SID '09 Preview / Honors and Awards Issue

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SID Honors Its Brightest and Best

- 2009 SID Honors and Awards
- SID Symposium Highlights
- Laser-Based Techniques for FPDs
- *Journal of the SID* April Contents

Information
DISPLAY

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COVER: "For an individual in the field of displays, an award or prize from the Society for Information Display, which represents his or her peers worldwide, is a most significant experience." The feature article will officially introduce the winners of the 2009 SID Honors and Awards winners and describe their accomplishments. See the article beginning on page 10.

CREDIT: Cover design by Acapella Studios, Inc.

Next Month in
Information Display

Display Week 2009 Show Issue
- Products on Display at Display Week
- 2009 Display of the Year Awards
- Plasmaco Revisted
- Digital Information Displays
- *Journal of the SID* May Contents

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On Truly Distinguishing Greatness

by Steve Atwood

One of my first writing assignments for *Information Display* was to cover the SID Honors and Awards dinner and convey the feeling of that evening to the readers. It was a relatively hard job, but not for the reasons one might think. Usually, we tend to think of achievement awards as something of a formality, a rite of passage for those who have paid their dues or served long enough to make the top of the list. Similarly, awards dinners are typically perceived to be stodgy affairs steeped in formality and weak on meaningful drama. So, as I approached my first assignment for *ID* you can imagine that I felt like I was in for a difficult challenge to bring some energy to the story. In fact, what I learned that first time was that my expectations were all wrong, and that lesson has stayed with me ever since. As I listened to the recipients talk about their achievements, I was mesmerized by the fact that I was listening to the personal histories of the very individuals who had created the technology I love so well. These were not people who marked their time or just hung around. These were people whose life's work was to contribute some crucial component to the web of science that made display technology possible. And these were humble people who had dedicated their efforts to the honest pursuit of science, and did so without seeking much fame or fortune. (Of course we know how even more elusive fortune can be in the display business.)

What I have learned since that night is that true innovation takes serious work, does not come easily, and is elusive even to the best and brightest among us. Even if endowed with a gifted appreciation of the underlying science and the ability to tenaciously pursue their vision, many dedicated people never achieve that true breakthrough that changes paradigms and enables the birth of new products and markets. Therefore, it is truly spectacular when these breakthroughs do happen, and a humbling experience to meet the progenitors of those feats of science, especially those who have achieved breakthroughs multiple times. What is more amazing is that in many cases, the discovery itself and its impact on the world does not occur in a single moment; nor is it immediately appreciated. More often it evolves slowly through a body of work that may not make its full impact for 10 or 20 or even more years later. I have observed this in many areas of our industry, where we have seen discoveries from the 1960s and 1970s making a fresh impact on technological innovations of the 1990s and beyond. So, in some cases the full measure of someone's work may only become clear much later in that person's life.

The people who serve on the SID Honors and Awards Committee know all this and take a great deal of time and consideration in making their recommendations. They receive many qualified nominations, and the selection process is always hard, as it should be. These are highly meaningful awards that are conveyed only when truly qualified recipients are identified.

That first night I was humbled by what I learned, as I have been every year since when I read the citations and learn more about the work of the deserving people chosen for these honors. Of course, this year is no exception, and on behalf of the entire staff at *ID* magazine, I heartily congratulate all the award winners.

In addition to announcing our SID Honors and Awards winners, this issue also previews the SID '09 Symposium, with highlights from all the technology tracks for you to browse. We hope this feature will help you plan your week in San Antonio

(continued on page 27)

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The Future of Plasma, Post-Pioneer

> **"Pioneer's strategy was to sell very-high-quality displays at a high price."**
>
> *– Larry Weber, co-founder, Plasmaco Inc.*

In February of 2009, Pioneer announced that it had decided to close its plasma-display TV production facilities as part of restructuring measures to offset current and future losses. Furthermore, the company announced that it was withdrawing from the display business altogether by March 2010. These announcements surprised many in the display industry because Pioneer is known for its state-of-the art plasma products and had only a year earlier introduced its new Kuro line of plasma TVs. Kuro technology features vibrant imagery and extremely deep blacks ("kuro" means black in Japanese) that favorably impressed many early reviewers.

With a key player such as Pioneer exiting the plasma arena, the question of whether other companies might follow naturally arises. A related issue with regard to plasma's general longevity is that LCDs have rapidly been catching up to the technology in terms of cost and performance.

But, in fact, Pioneer's departure from the display market means less than it might at first seem, according to plasma-expert Larry Weber. (Weber was co-founder of the former Plasmaco. Inc., one of the earliest developers of large-screen plasma displays.) First, he says, "The key announcement [with regard to Pioneer] happened last year, not this year." That was when Panasonic began making plasma panels for Pioneer units, which signaled an end to Pioneer's panel manufacturing even as the company was coming out with new products.

And, Weber continues, although Pioneer made excellent products; in terms of sales, the company was historically the weakest of the "big" plasma players, including LG, Panasonic, and Samsung. "Pioneer's strategy was to sell very-high-quality displays at a high price," he says. That was a strategy that worked to a point, but may have been harder to sustain in the economic environment of the last couple of years.

However, even if Pioneer was only a small part of the plasma industry, it was a highly visible part. And with rapid advances in LCD technology that are making it an ever-more viable rival to plasma, are plasma's days numbered? It is too early to count plasma out, according to Weber, and Panasonic spokesperson Jeff Samuels speaks in similar terms: "Panasonic still strongly believes in plasma," he says. "And we make LCDs too." In fact, he adds, "Of the major players, Sony is the only one not in plasma."

Kuro displays turned heads when they debuted slightly over a year ago. Shown is a concept model at a trade show. Image courtesy of Pioneer.

No one questions that LCDs are getting bigger, better, and more cost-effective. But at Panasonic, at least, there is still a break-off point in terms of screen size: "Our position is that if you are buying a display larger than 42 in., you should go for plasma rather than LCD," says Samuels. The biggest consumer plasma TV that Panasonic makes is 65 in., but the company also produces professional-level products as large as 103 in. These are purchased by sports arenas, restaurants, and hotels – and a few discriminating and financially well-off individuals, such as professional athletes. (Asked if Panasonic is going to acquire Pioneer's Kuro technology, and thus bolster the plasma expertise it already possesses, Samuels says, "Everybody asks that. We don't know.")

Plasma TVs also tend to handle motion better than LCDs, Samuels maintains, and are better at showing dark content (think *The Matrix*) as well as at showing most content in dark environments. LCDs do have the advantage over plasma in bright environments such as a sunny room.

However, on a consumer level, plasma has had several factors working against it: plasma displays have generally been heavier than LCDs (so may need extra wall support) and have conventionally been more difficult and expensive to install. They also, under some circumstances, consume more power (although this is changing). Weber notes that one of plasma's best features – its ability to display imagery in darkened environments – has often been rendered invisible when the displays are shown in a brightly lit store.

(continued on page 29)

Priorities in Electronic-Display Development

by Paul Drzaic
President, Society for Information Display

While there is plenty to like in the upcoming Display Week events in San Antonio, I have a special affection for the Technical Symposium. The Symposium papers span a wide gamut – some describe new concepts in electronic displays, while others demonstrate exciting performance improvements in existing displays. These papers indicate where the people shaping the electronic-display industry are placing their bets for the future.

This year, the SID Technical Program Committee reviewed the 450 papers scheduled for presentation and identified over 40 that were particularly noteworthy. I have had a lot of fun browsing through the list, and I am amazed at the breadth of topics that have been highlighted as important. While in this short column I cannot summarize each and every paper highlighted, I can pick out a few that illustrate two trends that show where today's priorities are in electronic-display development.

LCDs are working to maintain their advantage as the most cost-effective source of high-quality displays, so many papers deal with novel approaches toward reduced-cost manufacturing. For example, collaborators at Samsung Electronics and Nakan Corp. describe how they used a single laser-ablation step to replace a six-step process to pattern ITO in a TFT panel. A group at LG Electronics discusses the use of electrohydrodynamic jet technology as a reliable, high-throughput means for repair of the black matrix in a TFT panel. A contribution from Asahi Kasei EMD provides a detailed analysis of a means of inhibiting the contamination of photomasks. These papers (and others) show why it is going to be so hard to displace LCDs from dominance – the level of refinement in manufacturing is amazing.

Nevertheless, a major contender for replacing LCDs as the mainstream display technology is organic light-emitting-diode (OLED) displays. Several papers will focus on high-efficiency manufacturing of conventional OLED displays, including contributions from Dupont (multi-nozzle jet printing), Kodak (a Gen 5 flash evaporation system for organic molecules), and a collaboration between Doosan Mecatech and Veeco (a high-efficiency scanning evaporation system that could potentially build Gen 6 substrates). Emerging OLED displays also make their mark in the upcoming Symposium. Samsung SDI will present a paper on its remarkable achievement of a 6.5-in. flexible AMOLED using a metal-oxide transistor on a plastic substrate. Sony will describe its work on an OLED display driven by organic TFTs that is flexible, reliable, and manufactured using a scalable process. A collaboration between Kodak and Semprius will discuss work in OLED displays using ICs that are "printed" onto a substrate using a unique transfer process. With so much innovation, plus the optical advantage of OLEDs, perhaps LCDs do have some cause for worry after all!

