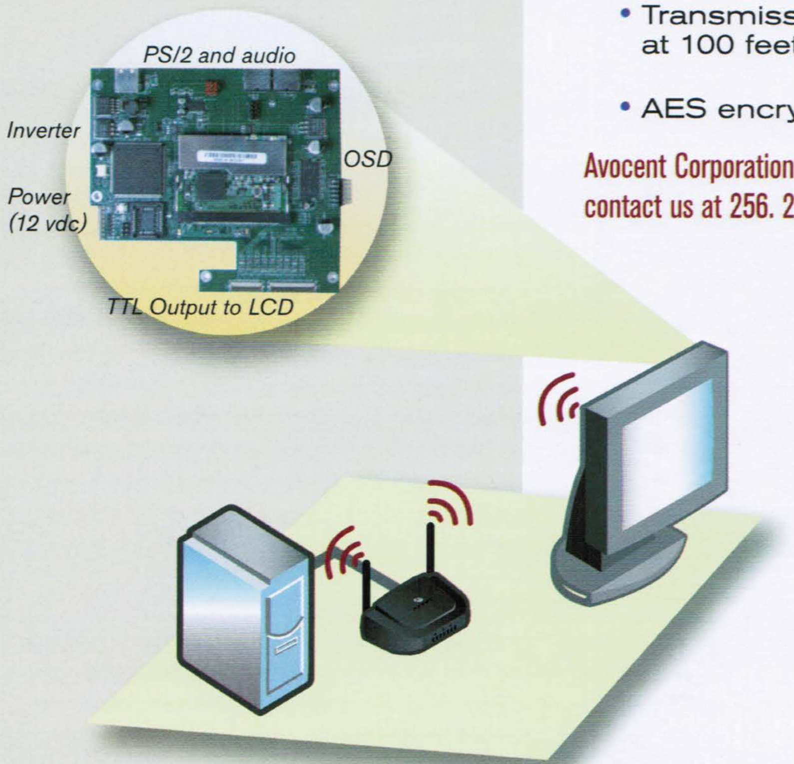
The Avocent new wireless technology eliminates the need for the video cable. Now, the LCD is free to go where no flat panel has gone before.

The Avocent wireless technology features:

- A transmitter with industry-standard analog RGB input
- A receiver with TTL or LVDS output
- Video resolution up to XGA
- PS/2 and audio interface
- Transmission of 30 frames per second at 100 feet
- AES encryption

Avocent Corporation is seeking OEM partners. For more information, please contact us at 256. 217.1318.

Avocent Wireless LCD Controller



Avocent
The Power of Being There®

Avocent Corporation
4991 Corporate Drive
Huntsville, AL 35805
TEL 866.286.2368
www.avocent.com

Circle no. 7

Designing a Display Into Your System?

Integrating a display into a product and designing a display subsystem can be challenging and time-consuming tasks for overburdened system and product designers.

Although the display is often the most important device/component in a product design, it is not like other components that system designers have been trained to work with. It is an electro-optical device, with parameters that are not part of the academic background of most electrical engineers. And understanding the demand placed on display parameters under a variety of environmental conditions is a specialty of its own. In addition, many displays incorporate touch input, which adds another layer of complexity.

But for every display application there is a unique set of specifications and parameters. Learning about them, and learning how to obtain additional information, while easing system designers through the integration process, will also allow them to select the best display technologies and the best specific displays for any application. ADEAC has been carefully designed to give you this information and this knowledge.

ADEAC Will Teach You About:

- Displays available to OEMs and product designers.
- Display-device manufacturers.
- Basic display background and characteristics of different displays.
- Procedures for selecting the best display device for any application.
- Display electronics and components available to OEMs and product designers.

ADEAC will consist of tutorials, seminars, keynote addresses, invited presentations, panel sessions, and interactive poster sessions focusing on display devices, display electronics, power supplies, backlights, system interconnects, system architectures, and system packaging. Display systems in consumer (cell phone, digital camera, palm pilot, TV, electronic billboard, etc.), industrial, and military applications will also be discussed. An exhibition will bring you face to face with suppliers of displays, electronics, interconnects, packaging, and test equipment.

Participating in ADEAC

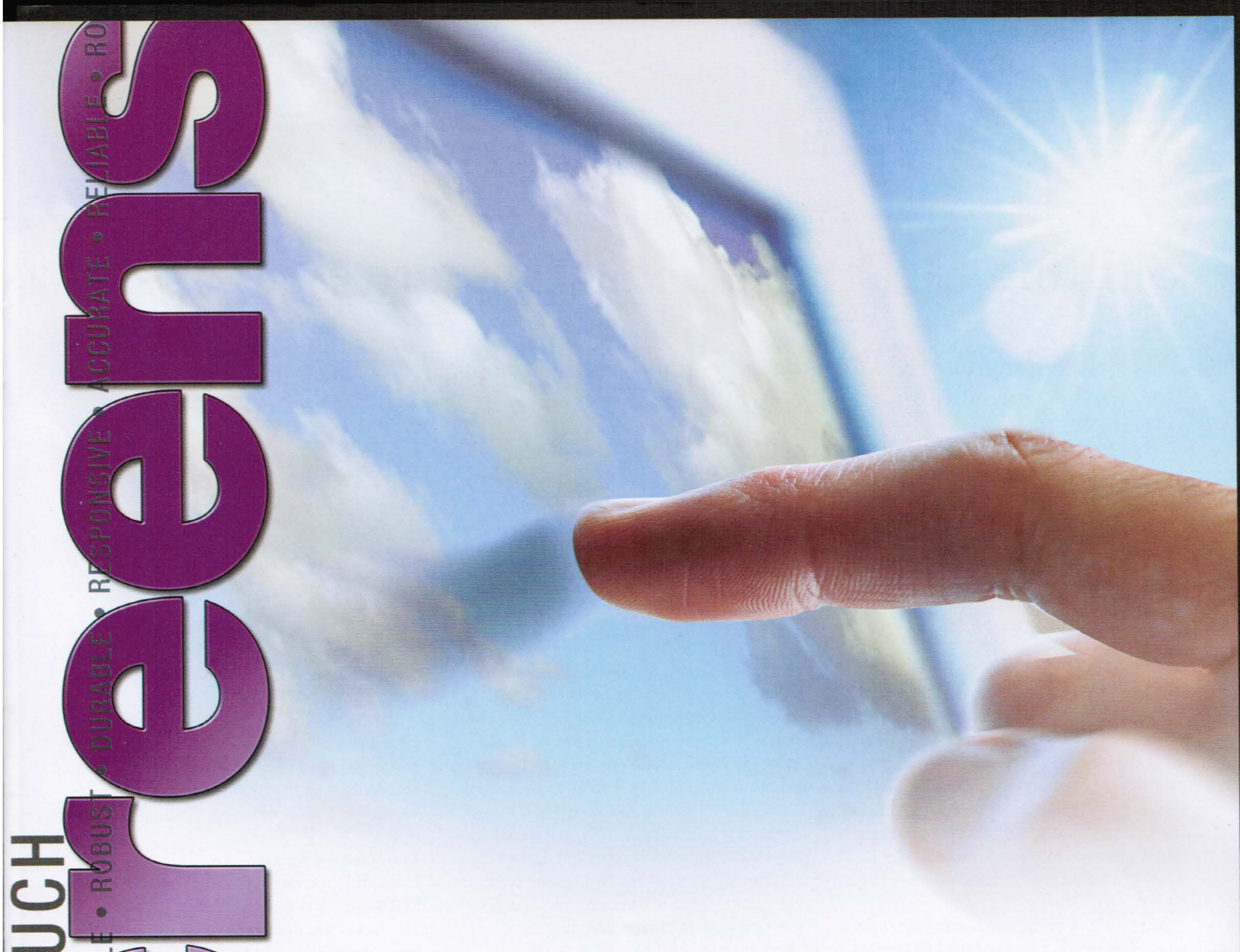
To submit a paper to ADEAC, see www.sid.org/conf/adeac04/call.pdf. To inquire about registering for the conference, call Mark Goldfarb, Palisades Convention Management, at 212/460-8090, ext. 202, or e-mail mgoldfarb@ pcm411.com. For information about exhibiting, call Kate Dickie at 212/460-8090, ext. 211, or e-mail kdickie@pcm411.com.

ADEAC is organized by the Americas Region of the Society for Information Display and Sponsored by SID.

SID
SOCIETY FOR INFORMATION DISPLAY

AMERICAS DISPLAY ENGINEERING & APPLICATIONS CONFERENCE

ADEAC 2004
October 25-27, 2004
Hotel Doral Tesoro and Golf Club
Fort Worth, Texas


TOUCH
screens
DURABLE • RESPONSIVE • ACCURATE • RELIABLE • ROBUST • DURABLE • RESPONSIVE • ACCURATE • RELIABLE • RO

Shifting LCD Panels into Overdrive

When designers realized that cell design alone could not make LCDs fast enough for video, "overdrive" response-time compensation brought LCD panels up to TV speed.

by Dick McCartney

ACTIVE-MATRIX liquid-crystal-displays (AMLCDs) are looking for new worlds to conquer. The notebook-PC market today flourishes in large part because AMLCDs provide a full-color flat screen that effectively puts a desktop monitor into a portable computer. After LCDs made notebooks possible, it was obvious that the next target would be to replace the bulky CRT desktop monitor with a lighter, thinner alternative.

This was not so easy to accomplish, however. The viewing angle of the LCD had to be expanded to accommodate the larger display areas. Larger LCD screens require that even a single viewer seated a comfortable viewing distance away from the screen be provided with a stable gray-scale viewing cone of more than 40° in order to see uniform color from one extreme corner to another. This problem has been addressed through the development of new enabling technologies.

Finally, LCDs have matured to the point that manufacturers can now turn their attention to the biggest display market of all: television. Many of us assume that LCDs will quickly dominate this market too. That could be easily accomplished, this line of thinking goes, by merely scaling existing LCD-monitor panels to wider (for 16:9 HDTV) and larger sizes. But more than size is required to succeed in the television market, and a number of the TV requirements exceed the state of the art of today's monitors. Brightness, contrast, color envelope, color temperature, and progressive scan and hold issues require a re-engineering of the monitor solution. Adding to the challenge is the extreme cost sensitivity of the TV market. Manufacturers are bringing new Generation 5, 6, and 7 factories on line expressly to address some of the key cost demands of TV.

However, beyond the engineering and business issues, the one fundamental deficiency of LCDs that must be overcome before they can be widely applied to TV is that they respond too slowly for TV video applications.

The Need for Speed

Users of LCDs might find it surprising that LCDs are too slow for video applications. The fact is that computer applications are very forgiving of slow pixel-response times. Applications such as PowerPoint, spreadsheets, text documents, and Internet graphics, which essentially consist of still images,

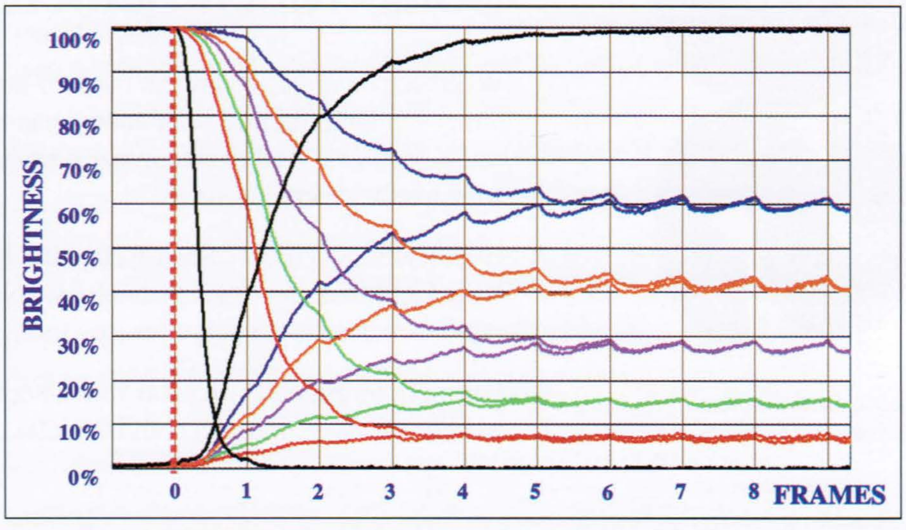


Fig. 1: *The typical uncompensated response of an LCD panel shows that rise and fall times are neither symmetrical nor fast.*

Dick McCartney *is Principal Display Technologist in the Displays Group at National Semiconductor, 2900 Semiconductor Dr., M/S A2-505, Santa Clara, CA 95051-0606; telephone 408/721-2682, fax 408/721-3696, e-mail: dick.mccartney@nsc.com. He is responsible for the strategic technology development of display products. A pioneer of response-time-compensation technology in the early 1990s for avionics applications, he led the effort at National Semiconductor to develop this technology for emerging LCD-TV applications.*

0362-0972/04/2001-012$1.00 + .00 © SID 2004

have image transition times of tens-of-microseconds. The fastest moving object in a typical computer application is the mouse cursor or a sliding image, which is also typically mouse-driven.

Even DVD movies are forgiving of slow response time. DVD movies are filmed at 24 frames per second (fps), which is about 42 msec/frame. Because the shutter is open much of that time, it is easy to understand that much of the faster moving imagery is recorded as smeared or blurred from the start.

Broadcast TV is another story. Each frame – or half-frame in the case of interlacing – is captured in less than 1/60th or 1/50th of a second. The original moving component of the image is captured in sharper detail, and, in addition, must be rendered on the display screen at faster rates than movie frames. Response time is much more of an issue for television than for most other video sources, and it is particularly important for high-definition TV (HDTV).

Why Optical Response Lags the Voltage Command

The light transmission through a liquid-crystal pixel is controlled directly and immediately by the orientation of the liquid-crystal molecules to the propagating light wave. But it takes time to move the molecules from one position to another, and this transition time is the response time that is characteristic of an LCD. The transition time between any two gray levels in an LCD depends on the strength of two factors: (1) the forcing torque and (2) the resistance to movement arising from properties such as flow dynamics, cell thickness, and viscosity.

In addition to these mechanical resistances, the dynamic capacitance of the liquid-crystal cell – isolated by the thin-film transistor (TFT) – has the effect of creating an opposing voltage to the one applied, which slows the response even further. Both the forcing torque and the various resistance mechanisms vary throughout the entire range of gray levels, which makes the transition time dependent on both the present gray-level state and the voltage commanding the new gray level.

The forcing torque on the LC molecule, *i.e.*, the torque that makes it move, is the momentary imbalance of two competing torques – the restoring torque that tries to pull the molecule back to its resting position and the exciting torque that is induced by the command voltage and tries to align the molecule in its electric field. This field-induced torque varies with the square of the applied voltage, but the restoring torque is not field-dependent.

When the applied torque in the present frame is higher, the response time varies inversely with the square of the applied voltage, slowed only by the predominately non-linear factors related to the resistance mechanisms. When the applied torque in the present frame is lower than it was in the previous frame, the molecules relax under the continuous pull toward their resting position and the response time varies inversely (roughly) with the applied voltage. Therefore, it should not be surprising that the unaided transition rise and fall times typical of an LCD monitor are not symmetrical (Fig. 1). In some instances, the response lag following the voltage command can last for more than a frame time. It is impossible to force black-to-white or white-to-black transitions faster than these intrinsic results, but it is possible to bound all the transitions to within these times. Virtually all of them can occur within one frame time.

Since there are two mechanisms at work, there must be two compensation strategies to accelerate the transitions. For this reason, the more generic term "response-time compensation" (RTC) – rather than "overdrive method" – is preferred because it represents the techniques more accurately. Depending on the direction of the transition, the purpose of the applied compensation is to either overdrive or underdrive the display. The mechanism to implement these strategies, however, is the same in both directions of compensation.

Theory of Response-Time Compensation

The basic theory of operation is the same for all the recently announced "overdrive" or dynamic capacitance compensation (DCC) methods (Fig. 2). The RTC block intercepts the digital video stream and compares the previous gray-level command to each pixel with the current gray-level command. It then chooses a predetermined alternative gray level from a look-up table (LUT). Because every combination of previous and current commands is accounted for in the LUT, both directions of compensation (both over- and under-boost) are provided.

