SID 2004 PREVIEW ISSUE

# Information DISPLAY

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SID

Official Monthly Publication of the Society for Information Display

## Seattle Hosts SID 2004

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- *Thin CRTs to Compete with FPDs*
- *Front Projectors for the Home*
- *FPD International Report*
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# Information DISPLAY

MARCH/APRIL 2004
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*Seattle – an attractive, multi-faceted, and richly endowed city – will host SID 2004 in May. One of the many popular attractions is Seattle Center, a 74-acre urban park on the site of the 1962 World's Fair, which contains the famous Space Needle.*

Seattle Convention and Visitors Bureau



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**Next Month in**
***Information Display***

SID 2004 Show Issue
- Products on Display
- Volumetric 3-D LCDs
- CRTs Still Shine Brightly
- Organic Electronics for FPDs
- LCoS Testing
- IDW Report


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editorial

## Honoring Heiju Uchiike

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

The organizers had hoped to attract 30 or so plasma professionals who were attending IDW. They got their 30, plus 100 more. As it turned out, the Saga Forum was more than a technical meeting. It was a gathering of the PDP clan to honor one of its central figures: Heiju Uchiike, currently Professor of Electrical and Electronic Engineering at Saga University, and previously (for 30 years) Professor of Electronics at Hiroshima University.

It is hard to overstate Prof. Uchiike's pivotal role in the development of the modern plasma-display panel (PDP). Gene Slottow and Don Bitzer invented the first primitive PDP at the University of Illinois in 1964. Prof. Uchiike visited the laboratory, and spent the 1978–1979 academic year at the university as a Visiting Associate Professor. Larry Weber and Roger Johnson were graduate students in Slottow's and Bitzer's group. Weber went on to found Plasmaco, now a division of Matsushita. Johnson brought PDP technology to SAIC, which produced several generations of successful monochrome plasma displays for military applications.

Dr. Uchiike went on to discover that magnesium oxide is the most-desirable dielectric material for the protective layer in ACPDPs – a significant discovery since MgO is used in all commercial ACPDPs manufactured today. He has contributed to our understanding of PDP operating mechanisms and has improved PDP performance in a variety of ways. Significantly, he has now trained several generations of PDP designers and engineers, including Tsutae Shinoda, whose work in the development of large-screen color PDPs helped make them a commercial reality, and incidently, made Fujitsu and, later, Fujitsu Hitachi Plasma (FHP) Display, leading suppliers of PDPs.

Shinoda, Weber, Johnson, and many other leaders of the plasma community were in the room when Dr. Uchiike made his introductory remarks. Hiroshi Amari of Samsung, a member of the youngest generation of plasma professionals present at Takeo Hot Spring, said she was overwhelmed at being in the same room with so many giants in the field, those who had written the textbooks and technical papers from which she had learned. But the openness and warmth of this group were palpable. By the time the evening banquet was over, Amari had settled in as a comfortable participant in the Saga Forum.

It is clear that Prof. Uchiike's position in the plasma community is based on deep affection, as well as respect for his remarkable technical contributions. Prof. Uchiike has nurtured his students as well as educated them, and is a friend to his colleagues as well as a co-worker. "Beloved" is not a word that often comes up at technical conferences, but it applies to Heiju Uchiike.

— KIW

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


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# my turn

## Glimpses of the Chinese Display Industry

**by Linsu Tong**

China has become one of the major countries that manufacture displays. From about 1970, the Chinese display industry has made a series of dramatic transitions.

Originally, the Chinese display industry and its market were almost completely based on black-and-white CRTs. The transition to color picture tubes (CPTs) began in the 1970s. At the end of that decade, the first two CPT production lines, with an annual production capacity of 960,000 units, were imported from Japan to the IRIS Group Co. China now has 12 factories with 58 production lines for the manufacture of CPTs. In 2003, the total annual production capacity was nearly 50 million CPTs and 30 million CDTs, which is almost 40% of world capacity. The Chinese Electronic Information Industry Development Research Institute predicts that the Chinese market will continue to absorb about 30 million CPTs per year for the next 10 years.

The first passive-matrix-LCD factories were built in the 1980s, with the main product being TN-LCDs. Now, there are more than 80 LCD factories located over the eastern part of China. A comprehensive industrial system for the manufacture of LCDs is now well established, and China is a major manufacturer of TN-LCDs and STN-LCDs, with a big market. Most of these passive-matrix LCDs are used in products such as mobile telephones, PDAs, calculators, automobiles, and watches. After an unsuccessful TFT-LCD production line was imported in 2000, more than seven successful TFT-LCD production lines have been installed in the Yangtze Delta to manufacture LCDs for monitors, notebooks, and TVs.

Prior to the 1990s, CPT screen sizes were predominantly 14 and 21 in. Now a substantial percentage of the CRTs manufactured in China have screen sizes of 29 and 34 in. Rear-projection TV based on CRTs, PDP TVs, and LC TVs have started to make inroads in the Chinese display market with modest shares – 900,000 for rear-projection TV, 30,000 for LC TV, and 80,000 for PDP TV in 2003. Other projection technologies, such as LCoS and DLP, are now emerging as well.

During the past 10 years, the Chinese display market began the transition from analog TV to digital TV. Digital TV will provide new opportunities (such as HDTV) for TV sets using large-area PDPs, CRTs, LCDs, or projection screens. Recently, this topic was discussed at a lively Evening Panel at the ASID Conference held in Nanjing on February 16, 2004. The theme of the panel was "Can PDP and LCD TV Follow the Projection-TV Wave in China?" I would guess that PDPs from 42 to 60 in. are likely to be the most suitable display devices for home-entertainment digital TV in China.

At the end of the 20th century, the Chinese Government encouraged the display R&D community to work energetically to bring forth new ideas for the various types of displays. Many professors and scientists working at universities and institutes for R&D and manufacturing of display devices in China are becoming more and more involved in the various symposia on display technologies organized by SID. Recently, some novel display devices have been

*continued on page 58*





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# Seattle Hosts the SID 2004 Symposium, Seminar, and Exhibition

*The Society for Information Display's premier event returns to Seattle during a time of record display sales, firm prices, and exciting technology and product developments.*

by Ken Werner

SEATTLE, a vibrant and cultured city with a rich tradition of technical and commercial innovation, is an appropriate location for the Society for Information Display's 35th International Symposium, Seminar, and Exhibition, which will be held from May 23 to 28, 2004 (Fig. 1).

The annual SID Symposium has become the leading international forum for discussing and analyzing electronic-display technologies and products and is covered by approximately 100 technical and business journalists from around the world. It incorporates the largest exhibition in North America devoted to displays; display components; display-manufacturing equipment; display test-and-measurement equipment; display controllers, electronics, and semiconductors; backlights; display products and materials; software; services; and publications. More than 450 booths have been sold thus far, said Exhibit Sales Manager Kate Dickie.

Display Week will kick off with half-day short courses on Sunday, May 23, followed on Monday by the 90-minute seminars and the second annual SID Business Conference. The seminars will continue on Friday, May 28.

The Sunday Short Courses, organized by Julie Brown of Universal Display Corp., are

- ***Fundamentals of OLEDs*** by Amal Ghosh of Eastman Kodak Co. and Michael Hack of Universal Display Corp.,
- ***Fundamentals of Color Plasma Displays*** by Tsutae Shinoda of Fujitsu Laboratories and display consultant Harm Tolner,
- ***Fundamentals of Liquid-Crystal Displays*** by Terry Scheffer of InFocus Corp. and Jin Jang of Kyung Hee University, and
- ***Fundamentals of Organic Electronics for Flat-Panel Displays*** by Michael Kane of Sarnoff Corp.

The first SID Business Conference, held last year, was successful and well-attended, with participants giving the presenters high grades. "This year's conference covers display markets, productivity, finances, future directions, and investment opportunities," said Business Conference Organizer Elliott Schlam (Elliott Schlam Associates). New this year is an evening reception exclusively for Business Conference attendees and presenters, sponsored by LG.Philips LCD.

Because Display Week is a can't-miss event for many executives in the display industry, the Business Conference attracted an elite group of speakers from around the world – a group that would be hard to assemble anywhere else. Bruce Berkoff, Executive Vice President of LG.Philips LCD, will begin the program with his Keynote Address, "Flat, Digital, and Resolution That Will Knock Your Socks Off: The Future of Displays." Among the other speakers are H. B. Chen (President & COO, AU Optronics Corp.), Jun Souk (Executive Vice President, Samsung Electronics), Larry F. Weber (Former President and CEO, Plasmaco/Matsushita), and Ding-Chang Wang (President and CEO, RiTdisplay Corp.).

Consultant Harm Tolner will launch the Monday Seminars at 8:00 a.m. with a Technical Keynote. That will be followed by 12 seminars in three simultaneous tracks on Monday and six more seminars in three simultaneous tracks on Friday. The seminars include

- ***LCD Television by Ian Miller*** (Samsung Information Systems America),
- ***OLED Manufacturing*** by OLED co-inventor Steven Van Slyke (Eastman Kodak Co.),
- ***Display Electronics*** by David Fish (Philips Research Laboratories),
- ***Flexible Displays*** by Gregory Crawford (Brown University),
- ***Projection Displays*** by George Pinho (Christie Digital Systems), and
- ***Electronic Paper*** by Karl Amundson (E-Ink Corp.).

There will also be seminars on plasma displays, organic TFTs, FEDs, microdisplays, and display measurements, among others, according to Seminar Chair Amal Ghosh (Eastman Kodak Co.).

A rich menu of exhibits, applications tutorials, Vendor Forum presentations, and up to six tracks of technical-paper sessions will all be offered from Tuesday, May 25, through Thursday, May 27. Sixty technical sessions will contain more than 250 papers, anchored by 35 invited papers, said Program Chair Wei Chen (Apple Computer). The Tuesday evening Poster Session contains over 130 papers. Among the invited papers are

- ***Transmissive a-Si TFT-LCD Using Low-Temperature Processes on Plastic Substrates*** (K. Chung, Samsung Electronics),

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



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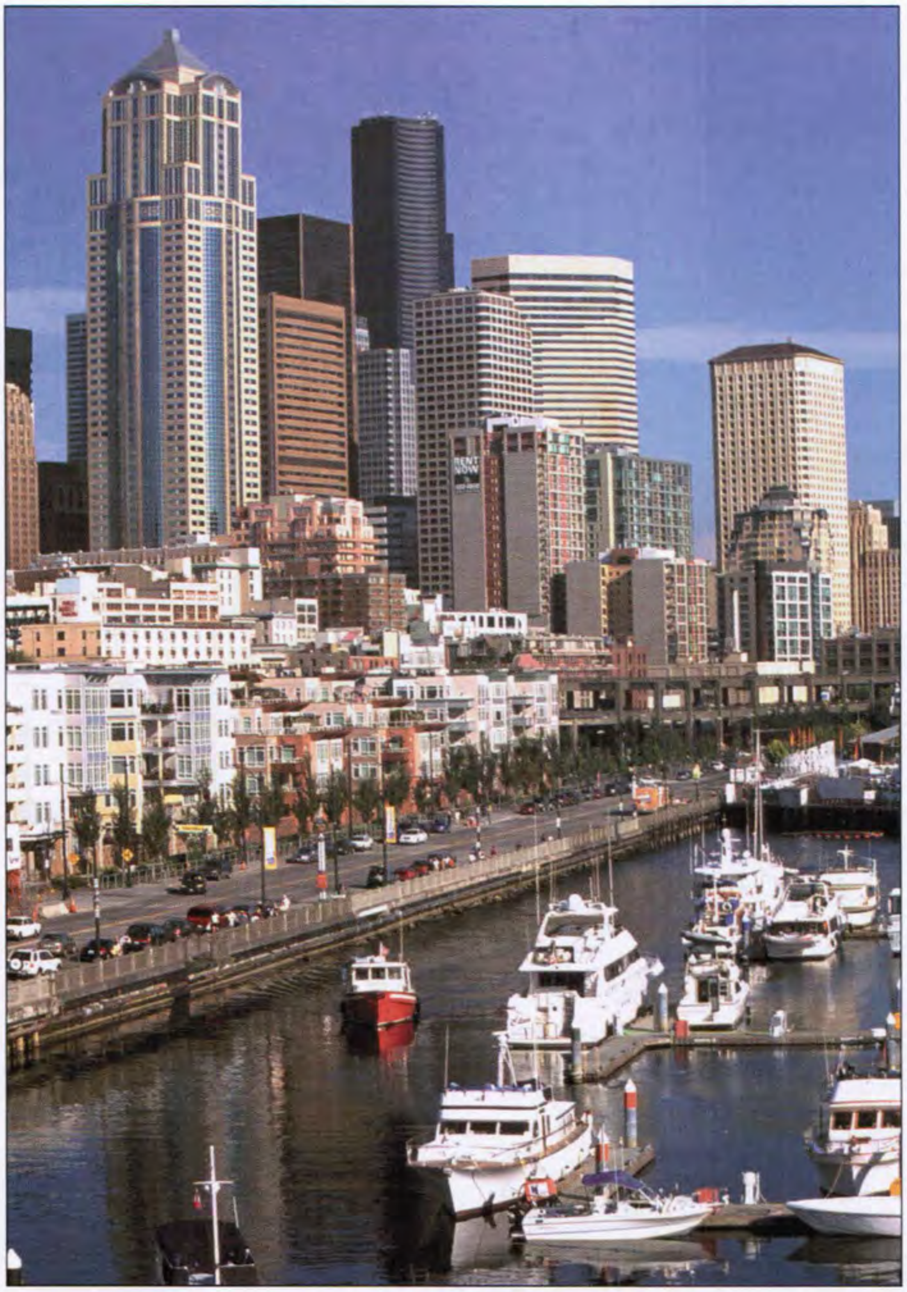


Seattle Convention and Visitors Bureau

*Fig. 1: SID 2004 will be held in Seattle. Pictured is the Seattle skyline with water traffic on Elliott Bay.*

- ***What Is Electronic Paper?: The Expectations*** (M. Omodani, Tokai University),
- ***Fourth-Generation PDPs: The Way to High Image Quality and Low Power Consumption*** (M. Uchidoi, Pioneer Corp.),
- ***Development of High-Quality LCD TV*** (M. Shigeta, Sharp Corp.),
- ***Latest Development of System-on-Glass P-Type Low-Power Low-Temperature TFT-LCDs*** (Y.-M. Ha, LG.Philips LCD),
- ***Large-Area High-Performance OTFT Arrays*** (T. Kelley, 3M),
- ***Video Display and Processing*** (M. Klompenhouwer, Philips Research Laboratories), and
- ***A Virtual Display for Mobile Use*** (J. Hakkinen, Nokia Research Center).