If I had more space, I would touch on 3-D technologies, touch technologies, flexible electronic paper, advanced driver technologies, components for pico projectors, wireless panel architectures, high-brightness reflective displays, and "electronic skin" technology. Alas, I don't. You will just have to enjoy discovering these papers (and others) on your own during Display Week 2009 in San Antonio. ■

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Display Week 2009 Product Showcase

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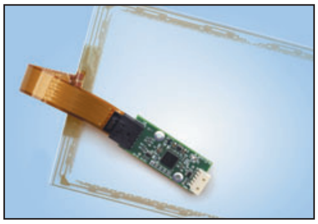

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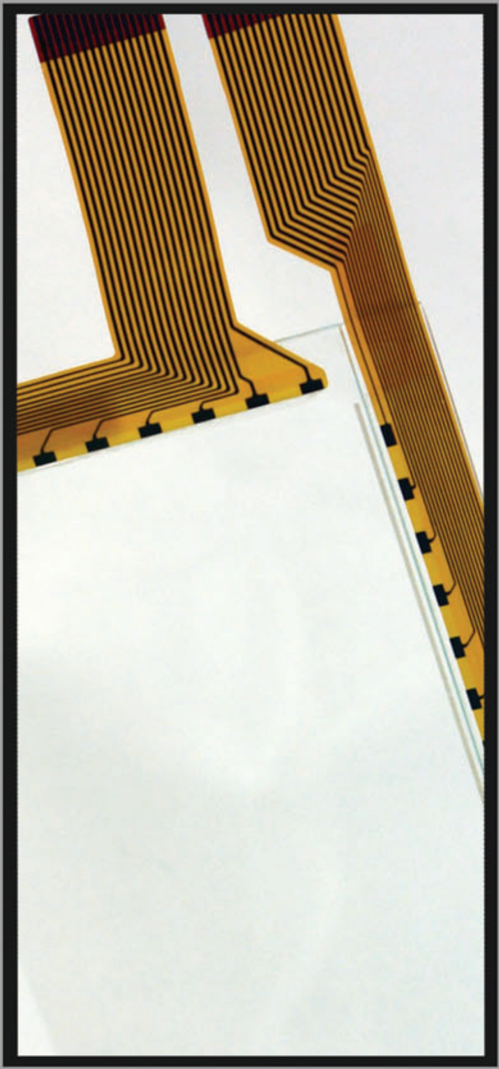

2009 SID Honors and Awards

This year's winners of the Society for Information Display's coveted Honors and Awards include Dr. Peter Raynes, who will receive the Jan Rajchman Prize for his work with twisted-nematic liquid-crystal displays; Dr. Ernst Lueder, who will be awarded the Slottow-Owaki Prize for his contributions as an outstanding and inspiring teacher; and Mr. Peter Baron, who has earned the Lewis and Beatrice Winner Award for years of service to the Society for Information Display.

by Jenny Donelan

EACH YEAR, the Society for Information Display (SID) honors individual scientists and researchers for outstanding achievements in the field of electronic information displays and for outstanding service to the Society. Only a small number of the preeminent members of the industry are nominated and fewer still are finally chosen as recipients. "In our professional lives, there are few greater rewards than recognition by our peers," says Honors and Awards Chair Christopher King. "For an individual in the field of displays, an award or prize from the Society, which represents his or her peers worldwide, is a most significant experience." The winners will be honored during Display Week 2009 at the awards banquet to be held on Monday evening, June 1, preceeding the Symposium.

Jan Rajchman Prize

This award is presented for an outstanding scientific or technical achievement in, or contribution to, research on flat-panel displays.

Dr. Peter Raynes, SID Fellow and Chair of Optoelectronics at Oxford University, has been awarded the Jan Rajchman Prize *"for his pioneering work enabling the development of dislocation-free twisted-nematic liquid-crystal displays, fast-responding and thermodynamically stable biphenyl mixtures, and dichroic supertwisted-nematic LCDs."*

Dr. Raynes' career spans nearly 40 years and includes more than 120 published papers and over 60 filed patent applications. He played a primary role in developing liquid-crystal displays and was responsible for many key device inventions.

Dr. Raynes began his professional career after graduating from Cambridge University with a Ph.D. in low-temperature physics. In 1971, he joined the Royal Signals and Radar Establishment (now part of QinetiQ) at Malvern, U.K., to work on liquid-crystal materials and devices.

Swiss physicist and inventor Dr. Martin Schadt recalls those times: "I have known Peter as an excellent scientist and good friend since the pioneering days of liquid-crystal field-effect displays and LC-material development in the early 1970s," says Schadt. Only a few years after Schadt and colleague Wolfang Helfrich had patented and published the twisted-nematic (TN) effect in 1970, Dr. Raynes started to do research on the new field effect as a young scientist at the Royal Signals and Radar Establishment. "Being interested in academic and application-related scientific problems," says Schadt, "Peter began research on the boundary conditions required for optimal operation of TN-LCDs. He discovered the importance of tilted surface alignment for proper static and dynamic operation of TN-LCDs."

Dr. Raynes was ultimately responsible for the invention, patenting, and development of surface-aligning technologies that enabled dislocation-free TN-LCDs; this included a means of preventing tilt as well as twist dislocations. His early work on the causes of surface-induced dislocations in TN-LCDs enabled industry to manufacture optically

Dr. Peter Raynes

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uniform twisted-nematic LCDs. All future LCD aligning technologies benefited from the aligning technologies he developed, and his aligning concepts were patented and licensed worldwide to the LCD industry.

Dr. Raynes also developed the first commercial cyano-biphenyl mixture, E7. "Following the invention of the cyano-biphenyls by George Gray and co-workers, Peter was the first to apply Schröder Van Laar formalism to determine thermodynamically stable compositions of multi-component liquid-crystal mixtures," says Schadt. "That first cyano-biphenyl mixture, E-7, was successfully commercialized by British Drug Houses (now Merck) and by Roche. E-7 is still a standard mixture for academic research." Last, notes Schadt, "Apart from his work on TN-LCDs, Peter invented the first super-twisted-nematic guest-host LCD in 1982."

In 1992, Dr. Raynes moved to the Sharp Laboratories of Europe, Ltd., at Oxford, U.K., where he was director of research until he took up the chair of optoelectronics in the Department of Engineering Science at Oxford University in 1998.

Slottow-Owaki Prize

Awarded for outstanding contributions to the education and training of students and professionals in the field of information display.

Dr. Ernst Lueder is receiving the Slottow-Owaki Prize *"for his many contributions as an outstanding and inspiring teacher, scientist, and mentor for the active-matrix community."*

As a professor at the University of Stuttgart in Germany and the founder of the Flat-Panel Display Laboratory at the University, Dr. Lueder's skills as a gifted and inspiring teacher were instrumental in repeatedly attracting brilliant students to his program. During his tenure, he supervised more than 600 undergraduate research projects, each representing several months of student laboratory work time; more than 630 master thesis research projects, each representing up to one year of research time; as well as 88 Ph.D. thesis projects. To date, 13 of his Ph.D. students have become full professors, with several of them now heading up sizeable research facilities and teams of their own.

Dr. Andras I. Lakatos, Editor of the *Journal of the Society for Information Display* (*JSID*), met Lueder almost 30 years ago when Lakatos was manager of TFT-LCD research at the Xerox Corporate Research Center. Ernst proudly showed me his very well-equipped laboratory at the University of Stuttgart," says Lakatos. "But what impressed me the most

2009 SID Fellow Awards

The grade of fellow is conferred annually upon SID members of outstanding qualifications and experience as scientists or engineers whose significant contributions to the field of information display have been widely recognized.

Dr. Amal Ghosh *"for his pioneering contributions to the technology of organic light-emitting-diode microdisplays, including device architecture, thin-film encapsulation, and overall fabrication."* Dr. Ghosh is currently Vice President, R&D and Engineering, for eMagin Corp. He holds a Ph.D. in physics from the Massachusetts Institute of Technology.

Dr. Min Koo Han *"for his many contributions to the design of thin-film-transistor arrays for liquid-crystal displays and compensation circuits for organic light-emitting-diode displays employing both amorphous-silicon and polysilicon thin-film transistors."* Dr. Han is a professor with the School of Electrical Engineering, Seoul National University, in Seoul, Korea. He has a Ph.D. in electrical engineering from The Johns Hopkins University.

Dr. Sang Soo Kim *"for his many contributions to the field of liquid-crystal displays, including advancements in the imaging performance of LCDs and for the groundbreaking development of large-area active-matrix LCDs."* Dr. Kim currently leads product development for Samsung LCD Business as a Samsung Fellow and Executive VP. He received his Ph.D. in physics from North Carolina State University.

Dr. Jun Souk *"for his many pioneering contributions to the technology of very-large-area thin-film-transistor liquid-crystal displays."* Dr. Souk is a Technology Advisor at Samsung Electronics, LCD Division. He received his physics degrees from Seoul National University and Drexel University. In 2008, he received an honorary Ph.D. from Kent State University for his pioneering work in the LCD field.