When the LUT determines that the previous and current gray levels are different, it outputs the predetermined compensation value experimentally chosen to just bring the luminance to the target value at the end of one frame. If the new gray level is lighter, an initially still-lighter gray-level command is sent (Fig. 3). If the new gray level is darker, an initially still-darker gray-level command is sent (Fig. 4).

Different RTC Approaches

The RTC method illustrated above is not new. Since about 1992, it has been used to improve the image quality of fast-moving graphical symbols on LCD-based flight instruments. But the specific implementation and associated compromises do vary among the different approaches. The two key ways in which the data can be more effectively managed in the implementation of RTC as shown in Fig. 2 are reduction in the size of the FIFO data storage and retrieval and reduction in the size of the LUT.

The FIFO can be quite large. Storing a 24-bit gray-scale value (8 bits for red, 8 for green, and 8 for blue) for every pixel in a wide-XGA+ panel (1366 × 768 pixels), for example, requires approximately a 24-Mbit

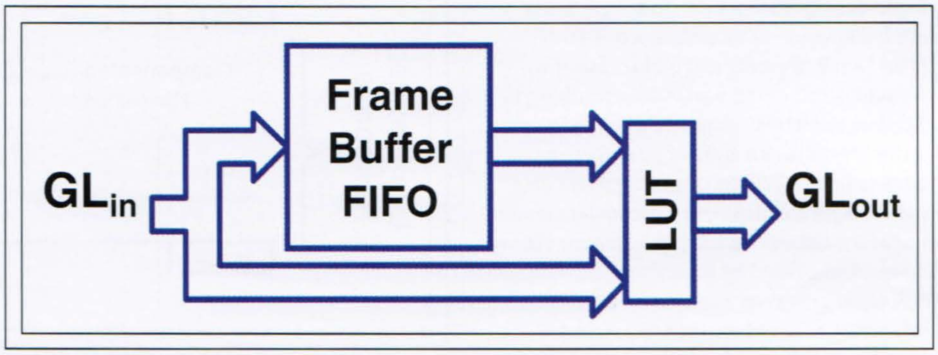


Fig. 2: This diagram of the RTC-block mechanism shows how the compensating commands for each pixel are determined using a look-up table (LUT).

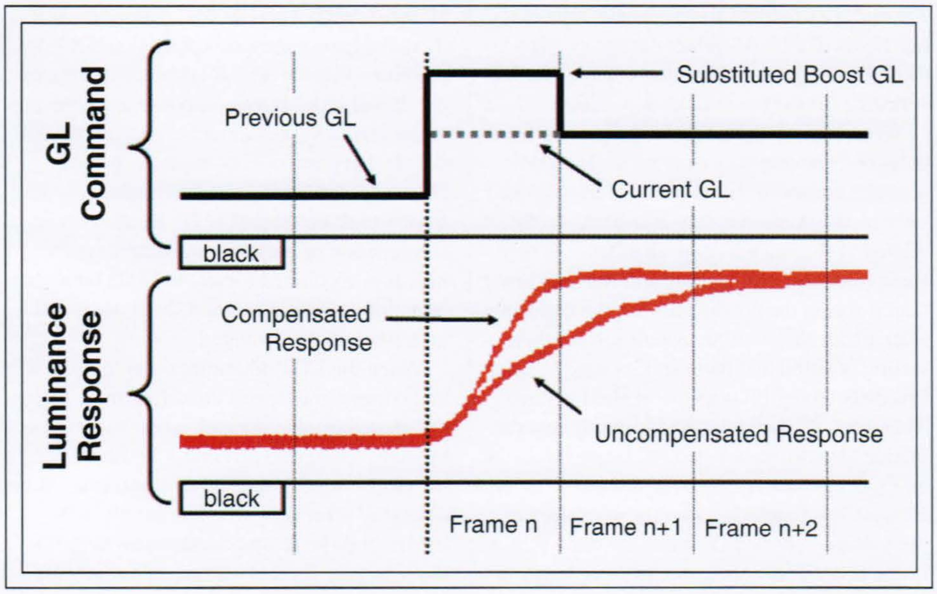


Fig. 3: *If the new gray level is lighter, a still-lighter gray-level command is applied to overdrive the display.*

RAM. Furthermore, in order to operate the RAM as a FIFO for each arriving pixel command to the panel, a 24-bit value must both be written and read from the memory. This often necessitates the use of two separate memory chips to support the required data-transfer rates. One approach to minimizing the data flowing between the RTC controller hosted in the timing controller (TCON) and the SDRAM is to compress the data before storage and decompress it upon retrieval. Compression ratios of 3:1 have been reported. Naturally, there is a die-area penalty to operate the compression algorithm.

Another approach, one that we have taken at National Semiconductor, is to reduce the data being transferred through truncation of the lower significant bits. In the common implementation of this approach, a 16-bit pixel [5 red, 6 green, and 5 blue (565)] is stored instead of the full 24 bits, resulting in a 3:2 data reduction. While others tried this unsuccessfully, we and our customers have demonstrated flawless operation when data reduction is coupled with a particular smoothing of the data in the LUT to eliminate the boundaries caused by truncation.

The other way to manage the data more efficiently is to reduce the size of the LUT. Ideally, there would be a LUT entry for each combination of previous and current gray levels, but this would require a large LUT of $256 \times 256 \times 8$ bits for each color. However, bi-linear interpolation between major data points allows a significant reduction in the size of this LUT. The contents of this table can make all the difference in the quality of the result, and it is especially important to avoid overcompensation. Undercompensation merely results in smeared images, but overcompensation enhances edge boundaries and exaggerates noise in the original image, often resulting in a far worse image than if no compensation had been applied.

System Design

Functionally, the RTC block can reside anywhere in the digital video stream. However, because the output of the RTC block is tied directly to a specific non-linear panel characteristic and specific column-driver voltages, placing the RTC block upstream of any image-processing block is problematic. The over- or under-boost values that exit the RTC block are coded in gray scale but actually represent voltages. These voltages are the values predetermined to provide just the right boost for a target gray-level command. Any manipulation of these values following the RTC block would produce erroneous response-time transitions. Likewise, any scaling of voltages in the column driver following the determination of the LUT contents would be flawed.

As a result, the most common location of the RTC block in the system is at the last stage of the TCON (Fig. 5). This keeps the RTC block safe from downstream image-processing manipulation and also keeps the display panel and the LUT that characterizes it in the same module, which is extremely important from a supply-chain perspective. In other words, each display module can be

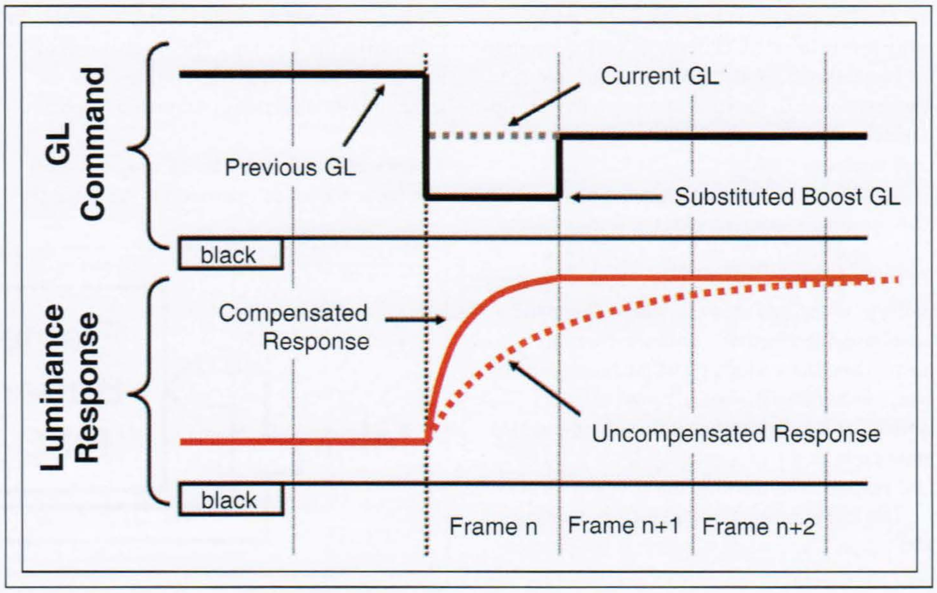


Fig. 4: *If the new gray level is darker, a still-darker gray-level command is applied to underdrive the display.*

designed to be interchangeable with another because all of the specific data particular to that module's response-time characteristics are embedded in the module.

On the other hand, the RTC function requires a frame buffer. This is an expensive component that is redundant with the frame buffer typically used upstream in the video-processing unit. One possible alternative to placing the RTC function in the TCON is to integrate it into the video processor in designs provided by vertically integrated suppliers. This system solution allows specific video-processor functions to be tied directly to particular panel designs.

How Well Does RTC Work?

Success in forcing the LCD to reach the target brightness value in one frame depends on a few factors. First, the RTC method cannot accelerate the relaxation time, which is governed by factors intrinsic to the panel design and cannot be controlled by the applied voltage. Second, the column-driver voltage limits the RTC method – higher voltage causes faster response time. Other limiting factors are the frame time and temperature. The RTC-boost values are predetermined based on a particular frame interval and also on a particular temperature. A LUT of values preselected for 60 Hz will not be optimal for 50- or 75-Hz operation. And higher temperature results in faster transitions. Thus, tables calibrated at one temperature are not good for another. Furthermore, transitions in one frame – even when that frame is 16.7 msec – can still be a compromise from a human-vision perspective. Transition times on the order of half this time – 10 msec, for example – are more ideal. But with this said, the improvement provided by RTC is clear and dramatic to anyone who has the opportunity to see images with and without it.

The Future of RTC

The primary disadvantages of the RTC overdrive method are the cost of the external SDRAM(s), together with the additional power consumption, electromagnetic interference, and printed-circuit-board area resulting from the high-frequency data path into and out of the SDRAM(s). There is a great deal of interest in eliminating the SDRAM component in some fashion. One approach being experimented with is to stack the TCON and SDRAM dice together inside the same package, thus eliminating the external data path. While this will reduce the EMI, power, and board area, its impact on cost is likely to go in the wrong direction.

Another approach is to fully integrate the SDRAM into the TCON monolithically using a small-geometry processes coupled with data compression. This, too, has merit, but migration to small-geometry IC processes also has cost penalties in addition to placing constraints on interface voltages foreign to the display application.

Another trend is to increase the column-driver voltages to provide faster response times. Since temperature and frame rate affect RTC quality as well, accommodating these parameters with better fidelity are goals for the future.

Today, the state-of-the-art resolution for LCD TV is 1366 × 768 pixels. But as the industry moves to full 1920 × 1080 HDTV resolution, there will be additional pressure to economize on the RTC circuitry. So the final form of RTC is far from clear, but it is clear that RTC is the key enabling technology for helping LCD monitors make the transition into the consumer-television market. Equipped with RTC, LCD TVs have the required sharp, bold, moving images needed to stand head-to-head and toe-to-toe with the entrenched alternatives on the TV-showroom floor. ■

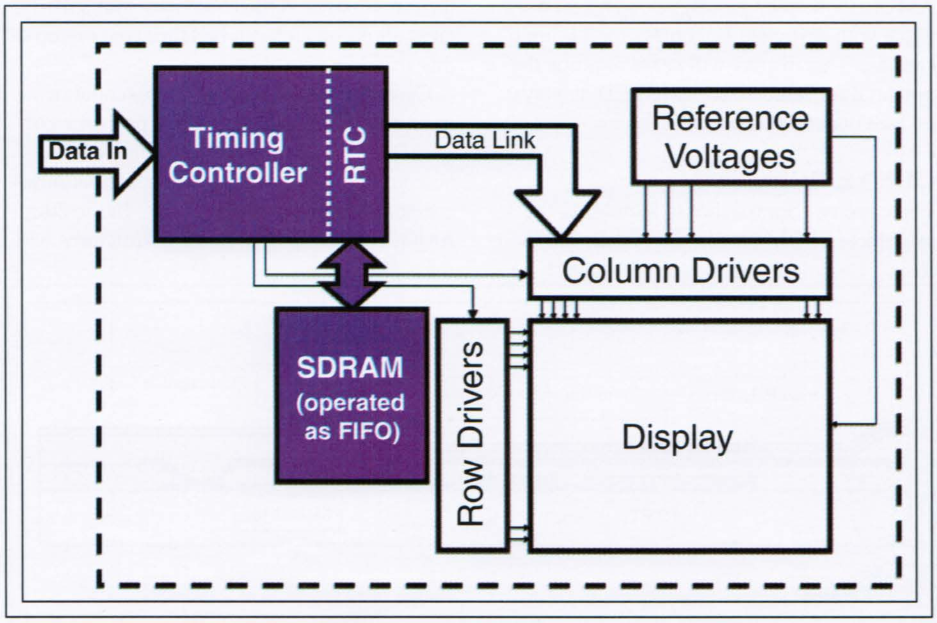


***Fig. 5:** The block diagram of a display module shows how the RTC can be linked closely to the panel for which it was designed.*

Driving AMOLEDs with Amorphous-Silicon Backplanes

It had been believed that current-hungry OLEDs required expensive polysilicon TFTs, but now it seems that amorphous-silicon TFTs can do the job – and that means inexpensive AMOLEDs for TV sets are possible.

by Koichi Miwa and Atsushi Tanaka

ORGANIC light-emitting diodes (OLEDs) are gathering interest as an up-and-coming display technology. The self-luminous wide-viewing-angle devices can be used to make flat-panel displays that are thinner than LCDs. Their fast response enables motion-picture quality equivalent to that of a CRT. The simple structure and the high efficiency of OLEDs look promising for low-cost and low-power displays.

For a variety of reasons, active-matrix addressing is preferred for large high-resolution displays. Polycrystalline silicon (poly-Si), or discrete crystalline silicon, was considered mandatory for active-matrix OLEDs (AMOLEDs) because it was believed that the high mobility of poly-Si is needed to manage the high driving current that OLEDs require. But poly-Si is a costly technology that limits panel sizes and brings other difficulties. This could be fatal for TV applications that must be cost-competitive with CRTs. If amorphous-silicon (a-Si) backplanes could be used for AMOLEDs, they would have a great advantage over poly-Si backplanes in terms of size, yield, and cost.

The low mobility and instability of a-Si thin-film transistors (TFTs) have been bottlenecks for OLED applications. The mobility is two orders of magnitude lower than that of poly-Si TFTs, and the threshold voltage (V_{th}) tends to shift during operation, leading to differential aging from pixel to pixel. At IDTech, we have fabricated a 20-in. AMOLED-display prototype on an a-Si backplane with sufficient brightness for TV applications. This display will serve to probe the potential for large-sized AMOLED displays on a-Si backplanes.

OLED Efficiencies

There are two approaches to increasing the brightness of OLEDs: improve their luminous current efficiency and increase the supply current from the driving TFTs. Both approaches must be pursued to satisfy the brightness requirements of TV applications.

Since the bottom-emission OLED structure limits flexibility in designing pixel circuits, the top-emission structure has been adopted for OLEDs driven by a-Si TFTs. The top-emission structure consists of an organic layer on a planarization layer, both of which cover the circuit layer. OLED devices with sufficient emission area can be fabricated on top of this structure (Fig. 1).