The formal opening of SID 2004, together with the Keynote Addresses and the presentation of the Display of the Year Awards, will be on Tuesday morning. Richard F. Rashid, Senior Vice President of Microsoft Research, will open the session with ***Peering into the Future through the Looking Glass of Technology*** (Fig. 2). He will look at how changes in processors, software, storage, graphics, and communications are altering the way we think about computing, and how they will change the way we interact with computers. He will explain that display technology has a critical role to play.

In ***Picturing Tomorrow ... New Perspectives Enabled by New Technology***, Johan van de Ven, CTO of Philips Mobile Display Systems & Communications Businesses and Senior Vice President of Philips Semiconductors, will paint a picture of how different human environments can evolve and how this can subsequently impact displays. What will this future world mean for the display industry?

Microsoft

*Fig. 2: Richard F. Rashid, Senior Vice President of Microsoft Research, will open the SID 2004 Keynote Session.*

## Visiting Seattle

In the late 19th century, many still thought of Seattle as "a damp fishing village somewhere between San Francisco and Canada." But the city was transformed by serving as the embarkation and supply point for thousands of miners on their way to the Klondike gold rush in 1897. 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. In that year, William Boeing established the Boeing Airplane Company and moved the company's engineering and manufacturing to the Red Barn, a boatyard building in which Boeing's personal yacht had been built. From this beginning, Boeing became the largest aircraft manufacturer in the world, and Seattle became one of the capitals of global aviation.

Thirteen miles WNW of Seattle is Microsoft's Corporate Campus in Redmond, a company that has brought technological stimulation and great wealth to the Seattle area.

Seattle is the home of the Redhook Ale Brewery, the company that triggered the craft-brewing revolution in the United States. Redhook's brewery is now in Woodinville, about 20 miles from downtown Seattle. Tours of the brewery are held every day in the afternoon (www.redhook.com). The renowned Columbia (www.columbiawinery.com) and Chateau Ste. Michelle (www.stemichelle. com) wineries are also in Woodinville, and offer winery tours and wine tastings.

The craft-brewing tradition is alive and well in Seattle. Downtown, there are many places to sample craft-brewed beer from the Seattle area and around the world. One is Pike Pub & Brewery, where the brewers work, and answer questions, in the middle of the main dining area.

Seattle is also where Starbucks was founded. Since 1985, Starbucks has grown from 17 locations in Seattle to 6000 locations worldwide. But in cities like Seattle, independent coffeehouses are the ones that capture the loyalty of coffee afficionados, and lovers of coffee and conversation will find many choices in Seattle.

### 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 1.5 miles of shops, restaurants, excursion boats, and sightseeing. The Washington State Ferry System is one of the state's top tourist attractions and its second-largest mass-transit system (Fig. A). 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 from Pier 52).

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. 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, and pubs.

Seattle Convention and Visitors Bureau

*A. The Washington State Ferry System is one of the state's top tourist attractions. Here, a ferry sails past downtown Seattle, with the skyline, the Space Needle, and the Cascade Mountains in the background.*

Dong-Hun Lee, Executive Vice President of the Samsung Electronics AMLCD Division, will describe Samsung's continuous-investment strategy in ***TFT-LCDs – Continuous Investment Drives Exponential Growth***, and he will discuss the benefits of partnering with Sony, the leading consumer-electronics brand, and the structure of their new $2 billion joint venture.

In a change from past years, the annual SID/*Information Display* Display of the Year Awards – the industry's most prestigious awards for excellence – will be presented immediately following the Keynote Session. Awards will be presented to LG.Philips LCD, Mitsubishi Electric Corp., Hitachi, Ltd., Universal Display Corp. and PPG Industries, Inc., Eastman Kodak Co., and NXT. The new

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 1962 World's Fair and the Experience Music Project (EMP), among other attractions. EMP is an interactive music museum devoted to exploring all forms of popular music: blues, jazz, hip-hop, funk, punk, country, and rock 'n' roll. There are interactive exhibits, artifacts, and performance spaces, and free live entertainment in the striking Liquid Lounge.

Seattle residents reportedly read more books than residents of any other city in the United States. Bookstores are plentiful, and museums are seemingly everywhere. The Seattle Art Museum has a strong collection of Asian, African, Northwest Coast Native American, modern, and European art.

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 history of the Pacific Northwest with engaging exhibits and programs.

Seattle is famous for live theater. The 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 the Seattle Mariners baseball team will be playing home games against Baltimore (May 18–20) and Detroit (May 21–23) the week before SID 2004, and three home games against Toronto following SID (May 31 – June 2) (Fig. B). The full schedule is available at www.mariners.org. Tickets are available in advance from Ticketmaster at 206/622-4487 or www.ticketmaster.com.

Seattle Mariners

*B. Safeco Field, where Ichiro Suzuki and the other players of the Seattle Mariners will play the Detroit Tigers on May 21–23, just prior to Display Week.*

format will allow brief presentations and demonstrations of the Gold Award winners.

### Applications Tutorials

On Tuesday, Wednesday, and Thursday mornings at 7:30 a.m., there are two parallel, 90-minute tutorials devoted to display applications, which are always well attended. The Tuesday Applications Tutorials are

- ***Electronic Paper: The Quest for the Killer Application*** (Paul Drzaic, Alien Technology) and
- ***Étendue and Its Application in Light-Engine Lumen Budgeting*** (Tony McGettigan, OCLI – A JDS Uniphase Company).

On Wednesday, the Tutorials are

- ***Applications for OLED and Alternative Display Solutions*** (Kimberly Allen, iSuppli/Stanford Resources) and
- ***Medical Display Metrology*** (Aldo Badano, Center for Devices and Radiological Health, U.S. Food and Drug Administration).

Thursday's Tutorials are

- ***Display Technologies for Mobile Applications*** (Zili Li, Motorola Advanced Technology Center) and
- ***Display Electronics for DTV and HDTV*** (Nikhil Balram, National Semiconductor Corp.).

### Tuesday Evening Panel

A 57-in. AMLCD prototype has now been built, 45-in. AMLCD-TV sets will be on the market this summer, and Gen 6 fabs will soon be coming on line that use motherglass in the vicinity of 1800 × 1200 mm. In ***How Large Will AMLCD Manufacturing Go?***, moderated by Charles W. McLaughlin (McLaughlin Consulting Group), the panelists will size up the situation. The panelists are Robert Bachrach (Director of Technology, AKT, Inc.), Bruce Berkoff (Executive Vice President, LG.Philips LCD), Peter Bocko (Division Vice President, Corning Display Technologies), Won Kie Chang (Senior Vice President, AMLCD Division, Samsung Electronics Corp.), and Takao Taguchi (Manager, Display Laboratory, Toppan Printing Co.). The panel discussion is sponsored by Corning Incorporated.

### Wednesday Luncheon and Special Event

The festive Wednesday luncheon will feature computer-graphics legend Alvy Ray Smith – co-founder of Pixar, former Director of Computer Graphics Research for Lucasfilm, founder of Altamira Software, and winner of two Academy Awards. In his presentation, ***Are We Really Here?***, Smith will look at what it takes to generate realistic images of virtual people. The luncheon is sponsored by Samsung Semiconductor.

On Wednesday evening, Merck KGaA, Darmstadt, Germany, will sponsor the Special Event in celebration of the 100th anniversary of commercial liquid-crystal production. The

## Getting to Seattle

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. Shuttle Express is a ride-sharing door-to-door van service. The fare from SEA–TAC 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. Their booth is located alongside the SEA–TAC ground-transportation information center. Coordinators in red jackets or vests are there to assist customers between the hours of 7:00 a.m. and 2:00 a.m. Those who arrive between the hours of 2:00 a.m. and 7:00 a.m. may use the courtesy phone in the Shuttle Express booth.

If you would prefer to take a cab, you can get a STITA Taxi (206/246-9999) at the ground-transportation center. Fares are approximately $30 to downtown Seattle, depending on traffic conditions. There are other taxi companies, but STITA is the only one permitted to wait for fares at the airport without requiring the traveler to call first.

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 a few blocks of the Convention Center (see the Official Housing Request form located on pages 56 and 57 of this issue). To make hotel reservations, log on to www.globetrottermgmt.com/sid, or call 301/570-0800 (press 2) for information.

## 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.

## Monday Night Awards Banquet

SID's awards for individual achievement are presented at a banquet held on the Monday of Display Week at 8:00 p.m. Attendees must order their tickets in advance; there is a convenient place to do this on the Advance Registration Form available at www.sid.org.

SID confers three principal awards for individual technical and scientific achievement: The Karl Ferdinand Braun Prize for an outstanding technical achievement in, or contribution to, display technology; the Jan Rajchman Prize for an outstanding scientific or technical achievement in, or contribution to, research on flat-panel displays; and the Johann Gutenberg Prize for an outstanding technical achievement in, or contribution to, printing technology.

At the Monday Awards Banquet this year, the Karl Ferdinand Braun Prize will be awarded to Shuji Nakamura for his pioneering inventions of high-efficiency blue, green, and white gallium nitride light-emitting diodes for full-color large-area outdoor displays and LCD backlighting. The Jan Rajchman Prize will be awarded to Tatsuo Uchida for his outstanding contributions to the science of liquid-crystal molecular alignment and the technology of high-performance LCDs. The Johann Gutenberg Prize will be awarded to Masaki Kutsukake for his development of high-quality sublimation transfer imaging media and their commercialization.

The Lewis and Beatrice Winner distinguished-service award will be awarded to Jay Morreale for outstanding service to the publications and conferences of SID.

In addition, Honors and Awards Chair Larry Weber has revealed that six new SID Fellows will be named at the Banquet, and six Special Recognition Awards will be announced.

event is an evening at the spectacular Museum of Flight at Boeing Field. The museum incorporates many exciting aircraft and space vehicles, including a newly arrived British Airways *Concorde*, and a Curtiss *JN-4D Jenny* with its intricate woodwork left exposed. Participants will have free use of the museum's flight simulators, at least one of which is not recommended for use after dinner. ■

# A Slim CRT to Compete with Flat Panels

*It is now possible to make a more-or-less conventional CRT much slimmer than before – if a system-level design process is used.*

by Frits C. Gehring, Joost van der Heijden, and Jan van Knippenberg

SIGNIFICANT ADVANTAGES in the physics behind the operation of color picture tubes (CPTs) based on cathode-ray tubes (CRTs) will be necessary to make them as thin as liquid-crystal displays (LCDs) or plasma-display panels (PDPs). However, this does not mean that CRT-based CPTs cannot become slim enough to meet consumer demands for affordable large-screen TV sets with depth profiles that suit modern lifestyles and interior design. LG.Philips Displays has recently developed new 4:3 format and wide-screen SuperSlim CPTs with a maximum depth of 35 cm in the region of the gun and a much shallower profile over the rest of the screen area, allowing them to be accommodated in slim TV-set designs.