Dr. Sashiro Uemura *"for his pioneering contributions to field-emission-display research through the development of new carbon-nanotube growth and activation technologies and for using carbon nanotubes to build experimental full-color FEDs."* Dr. Uemura is General Manager for Noritake and Director for Noritake Itron. He received his Ph.D. degree from Nagoya University.

Dr. John Z. Zhong *"for his many contributions to the application and commercialization of flat-panel-display technology, as well as the development of technology including the high-aperture thin-film-transistor array structure and multi-touch displays."* Dr. Zhong is Senior Manager, Display and Touch Engineering, for Apple, Inc. He earned his Ph.D. in physics from Case Western Reserve University.

was how proud he was of the individual members of his research team – the students, post-docs, and others who worked in his group. Later on, I realized that his great intellect always worked in concert with fairness and kindness. This was much appreciated by just about everyone who came in contact with Ernst."

Dr. Lakatos also notes that Dr. Lueder has been Associate Editor of *JSID* for nearly 10 years. "He works hard to improve the quality of the papers for which he is the technical editor. He always tries to teach the authors how to improve their original manuscripts," says Lakatos. "This is especially important when the authors are graduate students." In fact, Dr. Lueder has donated the $2000 stipend of the Slottow-Owaki Prize to support the annual prize money that is given to the winners of the *JSID* Annual Outstanding Student Paper Award, notes Lakatos, adding, "This is a much-needed and most generous gift."

Dr. Ernst Lueder

Dr. Lueder also conducted a number of SID Symposium short courses over the years and has authored several books, including *Liquid Crystal Displays: Addressing Schemes and Electro-Optical Effects*, the most widely sold book of the SID/Wiley series on display technology.

He also founded the Institute of Network and Systems Theory, as well as two major research institutions with extensive clean-room facilities, the aforementioned Flat-Panel Display Laboratory, and the Institute for Microelectronics in Stuttgart, which operates a CMOS line. The Flat Panel Display Laboratory has a class 10-100 clean room that is fully equipped for developing and fabricating AMLCD and AMOLED demonstrators on

2009 SID Special Recognition Awards

Presented to members of the technical, scientific, and business community (not necessarily SID members) for distinguished and valued contributions to the information display field.

Dr. Byung-Chul Ahn *"for his many contributions to the display industry through the development of advanced technologies for innovative high-performance active-matrix liquid-crystal display products and applications."* Dr. Ahn is Head of the OLED Business Unit at LG Display. He received his Ph.D. from the Tokyo Institute of Technology.

Dr. Peter L. Bocko *"for his central role in delivering innovative high-performance glass substrates for the display industry, including environmentally friendly display glass and substrates compatible with polysilicon backplanes for liquid-crystal and organic light-emitting displays."* Dr. Bocko is Chief Technology Officer for Corning East Asia. He received his master's and doctorate degrees in physical chemistry from Cornell University.

Dr. Hideo Hosono *"for his pioneering proposal to use amorphous In-Ga-ZnO as the semiconductor to make a transparent thin-film-transistor display backplane and for demonstrating a performance level that makes the material a candidate for the next generation of flat-panel displays."* Dr. Hosono is a professor at the Tokyo Institute of Technology. He received his Ph.D. in applied chemistry from Tokyo Metropolitan University.

Mr. Gary Jones *"for his entrepreneurial leadership in the advancement of field-emission and organic light-emission display technologies, including the development and commercialization of the world's first full-color active-matrix OLED displays."* Mr. Jones is the founder of Nanoquantum Corp. He received his B.S. degree in electrical engineering from Purdue University.

Dr. Hiro Kikuchi *"for his leading contributions to the research and development of optically isotropic liquid-crystal materials for the blue-phase mode that exhibits fast electro-optical response and requires no surface treatment for device fabrication."* Dr. Kikuchi is a professor with the Institute for Materials Chemistry and Engineering, Kyushu University, Japan. He holds a doctorate from Kyushu University.

Dr. Temkar Ruckmongathan *"for his pioneering contributions to display education in India and his research and development of matrix-addressing technologies with multi-line and wavelet-based techniques."* Dr. Ruckmongathan is a scientist and professor with the Raman Research Institute. He holds an M.S. degree and a Ph.D. from the Indian Institute of Science.

substrate sizes up to 40 × 40 cm. It has a 17-year track record of developing and demonstrating large-area display demonstrators entirely in-house and is the only university-based laboratory in the U.S. or Europe with this distinction.

Dr. Lueder studied electrical engineering at the University of Stuttgart, receiving a Diplom Ingenieur (comparable to a master's degree) in 1958 and a Ph.D. in 1962. He received his Habilitation (German university teaching credentials) in 1966. In addition to holding assistant and then full professorships at the University, Dr. Lueder was also a member of the technical staff at Bell Telephone Laboratories in Holmdel, New Jersey, from 1968 to 1971. He is now retired and has served as President of the Electro Optical Consultancy, which focuses on the display industry, since 2000.

Lewis and Beatrice Winner Award
Awarded for exceptional and sustained service to SID.

Mr. Peter Baron earned this award *"for his many years of innovative, tireless, and outstanding service to the Society since its inception in 1962, including his distinctive service to SID in numerous local and international positions."*

A member of SID since its founding in 1962, Mr. Baron has been active in Society

Mr. Peter Baron

activities since the early eighties. He has served in many capacities, including Program Chair and General Chair for the SID Los Angeles chapter offices. He has also been Director to the International SID Board for the L.A. chapter almost continuously since 1989. Along the way he also served as SID Regional Vice President for the Americas during a period of aggressive growth and internationalization of the Society. As a member of the program committee for the SID annual International Symposium, he spearheaded an effort to expand the scope of the conferences to significantly increase coverage of end-user display applications and later helped to organize the 2004-2006 Americas Display Engineering and Application Conferences (ADEAC). Mr. Baron has been the SID Archives/Historian Chair since 2003. According to *Information Display* Executive Editor and SID Director Stephen Atwood, who has worked with Mr. Baron on several endeavors, including the ADEAC conferences, "Peter has worked tirelessly for the betterment of SID and shown his endless devotion to both education and advancement of display technology in everything he has done."

Mr. Baron holds electrical engineering degrees from Purdue University and is the Founder and President of ABCD Technology. ■

The 2009 award winners will be honored at the SID Honors & Awards Banquet which will take place Monday evening, June 1, 2009, during Display Week at the San Antonio Hyatt. Tickets cost $50 and must be purchased in advance – tickets will not be available on-site.

Visit **www.sid2009.org** for more information.

Display Week 2009 Symposium Preview

Plan your visit to Display Week 2009 with an advance look at the key trends and issues that will be highlighted in the symposium's far-ranging collection of display-technology sessions.

by Jenny Donelan

THIRTEEN SUBCOMMITTEES have chosen the papers to be presented at the Society for Information Display's International Symposium at Display Week 2009 in San Antonio this June. From exciting new discoveries to cutting-edge research to ingenious manufacturing solutions, these papers will disclose results and ideas from top researchers from the international electronic-display industry.

The following is a list of session highlights by subcommittee, which includes active-matrix devices, applications, applied vision, display electronics, display manufacturing, display measurement, display systems, emissive displays, field-emission displays, liquid-crystal technology, OLEDs, and projectors. The thirteenth subcommittee, new this year, is flexible displays. For flexible-display highlights, see the article "Flexible Displays Come Into Their Own at Display Week 2009" that appeared in the March issue of *Information Display* magazine.

Active-Matrix Devices: Can Oxide Thin Films Substitute for Silicon?

The biggest news by far in the Display Week 2009 active-matrix sessions, according to subcommittee chair Hyun Jae Kim, Associate Professor with the School of Electrical and Electronic Engineering at Yonsei University in Seoul, Korea, will be the use of oxide-semiconductor technology as a replacement for silicon-semiconductor technology. "This is very new and promising," says Kim. "This technology affects not only thin-film-transistor liquid-crystal displays (TFT-LCDs), but also active-matrix organic light-emitting-diode (AMOLED) displays – future flat-panel displays." One of the papers focusing on that topic will be "Development of a Driver-Integrated Panel Using Amorphous In-Ga-Zn-Oxide TFTs" by Takeshi Osada from the Semiconductor Energy Laboratory Co. Osada's design team created a 4-in. quarter-video graphics array (qVGA) liquid-crystal panel integrated with a gate driver and a source driver by using bottom-gate bottom-contact (BGBC) TFTs made from an oxide semiconductor. They then prototyped the liquid-crystal panel and integrated the gate driver and source driver on the panel.

Kim notes that although this is not the first time that the above technology has been presented – there have been papers at IMID (International Meeting on Information Display) and ITC (International Thin-Film Transistor Conference) – SID '09 will represent the largest and most exciting confluence of such papers.

Other papers of interest include:

- "A Novel Driving Method for Cost-Competitive a-Si TFT-LCDs" by Su-Hwan Moon from LG Display discusses the application of six-times-rate driving (SRD) to a TFT-LCD.
- "A Novel Low-Power-Consumption All-Digital System-on-Glass Display with Serial Interface" by Kenji Harada from Toshiba explains how designers achieved a power consumption of 15 μW in a 2.26-in. format.