Careful material selection is essential in tuning the electrical and optical properties of OLED devices, but the cavity effect on the outcoupling efficiencies also has a great influence on the optical performance. In the 20-in. AMOLED displays, the OLED structures with

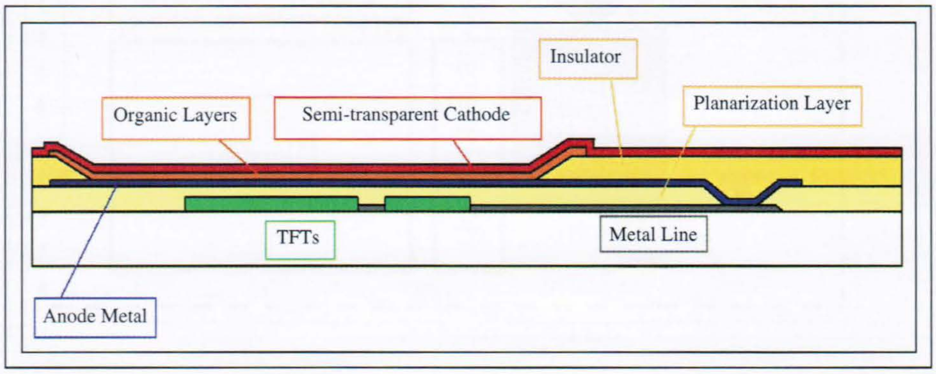
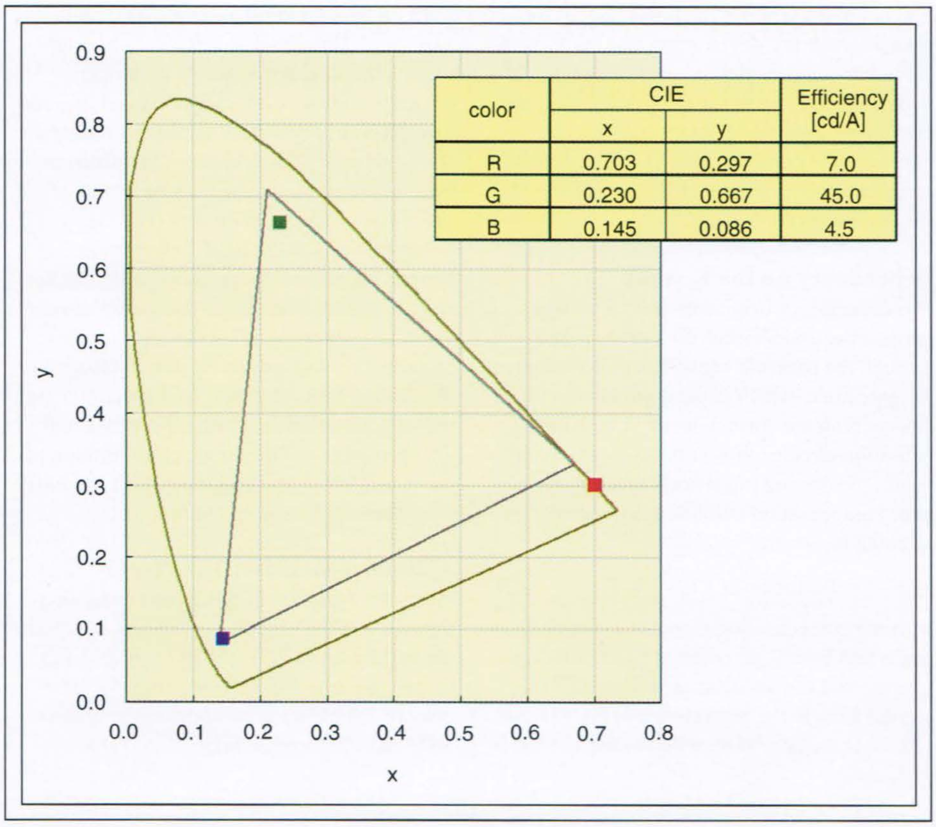


Fig. 1: The configuration shown is typical of a top-emission OLED structure.

***Koichi Miwa** is an engineer at International Display Technology's FPD Technology Development Research Center, 1623-14 Shimotsuruma, Yamato, Kanagawa 242-8502, Japan; telephone +81-46-215-2424, fax +81-46-277-0382, e-mail: koichi@idtech.co.jp.* ***Atsushi Tanaka** is an engineer at the FPD Technology Development Research Center; e-mail: atanaka@idtech.co.jp.*

0362-0972/04/2001-016$1.00 + .00 © SID 2004



color	CIE x	CIE y	Efficiency [cd/A]
R	0.703	0.297	7.0
G	0.230	0.667	45.0
B	0.145	0.086	4.5

Fig. 2: *Color coordinates and luminous current efficiency of typical RGB OLED emitters.*

suitable material sets are optimized to give the best efficiencies and color purity. This was achieved from calculations based on the classical radiative dipole model and experiments using the combinatorial device fabrications developed in the IBM Zurich and Tokyo Research Laboratories. The performance data for R, G, and B test devices is promising (Fig. 2). The current efficiency of white light (T = 7000 K) is now 13.3 cd/A, and the color gamut covers 97% of the NTSC specification.

The relatively high current that is necessary to achieve adequate brightness in OLEDs requires a large driving transistor. To compensate for the instability of a-Si, extra circuitry must be built into each pixel. One result of these requirements is that the a-Si pixel circuitry in AMOLEDs usually becomes dense.

The top-emission structure and low-resistivity metal lines secure sufficient space for the transistors. The two-story configuration of the top-emission structure leaves all of the lower level for circuitry, but the broad power line necessary to prevent substantial voltage drop along the line situated on the lower level is another consumer of space. The power lines must be of low resistance because a voltage drop produces brightness degradation towards the center of the display. Developing low-resistivity materials is an effective way to obtain a low-resistance line occupying minimum space. Applying the anode metal layer to the bottom of the upper level as a part of the power line is another way to minimize the voltage drop.

These efforts secure the space for a multiple-transistor circuit that includes a large driving transistor. However, they are still not sufficient to obtain the design flexibility required to handle the instability.

a-Si TFT Modifications

The drain current of a TFT is given by

$$I = (\mu CW/2L)(V_g - V_{th})^2, \qquad (1)$$

where μ, C, W, and L are the channel mobility, the channel capacitance, the channel width, and the length of the transistor, respectively. V_g and V_{th} are the gate voltage and the threshold voltage, respectively. Equation (1) indicates that a higher mobility and a higher gate voltage increase the supply current.

Conventional a-Si TFTs have a mobility of about 0.5 cm^2/V-sec and an on-to-off ratio of

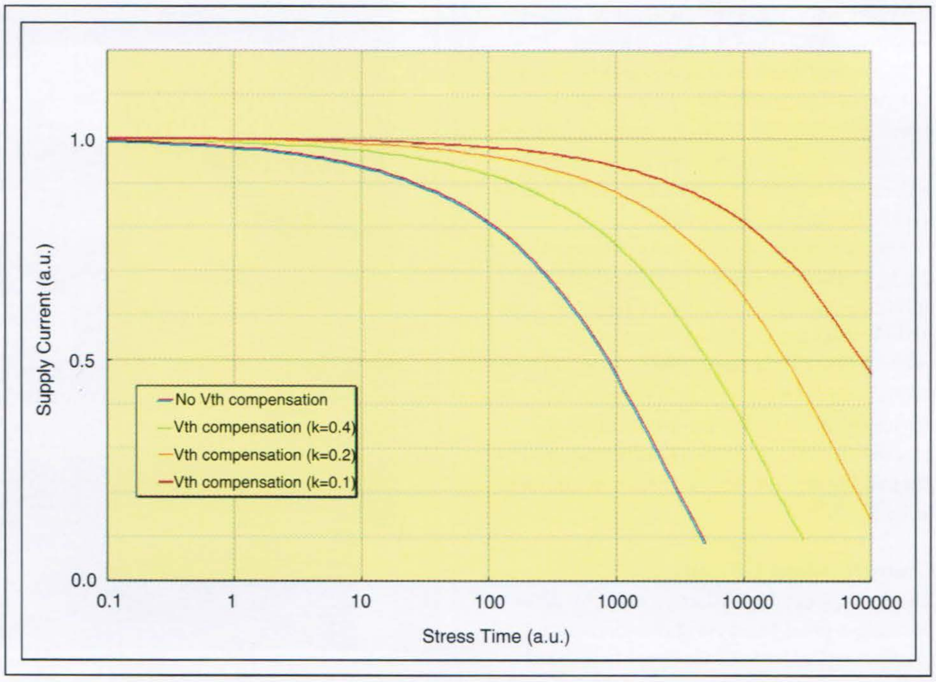


Fig. 3: *Supply-current decay of a-Si pixels with and without V_{th} compensation.*

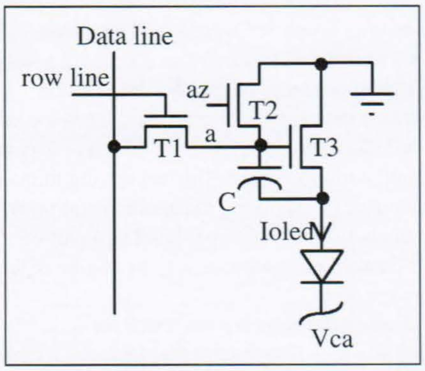


***Fig. 4:** IBM's V_{th}-shift compensating voltage-follower pixel circuit.*

about 10^6, which are sufficient for switching devices in LCDs. OLED displays require a higher mobility while maintaining the low leakage current. The scattering of carriers caused by sites in the a-Si network at the channel near the gate-insulator interface limits the mobility. Improving the a-Si film quality by optimizing the deposition conditions and minimizing the defects at the interface of the a-Si and the gate insulator will maximize the channel conductance. Our a-Si TFT test-element groups (TEGs) have exhibited a mobility up to 1.15 cm^2/V-sec, twice that of conventional ones, which will allow further improvement in the OLED brightness.

The major cause of a-Si instability is a shift in V_{th} that is proportional to the stress the device has suffered. The V_{th} shift is a consequence of the charge trapped at the interface. The rate of the shift is significant for predicting the lifetime of the device.

The two processes primarily responsible for the V_{th} shift are charge trapping and site creation. Reducing the number of trapping sites will obstruct the capturing process. Because heat accelerates these processes, keeping the display temperature low also reduces the device instability. We have optimized the process conditions, device configuration, driving conditions, and heat management to minimize V_{th} shifts.

Compensation Circuits

The V_{th} shift can be further reduced by incorporating a pixel-level compensation circuit. Compensation circuits are roughly divided into two groups: V_{th}-shift-compensation circuits and current-programming circuits. The latter are superior in compensating for both the mobility degradation and the V_{th} shift. But when we consider the overall benefits of a compensation circuit for a-Si backplanes, the current-programming circuit has little advantage over the other, for neither of the circuits can completely eliminate the dependency of the current on the V_{th} shift.

Dependency on the V_{th} Shift

The dependency originates from a voltage ramp at the drain/source node transmitted through the parasitic capacitance connected to the gate node, which is the dominant factor in determining the current decay in both compensation circuits on a-Si backplanes. As a result, the driving transistor's drain current after compensation still has a dependency on V_{th} equal to

$$I = (\mu CW/2L)(V_g - kV_{th})^2, \qquad (2)$$

with the compensation modulus k, which is much less than 1, determined by the driving scheme and the parasitic capacitances. The second term in the parentheses in Eq. (2) indicates that the degradation due to the V_{th} shift is reduced by a factor of k, but never completely vanishes. The parasitic capacitances determining the modulus k should be properly designed to realize an adequate pixel lifetime. The pixel supply current depends strongly on the modulus k. The lifetime – measured to half-initial-current – can vary by orders of magnitude with the value of k (Fig. 3).

Researchers at the IBM T. J. Watson Research Center have proposed a simple V_{th}-shift-compensation circuit consisting of only three TFTs (Fig. 4). This circuitry implies that the data voltage can be directly loaded to the driving-transistor gate, and it permits the use of column drivers with relatively small swing voltages. The simple configuration of the circuit provides design flexibility to fulfill brightness and stability requirements.

A 20-in. a-Si AMOLED Display

When the optimized OLEDs and compensation circuits are properly combined, it is possible to fabricate a 20-in. WXGA AMOLED display on an a-Si backplane (Fig. 5). The display achieves a good short-range uniformity and a high peak luminance (Table 1),

IDTech

***Fig. 5:** IDTech's 20-in. OLED display driven with super-amorphous-silicon TFTs.*

Table 1: Specifications of a 20-in. AMOLED display

Size	20.0 in. diagonal
Resolution	WXGA/HDTV compatible
Peak luminance	>500 cd/m^2
Numbers of colors	16 million
TFT design	Super-amorphous-Si TFT compensation circuit
OLED design	Top-emission structure
Color gamut	<105% of NTSC triangle
Response time	<1 msec
Contrast ratio	>1000:1

and has demonstrated the potential for OLED TVs based on the modified a-Si technology.

Since the V_{th} shift reflects the amount of stress the pixel has experienced, it could be applied to compensate for the differential aging of OLEDs themselves. With these developments now in place, large-sized low-cost high-quality OLED displays should be commercially available in the near future. ■

23 **04**

MAY

SID '04

SEATTLE, WASHINGTON
MAY 23–28, 2004

- SID's MAJOR ANNUAL EVENT
- An International Symposium, Seminar, and Exhibition – Featuring:
  - Technical Sessions – Poster Sessions
  - Author Interviews
  - Short Courses – Applications Tutorials
  - Technical Seminars – Applications Sessions – Business Conference
  - Product Exhibits – Vendor Theater

14 **04**

FEBRUARY

The 8th Asian Symposium on Information Display (ASID '04)

NANJING, JIANGSU, CHINA
RE-SCHEDULED
FEBRUARY 14–17, 2004

- One of the major regional information-display conferences, originated from the joint Japan-Korea information-display conference.
- Covering all aspects of display science and technology.
- Sponsored by the SID Asia Region

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

For Industry News, New Products, Forthcoming Articles, and Continually Updated Conference Calendar, see ***www.sid.org***

The Card That Drives the Display

Modern graphics cards can draw complex, rapidly changing images in real time with cinematic quality, even on multidisplays.

by Tony Tamasi

As IS TRUE of any product, customer expectations drive graphics processing units (GPUs), which, as far as end users are concerned, are used to create the images they see on their computer displays. Thanks to the influx of video games, computers, and computer-generated-imagery (CGI) movies, users have demanded progressively higher performance of computer graphics over the years.

Members of previous generations hear "computer graphics" and might think of *Pac Man* and *Donkey Kong*. But my children have a much different perception of computer graphics. They were raised on *Toy Story*, *Veggie Tales*, and *Shrek*. They do not even blink when they see a stunning CGI movie such as *Finding Nemo*. All the hardware my generation needed to play *Pac Man* on a 6-ft.-tall arcade game or the *Mario Brothers* on a stand-alone console and a television set are now packed into a hand-held gaming system that fits in the palm of its owner's hand. The bar that GPU manufacturers must vault over to impress the end user has been raised significantly!

The movie industry acts as a sort of R&D house for GPU manufacturers, constantly showing them the next level they must strive to achieve. To appreciate real-time graphics, it is important to understand the fundamental differences between CGI movies and the real-time graphics displayed on a desktop PC. A CGI movie is created by a roomful of servers, and each frame may take an entire day to render, or compute. Then the frames are spliced together like a conventional movie. To achieve true cinematic computing, rendered in real time on a desktop PC, the same effects and image quality must be rendered in 1/60 sec.

So what is required to achieve real-time cinematic computing, and what other features are important in a state-of-the-art graphics adapter?

DirectX 9 Shader Support

The latest generation of GPUs has ushered in a new age of cinematic visual effects by using vertex and pixel shaders. The power and precision of these new GPUs bring users to the dawn of real-time cinematic graphics. These dramatic advances shift the focus from simple transformed geometry and textured-pixel fill rate to sophisticated vertex and pixel shading.

The building blocks of any real-time computer-generated imagery, like a game, are polygons and pixels. For example, the 3-D objects that are visible in a scene of a game are commonly composed of hundreds or thousands of polygons, usually triangles. These triangles are all stitched together to create objects, characters, and an immersive world. The critical elements of any triangle are its three vertices. The vertex is thus one of the most fundamental building blocks of a real-time computer-graphics scene.

Traditionally, vertex processing in graphics involved moving the vertices – and hence the geometry – from the coordinate system of the game engine to that of the graphics processor, and then moving that geometry around and performing some basic lighting functions.

The latest generation of graphics processing offers a nearly limitless combination of processing capabilities to game developers. Previously, the game developers were limited to very basic operations; now, they can create custom programs, called vertex shaders, which allow them to manipulate and light the geometry and animation of their worlds in any way they see fit. These programs are, in essence, special effects for geometry.