## Market Demand

In 2002, 96% of the TV sets produced in the world were based on CRT technology, and it is still predicted that as far out as 2006 more than 85% of TV-set production will remain CRT-based. Despite having its origins in a technology that was invented more than 100 years ago, the CPT continues to offer a combination of price competitiveness and picture quality that has kept it at the forefront of TV-set production. CPTs are renowned for their vivid color rendition, excellent contrast ratio, and absence of motion artifacts (motion blurring or smearing), while still enabling TV sets to be offered at the price points needed to put one or more sets into virtually every home in the Western world and a very high proportion of homes in developing countries as well.

In terms of the viewing experience it offers to consumers, CRT technology has always competed well with other display technologies, and continues to do so against PDPs and LCDs. With the introduction of very flat CPTs over the last few years, even the perfectly flat screen of flat-panel displays (FPDs) has been matched by CRT technology. This continues to make front-of-screen performance comparisons among CPT, PDP, and LCD TV largely subjective.

Nevertheless, flat panels such as PDPs and LCDs have a major advantage over CPTs in one major respect: they have a much shallower depth than conventional CPTs. Despite the obvious appeal to consumers, however, this flat-panel appearance comes at a price. Typical 32-in. wide-screen plasma TV sets, for example, retail at 3–5 times the price of equivalent CPT-based TV sets, while 21-in.

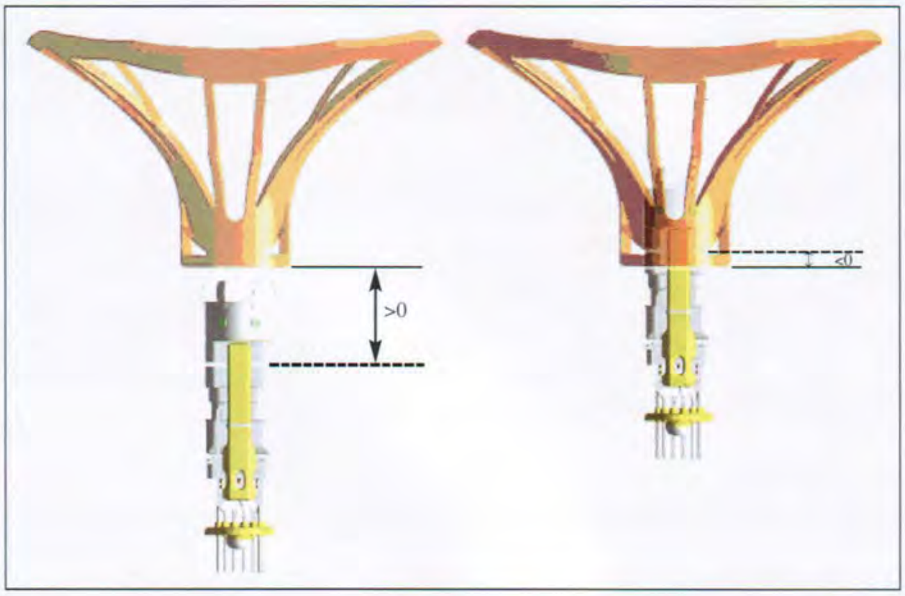



***Fig. 1:** LG.Philips Displays' new 21-in. SuperSlim Cybertube+ CPT reduces the depth of a 21-in. TV set by 25%.*

***Frits C. Gehring** is Manager, CPT SuperSlim, at LG.Philips Displays, Building RE-p, Zwaanstraat 2a, 5651 CA, Eindhoven, The Netherlands; telephone +31-40-2304-216, fax +31-40-2304-197, e-mail: frits.gehring@lgphilips-displays.com. **Joost van der Heijden**, CPT Architect, and **Jan van Knippenberg**, Global CPT Product Manager, are also at LG.Philips Displays in Eindhoven.*



0362-0972/04/2004-022$1.00 + .00 © SID 2004

LCD TVs typically retail at 2–3 times the price of their CPT equivalents.

Although the stylishly slim appearance of PDP and LCD TVs clearly appeals to consumers, those who buy them typically continue to place these sets on stands rather than mount them on a wall. Ironically, to achieve the necessary stability, the stand is quite often considerably deeper than the TV set itself.

### Breakthrough in CPT Design

By adopting a system-level approach to tube design, LG.Philips Displays has succeeded in reducing the total depth of CPTs to a mere 35 cm, even for wide-screen tube sizes up to 32 in. Because this depth applies only to the gun, with a much shallower profile being achieved over the remainder of the tube area, these new CPTs will allow set makers to produce stylish new TV sets that appear slightly deeper than flat-panel types.

The difference in depth between a 21-in. TV set containing a standard very flat CPT and one produced using the new 21-in. SuperSlim Cybertube+ CPT is substantial (Fig. 1). The figure illustrates the very high flare in the glass cone at the back of the tube, which makes it possible to produce TV sets with a slim appearance.

A system-level approach to the design of the new tube was required because good front-of-screen performance in these depth-reduced tubes depends on complex interactions among the gun, deflection yoke, shadow mask, and screen. Therefore, the design space for optimizing parameters such as spot size and homogeneity can easily encompass two or three of these components and none of them can be designed in isolation.

The main reduction in tube depth is achieved by moving the electron gun forward into the deflection yoke, which means that the electron beam begins to be deflected and distorted by the yoke's magnetic field before it exits the gun (Fig. 2). The gun design thus required simultaneous analysis of the effects of both electric and magnetic fields. In the gun design for a conventional tube, only the electric fields would have been considered.

Another example of the interaction between tube components is the way the deflection yoke and shadow mask distort the beam before it strikes the screen. At the very large deflection angles required in SuperSlim Cybertube+ CPT – 110° in the 21-in. 4:3-format tube and up to 125° in the 32-in. wide-screen version – the spot becomes vertically compressed and horizontally stretched. Analysis of these combined distortions led to the conclusion that additional beam-forming electrodes in the gun to pre-distort the beam would counter this effect. As a result, the new tubes achieve excellent spot size and homogeneity over the entire screen area.

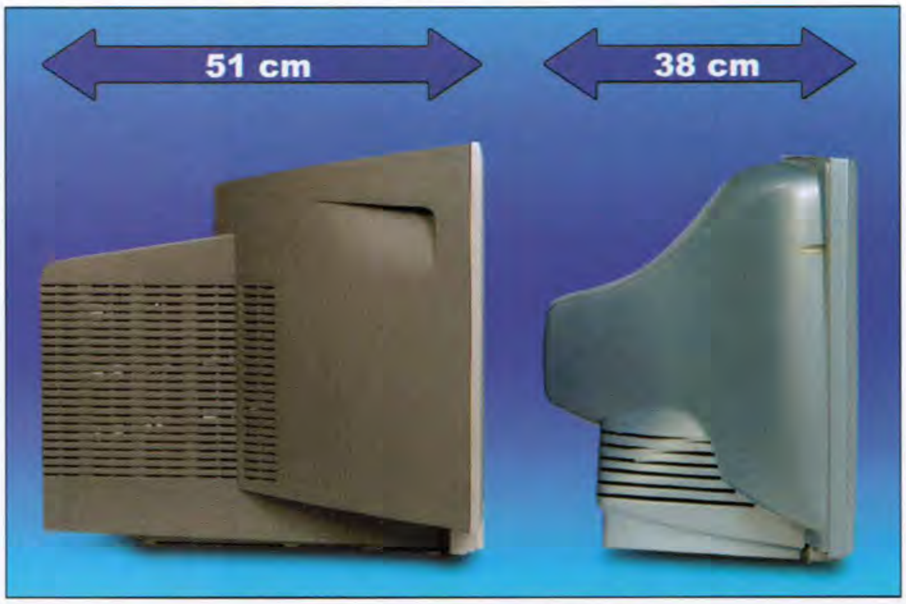



*Fig. 2: Moving the electron gun forward into the deflection yoke reduces the tube depth but requires simultaneous analysis of both electric and magnetic deflections in both the gun and yoke designs.*

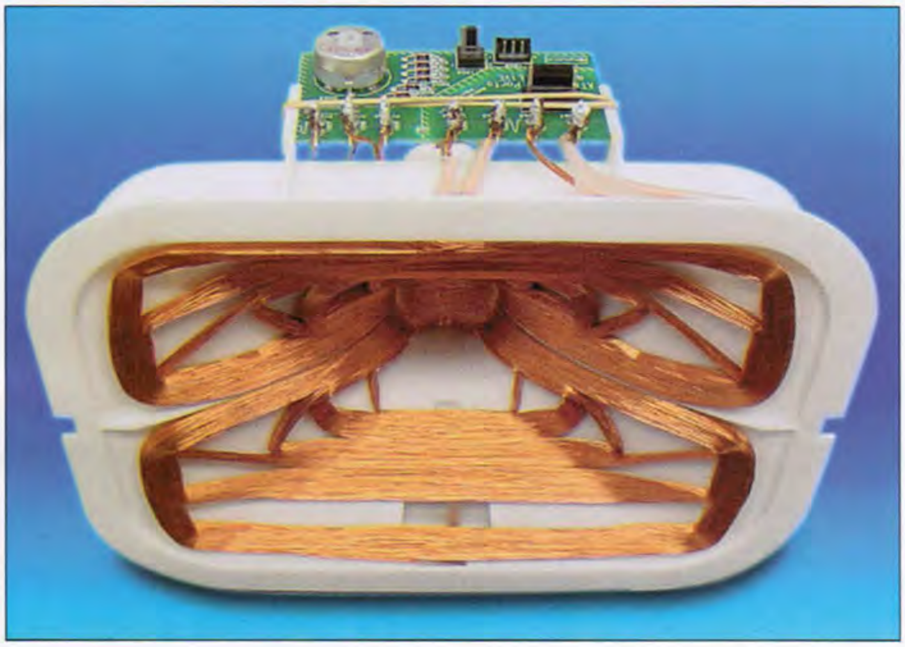
Because spot performance has been achieved without resorting to dynamic astigmatism and focus (DAF) control, the electron gun is less complex and the design of the chassis electronics is simplified. As a result, the 21-in. SuperSlim Cybertube+ CPT, which is currently in volume production, marries almost instantly with a standard 25-in. TV chassis. (A 25-in. chassis is needed only because of the required deflection sensitivity.)

Advances in the gun, such as the reduction in gun pitch from 6.5 to 5.5 mm and the incorporation of special beam-forming electrodes, have been achieved through the use of advanced computer-aided simulation techniques that accurately model the behavior of the electron optics. As a result, the gun used in SuperSlim tubes outperforms the zero-DAF guns used in the company's existing 21-in.-tube range and equals the performance of the DAF gun used in its existing 32-in. Cybertubes.

The design of the deflection yoke has also been fine-tuned in the new tubes. Specially developed computer-aided-design tools have been used, allowing the geometry of the windings in the rectangular-coil deflection yoke to be adjusted for optimum deflection sensitivity, color convergence, and picture geometry (Fig. 3). As a result, even the 32-in. wide-screen version, which features a deflection angle of 125°, achieves a deflection sensitivity of just below 50 mJ, convergence errors of less than 1.5 mm, and geometric distortion of less than 2 mm. An example of the rectangular-coil deflection yoke used in these tubes is shown in Fig. 3.

Because of the large deflection angle of this tube, the electron beam strikes the shadow mask at a very shallow angle close to the edges of the screen. Optimization of the mask curvature and careful design of the mask suspension system has compensated for this effort, resulting in ambient and local doming performance that matches that of a conventional 32-in. tube.

The uniquely shallow profile of SuperSlim tubes, particularly at the edges, has been achieved by employing high-surface-compression-glass technology. This technology enhances the glass strength without the need to increase its glass thickness. It can only be



LG. Philips Displays

*Fig. 3: The rectangular-coil deflection yoke used in the new slim tubes is designed using specially developed CAD tools.*

employed when there is very close control over the glass quality, heating and cooling processes, and the pre-stressed areas of the glass envelope.

### Lower Cost of Ownership

Because of their shallow profile, SuperSlim Cybertube+ CPTs use less glass and therefore weigh less than conventional tubes of the same screen size. These reductions in both the depth and weight of the tube offer set makers significant savings in logistics, packaging, and transport costs. Compared to conventional 21-in. TVs, for example, about 50% more 21-in. SuperSlim Cybertube+ TV sets can be packed into a standard transport container, and each set needs less packaging around it. This makes the overall cost of ownership for these tubes highly attractive compared to that of conventional CPTs. Less packaging and lower transport costs also help set makers meet their environmental-impact targets.

### Ease of Manufacture

Although these new tubes represent a breakthrough in tube design and, consequently, in CRT-based TV styling, they can be manufactured using standard CRT-production processes. As described earlier, the breakthrough has been achieved by taking into account the interactions between the different components rather than a radical redesign of any single part of the tube. As a result, set makers benefit from the combined advantages of a proven display technology and proven manufacturability, coupled with the excellent front-of-screen performance for which CPTs are known.