Applications: Color Comes Closer to e-Paper

Display applications are where the rubber meets the road – where the technology goes into real products and customer problems are solved. This year, the hot session topics include 3-D displays, LED backlights, and low-power solutions such as e-paper. "The 3-D application session will include unique implementations that relate to the evolving 3-D stereo field," says committee member Adi Abileah, Chief Scientist at Planar Systems. Among those papers are "An Autostereoscopic 3-D Display Using Tunable Liquid-Crystal Lens Array that Mimics Effects of a GRIN Lenticular-Lens Array" by Paul C.-P. Chao from National Chiao Tung University, and "VCMaster3D: A New Fourier Optics Viewing-Angle Instrument for Characterization of Autostereoscopic 3-D Displays" by Pierre Boher from ELDIM. The first paper discusses tunable liquid-crystal lenticular lenses that are unique in structure, says Abileah. The second is about a conoscopic camera specific to autostereo displays. "The angular resolution is very high, and it includes features that allow the characterization of viewing freedom range, stereo contrast, stereo luminance, and more."

In terms of low-power solution topics, the recent releases of new e-paper products has led to a related and growing question: how soon can electrophoretic technology be adapted to full color? Come to the session and see for yourself.

The paper that attempts to answer that question is: "Development of e-Paper Color Display Technologies" by Alex Henzen of

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iRex Technologies, an invited paper that addresses the possibility of going beyond the gray-scale reproduction to which electrophorectic layers are now limited. "The final goal," according to the paper's abstract, "must be a color image that challenges the performance of a color photograph."

Applied Vision: Optimizing Wide-Color Gamut

According to Applied Vision Chair Helge Seetzen, Director for HDR Technology at BrightSide Technologies, the Applied Vision subcommittee addresses a unique segment of the display industry, both in terms of technology and timing. The committee tends to review papers on physical devices that are already in the marketplace – with topics that include common applications as well as new trends. "We also have studies from R&D labs that are working extremely far forward," says Seetzen. It is uncommon, he notes, to receive a paper representing untried applications.

The Applied Vision focus this year, he notes, seems to be white color gamut. Last year's conference featured numerous papers across multiple sub-committees that were devoted to building wide-color-gamut displays. What the APV committee is seeing now, he says, are papers on how to optimize those displays. One such paper in particular is "Evaluation of Gamut-Expansion Algorithms for Wide-Gamut Displays" by Dr. Masato Sakurai of Sony Corp.

A forward-looking topic that is showing up this year is interactivity. "It's not just about making a display that works well," says Seetzen, "it's what can we do with it in terms of interaction with a touch screen or using it in more varied environments. "

Other interesting papers include:

- "Human Vision in Complex Environments" by Mary Hayhoe from the University of Texas at Austin, an invited paper in the session on Image-Quality Evaluation.

Display Electronics: A Display is More Than a Panel

A trend with regard to established display technologies, according to Display Electronics Chair Michiel A. Klompenhouwer, Senior Research Scientist with the Video Processing Group at Philips Research Laboratories, "is that innovations are shifting to electronics (driving and signal processing) rather than device physics, and also that the ongoing integration of components in the display module (to improve form factor and reduce cost and power) is driving the development of efficient electronics systems." A related trend, he notes, is the idea that a display is no longer just a panel. "To reach the high image quality, low power, and attractive form factor of today's displays," says Klompenhouwer, "it is just as important to develop innovative signal processing, interfaces, and driving technologies."

Other papers of interest include:

- "Low Overhead Clock-Shared Differential Signaling (CSDS): An Efficient Interface for Large-Sized TFT-LCDs" by Nyuntae Kim from Samsung Electronics Co., Ltd., and "A Reduced Voltage Differential Signaling (RVDS) Interface for Chip-on-Glass TFT-LCD Applications" by Jung Pil Lim also from Samsung Electronics Co., Ltd. Says Klompenhouwer: "These two papers mark the ongoing development of efficient interfaces (high bandwidth, low power, minimal wires) to cope with the high demands in current display modules, such as high resolution, thin form factor, and low power."
- "Advanced Local Dimming and Scanning LED-Backlight Driving System Using a Novel Driver IC" by Kyoung-Uk Cho from Samsung Electronics Co., Ltd., and "Color Optimization Model for High-Dynamic-Range LCDs with RGB Color Backlights" by Yi-Ling Chen from National Chiao Tung University are examples of the idea that a display is more than a panel, requiring advanced signal processing that is also fully integrated with the display.
- Two invited papers, "Key Requirements for High-Quality Frame-Rate Conversion" by Claus Nico Cordes from NXP Semiconductors and "A Consideration on Motion-Image-Quality Improvement of LCD-TVs" by Taiichiro Kurita from NHK Science & Technical Research Laboratories, provide an overview of the current status of motion artifacts in LCD TVs.

Display Manufacturing: Cost-Effectiveness Is Key

As SID President Paul Drzaic explains in this month's President's Corner, new approaches to reducing costs are a hot topic for papers in Display Manufacturing this year. This issue is especially relevant to LCDs: smarter manufacturing techniques will only bolster this technology's dominance, according to Drzaic.

Other papers of interest include:

- "Fabrication of a 26-in. PVA LCD Panel by Using a Laser Ablation Process" by Yonghwan Shin from Samsung Electronics Co., Ltd., (in collaboration with Nakan Corp.) describes how the team replaced a six-step process with a single laser-ablation step to pattern ITO in a TFT panel.
- "FPD Repair System Using Electrostatic Droplet Technology" by Hyungjin Lee from LG Electronics explores the use of electrohydrodynamic jet technology as a reliable means of repairing the black matrix in a TFT panel.

Display Measurement: A New Standard for Metrology

In terms of quantity and quality, this was one of the best years ever for submissions to Display Measurement, according to subcommittee chair Stephen Atwood, Principle Engineer, Azonix Corp. The biggest news in this area is the creation of the Display Metrology Standard (DMS) by SID's International Committee for Display Metrology (ICDM). Members of that committee have spent countless hours over the past few years, working on the altruistic and far-sighted goal of creating a common language for display measurements that can be used by anyone involved with displays. "It's like Linux for metrology," says Atwood. For more about the DMS and the ICDM's dedicated session at Display Week, see "ICDM Special Session: A Visionary Standard " in the March 2009 issue of *Information Display* magazine.

Another type of vision is the subject of a paper by Toni Järvenpää from Nokia Research Center, "Advances in Near-to-Eye Display Optical Characterization," takes an advance look at measuring displays that are not widely in use yet. Special glasses or head-up displays will help users more comfortably view movies and other content on the tiny screens of portable media. "It's hard to watch a movie on your iPod," says Atwood, "but you can put on these 'projector' glasses and plug them into your iPod and now you have a bigger, virtual image." What Järvenpää has done, Atwood explains, is to find methods to characterize these near-to-eye virtual displays – to apply as much practical metrology as possible to an area in which human factors and ergonomics will figure greatly.

Other papers of interest include:

- "Comparison of Motion-Blur Measurement Methods" by Andrew Watson from the NASA Ames Research Center and "Advanced Display Motion-Induced Color-Distortion Analysis Methods" by Jongseo Lee from Samsung Electronics Co., Ltd., both address the measurement of motion blur. Atwood describes the removal of motion blur as "one of the fundamental challenges to the LCD-panel industry. Having solid methods to characterize the phenomena and quantify the improvements will be critical."