Once the geometry has been transferred to the graphics processor, and animated and lit according to the game developer's wishes through the power of these vertex shaders, it needs to be rendered as pixels for display.

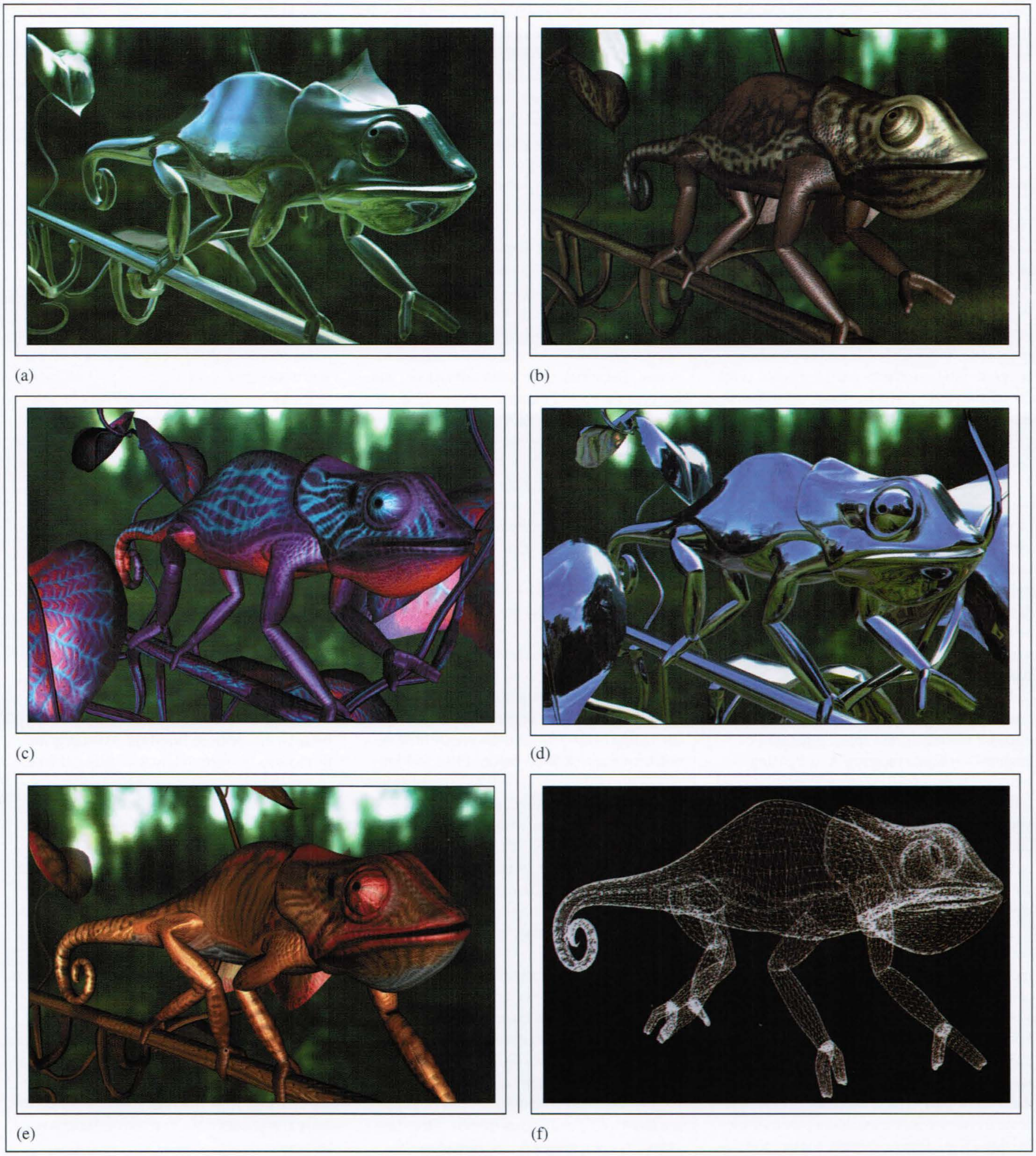
The final output of any 3-D graphics hardware consists of pixels. Depending on resolution, in excess of 2 million pixels and 10 million samples may need to be textured, rendered, lit, shaded, and colored.

In the past, graphics processors basically looked up a value for a pixel by obtaining it from a texture map. Texture maps are essentially pictures, as might be created in Adobe Photoshop, but then "mapped" to a polygon, similar to "mapping" a decal onto a model car. Artists typically paint or photograph these textures to create the appearance they want.

While texture mapping can have surprisingly good results, it cannot capture all the properties of light and shadow, the micro-faceted structure of materials, the interaction of a material with light or other materials, the "texture" of a surface, and other such attributes. This gave rise to the notoriously

Tony Tamasi is Vice President of Technical Marketing at nVIDIA, 2701 San Tomas Expressway, Santa Clara, CA 95050; telephone 408/486-2000, fax 408/486-4639, e-mail: ttamasi@nvidia.com.

0362-0972/04/2001-020$1.00 + .00 © SID 2004



*n*VIDIA

Fig. 1: *Using pixel shaders, a developer can apply a variety of stunning skin effects (a)–(e) to this chameleon's wire-frame model (f).*

"too clean" look of computer graphics, where things just looked too sharp and too pristine, and thus lacked the realism and "immersiveness" that developers were striving for.

The latest generation of Microsoft's DirectX 9 (DX9) graphics processors offers the developer the ability to write custom programs to describe those kinds of effects, and more, through what is known as pixel shading. Pixel shaders create lighting and other custom shading effects at the pixel level by giving the developer the ability to write small programs that mathematically describe the desired effects. Before DX9, developers were limited to very simple pixel effects, most often related to subtle advances in texture mapping. Previous GPUs and application programming interfaces (APIs) offered pixel processing that is best be described as configurable rather than programmable.

By giving developers the ability to write programs to algorithmically define how a pixel should look, the new graphics processors have freed them from the previous limits of texture mapping. For example, while it is possible to paint a very detailed texture of a brick, down to the pixel level, it is not practical to paint that level of detail for the entire game world. Therefore, textures are repeated, or tiled, which has tended to make interactive games less rich and dynamic than the real world.

Due to the advance in pixel shaders, the developer can take those basic textures developed by the artists and apply algorithmic changes to them, changing their lighting, bumpiness, and "dirtiness" in a complete and interactive way. This allows the developer to avoid that repetitious and overly "clean" look and more accurately reflect the vision of the content creators. In essence, these developers are writing special-effects code to push the boundaries of the imagery they create.

The extensive programmability of DX9 vertex and pixel shaders has already been incorporated into the leading digital-content-creation (DCC) tools, including Alias® Wavefront Maya, Discreet 3ds max, and Softimage® XSI. These applications provide artists, for the first time, with the tools necessary to interactively modify the appearance of the models they create, and they provide game programmers with the building blocks they need to create programmable vertex- and pixel-shader programs for translating those artistic visions into real-time imagery (Fig. 1). DX9 pixel-shader programs and the GPUs that support them break down the barriers between an artistic vision and a final product that can be shipped to and enjoyed by end users. If the displayed effect does not match the original vision, the developer or artist has the creative control to tune it and tweak it until it does. Developers are empowered to express their artistic vision, and end users will enjoy unprecedented visual experiences.

Getting the Right Answer

To create more-sophisticated special effects, a high degree of precision operations becomes critical. Historically, graphics processors have performed their computations at 8-bit-integer precision per component, or 32-bit color. Therefore, each color component can have, at most, 256 discrete values. This narrow range leads to a variety of artifacts which can include clamping and banding.

Video-adapter makers can offer developers the ability to create highly complex effects without the artifacts that arise from insufficient precision by combining several elements. GPUs that support the same level of precision that the film industry uses for CGI movies such as *Finding Nemo* and *The Hulk* are combined with the programmability facilitated by the new GPU architectures, both of which utilize APIs such as DX9.

Inherent 16- and 32-bit floating-point formats (FP16 and FP32) give developers the flexibility to create very-high-quality graphics. FP32 offers the ultimate image quality, delivering true 128-bit color. FP16 (64-bit color) provides an excellent balance of image quality and performance, not just for games but for film effects as well. In fact, the *n*VIDIA GeForce FX GPU natively implements the OpenEXR format for 64-bit color, the same format used by Industrial Light and Magic and other special-effects studios specializing in film-quality visual effects.

Image-Quality Features

Two features that are critical to improving image quality are multisample anti-aliasing and high-quality texture filtering. A primary visual-quality issue for PC users is on-screen aliasing, the "stair-step" effect that can be highly visible when diagonal lines or edges are shown on computer displays. This stair-step effect is commonly referred to as the "jaggies" because it makes a smooth line appear jagged. These jaggies can be extremely distracting to end users, detracting from their overall immersive experience.

Even when the edges of a still image look acceptable, visual artifacts can become more readily apparent in moving images because of temporal quantization errors. The diagonal edge of an object as it moves from one frame to the next can be greatly distorted. The eye is quick to notice these changes, which are especially distracting when segments of thin lines pop in and out of view from one frame to the next.

One solution to these problems is anti-aliasing (Fig. 2). The most common approach is to render additional samples. In essence, this creates more "steps" along edges, and the reduced size of these steps makes the artifact less noticeable.

There are a variety of techniques for performing anti-aliasing. The usual approach calls for rendering the scene at a much higher resolution than is ultimately intended for display, and then "sampling" it down. This approach can produce good results, but it is relatively inefficient.

Multisample anti-aliasing is a more sophisticated method. Multisampling produces results similar to those of supersampling, but instead of forcing the entire graphics processor to compute everything at higher resolution, multisampling GPUs have special-purpose hardware that computes the additional samples.

Another key GPU feature is support for high-quality texture filtering. Most graphics processors perform bilinear texture filtering, in which the texture maps are sampled in a 2×2-pixel region. Those four samples are then filtered to produce the final result. The purpose of texture filtering is to produce a smoother and less-aliased image, but bilinear texture filtering creates an artifact. As the technique is applied and different textures are accessed, it can generate edges between the 2×2 samples (or quads) of pixels. These edges often appear as annoying lines or bands of texture on the screen, and can often be seen in roads and walls in many games.

One way of dealing with this artifact is for a graphics processor to perform trilinear filtering. In this technique, an additional processing step performs filtering between the differently filtered textures to remove the annoying line or band.

Anisotropic filtering is an additional texture-filtering technique that improves image quality in scenes with objects that extend from the foreground to deeply into the background. The technique lets the developer choose the scale between a texture map and the "primitive," or polygon, onto which it is projected. Anisotropic filtering can be used in conjunction with bilinear- or trilinear-filtering schemes. The result is a high-quality image. By offering a variety of multisampling anti-aliasing modes and support for high-quality texture filtering, next-generation GPUs deliver unprecedented visual quality and performance.

Support for Multidisplays

PCs supporting multiple displays are rapidly becoming commonplace in all markets as users recognize the benefits of multidisplays. The versatility and increased productivity provided by multidisplays can benefit anyone, including multimedia users, marketing executives, game developers, and business professionals.

Multidisplay technology is more than just a second display connector; it must integrate key features in both software and hardware. Multidisplay software must provide end users with an easy multidisplay setup, robust multi-desktop management, and full window and application management, along with added features such as grid lines, zoom, transparent window effects, mouse kinematics, and multiple-user profiles to maximize productivity.

Unified Software Environment

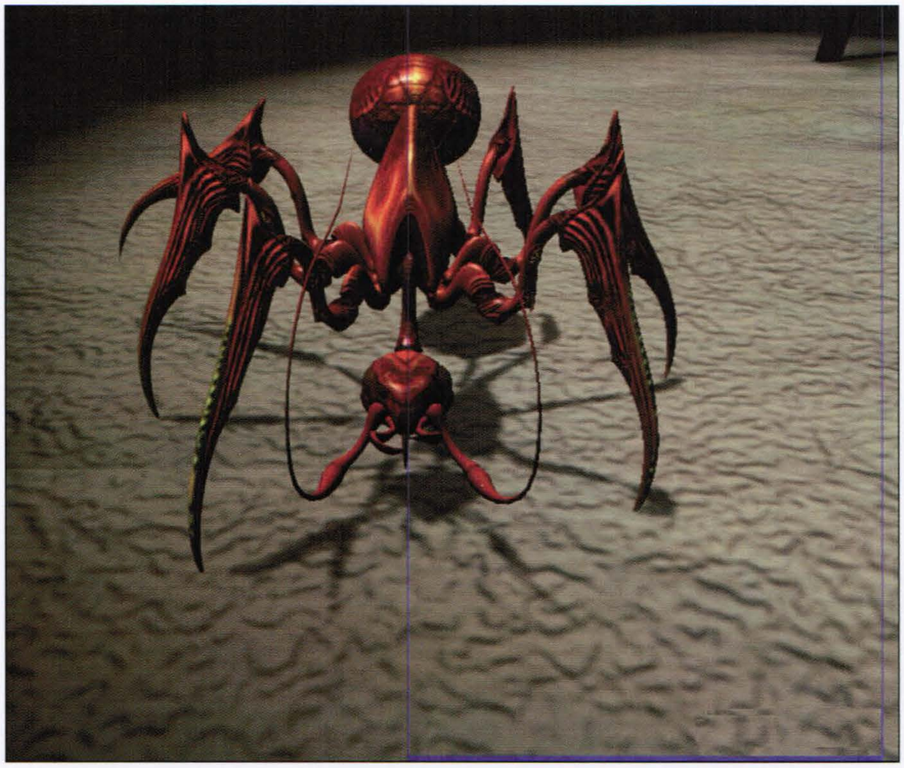
A unified-software-environment (USE) driver delivers forward-and-backward compatibility across all implementations of a company's desktop, workstation, mobile platform, and multimedia processors. A single USE driver delivers ongoing performance and feature improvements, reduced maintenance time, increased scalability, and a lower total cost of ownership, and only one driver has to be managed, configured, and installed. Because companies can continue to add more functionality and performance to the USE driver, older processors can be endowed with more features and can run faster at no additional cost. It reduces hardware/driver conflicts because every driver is thoroughly tested with all previous products, and new products are even tested with old drivers.

The Future of Computer Graphics

A state-of-the-art GPU now supports a 256-bit memory interface, a minimum of 128 or 256 MB of high-speed memory (700-MHz data rate or higher), DVI and/or VGA support, AGP 8X support, and a 400-MHz RAMDAC.

They have come a long way, but they still have a long way to go before the integration of film-quality CGI and real-time graphics is complete. When real-time rendering effects started to match the level of graphics in *Toy Story*, the movie industry moved ahead to the quality seen in *Shrek*. At present, we can create CGI movies such as *Shrek* and *Final Fantasy: The Spirit Within* in real time. By the time real-time graphics reaches the level of *Finding Nemo*, the movie industry will have reset the benchmark again.

A graphics card with the features outlined in this article can provide a cinematic experience on a desktop PC and make that PC ready for the upcoming flood of cinematic titles such as *Far Cry* and *Doom III*. With the addition of 3ds max and Maya DDC programs, that computer would also have the ability to create such movies. ■



*n*VIDIA

Fig. 2: *The smooth edges of the antennae and legs of the ant in the left half of this image are due to the use of anti-aliasing.*

Seattle, Innovation Incubator, to Host SID 2004

Aviation and software have blossomed in the Seattle area; and, from there, good coffee and micro-brewed beer spread across North America.

by Ken Werner

SEATTLE, where the 35th Society for Information Display International Symposium, Seminar, and Exhibition will be held May 23–28, is a vibrant and cultured city with a rich tradition of technical and commercial innovation. But in the late 19th century, many still considered it "a damp fishing village somewhere between San Francisco and Canada."

Seattle received infusions of wealth from lumbering and from being the embarkation and supply point for thousands of miners on their way to the Klondike gold rush in 1897. At that time, Seattle was called "Alaska's biggest city." It was also a lawless city that had more saloons than churches. (There is a ***Klondike Gold Rush National Historical Park*** and a free museum near Pioneer Square.) By 1917, Seattle was a city of about 300,000 and a major port. And something was about to happen that would deeply influence the rest of the 20th century.