The 21-in. 4:3-format SuperSlim Cybertube+ is currently in volume production at LG.Philips Displays' factory in Durham, U.K., and has required little or no modification to standard manufacturing processes. In fact, the combination of gun, deflection-yoke, shadow-mask, and glass design improvements actually make this tube more robust to manufacture and use than some previous designs. There are already strong indications that the 32-in. wide-screen version, which is currently being prototyped, will likewise prove to be highly manufacturable and will marry with a standard 32-in. TV chassis. We anticipate that dramatically thin set styling will be achieved with these 32-in. tubes (Fig. 4).

### Ubiquitous Displays

Many homes already contain several TV sets, and with the emergence of wireless-digital-networking standards, such as Wi-Fi (IEEE 802.11), which allows audio and video to be streamed anywhere in a house, it is all but certain that this trend will continue. Consumers, however, will no longer be looking for low-cost portables mounted on obtrusive wall brackets to fulfill the requirement for TV sets in their bedrooms, playrooms, kitchens, and studies. They will increasingly look for large-screen TV sets that give them a true "living room" experience in terms of picture and sound quality. With developments such as the SuperSlim Cybertube+ CPTs, the cost of enjoying that performance will not be prohibitive. ■

*Fig. 4: The 32-in. SuperSlim Cybertube+ flat-screen TV sets do not occupy much more furniture space than typical 32-in. LCD TVs.*

opinion

# Do Consumer Front Projectors Have a Future?

*Rapidly falling prices and improving performance could make front projectors for TV a mass-market product, but manufacturers must provide more installation flexibility and the industry must get serious about honest consumer education.*

by Brian Patrick

FRONT PROJECTION has quickly become a mainstay of modern business communications. The development of commercial front projectors was influenced by the advances made in personal computers and consumer electronics and the explosion of the Internet. But front projection has not permeated the consumer market in the same way. Primary reasons for this lack of adoption include traditionally high prices, lackluster motion-video performance, and difficulty or inflexibility of installation.

In the last few years, we have seen prices in the front-projection arena drop markedly, and manufacturers are building projectors to meet the demands of an increasing number of home-theater enthusiasts. As the consumer's appetite for immersive home entertainment grows, many display-industry analysts wonder if front projection will take off as a consumer television and display technology for a larger mass market (Fig. 1).

If this is to happen, it will be necessary to educate the average user – a daunting task. But for once, projection itself has the chance to revolutionize our electronic way of life instead of merely *adapting to* previous consumer revolutions, such as the home videocassette recorder, DVD player, personal computer, and the Internet.

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### Technology Trends and New Applications

The desires of technology-savvy consumers are quite different from those of commercial users. Consumers need a display that will reproduce motion video accurately. Even with the wonderful advances that have been made in commercial front projection, many business users are not concerned about creating perfect images for ordinary use. The venerable cathode-ray-tube (CRT) television served the average consumer well for many decades by simply doing an effective job of reproducing the broadcast signals it received. Now that digital television (DTV) is gaining acceptance among consumers and popular digital programming is widely available, the modern television must adapt to multiple scan rates, resolutions, aspect ratios, and connection types.

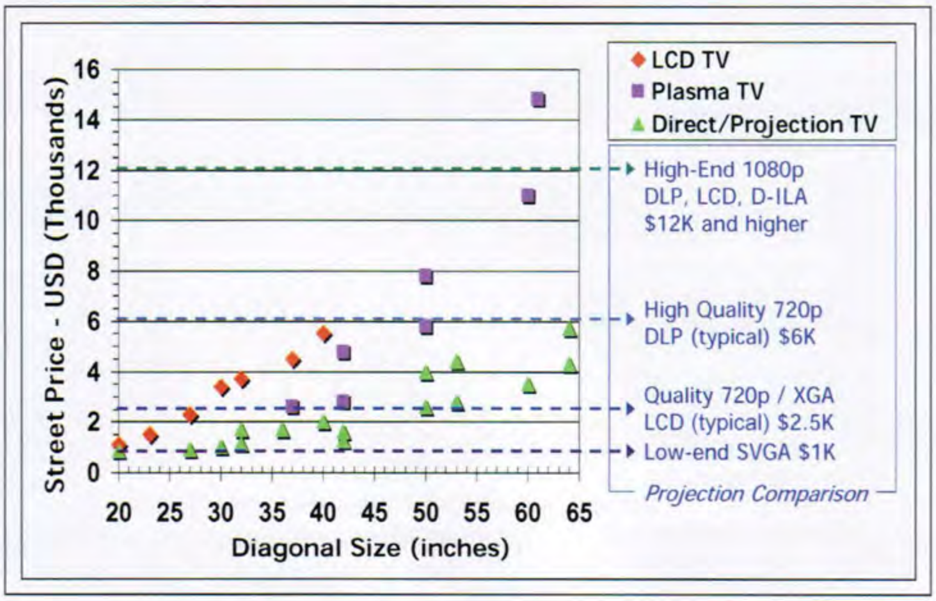


*Fig. 1: Projection becomes more price competitive as image size increases. Here street-level prices of typical self-contained consumer displays and various levels of front-projector technology are compared. (Data provided by Beyen Corp.)*



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Motion-video entertainment is the obvious driving force behind a consumer's purchase of a home-entertainment display. This has encouraged projector manufacturers to create machines with outstanding black-level performance, color saturation and accuracy, brightness uniformity, and up-scaling. Many of the prime-time television shows in the U.S. are transfers from 35mm film, which require very good black-level performance from the display. In North America, the exponential growth of the home-gaming industry, particularly in the PC-based segment, further supports the need for a display suited to high-resolution fast-moving images.

A minor driving force behind consumer projection is the display of personal camera images. Manufacturers can add functionality for still digital pictures with flash-memory-card or PCMCIA-card inputs. Other inputs may accept high-performance camcorder outputs, including IEEE 1394 or progressive-scan connections.

Personal computing frequently migrates into the home theater. While there are often conflicting demands for living-room PC use and television viewing, many consumers want to watch TV and surf the Internet on the same display from the comfort of their living-room couch. Some projector manufacturers have responded with picture-in-picture (PIP) capabilities, such as video windowed over the PC feed. But for home computing, whether personal or home-office, most average projectors will usually suffice. Again following the lead of the computer industry, the DVI input is now commonplace – if not the new standard – for PC connections.

It is worth remembering that the lines often blur between appliance- and PC-based entertainment. The rise of low-cost multimedia PC solutions continues to expand the do-it-yourself PC enthusiast's passion for quality entertainment.

The computer and audio–visual (AV) industries continue to merge technologies with some success. Many portable projectors incorporate wireless networking for control or maintenance as well as for transporting video images. True full-motion video has yet to be integrated into a consumer projector wirelessly. Many manufacturers are advocating for this solution for the mobile professional and for retrofit installation. Low-cost wireless video transmission could definitely help the consumer overcome the installation difficulties of connecting sources to the projector. Currently, Wi-Fi IEEE 802.11 wireless solutions dominate the successful implementations of wireless image transmission for projectors. Many manufacturers have been demonstrating new wireless-transmission techniques at recent conventions such as the Consumer Electronics Show (CES).

Networkable projectors are bringing innovation to the professional installed market. Such technologies could converge in the home market to create projectors with built-in Web-serving or mini-embedded PCs.

While imaging technologies still compete in the consumer market, digital-light-processing™ (DLP™) technology has risen to the top as the technology of choice for discerning consumers with a healthy AV budget. Most DLP-projection applications will use single-chip engines mated to color wheels designed for better black-level performance and color saturation at the expense of brightness. The Texas Instruments 1280 × 720 HD2 digital-micromirror-device (DMD™) chip should dominate the affordable and state-of-the-art home-theater marketplace for at least the next year. Nearly every major manufacturer wishing to penetrate the home-theater market will create a projector based on this DLP technology, with a few stalwart liquid-crystal-display (LCD) holdouts.

In the mid-priced majority of home-projection entries, there will be a significant number of low-end projectors, a mix of DLP, LCD, and liquid-crystal–on–silicon (LCoS) units with a low-cost 4:3-aspect-ratio chip and panel technology (Fig. 2). Recently, products such as the Sanyo PLV-Z2 have broken new ground, and initial market response has been excellent. This sub-$3000 unit marks a lower-cost alternative to the DLP solution that is attractive to a larger number of users, while maintaining a 1000:1 on/off contrast ratio, a luminance of 800 ANSI lumens, a resolution of 1280 × 720, and high-definition (HD) compatibility using 16:9 LCD panels. Similar to the DLP models, this and other home projectors sacrifice brightness for improved contrast using polarizing filters.

We could easily discuss state-of-the-art home projection at length, but these units do not exhibit the immediate sales-growth potential found in the consumer crossover segment. Three-chip DLP, D-ILA, and some LCD designs will continue to permeate the home market, particularly for large-screen home theaters and where high brightness is required. CRT projection is still available for video purists.

The next significant trend for the home-theater-enthusiast level of projection will probably be 1920 × 1080-pixel designs in sin-

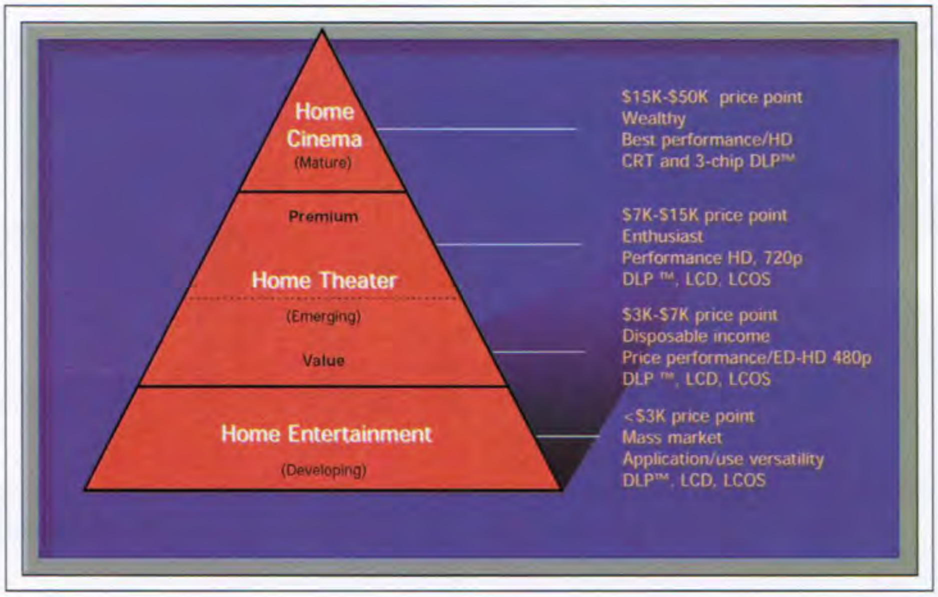



***Fig. 2:*** *Front projectors could become commonplace in homes if adoption is led by the new value-based "home entertainment" and price-conscious "home theater" segments. (Courtesy of InFocus Corp.)*

gle-chip-DLP and three-panel-transmissive-LCD designs. Sony's soon-to-be-released Qualia 004 three-panel LCoS projector uses this native HD resolution and claims outstanding performance, albeit at a cost only prosperous home-cinema aficionados can afford. This projector uses the well-known Carl Zeiss brand of optics familiar to consumers from various camera products. Three lenses are available for various projection distances – an important feature for home use.

Manufacturers are aggressively seeking ways to cut costs for their entry-level projectors marketed as potential replacements for large-screen TVs. But the current world economy makes importing parts to the U.S. even more difficult, and, for many parts, demand continues to exceed the supply. Reducing the cost of lamps is a top priority, both to reduce production cost for the manufacturer and life-cycle costs for the consumer. Even the $1000 projectors available today have replacement lamps that cost from $250 to $400 at retail.

A typical consumer may keep a conventional TV set for an average of 10 years, barring major technology changes, but we cannot predict that a home projector will survive that long. The consumer will spend more than $1000 on replacement projector lamps within that 10-year time period, assuming a 2000-hour lamp operating less than 3 hours per day. However, this should be acceptable to most users in exchange for enjoying significantly larger images.

Extending the lifetime of projector lamps to reduce life-cycle costs for the consumer is already being addressed. Some projector/lamp combinations are claiming 4000-hour lamp life using a lower lamp striking voltage. Putting this control in the consumer's hands offers the flexibility to choose high brightness during daylight hours and a low brightness when ambient light is not an issue.

In general, the common mercury-vapor lamps used in projectors are still an expensive part of the light engine. But in addition to lower direct cost, manufacturers want better standardization of components such as lamps. A lamp design that does not change form factor quite so often means lower engineering cost to the projector manufacturer.

In order to satisfy the needs of most users, many vendors are creating basically similar projectors, but with varying levels of sophistication at different price points. This strategy attempts to appeal to a wider consumer group. While this is not new to the industry, the classification of comparison groups for projectors between $1000 and $3000 has just begun.

Another variation on this approach already in use at the commercial level is the availability of advanced options that can be purchased separately. An optional feature using a highly recognized vendor's chip technology might make the purchase more attractive to the advanced or educated consumer. This approach has proven successful for several manufacturers in regard to the Faroudja DCDi™ deinterlacing chip, and there is no shortage of very-high-quality scaling chipsets available on the market.