Display Systems: 3-D TVs Get Closer to Home

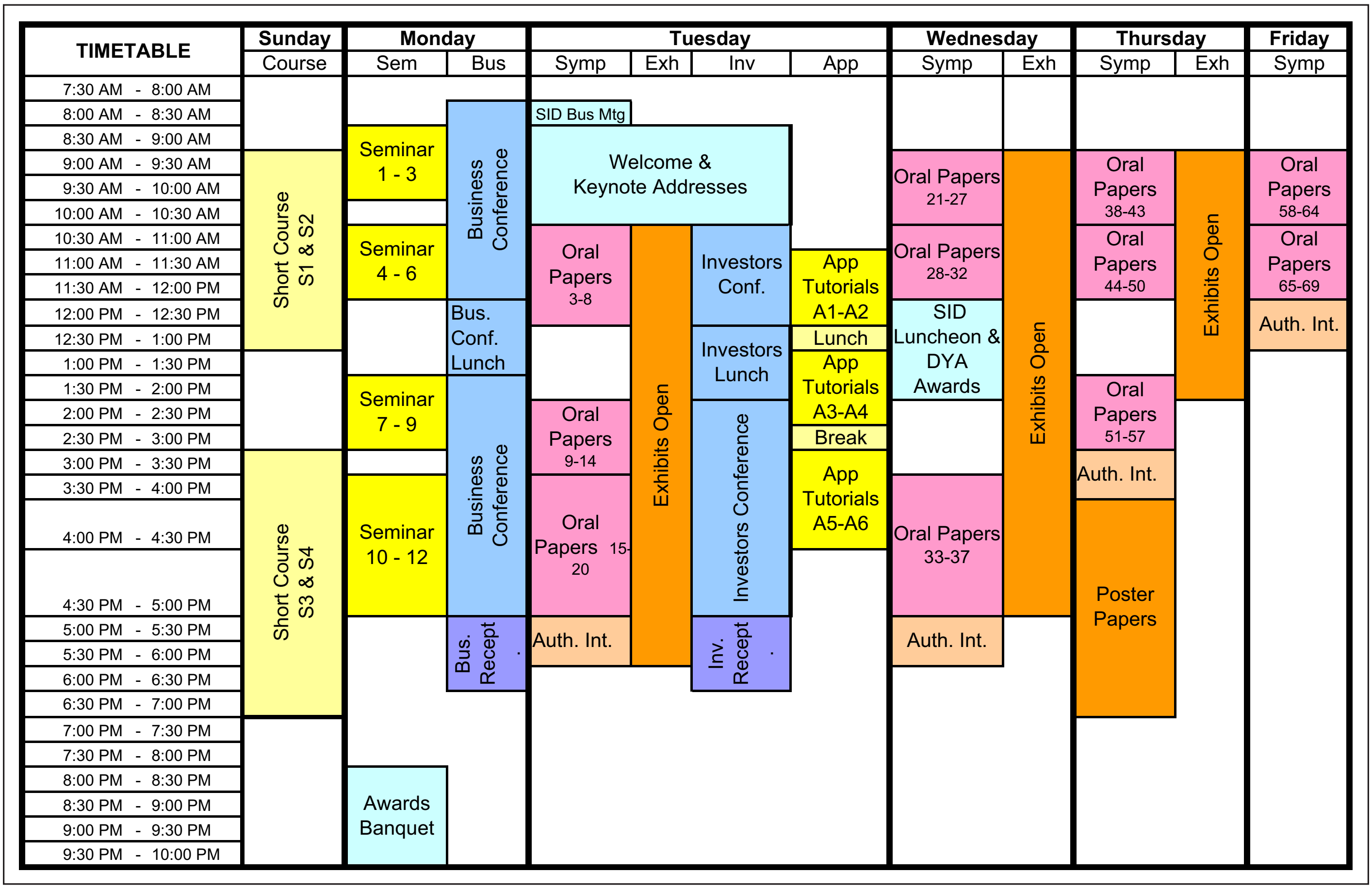
Now that 3-D has come to movie theaters in a big way – approximately 30 "A-list" pictures have been scheduled for release in 3-D throughout 2009 – is it only a matter of time before 3-D shows up in home televisions as well? Researchers and designers are betting on it. In fact, 3-D is one of the most exciting developments in Display Systems, according to Subcommittee Chair Brian Schowengerdt of the University of Washington's College of Engineering. Key to the development of 3-D televisions is high-speed LCDs that are optimized for 3-D use.

"One of the ways to create 3-D images is to flash the right and left images of a stereoscopic pair back and forth sequentially over time," says Schowengerdt. "Historically, it's been difficult to do this well with flat-screen displays because the 3-D mode effectively halves the refresh rate." LCDs have just not been fast enough. But both Samsung and Toshiba have developed new ways to increase the speed of LCDs, notes Schowengerdt, and representatives from both companies will be presenting papers in the display systems sessions. Samsung's Sang Soo Kim will be describing a full-HD 240-Hz TFT-LCD in a paper titled "World's First 240-Hz TFT-LCD for Full-HD LCD TV and Its Application to 3-D Displays." That LCD demonstrates twice the speed of a unit the company presented last year, Schowengerdt notes. Daiichi Suzuki from Toshiba will present an earlier-stage technology based on time-sequential optically compensated bend (OCB) LCDs that are "even faster but not as close to commercialization," he says. That paper is "Crosstalk-Free 3-D Displays with Time-Sequential OCB-LCDs."

Other papers of interest include:

- "Eco-Display High-Optical-Throughput Color-Filterless Field-Sequential LCDs" by Han-Ping D. Shieh and "Two-Color Field-Sequential Method for Color-

2009 Display Week Schedule at a Glance — Henry B. Gonzalez Convention Center



Filter-Free MVA-LCDs" by Yi Ru Cheng, a professor and student, respectively, from National Chiao Tung University in Taiwan, address color-filterless LCDs with lower power consumption and diminished color break-up.
- "1-mm-Diameter Full-color Scanning Fiber Pico Projector" by Brian Schowengerdt from the University of Washington discusses a miniature projector that is 1 mm in diameter and 9 mm in length and can project full-color images at 500×500 pixels.

Emissive Displays: Creating More-Efficient Plasma

Improving plasma-display panel (PDP) efficiency – partly by increasing xenon-gas content – is one of the trends that Subcommittee Chair Gerrit Oversluizen from Philips Research Laboratories says he is noticing in the area of emissive displays. There has also been "much attention given to the protective layer in PDPs," he says. In general, research efforts seem to be directed at lowering the cost of production while increasing performance. Oversluizen notes that there were no large-size commercial panel-improvement contributions from the industry this year.

Other papers of interest include:

- "Address Discharge Characteristics of High-Luminous-Efficacy PDP with SrO Protecting Layer" by Hae Yoon Jung from Seoul National University describes how researchers, in their words, "achieved low voltage driving and high luminous efficacy by applying SrO protecting layer in PDPs."
- "Control of Temperature Dependency of Exo-Electron Emission Behavior for MgO Film of ACPDPs" by Yong Seog Kim from Hongik University is an invited paper recommended by the chair.

Field-Emission Displays: Advances in Non-TV Areas

"Four or five years ago, every major display company had a large R&D program pursuing a field-emission-display (FED) color-TV project," says SID Fellow Jim Chen. Several major manufacturers demonstrated large, beautiful displays based on this technology. But the majority of these programs have gone quiet. Although no one nor any company has officially claimed a reason, Chen says, "the usual explanations are (1) the FED panels have a reliability problem or (2) the FED panels have a brightness-uniformity problem."

"So far not all of the players have officially withdrawn from pursuing the FED effort; they are hoping and waiting for a breakthrough invention to happen," Chen continues. In the meantime, researchers are trying to find new applications for FEDs, including backlight units for LCD panels and consumer lighting because in these applications the requirements for brightness uniformity and longevity are not so critical as for TVs.

This situation puts FEDs in a tough spot with regard to cutting-edge papers but nevertheless there are some good ones this year, notes Chen. One is "Improvements of Color CNT-FED Character Displays" by Hiroyuki Kurachi from Noritake Co., which presents a CNT-FED used in a character-display device. "This paper discusses the improvements of the higher pixel density and lower power usage of the new design," says Chen. "This is one of the very few successful FED products on the market."

Other papers of interest include:

- A 7-in. Field-Emission Backlight-Unit Assembly Using TiO_2-Coated Spacer for LCD Panels" by Jian-Min Jeng from Tatung University describes "a charge leakage coating on a CNT backlight unit's spacers to eliminate the discharge arcing problem in CNT backlight units," says Chen.
- " Enhanced Electron Emission of Carbon-Nanotube Emitters with Post-Growth Treatment" by Kyu Chang Park from Kyung Hee University discusses a new resist-assisted patterning (RAP) process to improve a CNT emitter's emission controllability and uniformity.

Liquid-Crystal Technology: Incremental Rather than Evolutionary Improvements

"LCDs have achieved maturity in performance and price and established themselves as the benchmark for all other displays." says Chair Birendra Bahadur of Rockwell Collins. "Most of the current LCD improvements are incremental and not evolutionary. Fast switching, cholesteric, flexible and mobile displays, optical films, and 3-D seem to be the hottest topics in LCDs." Further improvements, he continues, are also happening in viewing angle, response time, color gamut, resolution, power consumption, cost, LED backlights, and touch applications. "We have also noticed the emergence of other passive display technologies," says Bahadur. "There are many papers on electrowetting, electrophoretic, and other passive displays. A recommended paper in this area is 'Transmissive Electrowetting-Based Displays for Portable Multi-Media Devices' by Andrea Giraldo from Liquavista BV." Another overall trend to note, according to Bahadur, is the continuing "greening" of LCDs. "Newer displays consume less power and their manufacturing uses less materials and processes, which indirectly reduce the emission of green-house gases. LCDs can reduce paper and, hence, tree consumption significantly and can be used again and again. They are also effective in educating people in poor countries or remote places."

Other notable papers include:

- "An Over-500-Hz Frame-Rate-Drivable PSS-LCD: Its Basic Performance" by Norio Koshida from Nano Loa, Inc.
- "Fast-Switching Flexoelectric Display Device with High Contrast" by Flynn Castles, a student at the University of Cambridge, describes how a flexo-electro-optic effect provides a fast-switching mechanism suitable for use in field-sequential-color full-motion-video displays.

OLEDs: Advances in Manufacturing, Improvements in Performance

If from a research curve standpoint, OLED discoveries are flattening out somewhat – "This year we feel that OLED is a maturing technology," says Subcommittee Chair Denis Kondakov from Eastman Kodak Co. – key advances continue to be made. "We are seeing steady improvement in the important performance characteristics rather than sporadic breakthroughs," he says. And, in manufacturing, there is still much to be done before OLED-based products – especially larger ones – hit the market in a big way and fulfill their potential as a contender to LCD (see this month's "President's Corner"). Both "Multi-nozzle Printing: A Cost-Effective Process for OLED-Display Fabrication" by Reid Chesterfield from Dupont Displays and "Large-Area Color-Patterning Technology for AMOLEDs" by Min Chul Suh from Samsung SDI Co., Ltd., discuss manufacturing techniques for OLED displays.