On May 9, 20 days after the United States entered World War I, William Boeing reincorporated his unsuccessful Pacific Aero Products Company as the Boeing Airplane Company and moved the company's engineering and manufacturing to the ***Red Barn***, a boatyard building on the banks of the Duwamish (Fig. 1). The new company was quickly awarded a contract to build 50 float-plane trainers for the U.S. Navy.

Ken Werner *is the editor of* Information Display.

There were not many aeronautical engineers around then, but Boeing found one, a Chinese-American named Tsu Wong. Wong helped Boeing design the *Model C* float plane for a Navy contract, an improved version of Boeing's first plane, the Pacific Aero Products *B&W*, which the Navy had previously rejected. Parts for the *Model C* planes were made in the Red Barn by local carpenters, cabinetmakers, shipwrights, and seamstresses (who sewed the fabric skins for the aircraft).

Boeing struggled throughout the 1920s and '30s, staying afloat, in part, by building speedboats that were popular with rumrunners who smuggled whiskey into the U.S. from Canada during Prohibition. World War II changed Boeing's fortunes dramatically, and there were times when Boeing bombers literally filled the sky. The technology developed for those large airframes led directly to the propeller- and jet-driven airliners of the post-World War II era. Many, perhaps most, of the

MOHAI

Fig. 1: *William Boeing's Red Barn, shown under guard sometime during World War I, is now part of The Museum of Flight at Boeing Field.*

0362-0972/04/2001-024$1.00 + .00 © SID 2004

Seattle's Convention and Visitors Bureau

Fig. 2: Lovers of coffee and conversation can choose from among many coffee bars in Seattle.

attendees at SID 2004 will arrive at Seattle–Tacoma Airport in Boeing jetliners.

Boeing is now the world's largest aircraft manufacturer, and the Red Barn, which has been moved to Boeing Field, where it is part of ***The Museum of Flight***, is revered as the birthplace of aviation in the Northwest and the oldest airplane-manufacturing plant in the country. It is open, as is the entire museum, every day (except Thanksgiving and Christmas).

Thirteen miles WNW of Seattle is ***Microsoft's Corporate Campus*** in Redmond. Enough said? But you may not know that Microsoft was founded (by Bill Gates and Paul Allen) as "Micro-Soft" (with a hyphen and capital "S") in 1975 in Albuquerque, New Mexico, and moved to Bellevue, near Seattle, in 1978 – a move that would soon bring technological stimulation and great wealth to the Seattle area.

Not Just Technology

Easily within the memories of many SID members is a time in the United States when the overall quality of both beer and coffee was just plain terrible. Following World War II, the many local and regional breweries faded away, unable to compete with expanding national brewers who produced rather homogenized and characterless – but reliable and inexpensive – products. Travelers to Europe returned with the taste of well-crafted brews still on their tongues, and were disappointed by the choices available in the U.S. Then, in 1981, Paul Shipman and Gordon Bowker founded the Redhook Ale Brewery in Seattle, a brewery that made beer in small batches in the European tradition. That kicked off the micro-brewing revolution in the U.S., where it is now possible to buy a variety of craft-brewed beers almost anywhere in the country.

Redhook's Brewery is now in Woodinville, about 20 miles from downtown Seattle, and across the road from the excellent and beautiful ***Chateau Ste. Michelle Winery***. ***The Forecasters Public House*** at the brewery features live blues Friday and Saturday from 9:00 to 11:30 p.m., and tours of the brewery are held every day in the afternoon (see www.redhook.com for the schedule). The renowned ***Columbia Winery*** is also in Woodinville. Both Columbia (www.columbia winery.com/winery/default.asp) and Chateau Ste. Michelle (www.ste-michelle.com) have winery tours and wine tastings.

The craft-brewing tradition is alive and well in Seattle. There is even a micro-brew pub, ***C. J. Borg's***, between the C and D concourses at SEA–TAC Airport. Downtown, there are many choices for SID 2004 attendees. One is ***Pike Pub & Brewery***, where the brewers work, and answer questions, in the middle of the main dining area. Pike produces 100 bar-

Seattle's Convention and Visitors Bureau

Fig. 3: The Washington State Ferry System is one of the state's top tourist attractions.

Seattle's Convention and Visitors Bureau

Fig. 4: *Pike Place Market has an abundance of restaurants, seafood, produce, and craft stalls.*

rels a day in a former bookstore near the Pike Place Market.

Outside of urban centers with European populations, it was once as hard to find a good cup of coffee in the U.S. as it was to find a good glass of beer. That was before Howard Schultz, the director of retail operations and marketing for a local coffee company called Starbucks traveled to Italy in 1983, where he was impressed with the espresso-bar culture in Milan.

In 1985, Schultz founded a company to establish coffee bars and a coffee-bar culture in Seattle. Two years later, he acquired the assets of Starbucks and changed the name of his new company to Starbucks Corporation. That year, Starbucks had 17 locations. Now, it has over 6000 locations worldwide, and the standards of coffee drinking in the U.S. have risen immeasurably. Of course, in places like Seattle and San Francisco, independent coffee houses are the ones that capture the love and loyalty of coffee afficionados, and people now look down a bit on Starbucks. Regardless, lovers of coffee and conversation will find many choices in Seattle (Fig. 2) (see www.cs.washington.edu/homes/dickey/favorite-cafes.htm.)

Warehouse Stores, another commercial innovation, have changed the face of retailing

Getting There

Seattle is served by Seattle–Tacoma International Airport (SEA–TAC), which is 16 miles from downtown. There are about a thousand arrivals and departures daily, including direct or non-stop flights from Amsterdam, Beijing, Frankfurt, Hong Kong, London, Moscow, Munich, Osaka, Seoul, Shanghai, Taipei, and Tokyo, among others.

There are several ways to travel from SEA–TAC to Seattle's downtown hotels. Yellow Cab (206/622-6500) and Orange Cab (206/522-8800) will take you and your party for approximately $28–30. There is no curbside cab line at SEA–TAC. The cabs wait outside the airport and will pick you up at the ticket-counter level of your terminal when called. After you pick up your bags on the lower level, go up to the ticket-counter level and use the airport phones to call a cab using the numbers listed above. Wait outside on the ticket-counter level under the sign of your arriving airline, and your cab will arrive in 5–10 minutes.

Shuttle Express is a ride-sharing door-to-door van service. The fare from SEA–TAC airport to downtown is $21 total for one or two persons, and $25 total for three. SEA–TAC has consolidated most ground transportation in one central location on the third floor of the parking garage. Follow the red-and-black signs directing you to ground transportation. The third floor of the parking garage is on the same level as the baggage claim and lower drive level. To get across the lower drive, you must go up one floor and walk across the sky bridge. Once in the parking garage, proceed to the Shuttle Express booth by following the ground transportation check-in signs. Walk toward the middle and take an escalator or elevator back down one floor to Floor Three. You will find their booth alongside the SEA–TAC ground-transportation information center. Coordinators in red jackets or vests are there to assist customers between 7:00 and 2:00 a.m. If you arrive between the hours of 2:00 and 7:00 a.m., use the courtesy phone in the Shuttle Express booth.

The headquarters hotel for SID 2004 is the Sheraton Seattle Hotel and Towers, 1400 Sixth Avenue, which is adjacent to the Washington State Convention & Trade Center. There are several other hotels within two blocks of the Convention Center.

Getting Around

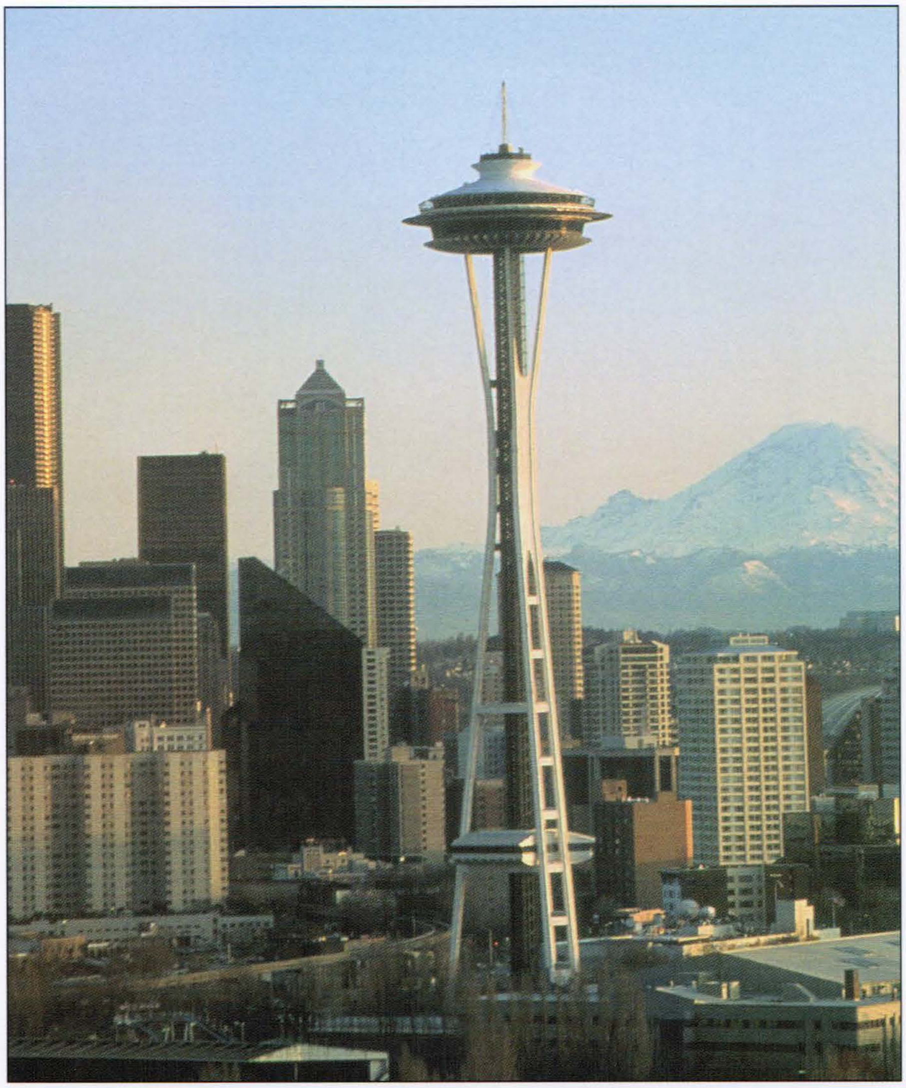
Once you arrive at your hotel, you will find that transportation around downtown Seattle is convenient. The Convention Center is less than half a mile from the Waterfront and Pike Place Market. Metro buses are free in a zone extending from the International District and Pioneer Square northward to Battery Street. One part of the free service is a Bus Tunnel that runs from Convention Place to the International District, with intermediate stops at Westlake Center (where you can get on the Monorail for that 90-second ride to Seattle Center), University Street, and Pioneer Square. The Monorail and the Waterfront Streetcar that follows Alaskan Way around Elliott Bay charge low fares.

– KIW

in the U.S. One of the leaders is Costco, which started in Seattle and has its flagship store there. Amazon.com, a notable survivor of the "dot.com" fiasco, also originated in Seattle and has its headquarters there.

Seeing the Sights

Seattle is a popular tourist destination, with Puget Sound to the west and Mount Rainier and the Cascade Mountains to the east. The Waterfront along Elliott Bay has $1^1/_2$ miles of shops, restaurants, excursion boats, and sightseeing. ***The Washington State Ferry System*** is one of the state's top tourist attractions and its state's second largest mass-transit system (Fig. 3). There are 20 routes overall and three from Pier 52 on the Seattle Waterfront to Bainbridge Island, Bremerton, and Vashon Island (pedestrians only to Vashon).



Seattle's Convention and Visitors Bureau

Fig. 5: Seattle Center, a 74-acre urban park on the site of the 1962 World's Fair, is home to the Space Needle.

Pike Place Market is the oldest continuously operating farmers' market in the country, and contains an abundance of seafood, produce, and craft stalls, as well as restaurants (Fig. 4). Pioneer Square is the oldest surviving section of Seattle, and it has been charmingly restored to reflect the way it looked at the close of the 19th century. The energetic residents solved the problem of waterlogged streets by raising the street level one story, leaving the bottom floors of their buildings below street level. This buried level, which was soon abandoned, is the subject of the popular and highly entertaining ***Underground Tour***. Tickets are available at ***Doc Maynard's Public House*** (610 First Avenue). The brick buildings of Pioneer Square now house shops, restaurants, pubs, and many opportunities for enjoying Seattle's nightlife.

Seattle Center, a 74-acre urban park on the site of the 1962 World's Fair, is 90 seconds from downtown by non-stop monorail. The Center contains the famous ***Space Needle*** from the World's Fair (Fig. 5), the ***Pacific Science Center***, the ***Seattle Children's Theater***, and the ***Experience Music Project*** (among others). The Experience Music Project (EMP) is an interactive music museum established by Microsoft co-founder Paul Allen and dedicated to guitar great Jimi Hendrix. It is housed in a remarkable building near the Space Needle designed by architect Frank Gehry, and EMP is devoted to exploring all forms of popular music: blues, jazz, hip-hop, funk, punk, country, and rock 'n' roll. There are interactive exhibits, arti-

Seattle's Convention and Visitors Bureau

Fig. 6: *The Seattle Art Museum – which has strong collections of Asian, African, Northwest Coast Native American, modern, and European art – is housed in this striking building designed by architect Robert Venturi.*

facts, and performance spaces, and free live entertainment in the striking ***Liquid Lounge***.

Seattle is a cultured city. Seattle residents reportedly read more books than residents of any other city in the United States, and the city ranked No. 2 in a recent study measuring literacy in the 64 largest cities in the U.S. (Minneapolis was No. 1). Bookstores are plentiful, and museums are seemingly everywhere.

The ***Seattle Art Museum*** has a collection of 23,000 objects, and is particularly strong in Asian, African, Northwest Coast Native American, modern, and European art. The museum is housed in a striking building designed by architect Robert Venturi (Fig. 6).

The ***Seattle Asian Art Museum*** in Volunteer Park houses a world-renowned collection of Japanese, Chinese, Korean, Indian, Southeast Asian, and Himalayan art. ***MOHAI***, the Museum of History and Industry, specializes in the rich history of the Pacific Northwest with engaging exhibits and programs. Current exhibits include "Boomtown: Seattle Before the Great Fire" and an exhibit on the Klondike gold rush, which transformed Seattle as has no other event.

There is lots of live theater in Seattle. The famous ***ACT Theater***, specializing in contemporary plays, is located next to the Washington State Convention & Trade Center, where SID 2004 will be held; and the ***Paramount Theater*** is across 9th Avenue from the Convention Center.

There are a variety of golf courses in the Seattle area, and do not forget Seattle Mariners baseball. The 2004 schedule has not been published yet, so please check www.mariners.org. ■

The 12th Advanced Display Technologies Symposium (FLOWERS 2003)

Proud of its roots in Soviet science, the Russian Federation's display community mounted a research-oriented symposium flavored with beginnings of commercial optimism.

by Ken Werner

THE 12th Advanced Display Technologies Symposium, also referred to as FLOWERS 2003, was held from August 25 to 28, 2003, in Korolev – Russia's "Space City". The Symposium was organized by the Russian, Belorussian, and Ukrainian chapters of the Society for Information Display. The Symposium has a unique character, emphasizing display research growing from the rich traditions of Russian, Belorussian, and Ukrainian science, but with a sharp eye for application and commercialization. However, because of the scarcity of investment capital, commercialization is spotty.

Starting with the opening reception (Fig. 1), the meeting was lively, with roughly 200 participants. As a result of the visa war between Russia and the U.S., some featured speakers – notably Hans Tolner (Philips) and Darrell Hopper (U.S. Air Force Research Laboratory) – did not receive their visas in time to attend. The visa war arose following September 11, when rigid and time-consuming visa screening procedures were imposed on U.S. consulates without a comparable increase in resources. At least one Russian scientist has been waiting 5 months for his visa to clear, with his passport in the hands of the U.S. consulate in Moscow for that entire time. This scientist has been to the U.S. many times and had been invited to speak by a U.S. military entity. The delay also prevented him from attending SID 2003 in Baltimore. I was told that such problems are common. Russia has retaliated by delaying the processing of visas for U.S. citizens and being very open about the reason for it.