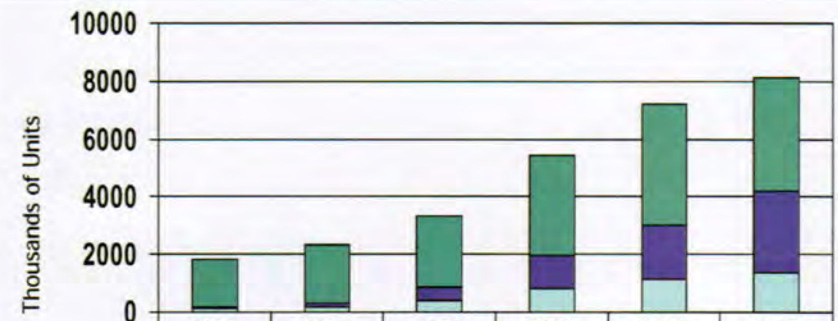
Many inexpensive consumer TVs incorporate dual-tuner PIP, and consumers have come to expect it. For a pure home-theater application, this is not important. Some enthusiasts are windowing baseband video over high-resolution RGBHV/DVI/480p component sources to gain the dual-tuner PIP function. Incorporating an RF demodulator for over-the-air (OTA) broadcast or standard cable-television reception will be useful for some users. However, the potential projector buyer will probably already own an advanced cable, satellite, or OTA tuner; and a $50 VCR will allow for basic television tuning. Perhaps an optional cable tuner on an input card is appropriate as a low-cost add-on.

Many of the professional-projector manufacturers now produce high-quality consumer units in addition to supplying the vendors whose brands are only found in the home-theater market. This move has brought the "Professional AV Channel" into the home-projector arena, which until recently has been a boutique market. The possibility that the home projector may soon be perceived as "mainstream" is very exciting to manufacturers.

### The New Mainstream

The recent increase in the availability of $1000 street-priced units has created an unusual amalgamation of users referred to as the "crossover segment." This user group exists only because of the recent affordability of projection, and industry analysts cannot describe it as either consumer or professional. Pacific Media suggests that sub-$1000 "crossover" and all other consumer projector sales could exceed established market professional sales by 2007 (Fig. 3).

Manufacturers understand the need to build a high-quality projector at a very reasonable price. What is "reasonable" varies over time as each new generation of display technology somewhat obsoletes its predecessor. Prices fall and the performance standards increase. For example, in the fall of 1999, Sony released the VPL-VW10HT LCD projector, which was competitively priced for the consumer market. It was a well-performing unit that was, at the time, the only native 16:9 HD-capable projector available. Perhaps it was the then-unique wide-screen feature, coupled with a design based upon motion video rather




| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| $1000-Plus Pro | 1664 | 2012 | 2462 | 3439 | 4193 | 3942 |
| Sub-$1000 | 22 | 153 | 454 | 1165 | 1884 | 2813 |
| $1000-Plus Con | 153 | 178 | 422 | 811 | 1139 | 1390 |

***Fig. 3:** Some analysts believe that sales of sub-$1000 projectors may surpass all others in consumer and professional markets by 2007. (Courtesy of Pacific Media Associates).*

than computer data, that caused home-theater enthusiasts to purchase these units at a remarkable rate. It was just what many were looking for, a very good video projector without the maintenance trouble and cost of CRT projection. Such niche-market dominance will be more difficult now that there are several competing projectors in the marketplace. On the other hand, the enormous installed base of aging CRT-projection sets offers great potential for sales – along with great obstacles for consumer acceptance.

While many potential buyers use the Internet to research and often purchase technology items, the vast majority still want to touch, see, and hear any product that is significantly expensive before buying it. This is especially true of consumer displays. In the U.S., most of the major retail department stores and electronics stores are selling flat-panel plasma, LCD, and DLP-projection TVs alongside direct-view and projection CRT televisions. It is extremely rare to find a front projector in this environment. When one is spotted it is usually lost among the hundreds of TV sets or relegated to a special hooded kiosk placed in the store at a very high cost to the manufacturer.

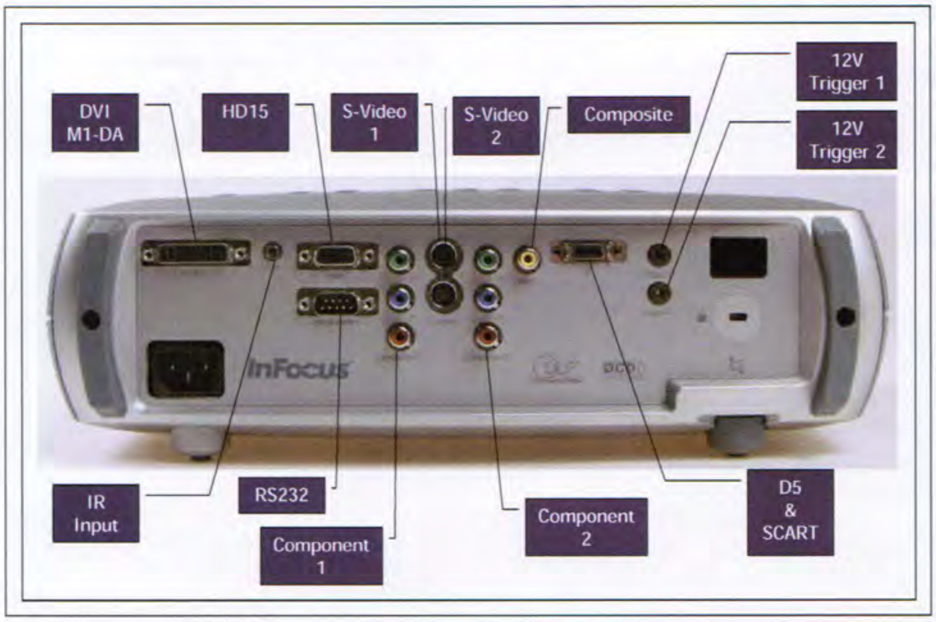



*Fig. 4: Most state-of-the-art home-theater projectors incorporate a variety of connectivity options to satisfy the needs of the majority of consumers, as is the case with the InFocus ScreenPlay™ 7200 Projector. (Courtesy of InFocus Corp.)*

## Connectivity and Installation

A ubiquitous connectivity standard is greatly needed in the home-projection market. Currently, DVI has gained favor as the connection of choice for high-resolution sources such as HD-capable digital satellite receivers and state-of-the-art DVD players. In both of these set-top sources, the HDCP encryption standard created by Intel and licensed by Digital Content Protection can be found. Consumers seeking the best possible digital-video experience will be very disappointed when they realize their recently purchased projector's DVI input will not translate the HDCP-coded video.

Nevertheless, connectivity options abound on most state-of-the-art home-theater projectors in order to please the majority of consumers (Fig. 4). In the future, I would like to see a projector/switcher combination with a single cable or wireless connection between the switcher and the display engine. Inputs could be modular, easily allowing customization for each end user. If consumers needed additional connections to match their source equipment, upgrading their projector investment would be inexpensive. For slightly different reasons, this approach was very common when CRT projectors were the sales leaders.

Some consumers want a rear-wall or ceiling-mounted projector, but many users would rather install their projector on or under a coffee table much closer to the projected image. The standard zoom lenses centered around a throw distance of twice the screen width simply do not meet everyone's needs for a projector to replace the TV set. It would be very desirable for lens manufacturers to create field-replaceable low-cost optional lenses for low-cost projectors. At the time of sale, the consumer would decide what lens was needed based on how the projector was intended to be placed in the room.

## Education

As with any modern technology that proves to be useful and desirable to the public, the device must be extremely simple to operate – or education of the consumer must be part of the sale. In the context of consumer front-projector purchases, education of the consumer must cover the following:

- Necessary and/or desirable features.
- Integration of the projector into the AV environment.
- Expectations, including maintenance, over the product life cycle.

A major U.S. electronics retailer recently began selling a handful of sub-$3000 projectors. But these units are not actively displaying images in most of their stores. Consumers are currently handicapped by the lack of brick-and-mortar establishments displaying projectors to the public. Projection screens are also suffering this fate. Europe seems to be far ahead of the U.S. in this area.

For widespread consumer adoption, a new channel is needed that will devote resources to displaying images from multiple projectors in a seven-day-a-week retail environment. Currently, manufacturers must rely on Web sites that review projectors to promote sales for their products. Many of these sites, including user-group listservs and bulletin boards, can both educate and confuse potential buyers because postings may be unregulated and inaccurate.

Unfortunately, because of commercial competition, most retail stores at which the majority of consumer electronics is purchased follow a model that is at odds with educating the public about the complexities of front projection. To be blunt, the average retail salesperson is not qualified to educate the consumer about projection-technology purchases. Part of the difficulty is the lack of units available for retail sale, mainly because of price. Many manufacturers provide a brief "features" list to serve as product specifications, but this is dangerous for front projectors. Videophiles aside, the public simply has no idea what they are getting into when considering a home-theater projector, and retail sales staffs are, in general, improperly educated about current technology.

Perhaps there is a way for manufacturers to distill the relevant technical information into a format easily digestible by the consumer. I am not saying that true standards-based specifications should be unavailable to the consumer, but a simple high-level technical text could make terms foreign to consumers part of their lexicon. ■

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# FPD International 2003

*With its exhibition of new display modules, manufacturing equipment, components, and materials – together with strategy statements from senior executives and an opportunity to do serious business – FPD International 2003 drew more than 50,000 visitors to Yokohama.*

## by Ken Werner

FORMERLY known as LCD/PDP International, FPD International is a major display-industry exhibition held annually at the Pacifico Yokohama Exhibition Center in Yokohama, Japan, along with an accompanying seminar program (Fig. 1). FPD International 2003, held October 28–31, 2003, marked the event's 10th anniversary with a visitor total of 55,257, compared with 46,004 in 2002, said Kazuya Sasaki of Nikkei Business Publications, the event's General Manager. In 2003, 243 exhibitors, 16% more than in 2002, displayed their wares in 531 booths, Sasaki said.

FPD International is multi-faceted. It is an event at which the members of the Asian display industry communicate with each other and their OEM clients. It is where the latest lines of LCD and PDP modules are shown to prospective customers, the reception of new product ideas is evaluated, and developers of new display technologies show their prototypes to let potential customers know that they are in the game. It is also a place where the world's makers of display-manufacturing equipment, components, and materials show their wares to the industry. It was at the 2003 show that many got their first look at a piece of Generation 7 LCD motherglass, which measures roughly 1800 × 2100 mm (Fig. 2).

### LCD and PDP Modules

With much fanfare, LG.Philips LCD took the lead from Samsung TFT-LCD in the continuing struggle between the two companies to produce the largest thin-film-transistor liquid-crystal-display (TFT-LCD) panel prototype (Fig. 3). The new LG.Philips LCD 55-in. TFT-LCD panel outstripped Samsung's previous record-holding display by a whopping one diagonal inch. This LCD-prototype battle between the two companies is in part a contest between two LC-cell technologies, with LG.Philips LCD championing super in-plane switching (S-IPS) and Samsung pushing the patterned vertically aligned (PVA) cell structure, which is a variant of the multi-domain vertically aligned (MVA) structure. LG.Philips LCD has developed an attractive IPS logo, which was displayed in various

Ken Werner

*Fig. 1: FPD International is a major display exhibition held annually at the Pacifico Yokohama Exhibition Center in Yokohama, Japan.*

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



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Ken Werner

***Fig. 2:** Many attendees got their first look at a piece of Gen 7 LCD motherglass at FPD International 2003. This piece was coated with amorphous silicon by Unaxis.*

booths on the show floor by LG.Philips LCD and its technological allies. Both technologies are capable of fast response times, especially with the help of overdrive technology. Better color fidelity is claimed for S-IPS at high viewing angles while higher luminance is claimed for PVA . (The arguments get much more complicated than that, but that is a discussion for another time.)

***Samsung SDI*** had its own world's record, a 70-in. plasma-display panel (PDP). Samsung SDI is not to be confused with Samsung TFT-LCD. Indeed, it sometimes seems as if the two Samsung companies compete more fiercely with each other than they do with LG.Philips LCD and other competitors. Large signs in the Samsung SDI booth, as well as badges worn by its booth personnel, seemed to be trying to establish an SDI brand independent of Samsung's.

Luminance and luminous efficacy have been challenges for PDPs, and tremendous effort has been exerted by PDP developers to improve these characteristics. The brightest and most efficient PDP at FPD International 2003 was claimed by the Taiwanese company AU Optronics Corp. for its 50-in. prototype. The unit, with 1366 × 768 pixels, boasts a luminance of 1200 nits and a luminous efficacy of 2.4 lm/W, which are impressive numbers. The high luminance of the AU Optronics Corp. PDP was readily visible, but other manufacturers were reaching 1000 nits – and doing it with production models rather than prototypes. NEC Electronics was showing 42-, 50-, and 61-in. PDPs, including a 61-in. prototype that was only 45 mm thick.