Other papers of interest include:

- "AMOLED Displays Using Transfer-Printed ICs" by John Hamer from Eastman Kodak Co. describes how active-matrix OLED (AMOLED) displays were fabricated using backplanes with transfer-printed microscale-silicon integrated circuits in place of conventional thin-film transistors (TFTs).

Projection Displays: Picos Generate Plenty of Interest

"There is a great deal of activity and new development in pico projectors," says Edward English from REE Optical Systems, Chair of the Projection Displays subcommittee. "This is a very active area; there have been several big announcements and a lot of press about these devices. It is a nascent product group, with some uncertainty about whether it will become a large category vs. a novelty type device."

Key areas with regard to picos, he continues, include (a) development of an affordable, mass-produceable green laser, (b) small, fast field-sequential microdisplay devices, and (c) effective thermal and power management. "There is also a great deal of commercial activity – new product launches – for small, so-called companion or pocket

2009 Display Week Symposium at a Glance — Henry B. Gonzalez Convention Center

Day	Times	Ballroom C1	Ballroom C2	Ballroom C3	Room 214A/B	Room 214C/D	Room 217A/B	Room 217C/D	Times	Day
Tuesday, June 2	8:00 – 10:20	SID Business Meeting and Keynote Session (Ballroom C)							8:00 – 10:20	Tuesday, June 2
	10:50 – 12:10	3 AMOLEDs I	4 Flexible-Display Components		5 Emerging Applications	6 Field-Emission Displays	7 Plasma-Display Efficacy and Cell Design	8 Front-Projection Display Systems	10:50 – 12:10	
	2:00 – 3:20	9 AMOLEDs II	10 Flexible-Display Manufacturing (Joint with Manufacturing)		11 3-D Applications	12 Field-Emission Applications	13 Plasma-Display Driving	14 Pico Projectors	2:00 – 3:20	
	3:40 – 5:00	15 Oxide TFTs I	16 Flexible Active-Matrix Backplanes		17 Understanding Visual Display Artifacts	18 Field-Sequential Color	19 Phosphors	20 Solid-State Projection Light Sources	3:40 – 5:00	
	5:00 – 6:00	Author Interviews (Exhibit Hall D)							5:00 – 6:00	
Wednesday, June 3	9:00 – 10:20	21 Oxide TFTs II	22 Cholesteric LCDs	23 OLED Devices I	24 Display Measurement Methods and Standards	25 Autostereoscopic Displays	26 Plasma-Display Protective Layers	27 Driver-IC Technology	9:00 – 10:20	Wednesday, June 3
	10:40 – 12:00	28 System-on-Glass AMLCDs	29 Mobile Displays	30 OLED Devices II	Special Session Focus: The ICDM	31 Advance TV and 3-D Displays		32 Touch-Panel Electronics	10:40 – 12:00	
	2:00 – 3:30	Designated Exhibit Time (Exhibit Hall C)							2:00 – 3:30	
	3:30 – 4:50	33 Novel Active-Matrix Devices	34 Novel Display Technologies	35 OLED Devices III	36 Characterization of Display Systems and Components	37 Novel Displays			3:30 – 4:50	
	5:00 – 6:00	Author Interviews (Exhibit Hall D)							5:00 – 6:00	
Thursday, June 4	9:00 – 10:20	38 Touch-Screen Active-Matrix Displays	39 Fast Response I	40 OLED Manufacturing (Joint with Manufacturing)		41 Stereoscopic Projection (Joint with Projection)	42 Display Manufacturing: Processes	43 Backlight Driving: Color Processing	9:00 – 10:20	Thursday, June 4
	10:40 – 12:00	44 Organic TFTs	45 Fast Response II	46 OLED Mechanisms	47 Image-Quality Evaluation	48 Slim LCD TVs	49 Display Manufacturing: Patterning	50 Backlight Driving: High-Dynamic-Range Processing	10:40 – 12:00	
	1:30 – 2:50	51 E-Paper	52 LC Alignment	53 AMOLED Displays	54 3-D	55 LED Backlights (Joint with Applications)	56 Display Manufacturing: Interconnects and Metalizations	57 Video Processing and Motion Fidelity	1:30 – 2:50	
	3:00 – 4:00	Author Interviews (Exhibit Hall D)							3:00 – 4:00	
	4:00 – 7:00	Poster Session (Exhibit Hall D)							4:00 – 7:00	
Friday, June 5	9:00 – 10:20	58 Emerging Active-Matrix Technologies (Joint with Active Matrix)	59 Optical Films for LCDs	60 White OLEDs	61 Image-Quality Modelling	62 RGBW Color (Joint with Electronics)	63 Display Manufacturing: OLEDs	64 Interface Technologies	9:00 – 10:20	Friday, June 5
	10:40 – 12:00	65 Flexible AMOLEDs	66 Novel LC Materials and Effects		67 Color	68 Novel Backlights	69 Display Manufacturing: Substrates		10:40 – 12:00	
	12:00 – 1:00	Author Interviews (Exhibit Hall D)							12:00 – 1:00	

TECHNOLOGY TRACKS KEY						
Active Matrix	Applications	Applied Vision	Electronics	Emissive	FEDs	Flexible Displays
Liquid Crystal	Manufacturing	Measurement	OLEDs	Projection	Systems	

projectors in the 100–200-lm ~50-W range."

Important papers, says English, include "LCOS Devices for Professional Projection Displays" by Andre Van Calster from Ghent University, which reviews the development of LCOS microdisplay devices. In "High Contrast in Bright Ambients with Angle-Shifting Front-Projection Screen," Baku Katagiri from Tohoku University will describe "a high-contrast screen that works well in bright, ambient environments using an angle-shifting structure," according to English. And Jan Drumm of OSRAM will present advances in creating a compact RGB laser module that is suitable for pico-projector applications in "Compact RGB Laser Module for Embedded Laser Projection."

Other papers of interest include:

- "White-Point Calibration of Color-Sequential Mobile Projector" by Yongchan Keh from Samsung Electronics Co., Ltd., presents an analysis of how LED binning and optical tolerances affect the white-point calibration for projectors.
- "Perceived Brightness of LED Projectors," a paper from Tsung-Hsun Yang, a student from the National Central University in Taiwan, presents "a nice analytical derivation of why we might perceive an LED-illuminated projector as brighter than a UHP-lamp-illuminated projector," says English.

Some Necessary Inspiration

From new flexible displays to the Display Measurements Standard to 3-D TVs, the Symposium sessions are proof that great discoveries and advances in display technology have not stopped just because we are in a very tough economy. The Symposium is an excellent place to learn about new manufacturing processes and materials that might give your business the edge it needs. Come get inspired at Display Week 2009. ■

Lasers Enable Diverse Display Production Techniques

Laser-based techniques are finding increased use in certain aspects of flat-panel-display manufacturing. Lasers provide the option of a non-contact high-spatial-resolution tool that is appropriate for a variety of processing tasks, including thin-glass cutting, laser direct patterning, low-temperature-polysilicon annealing, and laser lift-off.

by Rainer Paetzel

DISPLAY MANUFACTURERS continually face market pressure to improve display performance and reduce product weight and thickness without significantly increasing cost. Several innovative manufacturing technologies have been developed to address the resultant fabrication challenges, and the laser has emerged as a critical enabling tool for many of them. This article reviews four major laser-based techniques currently being employed in display production: thin-glass cutting, laser direct patterning, low-temperature polysilicon annealing, and laser lift-off for flexible-display manufacture.

Thin-Glass Cutting

The conventional mechanical technique for cutting glass has certain drawbacks for very thin substrates, such as those used in miniature displays. In particular, the mechanical force of the cutting tool produces microcracks in the material, and the subsequent breaking step yields small chips and debris, plus an edge that is not necessarily perpendicular to the glass surface. Furthermore, mechanical cutting leaves significant stress in the finished edge. To prevent further cracking or breaking in downstream handling and processing, it may therefore be necessary to grind or polish the cut surface after cutting. Also, a post-process cleaning step may be required to remove debris that could otherwise interfere with subsequent processes, such as circuit formation.

Laser glass cutting is a non-contact process that eliminates the problems of microcracking and chipping. Also, laser cutting produces essentially no residual stress in the glass, resulting in higher edge strength. This is critical because even when force is applied to the center of a glass panel, any break usually initiates at the edge. Consequently, laser-cut glass can withstand two to three times as much force as mechanically cut glass.

Laser cutting can also reduce the number of process steps, since it does not require any subsequent cleaning or grinding stages. Therefore, while the capital cost for a laser-cutting station is higher than for a mechanical system, the overall investment in laser cutting can be lower than for mechanical processing if an additional grinding machine can be eliminated. As a result of the above factors, laser processing has been widely adopted in the display industry for the cutting of glass substrates having a thickness of 1 mm or less because this is the area where the technology's advantages are most pronounced. In terms of processing speed, some laser glass-cutting techniques are faster than their mechanical counterparts; some are slower (see Table 1 below for a comparison).