In the Plenary Session, Victor Belyaev (Cometa Central R&D Institute) surveyed the Russian display market and described a selec-

Yuri Trofimov

Fig. 1: *The opening reception at FLOWERS 2003 in Korolev, Russia. From left to right: Vassili Nazarenko and Victor Sorokin (Ukrainian National Academy of Sciences), Igor Kompanets (Lebedev Physical Institute), Jyrki Kimmel (Nokia), Ken Werner (*Information Display*), Alexander Smirnov (Belorussian State University of Informatics and Radioelectronics), and Victor Belyaev (Cometa Central R&D Institute).*

Ken Werner *is the editor of* Information Display.

0362-0972/04/2001-030$1.00 + .00 © SID 2004

Display Invention Competition in Korolev

The final technical event at FLOWERS 2003 was an unusual Display Invention Competition held on August 28. The competition referees (of whom I was one) seemed to favor entries that could show prototypes or demonstrate the existence of hardware implementations. All entries had to have been awarded patents, many of which were Russian Federation patents that are far less expensive to obtain than European Union or U.S. patents, but still feature some reciprocity with East Asian countries.

The first award went to Yuri Trofimov and his colleagues from the Institute of Electronics NASB (Minsk, Belarus) for a bright LED-matrix character module that is addressed both electrically and optically. Each LED location is bistable in terms of addressing by virtue of optical feedback (although power must be continuously applied), and each pixel can be written by a red laser and erased with a green one. The operation of each 10×10 module is stable up to 1000-lux ambient illumination.

B. I. Gorfinkel and N. P. Abanshin of Volga-Svet, Ltd. (Saratov, Russia) and A. Kastalsky and his colleagues from CopyTele, Inc. (Melville, New York, U.S.A.) received the second award for an FED that uses thin-film planar-edge cathodes (TFPECs) with a diamond-like carbon edge. Gorfinkel said the planar cathodes are much easier to fabricate than Spindt tips. CopyTele officials told Gorfinkel that the company intends to use the TFPEC FEDs for parking meters in Canadian municipalities where it is too cold for LCDs to operate effectively.

The third award was presented to Andrei Rybalochka, Victor Sorokin, and Vassili Nazarenko of the Ukrainian National Academy of Sciences (Kiev, Ukraine) for a dynamic addressing scheme for matrix cholesteric LCDs that uses only two voltage levels on the rows as well as on the columns (2+2), in contrast to the 7+2 levels required for conventional dynamic addressing schemes. The smaller number of voltage levels allows cheaper drivers to be used. The presenters said they are working with a Chinese company that is interested in manufacturing low-cost notebook-sized displays.

Monetary awards for the three winners were contributed by the Texas Chapter of the Society for Information Display, which was a sponsor of the competition.

– KIW

tion of Russian display products. The number of PC monitors sold in 2002, he said, was 2.8 million, up from 1.8 million in 2000, and the size of the Russian IT market is growing at 18% per year. Belyaev placed the value of the 2002 monitor market at $0.8 billion, and forecast a market of $2.4 billion in 2010 if unit prices are reduced by half.

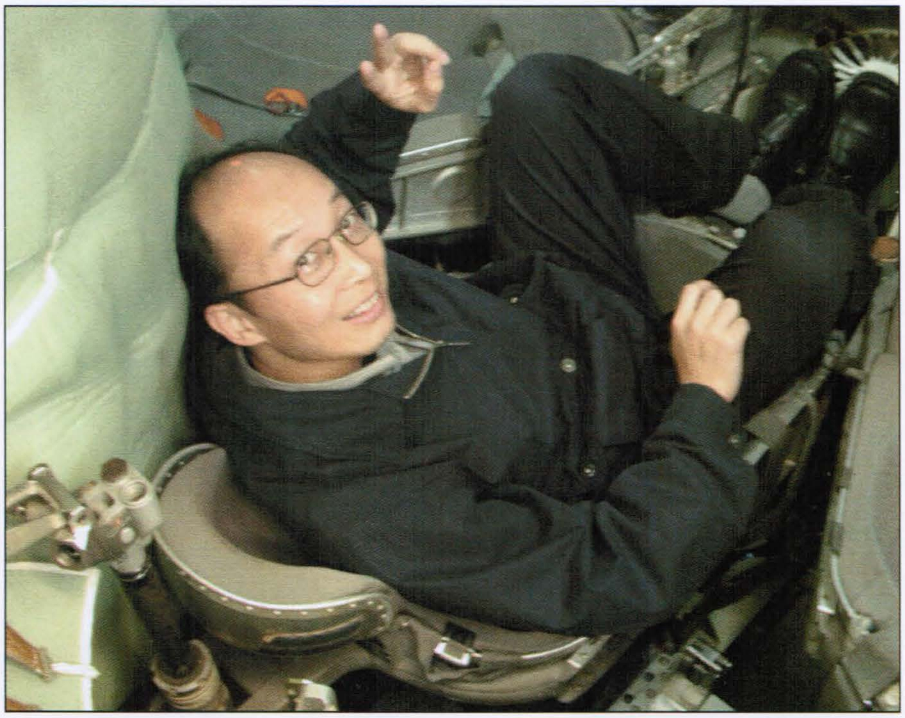
The Russian company Rolsen had 10% of the monitor market in 2003, with the other 90% going to companies such as LG, Samsung, Sony, Apple Computer, and PowerCyber. Rolsen's factory in Fryazino was predicted to have an annual capacity of 300,000 units by the end of 2003.

The total number of LCD monitors sold in Russia in 2001, the last year for which Belyaev had figures, was 120,000, up from 30,000 the year before. Notebook computers are selling at a rate of about 70,000 per year, which saturates the market, he said.

As for television receivers, the total Russian market in 2002 was 4.4 million units, growing at 25% per year. The leading companies are Samsung and LG, which together have 55% of the market. LCD TVs accounted for about 25,000 units – less than 1% of the market – in 2002.

The Technical Conference

Alexander Smirnov (Belorussian State University of Informatics and Radio-



Ken Werner

Fig. 2: One of the special events at FLOWERS 2003 was a visit to the museum at the Energiya Corp., the maker of Soviet and Russian space vehicles. Settling into the form-fitting seats in a charred space vehicle that had actually flown into space turned out to be a popular activity. Here, Xiaowei Sun (Nanyang Technological University, Singapore) takes his turn.

electronics, Minsk, Belarus) described an inorganic electroluminescent (EL) microdisplay based on aluminum–nanostructured-porous-silicon (Al–PS) reverse-biased light-emitting Schottky diodes. Recent examples have a typical response time of 1.2 nsec, a minimum pixel size of 1 × 1 μm, and an estimated lifetime greater than 10,000 hours. The devices are thin, reproducible, and stable, even at high current densities, and they are completely compatible with modern silicon fabrication technology. The main disadvantage of these devices is low efficiency (quantum efficiency, 1%; power efficiency, 0.3%), but the author implied there are applications for which this will be tolerable. Next year, Smirnov plans to demonstrate a complete microdisplay. But, he emphasized, the unique thing is that the PS technique permits light emission directly from silicon.

Nothing could have been further from Smirnov's device – which had been fabricated, photographed, and measured – than the concept presented by Alexander Ilyanok (Atomic and Molecular Engineering Laboratory, Minsk, Belarus) for a self-scanning display based on a cluster of electrons maintained in a serpentine channel in a nanostructured substrate, which was presented as an entry in the FLOWERS Inventions Competition (see textbox). When a 1-kV bias is applied across the thickness of the plate, the electron cluster migrates along the serpentine path, establishing the mechanism for a self-scanning display. If, for instance, the equivalent of plasma cells were created between the nanostructured substrate and a transparent top plate, the moving cluster could ignite the cells as it passed by, Ilyanok said. A prototype reportedly exists, but could not be brought to the conference.

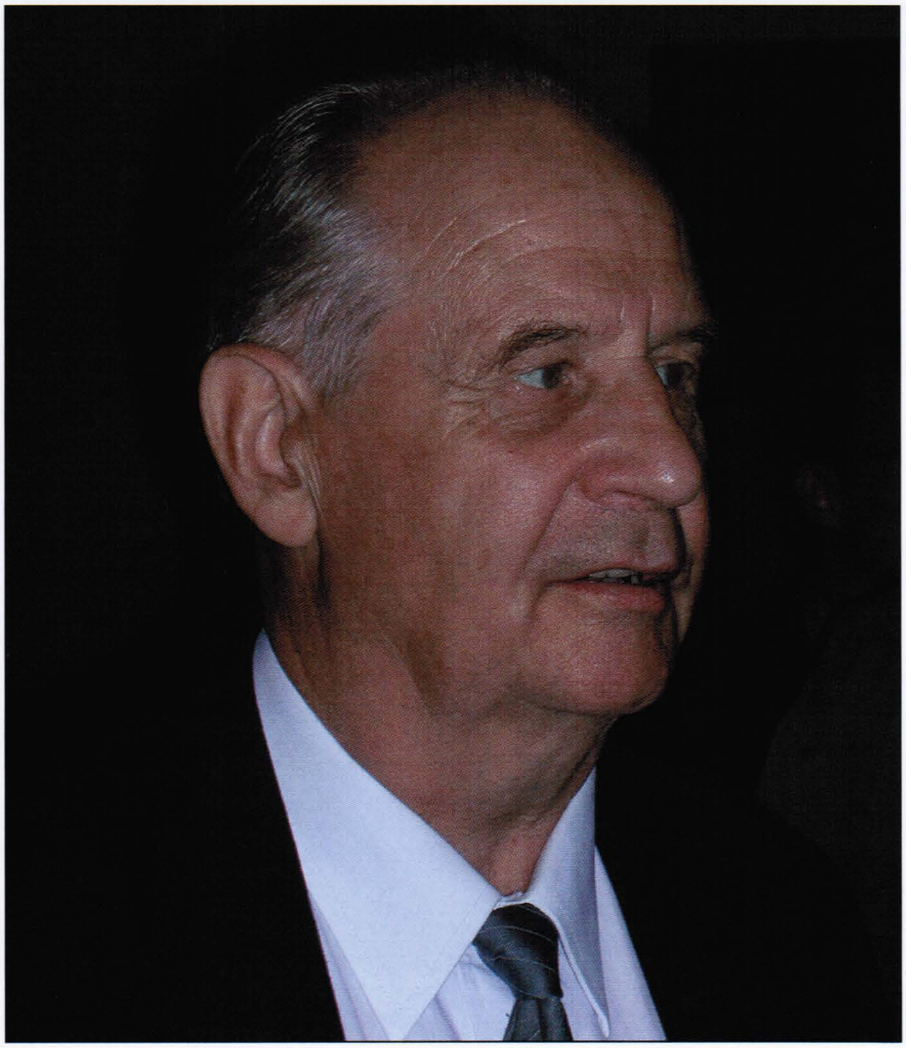


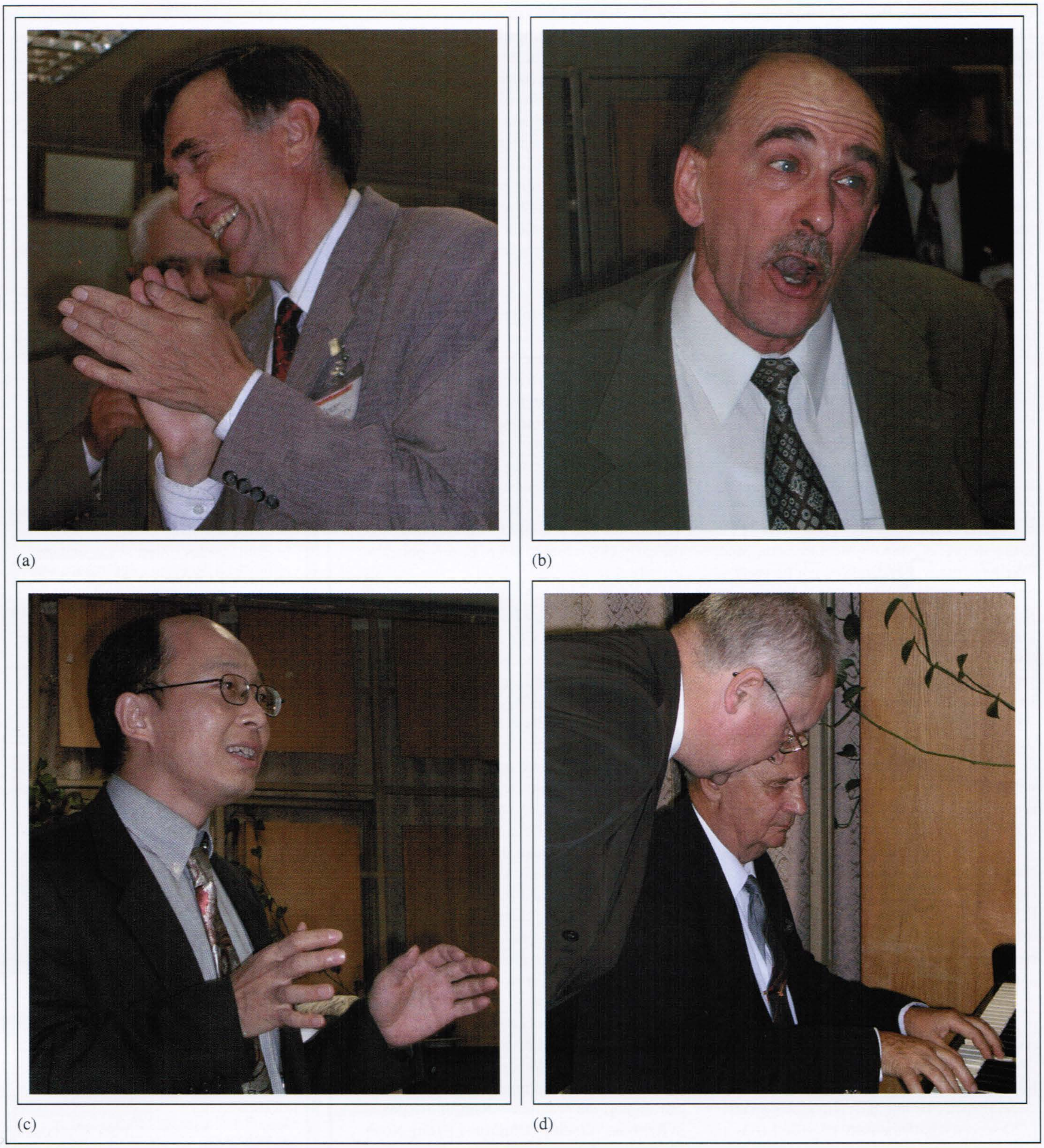
Fig. 3: Vladimir Samsonov, head of display design at the Russian Mission Control Center in Korolev.

The author's indirect style of presentation made communication of the technical content difficult, to the extent that many listeners did not seem to understand what Ilyanok was proposing. But for those with the patience to dig to the core of this presentation, which was only possible in face-to-face conversation, the possibilities are intriguing.

In "Modern Vacuum Fluorescent Displays," B. I. Gorfinkel and his colleagues from the R&D Institute Volga (Saratov, Russia) touted the benefits of vacuum fluorescent displays (VFDs), and suggested that with active-matrix driving, they have potential in high-resolution applications. The authors have built color active-matrix VFDs up to SVGA format, but the lifetime of standard sulfide phosphors is not long enough and the cost of suitable driver ICs is too high. The authors are working on these issues and believe that in a number of applications, low-voltage active-matrix VFDs can successfully compete with LCDs. Particularly interesting are active-matrix VFDs built on a monosilicon chip as a substrate. The authors believe the use of multiple chips might make active-matrix VFDs with diagonals of 6 and 12 in. feasible. Gorfinkel believes that Russia is particularly suitable for organizing the production of such displays because 200-mm silicon-wafer lines are well established and the investment required would be minimal.