Over the last year or so, both LG.Philips LCD and Samsung TFT-LCD have been aggressive in communicating the idea that TFT-LCDs would inevitably surpass PDPs in quality and undercut them in price for TV sets in the largest sizes. That is not an idea that seemed to carry much weight among the PDP manufacturers at Yokohama, which included Matsushita, NEC, Pioneer, Fujitsu Hitachi Plasma, Chunghwa Picture Tubes, and Formosa Plasma Display, as well as Samsung SDI – all of whom were bullish at Yokohama.

Keiji Nunomura, Chief Manager at NEC Plasma Display Corp., which makes PDP modules for Sony, among others, and makes monitors under its own name for the business market, told *Information Display* that PDPs are less expensive to produce than LCDs. "A PDP," he said, "is a very simple structure." The electric-circuit costs of the PDP are higher, with relatively high voltages adding to cost directly and also through higher power consumption, which creates a need for more-expensive power supplies and other components. But efficiency and power consumption are being improved, and costs are decreasing by 15–20%, he said. Another angle of attack is to decrease the parts count, and that is also a major effort.

In the Seminar Program Keynote Session, Ken Morita, V.P. of Matsushita's Panasonic Visual Products and Display Devices Business Group, also addressed the cost issue. He agreed that the PDP has high-voltage drivers, which are more expensive than LCD drivers, but the backlight unit and color-matrix filter in an LCD TV are also expensive components, and it is hard to reduce their cost. "So," Morita said, "for 37 in. and above, PDPs will be less costly. And PDP processes are


Ken Werner

***Fig. 3:** LG.Philips LCD introduced the world's largest TFT-LCD prototype at FPD International 2003 – 55 diagonal inches – temporarily taking the lead in its rivalry with Samsung TFT-LCD. On the screen is the new IPS logo, which could be seen in several booths on the show floor.*


Ken Werner

***Fig. 4:*** *Sharp's System LCD Panel with Integrated Audio Circuit, which utilizes NXT's SoundVu® technology, drew long lines.*

simpler than LCD processes," he added. Panasonic attained a 90% yield for all PDP models in 2002 and is rapidly adding capacity to meet demand. The company's first Shanghai factory is producing 45,000 units per month, and they are adding a second factory to produce an additional 80,000 units per month, which will go on line starting in late 2004.

Bruce Berkoff of LG.Philips LCD has said he feels that PDPs will have trouble competing with LCDs between 30 and 40 in., and Sharp seems to be voting with its product line, pushing LCD TVs with 30- and 37-in. diagonals in Yokohama (as well as smaller sizes), but nothing above. So, in the near term, it seems that we will see direct large-screen-TV competition between PDPs and LCDs only at 37 in., with everybody seeming to agree that the area above 40 in. is PDP territory.

All of the major purveyors of PDP modules exhibited at Yokohama. Chunghwa Picture Tubes Ltd. (CPT), the first commercial manufacturer of PDPs in Taiwan, supplies 46-in. PDP TVs to Gateway in the U.S., and, two weeks prior to FPD International, inked an agreement to provide PDP TVs to Haier, the large Chinese consumer electronics and appliance company. The current fab is optimized for 46-in. panels, said George Liu, and that is the only size being produced now. A new manufacturing line opening next year will produce 42-, 50-, and 63-in. panels, he said.

Fujitsu Hitachi Plasma Display (FHP) showed its extended ALiS (e-ALiS) 55-in. HD (1366 × 768) PDP. The 16:9 panel has a luminance of 1000 nits – and looks it. FHP also showed 32-, 37-, and 42-in. 16:9 ALiS panels with luminances ranging from 1000 to 1100 nits. Sharing a sizeable booth with FHP was Formosa Plasma Display Corp. (a partnership between Formosa Plastics Corp. and FHP), showing its good looking 42-in. VGA F1 module with 852 × 480 pixels, 700 nits, and a 2000:1 contrast ratio.

Brightness, contrast in bright rooms, efficiency, and motion artifacts have been issues for PDPs, but LCD TVs have their own challenges. A major one has been making the response time from one gray level to another – the so-called gray-to-gray (GTG) response time – fast enough so that rapidly moving video images do not smear. Overdriving, or response-time compensation (RTC), has improved the situation markedly, and many of the TFT-LCD modules for TV applications shown at Yokohama used RTC to obtain GTG switching times of 12 msec. The results were generally impressive and might satisfy most TV viewers, but more can be done.

Sanyo Electric Corp. had a 101-cm (39.6-in.) WXGA TFT-LCD module with portrait orientation and a response time of 8-msec GTG, and Hitachi Displays, Ltd., showed a new 30-in. 1280 × 768 TFT-LCD "WOOO" module with the company's Super Impulse Driving Method (SIDM). SIDM turns off the backlight for a period between frames, which Hitachi calls "black data insertion." The concept is somewhat analogous to that of the mechanical shutter used in motion-picture cameras and projectors, although the means here is optoelectronic. The results are impressive, with crisp motion, deep blacks, and subtle color gradations, all of which have been combined to give a remarkable sense of depth. TFT-LCD modules with black data insertion in 30- and 21.2-in. sizes are available to OEMs now.

Toshiba Matshushita Display (TMD) showed two 1280 × 720 TFT-LCDs with what appeared to be an 18- or 20-in. diagonal. One of the LCDs used the optically compensated bend (OCB) mode and had a total response of 5.5 msec. Next to it was a conventional TFT-LCD with 25-msec response time. The difference in motion smearing between the two panels was striking.

Bigger and faster are not the only goals for LCD makers. Sharp Corp. uses its CG Silicon, which is a very fast semiconductor material for TFTs, to build system electronics onto the glass substrates of some of its displays and to make very-high-resolution displays. One impressive example of such a "System LCD" was a 2.6-in. VGA TFT-LCD with 300 ppi. On this small display, it was possible to read a 22-line spreadsheet.

The major makers of LCD modules showed extensive product lines in Yokohama. Among them were LG.Philips LCD (Korea), Samsung TFT-LCD (Korea), AU Optronics Corp. (Taiwan), Chunghwa Picture Tubes Ltd. (Taiwan), Chi Mei Optoelectronics/IDTech (Taiwan), Hitachi Displays Ltd. (Japan), Mitsubishi Electric Corp. (Japan), Sanyo Electric Corp. (Japan), Sharp Corp. (Japan), HannStar Display Corp. (Taiwan), Toppoly Optoelectronics (Taiwan), Toshiba Matsushita Display (Japan), and BOE HYDIS Technology Co., Ltd.. (Whether BOE HYDIS is a


Ken Werner

***Fig. 5:** Epson put substantial energy into promoting its high-temperature-polysilicon (HTPS) TFT-LCD imagers for home-theater applications.*

Korean or Chinese company depends to some extent on which press release you read. Making a long story very short, Korean Hydis – originally the display business of Hyundai and then Hynix – was sold to China's BOE Group. Production on Gen 5 lines will begin in Beijing in 2005 for 17-in.-and-larger panels intended for TV. Smaller sizes for notebooks and monitors will continue to be made in Korea. BOE says the Gen 5 fab will be the first TFT-LCD fab in mainland China.)

## OLEDs

A year or so ago, only Kodak was showing a small full-color active-matrix organic light-emitting-diode display (AMOLED). At FPD International 2003, a variety of manufacturers were showing polished prototypes. ELDIS, a joint venture of the Semiconductor Energy Laboratory (SEL), Sharp, and Tohoku Pioneer were showing AMOLED prototypes that use the company's TFT backplanes based on CG Silicon. As is common in Japan, the company prefers to use the term organic electroluminescence (OEL) instead of OLED. On display in the ELDIS booth were a 4.3-in. VGA top-emission OLED prototype with an ELDIS backplane, a 2.4-in. full-color QVGA AMOLED with 170 ppi, a 2.1-in. QCIF+ full-color AMOLED, and a full-color passive-matrix-driven 1.1-in. display.

In his opening address in the Seminar Program Keynote Session, Shoichi Yamada, President and Representative Director of Tohoku Pioneer, said that ELDIS was currently in its final ramp-up stage and would be mass-producing CG-Silicon backplanes in 2004. Tohoku Pioneer will have a small CG-Silicon AMOLED in production in 2004, a 4-in. in 2005, and a 5-in. in 2008, Yamada said, and the company is targeting a market share of 30% (for both active- and passive-matrix displays) in 2008. As for OLEDs, "We are committed to becoming the world leader in the field," said Yamada. "OEL is not a simple technology, but it will create new fields of application."

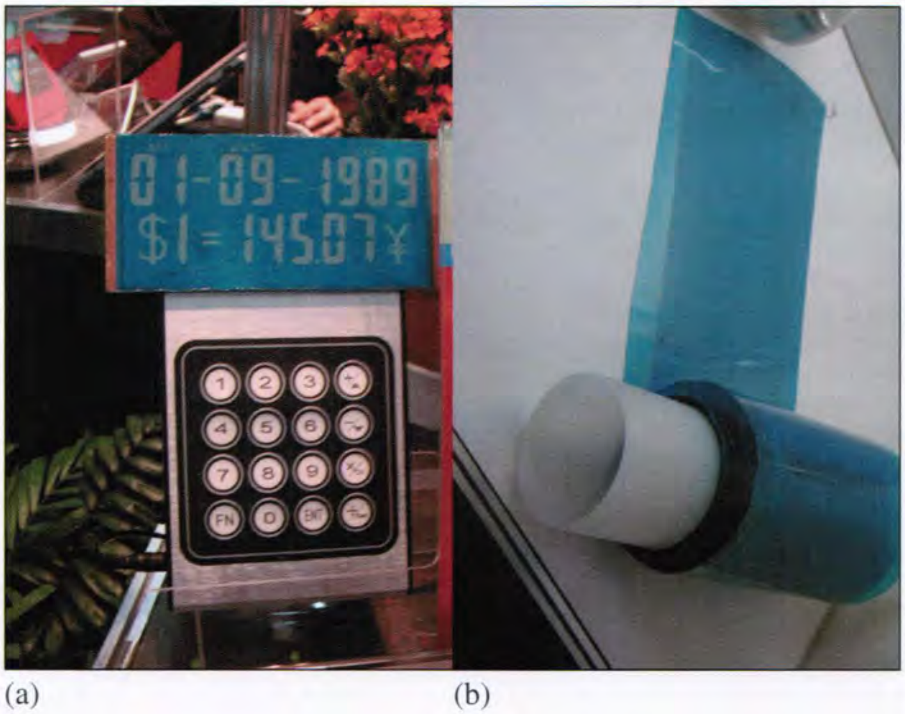
Sanyo, Kodak's partner in the manufacturing joint venture SK Display, showed several AMOLEDs using a white emitter plus color filter. A 2.5-in. unit with 240 × 320 pixels was particularly impressive.

Epson had a 2.1-in. polymer AMOLED fabricated with Epson's own ink-jet technology. The developmental unit had a 200:1 contrast ratio, 262k colors, and, said an Epson representative, a luminance of 100 nits with the polarizing filter in place. The TFT circuits were made with low-temperature polysilicon (LTPS), and the colors were produced with RGB bottom-emitting OLEDs. The game graphics being shown were fast and smooth, with well-saturated colors, but the images looked as if they would benefit from being brighter.

DuPont showed a 9.1-in. full-color WVGA 800 × 480 OLED, which was not too bright but looked good otherwise. Also on the stand was a single-color yellow-green 2.1-in. with 128 × 64 pixels. Kodak showed the 2.16-in. full-color AMOLED that won the SID/*Information Display* Display of the Year Award in 2002 as well as a 2.5-in. prototype.

AU Optronics Corp. showed a 1.93-in. AMOLED for mobile telephones with a luminance of 120 nits, a contrast ratio of 1000:1, and a fully compatible TFT-LCD driving interface.

Impressively, Samsung SDI exhibited a 15.5-in. 1280 × 768 AMOLED that appeared to be defect-free. With its response time of




(a) (b)

Ken Werner

***Fig. 6:** SiPix Imaging was proudly showing the latest iteration of its direct-drive bistable electrophoretic displays (a), the first displays to be made with roll-to-roll-processed material (b).*

less than 0.1 msec, Samsung's AMOLED – and other AMOLEDs, too – showed smooth motion and sharp contours. The combination of small "spot" size and freedom from motion artifacts makes OLEDs an attractive direct-view display technology for television. But we are a long way from mass production of large-sized OLEDs, and LCDs are always a rapidly moving target.