Table 1: Comparison of mechanical and laser glass-cutting methods

	Mechanical Scribe	Laser Scribe	Laser Full-Body Cut
Speed*	500 mm/sec	<1500 mm/sec	<20 mm/sec
Accuracy	50 µm	25 µm	200 µm
Thickness range	30 µm – 20 mm	200 µm – 10 mm	30 µm – 1 mm
Cooling	—	Water, ethanol, CO_2	Clean dry air, nitrogen
Post processing	Breaking, grinding, cleaning	Breaking	—

*Based on 0.5-mm-thick sodalime glass, with a 200-W laser and water cooling.

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There are two basic laser-based techniques for glass cutting: laser scribing, which is primarily used for substrates in the 0.3–0.7-mm thickness range and laser full-body cutting, which is utilized mostly with very thin substrates of 0.2 mm or less. Both methods typically use a continuous-wave (CW) CO_2 laser or a pulsed CO_2 laser with a repetition rate high enough to appear as a CW at the feed rates used in this application.

In laser scribing, the laser is focused onto the surface of the glass, which is translated so as to create a continuous cut. Since all glasses strongly absorb the 10.6-μm CO_2 laser wavelength, all the laser energy is deposited at or near the surface of the glass, causing rapid heating. Either liquid or air is then delivered by nozzles onto the glass to quickly cool it; the resulting thermal shock produces a continuous crack in the glass that is typically about 100 μm deep (Fig. 1). After the entire scribing is completed, the glass then passes under a mechanical roller or controlled chopper bar that imparts enough force to propagate the crack through the entire substrate and break it. This break is free of debris and perpendicular to the surface.

Laser full-body cutting utilizes an alternative, non-mechanical method for breaking the glass. Here, the original scribe crack is created by a laser beam but with cooling only from an air or nitrogen jet. A second laser beam then causes rapid expansion of the glass and drives the crack all the way through the substrate, eliminating the need for a separate breaking process. No cooling is used with the second laser beam.

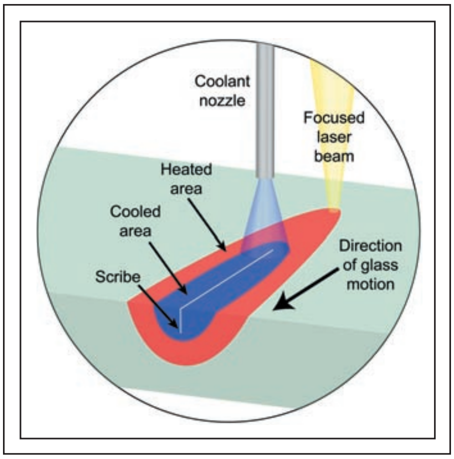

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Fig. 1: Laser scribing creates a continuous crack through the glass.

The set-up for laser full-body cutting is similar to that of laser scribing, with translation of the substrate. The table summarizes the characteristics of mechanical cutting and the two laser techniques.

Laser Direct Patterning

Lithography is used to pattern circuit elements at various production stages for several different display technologies. Conventionally, the photolithographic process involves at least six separate steps (resist coating, baking, exposure, developing, etching, and resist stripping). Each of these steps requires dedicated capital equipment, which takes up manufacturing floor space and each requires time to complete. Additionally, some of these processes involve chemicals that are not environmentally friendly.

In some cases, a single step in which a laser directly ablates a material layer can replace the six steps of conventional lithography. Laser direct patterning can increase manufacturing efficiency by reducing cycle time, increasing yields, and reducing manufacturing floor space, as well as decreasing the environmental impact of production.

Currently, a common application for laser direct patterning is in selectively removing the clear conductive layer of indium tin oxide (ITO) on the front glass of a plasma-display panel (PDP) to form the front electrodes. This task is usually performed using a multimode Nd:YAG operating in the near-infrared.

Most laser-based micromachining is performed using either a direct-write or a mask-based approach (see Fig. 2). In the case of ITO patterning, a combination of the two processes is employed. In particular, a mask is used to define the pattern and the laser is raster-scanned over the large glass substrate, rather than illuminating it all at once. This

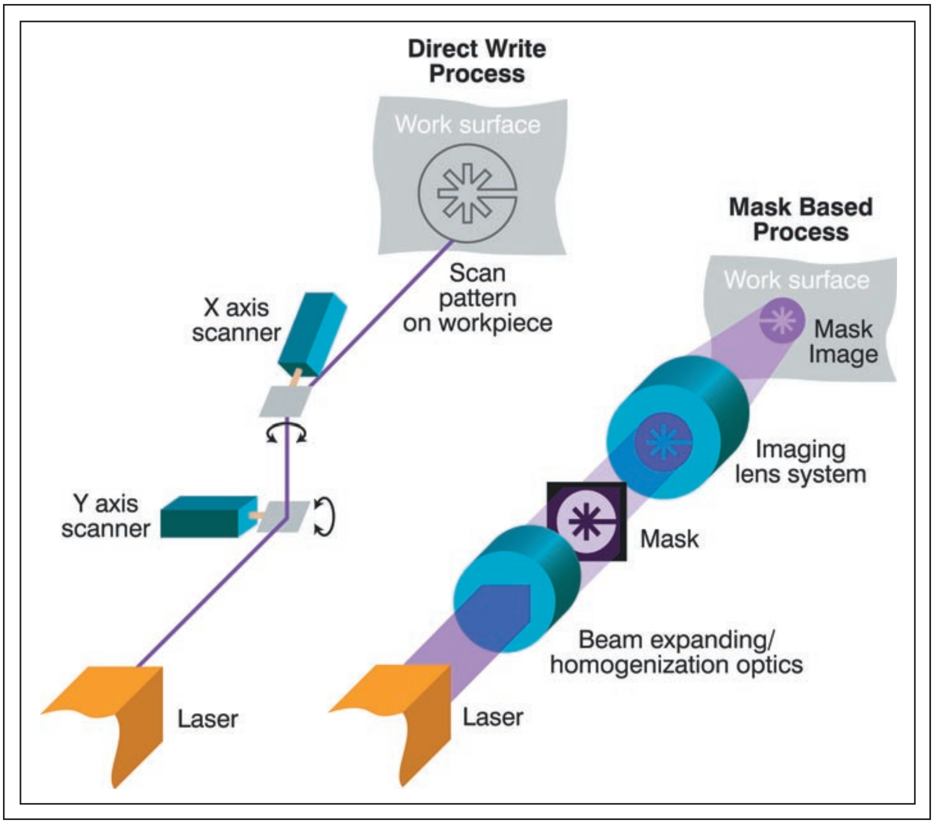

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Fig. 2: Direct-write and mask-based laser processes are shown side by side. In direct writing, the focused laser beam is scanned by galvanometer mirrors to trace out the desired pattern on the workpiece; in mask-based imaging, the laser illuminates a mask containing the desired pattern, which is then re-imaged on the workpiece.

process produces the desired pattern on the work surface. The multimode Nd:YAG laser is the machine of choice for this application as long as relatively low resolution is required; this is because it is inexpensive, yet still supplies sufficient optical power to enable the process to occur at adequate throughput rates. Estimates are that about half of the PDPs currently in production are laser processed in this manner.

The laser-generated features on PDPs are several hundreds of microns in size. However, there are other applications in the production of other FPD types that require higher resolution. For example, in some LCD architectures, the transparent-conducting-oxide (TCO) electrodes on the color-filter panel must be precisely formed in order to properly shape the electrical field, which controls the vertical alignment of the liquid-crystal molecules within each red, green, and blue subpixel. The feature sizes of these electrodes are on the order of 5 μm and below; *i.e.*, too small to be patterned by Nd:YAG lasers. These are currently produced lithographically.

The only practical laser method to achieve the spatial resolution and placement accuracy necessary for this task is to use an excimer laser in a mask-imaging process. This application is currently at an early stage of development and has not been deployed in production by any manufacturer. The deep ultraviolet output of the excimer laser enables production of micron-sized and even submicron-sized features (which is why they are used for integrated-circuit microlithography). In addition, the high pulse energy of the excimer laser can remove the entire TCO thin film in a single pulse, thus providing the required process throughput rate. The mask pattern is imaged at a demagnification on the work surface. This makes the power density on the mask much lower than that achieved on the work surface (see Fig. 2). To make this process practical, a mask must be created containing the circuit pattern for a large number of pixels to enable the parallel ablation of many pixels with one laser pulse. After each exposure is made, the substrate must then be translated relative to the laser beam for another shot; this is repeated until the entire display is processed.

Another emerging laser process is producing scribe lines on touch screens. Specifically, touch-screen production usually involves scribing multiple lines of about 25–50 μm in width through a TCO layer. The laser-based process for touch-screen scribing uses a high-power diode-pumped solid-state laser operating in the ultraviolet (typically over 20 W at 355 nm). Once again, the short UV wavelength can easily be focused to produce the desired feature size. Furthermore, this wavelength does not penetrate far into the substrate, meaning a minimal heat load on what is often a delicate thin glass or plastic substrate. The physical size of the scribe patterns, together with their simplicity (usually a checkerboard configuration), can be easily produced with a direct-write process.

Low-Temperature-Polysilicon Annealing

In active FPDs, silicon forms the basic semiconductive layer for the build-up of the thin-film transistors (TFTs) of the active matrix for various display applications including LCDs. This layer is initially created by standard PE- or LP-CVD techniques and is amorphous in nature. Amorphous silicon (a-Si) is the dominant material used in FPDs today; however, it has limited electron mobility, which in turn drives compromises in other aspects of display designs. Increasing the electron mobility is highly desirable and electron mobility can be dramatically increased by converting the a-Si into polysilicon (poly-Si) through an annealing (re-crystallization) process.