Victor Sorokin (Institute of Semiconductor Physics of NASU, Ukraine), in "Cholesteric Reflective LCD Characterization," said his group has developed a nematic cholesteric display and fabrication process they believe is not covered by Kent State's umbrella patent. He added that Chinese companies are making cholesteric displays for notebook PCs, possibly infringing upon the Kent patent.

In "Polymer-Dispersed Liquid Crystals for Information Displays," S. J. Klosowicz (Institute of Applied Physics, Military University of Technology, Warsaw, Poland) proposed



(a) (b) (c) (d)

Fig. 4: *Singing was an important part of the entertainment at the conference banquet: (a) Igor Kompanets, (b) Victor Sorokin, (c) Xiaowei Sun, and (d) Alexander Maximov and Vladimir Samsonov.*

that the electrically induced transparency of PDLCs be used in composite advertising signage. The idea is to use the PDLC as an optical element to add dynamics to a printed display, for example, rather than use it as a complete information display by itself. The low system cost should be attractive, particularly in Eastern Europe, he said.

Jyrki Kimmel (Senior Research Manager, Nokia Research Center, Tampere, Finland) presented "Display Technologies for the Mobile Information Society." He noted that Russia and India have the largest growth rates for mobile phones, and that the huge amounts paid by network providers for Gen 3 cellular licenses are now limiting their ability to deploy those networks.

High-end mobile devices are beginning to converge, which is accelerating the need for high-quality small displays. Will those displays be OLEDs? "It is hard for OLEDs to penetrate the mobile-telephone market," Kimmel said, "because in bright sunlight you can see absolutely nothing on the display."

In "3-D Display Technologies," Igor N. Kompanets (Lebedev Physical Institute) said, "We have many 3-D displays, but no good ones because they are based on 2-D screens." Kompanets noted that a good 2-D display has 1000×1000 pixels. An equivalent 3-D display has a factor of 1000 more, *i.e.*, 10^9 volume pixels (voxels). That is not feasible, so he went on to discuss compromises and approaches that could be practical. Kompanets thinks that instead of 1000 "layers" in the z direction, good results can be obtained with 100. For smooth parallax motion, a separate view is needed for every 10 or 20 minutes of arc. That, also, is not practical.

Kompanets proposed a method based on a multilayer electro-optical light-scattering medium. The most suitable materials have a 60% light-scattering efficiency and a response time of 50 μsec, and they can be used for more than 100 scattering planes. The required applied voltage is 5–30 V.

Phil Surman and his group from De Montfort University, Leicester, U.K., focused on a practical 3-D system for television in "Beyond 3-D Television: The Multi-Modal Multi-Viewer TV System of the Future." The system places the left and right views on an LCD screen simultaneously because LCDs are not fast enough to display them sequentially. The views are presented on alternate lines of the LCD (they used an IBM panel with 2000 lines). Surman thinks that because viewers usually sit in one place when they watch TV, it is reasonable to eliminate the data and processing necessitated by presenting images with parallax. Therefore, the De Montfort system presents the same 3-D image to all of the viewers in the room (no parallax). The trick, Surman says, is to create a large exit pupil that covers the entire room. The De Montfort is to use multiple sources; there is one set of LCDs for each viewer. The Q&A following the presentation was lively.

Special Events

The organizers took full advantage of the conference's location in Korolev, Russia's "Space City," that was renamed a few years ago after the director of the Soviet space program at its peak. There were afternoon excursions to the Russian Mission Control Center, to the Yuri Gagarin Center for Astronaut Training, and to the museum at Energiya Corp., the maker of Soviet and Russian space vehicles. Settling into the form-fitting seats in a charred space vehicle that had actually flown into space in the early 1980s turned out to be a popular activity (Fig. 2).

During the visit to Mission Control, Vladimir Samsonov, who has been in charge of display-system design at the facility for many years, shared anecdotes about the history of the facility and the development of the display systems (Fig. 3). Among them was the fact that some design ideas were obtained by the KGB from technical conferences held in the U.S. These were open conferences, and Samsonov speculated that it probably would have been cheaper to simply send some Soviet engineers to the conferences rather than get the information through the KGB.

"In the 30 years since the Mission Control Center was built, this is the first time a display group has been here," Samsonov said. "When I first started working here, it would have been unthinkable that foreigners and non-governmental workers would even come here." There are now open exchange visits between the Korolev center and Houston. Samsonov continued by saying, "This is now a civilian, not a military, operation. We need to continue to find commercial projects that can support the program." Samsonov spoke in Russian. Vladimir Chigrinov (Hong Kong University of Science and Technology) translated for an English-speaking group that clustered around him.

At the Symposium Banquet, enthusiastic singing by the attendees was an important pa of the entertainment (Fig. 4). ■

SID Conference Calendar

Next Show!

The 8th Asian Symposium on Information Display (ASID '04)

The Asian Symposium on Information Display (ASID), originated from the joint Japan-Korean information-display conference, has become one of the major regional information-display conferences organized by SID.

The purpose of the conference is to provide a friendly and collegiate environment for display researchers, especially in the Asian region, to present their works and exchange information.

ASID '04 will cover all aspects of display science and technology including, but not limited to, Emissive Displays, Non-Emissive Displays, and Others.

14 FEBRUARY 04

The 8th Asian Symposium on Information Display (ASID '04)

NANJING, JIANGSU, CHINA
RE-SCHEDULED
FEBRUARY 14–17, 2004

- One of the major regional information-display conferences, originated from the joint Japan-Korea information-display conference.
- Covering all aspects of display science and technology.
- Sponsored by the SID Asia Region

23 MAY 04

SID '04

SEATTLE, WASHINGTON
MAY 23–28, 2004

- SID's MAJOR ANNUAL EVENT
- An International Symposium, Seminar, and Exhibition – Featuring:
  - Technical Sessions – Poster Sessions
  - Author Interviews
  - Short Courses – Applications Tutorials
  - Technical Seminars – Applications Sessions – Business Conference
  - Product Exhibits – Vendor Theater

24 OCTOBER 04

The 24th International Display Research Conference (Asia Display '04)

DAEGU, KOREA
AUGUST 24–27, 2004

- An international conference on display research and development aspects of:
- Display Materials (liquid crystals, small-molecule and polymer OLEDs, phosphors, optical compensation films, flexible substrates, etc.) • Display modeling, Design and Processing • Display Systems and Human Interfaces

25 OCTOBER 04

Americas First Display Engineering & Applications Conference (ADEAC 2004)

FT. WORTH, TEXAS
OCTOBER 25–27, 2004

ADEAC will focus on:
- Displays available to OEMs and product designers; • Display device manufacturers;
- Procedures for selecting the best display device for any application; • Display electronics and components available to OEMs and product designers.

For additional information:
Dee Dumont
Society for Information Display
610 S. 2nd Street
San Jose, CA 95112
408/977-1013, fax - 1531
www.sid.org

SID
SOCIETY FOR INFORMATION DISPLAY

Since 1962, a professional worldwide interdisciplinary society committed to the advancement of information display.

The Wiley-SID Series in Display Technology

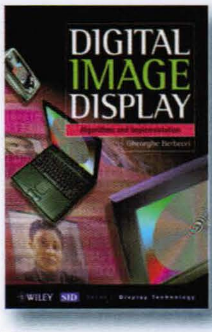
SERIES EDITOR: ANTHONY C LOWE, The Lambent Consultancy, UK
acl@waitrose.com

This book series is intended to explain the latest developments in information display technology at a professional level. The broad scope of the series addresses all facets of information displays from technical aspects through systems and prototypes to standards and ergonomics.

NOW AVAILABLE

Digital Image Display

Algorithms and Implementation



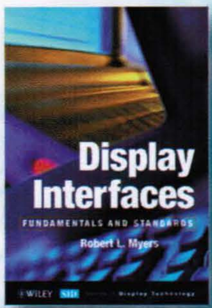
GHEORGHE BERBECEL, Valence Semiconductors Inc, Canada.

- Designed to meet the needs of professionals and developers
- Covers the evolution of the MPEG-2 standard and the requirement for MPEG-2 compliant displays
- Outlines display testing methodologies and compares image processing for flat panel and traditional CRT displays

0470 84921 5 March 2003 320pp Hbk
SID Members $96.00 / Non-members $114.00

Display Interfaces

Fundamentals & Standards



ROBERT L MYERS, Hewlett Packard, USA

- Identifies the basic requirements and applications of all popular television and computer video interface standards
- Outlines the difficulties related to practical application and system implementation
- Looks to the future and considers the development of wireless display interfaces, virtual displays and the Digital Packet Video Link (DPVL)

0471 49946 3 August 2002 312pp Hbk
SID Members $72.00 / Non-members $90.00

Colour Engineering

Achieving Device Independent Colour

PHIL GREEN, London College of Printing, UK and LINDSAY W. MACDONALD, University of Derby, UK

- Comprehensive analysis of methods for characterizing devices in the colour imaging chain
- Presents an overview of the key topics in colour management
- Prvoides the different approaches to implementing colour systems

0471 48688 4 June 2002 482pp Hbk
SID Members $68.00 / Non-members $80.00

Also available in the Wiley-SID Series..

Liquid Crystal Displays

Addressing Schemes Electro-Optical Effects

0471 49029 6 April 2001 368pp Hbk
SID Members $68.00 / Non-members $80.00

Reflective Liquid Crystal Displays

0471 49611 1 April 2001 352pp Hbk
SID Members $56.00 / Non-members $70.00

Projection Displays

0471 98253 9 1998 438pp Hbk
SID Members $90.00 / Non-members $130.00

Display Systems

Design and Applications

0471 95870 0 1997 446pp Hbk
SID Members $70.00 / Non-members $95.00

COMING SOON

Introduction to Microdisplays

DAVID ARMITAGE, Technical Consultant, Lost Altos, USA, IAN UNDERWOOD, Microemissive Displays Ltd., Edinburgh, Scotland and SHIN-TSON WU, University of Central Florida, USA

0470 85281 X March 2004 384pp Hbk

www.sid.org

SID
SOCIETY FOR INFORMATION DISPLAY

WILEY

4862

continued from page 4

monitor usually resulted in a complete crash of my desktop PC, which required a subsequent re-boot into Windows XP "safe" mode to repair the damage.

A new DVD player from Bravo (also distributed by V, Inc.) touts its DVI output as providing the best image quality. In 720p DVI mode, which some of the review monitors had problems with, the image quality was indeed crisp, sharp, and detailed. But switching to a native DVI output rate – 480p, or simple progressive-scan conversion of the DVD source video – did not look good at all. In fact, the component analog outputs provided a better 480p signal to each monitor than did the player's DVI output.

In retrospect, I would have to say that my tests resulted more in "plug and guess" and "plug and crash" than in "plug and play." At least the NEC plasma monitor had the good sense to bow out when confronted with a signal it was not prepared to display, although its "Illegal Signal" on-screen display was a bit Orwellian. A simple "Signal Out Of Range" or "Non-Compatible Signal" would have sufficed.

For now, it appears that the DVI interface can be very hit-or-miss. And things may not be helped with the HDCP version of 480p, 720p, and 1080i DVI signals. As for compatibility with plain-vanilla PC DVI standards, it looks like some LCD and plasma monitor manufacturers need to go back to the drawing board. ■

Peter H. Putman *is President of ROAM Consulting, Inc., 200-D North St., Suite D, Doylestown, PA; telephone 215/345-8004, fax 215/345-8007, e-mail: peteputman@projectorexpert.com, URL: www.projector expert. com. He is a senior contributing editor for Primedia Business Media. ROAM Consulting provides training, marketing communications, and product testing/development services to manufacturers of projectors, monitors, integrated TVs, and display interfaces. He also holds certifications from the ICIA (Certified Technology Specialist) and the Imaging Science Foundation (ISF).*

For Industry News, New Products, Forthcoming Articles, and Continually Updated Conference Calendar, see

www.sid.org

SOCIETY FOR INFORMATION DISPLAY NEWS

Professor Shosaku Tanaka (1950–2003)

Friends and colleagues attending IDRC 2003 in Phoenix were grief-stricken when they heard the sad news from Japan that Prof. Shosaku Tanaka of Tottori University had passed away on September 15, 2003, at the age of 53.

Prof. Tanaka took on the demanding task of Program Chair for Asia Display/IDW '01, which was held in October 2001, refusing a doctor's advice that he should be hospitalized. In spring 2002, when he was given permission to leave the hospital, he rushed back to the academic life. This was the result of a decision to spend the remainder of his life productively after being informed he had cancer. Prof. Tanaka devoted his remaining life to research, education, university management, and various activities in the display community. We were able to enjoy working with him for an additional year and a half.

Prof. Shosaku Tanaka, born in January 1950, received his Ph.D. degree in physics from Osaka University in 1980. He joined Tottori University as a research assistant in 1974, and has been a professor in the Department of Electrical and Electronic Engineering since 1990.

In 1972, Prof. Tanaka began his research on Mn- and rare-earth-doped ZnS thin-film electroluminescent (TFEL) devices. After 1985, his work focused on the rare-earth-doped alkaline-earth sulfides for color and white EL phosphors, and in 1988 he proposed that a full-color TFEL display could be realized by broadband EL phosphors combined with color filters. This approach is currently in commercial use.

Prof. Tanaka received the SID Special Recognition Award in 1993 with a citation "For his many contributions to thin-film electroluminescent display technology, especially for improved color electroluminescent phosphors." He was named a SID Fellow in 2001 "For his research and development on thin-film color EL displays that employ broadband EL phosphors and color filters, and for leadership in the display community."

It was Prof. Tanaka's wish that all of his friends and colleagues in the display community do their best to build upon the achievements of his energetic and fruitful life. May his soul rest in peace.

Shohei Naemura
Director, SID Japan Chapter ■

14 **04**

FEBRUARY

The 8th Asian Symposium on Information Display (ASID '04)

NANJING, JIANGSU, CHINA
RE-SCHEDULED
FEBRUARY 14–17, 2004

- One of the major regional information-display conferences, originated from the joint Japan-Korea information-display conference.
- Covering all aspects of display science and technology.
- Sponsored by the SID Asia Region

23 **04**

MAY

SID '04

SEATTLE, WASHINGTON
MAY 23–28, 2004

- SID's MAJOR ANNUAL EVENT
- An International Symposium, Seminar, and Exhibition – Featuring:
  - Technical Sessions – Poster Sessions
  - Author Interviews
  - Short Courses – Applications Tutorials
  - Technical Seminars – Applications Sessions – Business Conference
  - Product Exhibits – Vendor Theater

editorial

continued from page 2

will be held. I always enjoy writing these articles. They give me a chance to play at being a travel writer, and, more importantly, the research gives me a chance to learn about a city I will be visiting so I can enjoy it more. I hope the article does the same for you. A preview of SID 2004 itself will appear in our March/April issue. (I guess that counts as a January prediction, after all, but at least it's one over which I have some control.)

– 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).

continued from page 44

screen size and direct digital compatibility, and the advent of more cost-effective LCoS devices and improved DLP chips will keep that segment of the market interesting."

Paultre also noted the existence of "a couple of dark horses in the big-screen race." These, he said, "may not be ready by 2004 but should be showing a shadow on the horizon by then, such as nanotube-based FEDs. Two thousand four is also the year," he noted, "for iFire Technology to finally prove its claims to the success of its inorganic EL flat-panel technology."

As for small- and medium-sized displays, he expects to see "the first generation of hand-held devices with alternative-technology flat displays" by year's end. "At the risk of being too optimistic, I'd say that OLED, electronic-ink, as well as other displays will arrive, which will put further price and performance pressure on LCDs. And responding to that challenge," he added, "LCDs will continue to fall in price or, at the very least, will provide a bigger bang for the buck in performance or features in order to compete."

Bob Raikes of Meko, Ltd., also believes that in 2004 "we should finally start to see the arrival of bistable and extremely low-power devices in portable applications."

Chris Chinnock of Insight Media noted that while LCD, plasma, DLP, and LCoS technologies are already causing some displacement of CRTs in TV sets, "in the near term, these new technologies will propel the TV industry beyond a simple replacement model to swell the size of the market. It is impossible, however, to predict how the different technologies will fare because of the complicated market dynamics in play at this time."