## Emerging and Miscellaneous

The scattering of 3-D displays on the show floor was a new phenomenon. Sharp has been particularly successful with its convertible autostereoscopic (no glasses) 2-D/3-D LCDs for cell telephones, which have become a fad with Japanese teen-agers, and has announced the availability of a 3-D notebook PC in North America. In Yokohama, Sharp was showing 3-D displays in 50- and 60-cm notebook sizes, and also in a 70-cm size for desktop monitors. Sharp uses its CG-Silicon process to build the electronics for the 3-D capability onto the glass substrate.

Sharp was also demonstrating its speaker-on-panel technology, which uses the NXT SoundVu® technology that won the 2003 SID/*Information Display* Display Material or Component of the Year Silver Award. Interest was intense, and the lines were long (Fig. 4).

Toshiba Matsushita Display (TMD) showed an input display, in which on-glass sensors can record the image from a piece of paper held up to the display – like a scanner without moving parts. A monochrome-record/color-display version made quite a splash at SID 2002 and now the input display both records and displays in color.

SMK demonstrated a "force-feedback" touch panel. In response to touch input, the panel vibrates under the user's finger with a selectable waveform – in addition to whatever optical or acoustic feedback the system is designed to deliver. It is very effective, and could be valuable in some system designs.

Epson showed its "Crystal Fine" technology for optimizing the optical performance of transflective LCDs and producing displays with an improved reflectivity of about 20% and higher contrast. A 1.2-in. 160 × 120 display looked particularly impressive in reflective mode. The company's major effort, though, was promoting its high-temperature polysilicon (HTPS) TFT-LCD imagers for home-theater applications. The top of the line are 16:9 full-HD (1920 × 1080) imagers with 1.65- and 1.3-in. diagonals. Customer rear-projection products from Samsung, Panasonic, LG Electronics, and Hitachi using the full-HD imagers were on display (Fig. 5). The images on these units were similar to each other and of excellent quality, and without the granularity in neutral areas that is often seen in DLP™ projectors.

## West to East

Several small European and U.S. companies decided that FPD International 2003 was a good place to show their new ready-to-manufacture (or ready-to-be-incorporated-in-products) technologies. Nemoptic (France), SiPix Imaging (U.S.), and ClaireVoyante Laboratories (U.S.) said they were very happy with the attention they were receiving, both on and off the show floor. Also present were Micro-Emissive Displays (U.K.), Kopin Corp. (U.S.), eMagin Corp. (U.S.), and E-Ink Corp. (U.S.) – in the booth of its partner, the Toppan Printing Co.

Nemoptic said it had finished the transfer of its monochrome bistable nematic BiNem® LCD technology to licensee PicVue Electronics, which is currently advertising a 6.4-in. reflective BiNem® module with touch capability. Now, Nemoptic says, it has developed eight-color STN displays with good color saturation as well as gray-scale driving with up to 32 gray levels that are fully bistable. The gray levels are obtained by stopping the backflow of the liquid-crystal material at different stages.

SiPix Imaging also has a bistable technology, in this case electrophoretic. But the company's most dramatic claim to fame is that it is making the first roll-to-roll commercial displays, using its Microcup™ technology. The initial displays are direct-drive [Fig. 6(a)], and the first commercial customer is using the display in a smart card. Rolls of roll-to-roll-processed material could be seen in the booth [Fig. 6(b)], and all displays in the booth had been made on production machines, a company representative said. Gray-scale capability is next, and a demonstrator was being shown. Ramp-up was scheduled for Q1 '04.

FPD International, organized by Nikkei Business Publications, is one of the major events in the annual display calendar. FPD International 2004 will be held in late October in Yokohama. ■

# The 11th Color Imaging Conference

*True color, from bright daylight to dark cinemas, and digital cinema itself were recurring themes at this highly respected color science and engineering conference.*

## by Michael H. Brill

THE 11th annual Color Imaging Conference (CIC 11), held November 5–7, 2003, drew 265 color scientists and engineers (up from 258 in 2002) to the SunBurst Resort Hotel in Scottsdale, Arizona. The conference is jointly sponsored by the Society for Information Display (SID) and the Society for Imaging Science and Technology (IS&T). For more than a decade, the high quality of the refereed papers has maintained CIC's reputation as the premier forum for color imaging.

Last year's CIC offered a record number of display-related papers, but other topics predominated this year. A new session on digital cinema drew professionals who had never before attended the CIC. Late-breaking-news papers constituted another new type of session in which the papers were more timely and less rigorously refereed than the contributed papers, but still of high quality. Finally, the interactive poster session featured two-minute spotlight previews by the authors in each half-hour session within the single-track conference format.

A significant theme at CIC 11 was the dynamic range of an image. Several papers dealt with high-dynamic-range (HDR) input images compressed into low-dynamic-range outputs. The color management of faithfully rendered bright-daylight colors was a subject of discussion. The low-luminance regime also received attention through models and methods of dealing with the mesopic regime, in which both rods and cones contribute to color vision.

The papers concerning the low-luminance regime worked well with the digital-cinema theme. Cinema screen-white has a luminance of only about 50 cd/m$^2$, and darker colors are at least two decades lower – well into the mesopic range. The light is intentionally kept this dim because if it were any brighter we would be disturbed by the 24-frame-per-second (fps) flicker. I think that if the papers on digital cinema and mesopic color vision were separate, digital cinema might someday address the issue of mesopic color matching, if only because today's high color quality raises the demand for still-higher quality.

H. Spitzer, Tel-Aviv University

***Fig. 1:** The compression of a high-dynamic-range (HDR) cathedral image was shown in Spitzer's paper at CIC 11. The original is shown on the left, and the compressed version is shown on the right.*

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## Through a Glass Darkly

How can we "tell the truth" about color when four visual receptors (rods and three kinds of cones) are at work? Will three-primary methods always suffice? Apropos of CIC's Arizona venue, here are two Apache legends. According to one legend, drinking from the Hassayampa River (northwest of Phoenix) forces the drinker always to lie. According to the other, holding an Apache tear (a rounded piece of dark, transparent glass) forces one always to tell the truth. Which agent is at work when we transport three-color images from daylight settings to dark movie houses? The Hassayampa influence would make three-color matches break down because of the fourth visual receptor. However, the Apache-tear influence reduces our sensitivity to color differences, so the lies viewed "through a glass darkly" become half-truths.

Two papers, one oral and one interactive poster, quantified aspects of mesopic color vision. The oral paper, "Prediction of Lightness in Mesopic Vision," was delivered by Lindsay MacDonald (now at the London College of Printing) in collaboration with Youngshin Kwak and M. Ronnier Luo. Guided by lightness-matching experiments, MacDonald generalized the lightness predictor of CIECAM02 to include rod contributions.

The poster paper, "Color Appearance in Mesopic Vision and Its Modeling," by JaeChul Shin, Naoki Matsuki, Hirohisa Yaguchi, and Satoshi Shioiri (Chiba University, Japan), provided an experiment and a model for predicting asymmetric color matches across vastly different illuminance levels. The experiment was to match a CRT-simulated patch at 1000 lux with an actual patch under illumination at six illuminance levels from 0.01 to 1000 lux. The experiment was probably difficult, but the model is the first I have seen that predicts mesopic color matches of any sort.

## High-Dynamic-Range Image Processing

One session featured the compression of high-dynamic-range (HDR) images – such as a film-captured daylit scene with dark portions – to fit the smaller dynamic ranges of print and displays. Garrett Johnson, in collaboration with Mark D. Fairchild (Rochester Institute of Technology), discussed "Rendering HDR Images," and Hedva Spitzer (Tel-Aviv University, in collaboration with Y. Karasik and S. Einav), reported on "Biological Gain Control for High-Dynamic-Range Compression." Both works used spatio-chromatic vision models that produce, as Johnson said, "a tone curve for each pixel in the image, depending on the luminance of the surrounding neighborhood" (Fig. 1).

As in similar work reported in the past, the HDR compression improved the visibility of details in the light and dark areas, but one step that is a common part of color management seems always to be missing from such "eye-like" image-processing models. Such models convert the input from the source medium to an "eye-like" response, which in turn directly drives the destination medium without an inverse "eye-like" transform on the way to the destination device. In the Johnson–Fairchild paper, we begin to find an inverse transform, but only for the color and not for the spatial processing. To apply color-management methods to spatial-image management seems to be work for the future.

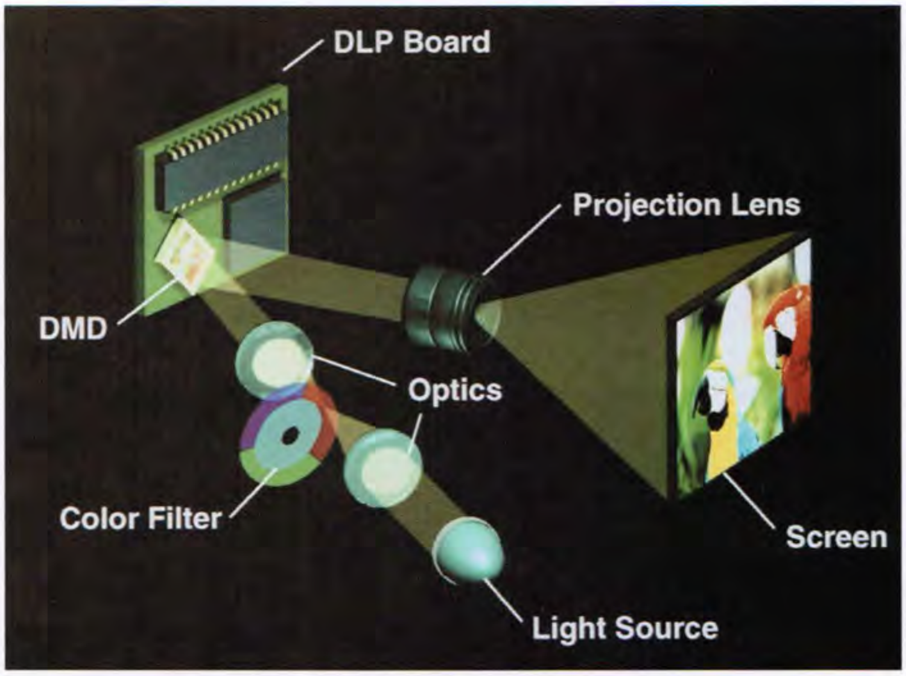



*Fig. 2: David R. Wyble presented a clear and sensible device characterization for a typical DLP™ conference-room projector: linear in light with white and black offsets. A typical light path for DLP projectors is shown, but the color wheel here is RGB only. (Figure courtesy of Texas Instruments.)*

## Digital Cinema

A move is afoot to stop distributing cellulose reels to theaters, and instead to transfer digital files to digital light projectors. Accordingly, the session on digital cinema was timely. Chuck Harrison (Far Field Associates, Snohomish, Washington) started out the session with "The Evolving Digital Workflow in Cinema." Although attempts at theatrical presentation using electronic projectors date back to the 1930s, only recently have electronic projectors been good enough for consumers to judge them equivalent to 35mm film. As cinema continues to evolve, digital methods – including color management – are replacing photochemical ones, but in piecemeal fashion.

Color management in cinema is unlike that in other media. First of all, the darkness in a movie theater removes the external "reference white" to which the eye may adapt; we adapt to whatever light is on the screen. The dark viewing environment suppresses extraneous light, so the screen contrast can vary from 500:1 to 10000:1 – a much wider range than afforded by other media. However, film can capture even more dynamic range, so one must decide how to present that range on the screen. The luminance level, 50 cd/m$^2$ at most, is quite low compared with that of other media. Despite the artistic intent that is present in cinematography (which is impossible to color-manage), it is desirable to automate such tasks as the "color timing" step, which adjusts the color casts in different reels of film to minimize the jarring effect of a reel change.

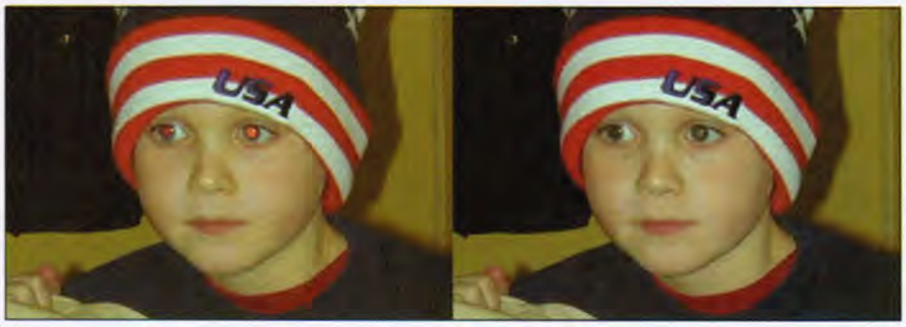
Although Harrison emphasized the transition from film to digital light projectors, Ado Ishii (Imagica, Tokyo) in "Color Management Technology for Digital Film Mastering" and Dave Bancroft (Thomson Broadcast & Media Solutions, Reading, U.K.) in "Emulating the Film Color Model in Digital Movie Production," discussed workflow that sometimes led back to a hardcopy print. In "An Experiment in Digital Intermediate Color Management Using ICC Profiles," Joseph Goldstone (previously at Industrial Light + Magic, now at Lilliputian Pictures) reported his transport of images from a digital HDTV original to film. I will return to Goldstone's paper in "Standards Update."

When does device characterization become "Reverse Engineering"? "Colorimetric Characterization Model for DLP™ Projectors" by David R. Wyble and Hongqin Zhang (Rochester Institute of Technology) created some controversy by dint of its association with the session in which it appeared – digital cinema. In subsequent discussion, there was comment that Wyble's digital light projector, although made by Texas Instruments (who are also makers of the digital-cinema projectors) is a low-end conference-room projector that has a different design. This is not a nit-pick: I hear that TI forces any user of their digital-cinema projector not to disclose publicly the user's characterization of the device. The conference-room projector is exempt from that restriction.

Off-line discussion revealed two issues that will be important to those who characterize displays for a living. First, when does characterization become "reverse engineering" (a somewhat pejorative term)? Second, when does a ban on measurement and disclosure reinforce a monopoly, restrict scientific methods, and even violate First Amendment rights? In any event, Wyble described a clear and sensible device characterization: linear in light with white and black offsets (Fig. 2).

### Image Mathematics

A session on mathematical analysis of color imaging, chaired by Michael H. Brill (Datacolor/ColorVision), featured two papers, one applying known invariant expressions to sort images numerically, and the other using a symbolic-manipulation program to generate all the invariants in a new situation automatically. Steven D. Hordley (University of East Anglia, U.K.), in collaboration with Graham D. Finlayson, G. Schaefer, and G. Y. Tian, discussed "Illuminant and Device Invariance Using Histogram Equalization." Hordley examined the extent to which histogram equalization can sort images independently of illuminant and device, and found the results encouraging. Next, Reiner Lenz (Linköping University, Sweden), in collaboration with Linh Viet Tran and Thanh Hai Bui, presented "Group Theoretical Invariants in Color Image Processing." Lenz reported on a program in Maple™ that, based on the theory of Lie groups, enumerates all the illuminant invariants in a scene without over-counting them. He used a new kind of dichromatic-reflection model to illustrate the program.



Robert Ulichney, Hewlett-Packard

***Fig. 3:*** *In return for offering a red-eye image (left) to the Redbot database, the donor receives a red-eye-corrected version (right) of the image, usually in less than a second.*

### Standards Update

Color-communication standards have been spearheaded by the International Color Consortium (ICC). The ICC solves the problem of color communication by use of profiles – data protocols for connecting the colors rendered by a source device, through the color-command variables for that device, to a specific color space (called a profile connection space) that expresses four different rendering intents: ICC absolute colorimetric, media-relative, saturation, and perceptual.

The "absolute" colorimetric intent is not really absolute because it transforms a screen-white to a D50 chromaticity. The media-relative intent represents the color as if on a printed document under a D50 illuminant, with specific black and white reflectances (a yellow parchment will appear yellow for absolute intent, but D50-white under media-relative intent). Saturation and perceptual intent are far more difficult to unravel. At the ICC meeting held just before CIC 11, I learned that saturation intent leads to gamut clipping, but perceptual intent leads instead to continuous distortion of the source-device colors so they fit inside the destination gamut.

At CIC 11, two papers described case studies of ICC-based color management. One was "Issues Encountered in Creating a Version 4 ICC sRGB Profile" by Kok-Wei Koh, in collaboration with Ingeborg Tastl, Mary Nielsen, David M. Berfanger, Hauzhao Zeng, and Jack Holm, all from Hewlett-Packard. In looking at the ICC system, it is natural for one to ask, "Why do you need an intermediate reference device between a source and a destination device when a lookup table between the endpoints would manage the color?" Koh's answer was that in the current (Version 4) ICC system, color re-rendering is incorporated in the profiles themselves, and thereby improves consistency among different software tools.

In applying ICC profiles for the first time to digital cinema, Joseph Goldstone (whose paper was discussed above) found that some of the re-rendering caused difficulties. For one thing, the ICC profile contains underlying assumptions, such as that all device values are intended to represent color information (unlike HDTV's Rec 709 standard) and that the highest valid device value represents a 100% white diffuse reflection. Goldstone said that the ICC "business model encourages a conflation of device characterization and gamut mapping" to the detriment of someone who would like to deal with the issues separately. Finally, Goldstone asserted that, despite the putative interoperability of the profile syntax, the ICC's accommodation of proprietary color-management modules encourages the use of public tags to convey special messages to proprietary software. As in a game of bridge, one can use standard bids for nonstandard purposes, but unlike in bridge, not everybody at the table is allowed to know what the bids mean. Nonetheless, the ICC has success stories, such as the entire workflow in the European edition of the *Reader's Digest*.

### Three Keynotes and an Evening Speech

In the tradition of CIC, three keynote presentations highlighted CIC 11, one of them by Robert W. G. Hunt (University of Derby, U.K.). In "The Importance of Not Being Too Earnest," Hunt described corrections for such image distortions as lens vignetting, camera spectral sensitivities, reproduction gamut, and spatial-resolution limitation. He concluded that "means for correcting these deficiencies are sometimes available, but the earnest application of these methods can be undesirable in practice."

In harmony with Hunt's point of view, Reiner Eschbach (Xerox, Webster, New York) discussed "Image Reproduction: An Oxymoron?" Eschbach stressed that an image inherently loses information relative to its "original," and that we seek less to reproduce an image than to produce one that satisfies a need. Finally, David Brainard (University of Pennsylvania) discussed "Computational Methods of Color Constancy," and showed some startling effects that call for new high-level vision models.

David G. Stork (Ricoh Innovations and Stanford University) delivered Thursday evening's address, "Did the Great Masters 'Cheat' Using Optics?" The presentation replied to an analysis by artist David Hockney and physicist Charles Falco which claims that artists as far back as 1430 relied on images cast by a mirror-based camera obscura. By showing in the paintings that (among other things) parallel lines did not converge to vanishing points, Stork assured us that Renaissance artists probably did not use optics to trace images.

### Other Highlights

The winner of the annual "Cactus" poster award was "Illuminant Multiplexed Imaging: Special Effects Using GCR" by Gaurav Sharma (University of Rochester) and Robert P. Loce, Steven J. Harrington, and Y. (Juliet) Zhang (Xerox). By clever ink and lighting design, these authors produced a picture that transformed into another picture when the lighting changed. Henry Hemmendinger (recently deceased) talked of seeing somewhere in San Francisco a plate by M. C. Escher that had the same property. In that case, a moonlit scene transformed into a sunlit scene. Neither Hemmendinger nor anyone else I know could find that plate again. If you have seen it, please let me know.

Finally, the late-breaking-news session at the end of the conference featured four high-quality papers. The first, by Robert Ulichney, in collaboration with Matthew Gaubatz and J. M. Van Thong, Hewlett-Packard, Cambridge, Massachusetts, was "A Web Service for Correcting Photo Red-Eye." The Web site www.redbot.com is a research site to which anyone can upload a digital photograph in which a flash has created a red retinal reflection from the eye of a photographic subject. In return for offering the image to the Redbot database, the donor receives a red-eye-corrected version of the image, usually in less than a second. Although the algorithm is still being adjusted, its performance is quite good (Fig. 3). Other papers in this session dealt with new developments in printer and camera technologies.

### Plans for 2004

In 2004, CIC 12 will be held November 9–12, again in the SunBurst Resort Hotel in Scottsdale. In addition to developing themes from previous years, CIC 12 will include new themes, such as astronomical imaging, imaging of art works, and preservation of color ("color for the 22nd century and beyond"). The late-breaking-news session was successful enough this year to warrant its continuation in 2004. And the evolving color-communication standards will certainly generate continuing interest. ■

## my turn

*continued from page 4*

developed. One of the most notable of these is the 34-in. Shadow Mask PDP developed by Southeast University in Nanjing.

In addition to the better-established display technologies, OLEDs are also generating excitement within the Chinese display R&D community.

Another characteristic of the Chinese display field is that more and more companies and display experts from outside China are cooperating with Chinese research institutes and universities. A particularly successful cooperative institute, the Dong Fei Display Tube Technology R&D Center, was founded in 1994. In 2002, the name was changed to the Jin Dong Fei Display Technology R&D Center to reflect the changes in the display industry and its market. Partners in this co-operative venture are LG.Philips Displays and Southeast University in Nanjing.

I believe that the stature of the Chinese display industry will continue to grow as manufacturing expands. The continuous increases in product sophistication will fuel R&D at Chinese universities and institutes for many years to come. ■

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## backlight

*continued from page 60*

limit the performance, reliability, functionality, and affordability of battlefield systems." According to John Pelligrino, chairman of the DoD technology panel on electron devices and director of ARL SEDD, "The industry focus on glass substrates will push the introduction of commercial flexible displays out to the next decade. We want to move the possible date closer." Specifically, he said, hopes are that some flexible displays will be available for the Objective Force Warrior program in 2008.

"Current display approaches, generally based on glass LCD panels and cathode-ray tubes, impose severe compromises on military systems and personnel because of their size, weight, fragility, and cost," said SEDD's Henry Giralomo. He pointed out that because the volumes are small, the military must work with the commercial market to supply displays for military applications.

Flexible displays are a "primary need for the common soldier of the future," said Dr. M. Robert Pinnel, chief technical officer of USDC. "Durability, weight, and form factor are the main drivers, especially for special-operations units which are in the field for a long time."

Given that there are no killer apps to drive the market-entry timeline and assure success, and that there are rigid alternatives to flexible displays that can do the job, it is important to have a springboard of flexible-display applications, he argued. The early support from the military for the flexible quest, said Pinnel, "provides impetus, focus, and schedule; defines requirements for early-adopter applications; and provides modest but very useful R&D support." This, he said, will "provide a springboard to compatible high-volume commercial applications where no killer app has been identified to drive the development and move the manufacturing technology down the learning curve. Moreover, Pinnel noted, if we are talking about outfitting every soldier with a display, that gets to real volume.

We are still in the very early stages of flexible-display work, however, and I am betting that not much has changed over the past year, although I would be delighted to hear otherwise. No doubt, developers continue to shovel away at the difficulties of the quest, and, without doubt, the gods of chemistry and physics continue to snow down new challenges as previous ones are cleared away. Shovel on, men and women. Shovel on. ■

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

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## Deep Freeze in the Northeast

**by David Lieberman**

Sitting here in Massachusetts, surrounded by mountains of snow, I am taking a break from shoveling and shoveling and shoveling to fantasize a bit while putting heating pads on some parts of me and ice packs on others. I am thinking about how nice it would be to escape to the heat of Phoenix, Arizona, in February, the dead of winter up here in the Northeast, and how nice it would be to treat myself to a trip to San Francisco, California, in April, to reward myself for surviving yet another nasty New England winter. The former time and venue mesh with the annual U.S. Display Consortium (USDC) conference on flexible displays and electronics, while the latter are when and where Intertech's conference on the same topic will be held. Almost a year has rolled around since I had my first in-depth introduction to flexible circuits and screens at these conferences, and I am very curious to find out how things have progressed.

One year ago, flexible devices looked like a very exciting quest, but one that was unlikely to yield great fruit in the short term. The materials and manufacturing challenges, particularly for flexible active-matrix displays, seemed too new and difficult for quick solutions to emerge. Furthermore, the practical benefits seemed too murky in a difficult financial period to justify the expenditure of R&D dollars when projects in other realms promised quicker solutions with more clearly perceived value. Moreover, most display applications were faring quite well, thank you, with their traditional, conventional rigid screens. I concluded that flexible displays would in fact be frozen out of any chance for near-term success. And yet, I perceived both sizzle and steak in the flexible display story, the sizzle being the much-hyped rollable and foldable flexible-display concept, the real meat being survivability.

But where will survivability be valued? "When I hear 'flexible,' I think of highly mobile applications," said Joel Pollack, Vice President of the Display Products Business Unit at Sharp Microelectronics of the Americas. "Increasingly, people tend to do nasty things to their PDAs, which usually break because the glass touch panel breaks, not the LCD," he said. "In time, people will move more to plastic touch panels, and I imagine the next thing that would threaten to break is the LCD."

Certainly, impact-resistant displays would be a great boon to notebook computers, but the wrinkles in making a flexible display of the required size have yet to be ironed out. And even when the technical problems are solved, it will take some time down the learning curve until the technology matures and achieves its potential benefits in manufacturing cost so that a flexible display will have appeal in cost-sensitive applications. In the meantime, there is one market where survivability has great perceived value: the military market. It is no surprise, then, that the U.S. Department of Defense (DoD) is leading the charge on flexibility. It is funding, for example, an ambitious flexible-display initiative sponsored by the Army Research Laboratory (ARL), specifically ARL's Sensors and Electron Devices Directorate (SEDD).

The mission of ARL, according to its literature, is "to enable technologies that will meet future Army combat needs and solve the critical technical barriers that

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