He noted, however, "several possible scenarios that will play out for microdisplay-based systems in the entertainment segment. Optimistically, branders and integrators will successfully build consumer enthusiasm for microdisplay-based rear-projection TV. Pessimistically, the technology will capture only a low-end niche while direct-view flat-panel TVs based on plasma and/or LCD technology dominate the market. But clearly, the near-term prospects for microdisplays hang on their success or failure in the television market."

Raikes also sees 2004 as being primarily a TV story. "LCoS technology could finally start to see some increased display action as LCoS TVs prove to be a good alternative to direct-view technologies, and TI will do well with DLP, too," he said. "And the arrival of Gen 6 production will boost LCD-TV sales in the 30–40-in. class and bring LCD TV right into the consciousness of TV buyers."

According to Dave Mentley of iSuppli/Stanford Resources, "The flat-panel-TV market will be enjoying a price war between LCDs and PDPs, and the OLED industry will see significant consolidation (and growth)."

According to Barry Young of DisplaySearch, "2003 will end with a scarcity of large-area flat panels and prices going up. We believe 2004 will end with a glut of large-area panels and prices going down."

What do you see going forward? ■

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

Society for Information Display (SID-2004)

Seattle, WA - May 23-28, 2004

hrtt Solutions

"Your outsource partner for full service, traditional and online *housing, registration, travel* and *technology*"

A DIVISION OF GLOBETROTTER TRAVEL

Hotel	Single Occupancy	Double Occupancy	Blocks from Washington State Convention & Trade Center	Indoor Pool	Outdoor Pool	Whirlpool	Exercise Room	Business Center	Lounge / Bar	Restaurant(s)	Room Service	Self Parking Fee	Hotel Star Rating	High Speed Internet Available
1 Sheraton Hotel & Towers (Headquarter Hotel)	198	218	1	●		●	●	●	●	1	●	22	3	
2 Grand Hyatt Seattle	225	245	1			●	●	●	●	3	●	22	4	●
3 Hilton Seattle	180	200	3				●	●	●	2	●	19	3	●
4 Mayflower Hotel	159	179	5				●	●	●	1	●	21	3	●
5 Red Lion Hotel	169	179	3				●	●	●	2	●	19	NOT RATED	●
6 Renaissance Seattle Hotel	199	199	6	●		●	●	●	●	2	●	19	3	●
7 Summerfield Suites by Wyndham	155	165	1		●	●	●			0	●	18	3	●
8 Westin Seattle	185	205	4	●		●	●	●	●	2	●	24	4	●
	Rates do not include 15.6% Tax													

- - - - - - FREE DOWNTOWN BUS

.... UNDERGROUND BUS TUNNEL

- - - - MONORAIL TO SPACE NEEDLE (NON STOP)

GLOBETROTTER
We think of everything.

Official Housing Request Form: Society for Information Display (SID-2004)

Seattle, WA - May 23-28, 2004

The official housing closing date is April 16, 2004. 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, MD 20832
Fax: 301-570-9514

No Reservations Will Be Taken By Phone
For Housing Information Only Call:
301-570-0800 (Press 2)
ON-LINE RESERVATIONS:
http://www.globetrottermgmt.com/sid
Save up to 15% on Published Air Fares.
Call 301-570-0800 (Press 1)
E-Mail us at sid@globetrottermgmt.com

Hotel	Distance from Event	Single Rate	Double Rate
1 Sheraton Hotel & Towers (Headquarter Hotel)	1 Block	$198	$218
2 Grand Hyatt Seattle	Connected	$225	$245
3 Hilton Seattle	3 Blocks	$180	$200
4 Mayflower Park Hotel	3 Blocks	$159	$179
5 Red Lion Hotel	3 Blocks	$169	$179
6 Renaissance Hotel	6 Blocks	$199	$199
7 Summerfield Suites by Wyndham	1 Block	$155	$165
8 Westin Seattle	4 Blocks	$185	$205

All reservations are on a first come first served basis. Globetrotter will acknowledge the reservation within 5-7 business days for forms faxed or mailed. Acknowledgment is automatically generated for on-line bookings. You will receive confirmation directly from your hotel approximately 2-3 weeks prior to the convention. If you have any special requests, please list them here:____________________

Contact Information:

Name:____________________

Company:____________________

Address:____________________

City__________ St____ ZIP________

Country____________________

Phone:____________________

Fax:____________________

E-Mail____________________

Please Check One of the Categories Below:

☐ Attendee
☐ Exhibitor

Hotel Choices: 1)________ 2)________ 3)________ 4)________

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

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

All reservations require a deposit of the first night with a credit card number or check made payable to Globetrotter Travel in US funds.

Credit Card Number:____________________ **Exp Date:**________

Cardholder's Name:____________________

Cardholder's Signature:____________________

Check Enclosed:________

sustaining members

Acheson Industries, Inc.
Ad-Vance Magnetics, Inc.
Advance Reproduction Corp.
Aerospace Display Systems, LLC
Amulet Technologies, LLC
Applied Concepts, Inc.
Astra Products, Inc.
AuGRID Corp.
AU Optronics Corp.
autronic – Melchers GmbH
Avery Dennison Microreplication

Brillian Corp.
Brimar Ltd.

Candela Instruments
Cando Corp.
Canon, Inc.
CELCO
Chi Mei Optoelectronics Corp.
Chunghwa Picture Tubes, Ltd.
Ciba Specialty Chemicals
ClairVoyante Laboratories, Inc.
Clinton Electronics Corp.
Corning Incorporated
Corning Japan K.K.
CYRO Industries

DisplaySearch
DIY Theatre, Inc.
Dontech, Inc.
DuPont Displays

EarthLCD
E-Ink Corp.
Electro Plasma, Inc.
ELDEC Corp.
Elo TouchSystems, Inc.
eMagin Corp.
Endicott Research Group, Inc.
ERSO/ITRI

Futaba Corp., Product Development Center

GDS
Gebr. Schmid GmbH & Co.
Gennum Corp.
GPO Corp.

Hannstar
Hitachi, Ltd.
Hoya Corp. USA

i-Chips Technology, Inc.
iFire Technology, Inc.
IMT Masken und Teilungen AG
Incom, Inc.
Industrial Electronic Engineers, Inc. (IEE)
Info Incorporation
Innova Electronics, Inc.
Instrument Systems
Interface Display & Controls, Inc.
iSuppli/Stanford Resources, Inc.

Japan Patent Office

Kent Displays, Inc.
Kuraray Co., Ltd.

LCD Lighting, Inc.
LG.Philips LCD
Luxell Technologies

Main Tape Company
Micronic Laser Systems AB
Microvision, Inc.
Microvision, Inc.
Mitsubishi Electric Corp.
Myson Century, Inc.

Nano-Proprietary, Inc.
National Semiconductor Corp.
NEC Corp.
Nippon Seiki Co., Ltd.
Noritake Itron Corp.
Novaled GmbH

OCLI – A JDS Uniphase Company
OES/ITRI
One Stop Displays
Optical Filters, Ltd.
Optimax Technology Corp.
Optiva, Inc.
Optrex America, Inc.

PCS, Inc.
Photon Dynamics
Photo Research, Inc.
Picvue Electronics, Ltd.
Planar Systems, Inc.
Plasmaco, Inc.
Polar Vision, Inc.
Polytronix, Inc.

Quanta Display, Inc.
Quantum Data, Inc.

Reflexite Display Optics
ROLIC Research Ltd.
ROLIC Technologies, Ltd.
Royal Philips Electronics

Samsung Electronics
Samsung SDI
Sarnoff Corp.
Schott Corp.
Sharp Corp.
Silver Cloud Manufacturing Co.
Sony Chemicals Corp. of America
Sony Corp. Research Center
Supertex, Inc.
Symbol Technologies, Inc.

Tannas Electronics
Three-Five Systems, Inc.
Tiun Yuan Technology Co., Ltd.
TLC International
Toppoly Optoelectronics Corp.
Topro Technology, Inc.
Toshiba America Electronic Components, Inc.

Unaxis Balzars, Ltd.
UNIGRAF
Universal Display Corp.
USA EELY-ECW Optoelectronics, Inc.

Video Electronics Standards Association (VESA)
Viratec Thin Films, Inc.
Vishay–Dale Electronics, Inc.
VON ARDENNE Coating Technology

Westar Corp.
WINTEK Corp.

ZBD Displays, Ltd.

index to advertisers

Business and Editorial Offices
Palisades Convention Management
411 Lafayette Street, 2nd Floor
New York, NY 10003
Jay Morreale, Managing Editor
212/460-8090 x212 Fax: 212/460-5460
jmorreale@pcm411.com

Sales Office – Europe
George Isaacs
12 Park View Court
The Paddock, Eaton Ford
St. Neots, Cambridgeshire
PE19 7SD U.K.
Phone/Fax: +44-(0)-1480-218400
george@gandg.demon.co.uk

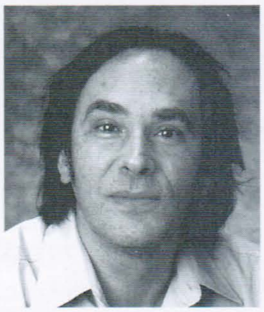
Sales Office – Japan
Ted Asoshina
General Manager
Echo Japan Corp.
Grande Maison Room 303
2-2, Kudan-Kita 1-chome
Chiyoda-ku, Tokyo 102-0073 Japan
+81-3-3263-5065
Fax: +81-3-3234-2064
echoj@bonanet.or.jp

Sales Office – U.S.A.
Palisades Convention Management
411 Lafayette Street, 2nd Floor
New York, NY 10003
Kate Dickie, Sales Manager
212/460-8090 x215 Fax: 212/460-5460
kdickie@pcm411.com

Sales Office – Korea
Jung-Won Suh
Sinsegi Media, Inc.
Masters Tower, Room 2410
553, Dowha-dong
Mapo-ku, Seoul 121-040 Korea
+82-2-313-1951/2 Fax: +82-2-312-7335
sinsegi@sinsegimedia.info

Sales Office – Taiwan
Michael Young
Trade Media Representative, Inc.
3F, No. 140, San Min Rd.
Taipei, Taiwan, R.O.C.
+886-2-2763-2438
Fax: +886-2-2545-7868
mediarep@seed.net.tw

backlight



Ring in the New

by David Lieberman

A Very Happy New Year to you all! As we say goodbye to the old year and welcome the new, I thought it might be appropriate to take a look forward to try to discern what the coming year may bring in flat-panel displays. I also thought it might be more interesting if I got some industry participants and observers involved than if I provided only a look at my own crystal ball. So here is how some display folks think the year 2004 may turn out.

Alfred Poor, an independent display journalist (who is incidentally a Contributing Editor to *Information Display*, as well as to *PC Magazine*) expects the new year to bring "cheaper, better, and bigger displays. Buyers expect nothing less, and manufacturers will have to deliver in order to be successful," he said.

As for particular FPD technologies, "I'm no market researcher," said Poor, "but I can't see anything but a glut of LCD panels this time next year. The Gen 6 plants will almost certainly have the bugs worked out by then, which means a flood of glass. I am guessing that it will be even more difficult to make a profit on LCD panels this time next year than it is now."

LCDs and PDPs, Poor continued, "are going to continue to eat away at the consumer-entertainment market. People are catching on to the attractiveness of the products, even to the point where they are willing to overlook some of the shortcomings." And as for novel technologies such as bistable LCDs, FEDs, and OLEDs, "it is still not time for them to make a market splash," Poor said, "but the interest and research in them will continue unabated."

Tom Holzel, independent product-positioning consultant, sees most of the action over the coming year occurring in PDPs and LCDs, and Roger Johnson of Manufacturing Technology, Ltd., agrees. "The only thing of note in my book will be to check the scores in the IFPL (International Flat Panel League)," said Johnson, "in particular PDPs *vs.* LCDs in the 40–60-in. range." By the end of 2004, he said, "I think we will be able to tell if the stories about the death of PDPs are premature or not."

Because of LCDs, according to Holzel, "the CRT computer monitor will all but disappear within the next 2 years." As for the TV market, "LCD TVs will grab a larger share of the below-32-in. market as their price comes down," he said, "but no one will make any money selling them, and PDPs will see a nice jump in sales as the 42-in. price breaks the $3000 barrier."

Holzel said that the latest PDPs "have finally solved enough of their artifact problems to offer images as good as – and perhaps even better than – those of a CRT at normal viewing distances, while LCD TVs larger than 32 in. will never achieve PDP image quality (except for still images) and, thus, suffer a very costly loss in the wall-TV battle." For hang-on-the-wall TV, he said, "$2000 is the magic number. If and when any wall-TV maker can get the street price of its 42-in. display down to $2000, a huge explosion of sales volume will follow, and – for the first time – the reigning CRT will see a significant negative impact."

Alix Paultre of *Electronic Products Magazine* sees a greater degree of diversity in the TV arena in the coming year. "In the large-screen arena, rear-projection sets with better optics for a flatter profile will continue to fight it out with PDPs and LCDs," he said. "Projection TV offers benefits such as low weight to

continued on page 39

calendar

Electronic Imaging 2004. Contact: IS&T, telephone 703/642-9090.
January 18–22, 2004 San Jose, CA

8th Asian Symposium on Information Display. Contact: Lu Liu, telephone +86-25-379-2449, fax +86-25-336-3222, e-mail: liulu@seu.edu.cn
February 14–17, 2004 Nanjing, China

CeBIT 2004. Contact: Telephone +49-180-525-02-01, fax +49-5041-97-00-34.
March 18–24, 2004 Hannover, Japan

SID 2004 International Symposium, Seminar & Exhibition. Contact: Mark Goldfarb, PCM, 212/460-8090 x202, fax -5460, e-mail: mgoldfarb@pcm411.com.
May 23–28, 2004 Seattle, WA

INFOCOMM 2004. Contact: infocomm04.expoexchange.com.
June 5–11, 2004 Atlanta, GA

Display Taiwan 2004. Contact: +886-2-2396-7780, fax +886-2-2341-4559, e-mail: sysop@mail.pida.org.tw.
June 9–12, 2004 Taipei, Taiwan

24th International Display Research Conference (Asia Display 2004). Contact: SID HQ, 408/977-1013, fax -1531, e-mail: www.sid.org.
August 24–27, 2004 Daegu, Korea

Advanced Display Technologies Symposium (FLOWERS 2004). Contact: Prof. A. Smirov, +375-17-2398858, fax -2398486, e-mail: smirov@gw.bsuir.unibel.by.
September 7–10, 2004 Minsk, Belarus

EL2004 International Conference and Workshop. Contact: Adrian Kitai, McMaster University, e-mail: el2004@mcmaster.ca.
September 20–23, 2004 Toronto, Canada

48th Annual Human Factors & Ergonomics Society Meeting. Contact: HFES, 310/394-1811, fax -2410, e-mail: info@hfes.org.
September 20–24, 2004 New Orleans, LA

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

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

12th Color Imaging Conference 2004. Contact: IS&T, 703/642-9090, fax-9094, e-mail: info@imaging.org.
November 9–12, 2004 Scotsdale, AZ ■

Guarantee your competitive edge.

Be there at the beginning. Participate in the development of ground-breaking display industry standards with VESA's (Video Electronic Standards Association) international team of industry experts.

First ones to know

Join over 120 member companies from around the world who already benefit from advanced knowledge of new technology standards.

As a member, you are invited to take part in monthly committee and workgroup meetings, or simply be the first to access resulting technical papers and industry standards.

Display industry leaders

Steadfastly dedicated to innovation and market growth, VESA members lead through their visionary efforts to develop and promote open standards.

Current Committees

Display
Display Metrology
Digital Packet Video Link
Japan
Microdisplay

VESA Committees are currently creating standards that will cover several areas, including: advanced and packetized video interfaces, multi-display, mobile digital display, flat display mounting interfaces and Plug and Play enhancements.

VESA

See our virtual trade show at VESA.org

920 Hillview Court, Ste. 140, Milpitas, CA 95035   408.957.9270   fax 408.957.9277   sales@vesa.org

Circle no. 12