Increasing electron mobility delivers several benefits. First, it enables the implementation of smaller TFTs supporting higher aperture ratios and therefore brighter AMLCDs and/or higher overall electrical efficiency. Smaller TFTs can also enable higher-resolution displays. It also makes it practical to implement drivers and other circuitry directly on the display, simplifying overall system construction and lowering total costs. As a result, poly-Si annealing is a critical enabler for system-on-panel (SoP/SoG) displays. It also delivers the ideal combination of high performance and reliability to act as an ideal support matrix for AMOLEDs. However, despite the performance benefits of poly-Si, its use is unlikely to spread beyond these display types any time soon.

Excimer-laser-based low-temperature-polysilicon (LTPS) annealing is now the preferred approach for producing the poly-Si layer during FPD fabrication because it can be performed at low temperatures, possibly as low as 200°C. At present, the two LTPS techniques most widely used are excimer-laser annealing (ELA) and sequential lateral solidification (SLS). Both of these require excimer lasers that combine high pulse energy (1 J) and repetition rates of several hundred hertz at very high-energy stability (Fig. 3).

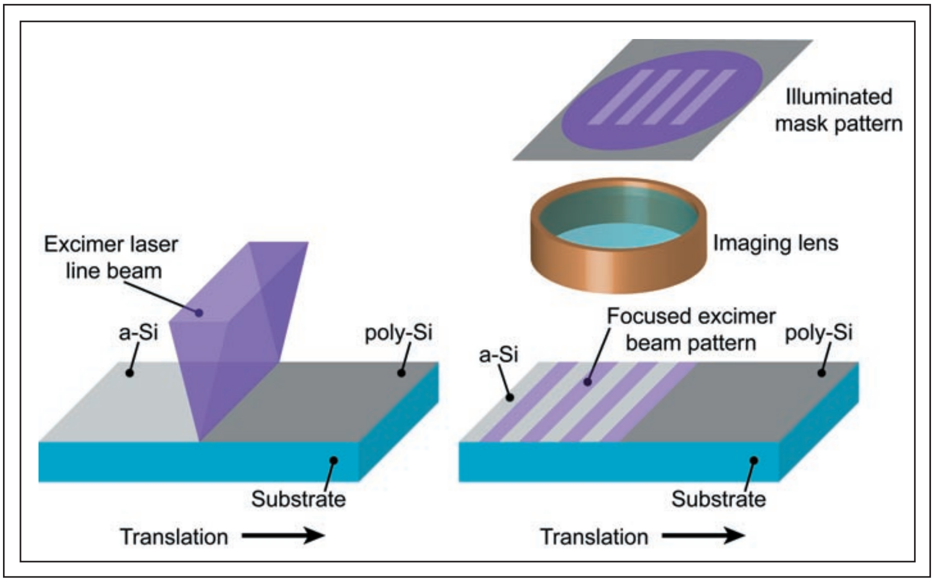

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Fig. 3: Shown is the ELA polysilicon annealing processes (left) and the SLS process (right). In ELA, the excimer beam is shaped into a long line and scanned over the substrate. In SLS, the laser beam is projected as a series of stripes onto the substrate. An exposure is made and then the substrate is translated by half the pitch of the pattern for another exposure.

In ELA, the rectangular beam from a 308-nm excimer laser is optically homogenized and re-shaped to form a long narrow line (typically around 465 mm × 0.4 mm) that has a high degree of energy uniformity throughout its profile. This line profile is directed at the silicon-coated substrate, which is then scanned relative to the beam.

Silicon efficiently absorbs 308-nm radiation, making it possible to achieve near-complete melt with each individual pulse. This leads to efficient crystal formation due to crystal growth in the vertical direction, starting at the interface between the molten and residual unmolten silicon.

In SLS, the laser beam is projected through a mask, creating a striped pattern on the substrate. This particular mask design makes it possible to scan the substrate and crystallize each location by just two consecutive laser pulses. The first pulse melts through the entire depth of the Si layer, producing a pattern of lines of poly-Si with a-Si in between. The typical line width is a few microns. The substrate is then offset by half the line pitch of the mask for the next exposure. This exactly fills in the area missed in the first exposure, yielding a continuous layer of laterally crystallized polysilicon.

The primary advantage of SLS is that it can potentially deliver as much as twice the throughput over ELA for the same process requirements. However, at the present time, the industry uses ELA almost exclusively, and it is the only process qualified for mass production of AMOLEDs.

Laser Lift-Off

Flexible displays have enormous commercial potential, but their introduction has been slowed by several significant technical challenges. In particular, the thin plastics substrates used for flexible displays are too delicate to be handled with conventional tooling and will typically lose their limited rigidity at the high temperatures experienced in some production steps. Thus, flexible-display production requires either substantial process modification or will be restricted to a very small range of materials.

Two laser techniques – SUFTLA (surface-free technology by laser annealing) and EPLAR (electronics on plastic by laser release) – have already proven capable of avoiding these limitations. Both techniques employ the same concept to enable mass production of flexible displays – fabricating the display circuitry on a rigid substrate using conventional methods and then using the laser to deposit highly localized energy at a layer or interface, allowing lift-off of the active devices from the rigid carrier.

In SUFTLA, a sacrificial silicon layer is deposited on a standard substrate, and display circuitry is fabricated on top of this layer using completely conventional methods. Then, a series of steps are performed to bond the circuitry to a temporary substrate, release the original glass substrate, and then bond to a permanent, flexible plastic substrate (see Fig. 4). This technique was developed by Seiko-Epson and is currently used in products based on E Ink technology.

Electronics on plastic by laser release is another lift-off process, pioneered by Philips Research and is currently being used in production. Here, a polyimide film is spun onto the glass substrate prior to device fabrication. The polyimide is baked to a temperature higher than any used for subsequent TFT processing steps. Once again, display circuitry is fabricated using completely conventional methods. The plastic can withstand this processing because it is physically supported by the glass substrate. Next, a high-power ultraviolet excimer laser is directed through the glass substrate. This light is absorbed strongly by the plastic and a thin layer of it is ablated, thus separating the flexible display from the carrier.

Both SUFTLA and EPLAR offer similar benefits. Specifically, they employ rigid glass carriers, thus eliminating the need for special handling during fabrication, and they allow the use of standard processes and tools for display circuitry fabrication. Additionally, the glass substrates can be cleaned and reused repeatedly.

In conclusion, lasers are finding increasing use in FPD manufacture. They offer a non-contact high-spatial-resolution tool that is useful for a variety of processing and measurement tasks. In many instances, these characteristics result in increased yields, higher throughput, improved performance, and more environmentally friendly production. ■

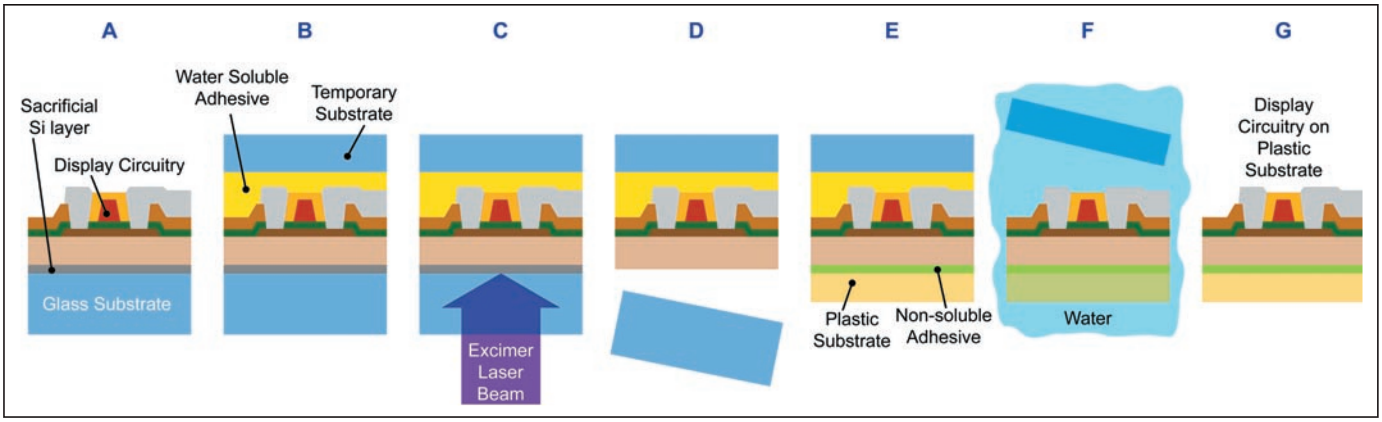

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Fig. 4: SUFTLA process overview: (a) Display circuitry is fabricated over a sacrificial layer on a glass substrate. (b) The circuitry is bonded to a temporary substrate. (c) The laser ablates the sacrificial layer. (d) The circuitry separates from the glass substrate. (e) The flexible plastic substrate is permanently bonded to the circuitry. (f) Water dissolves the adhesive holding the temporary substrate. (g) The display is now on a flexible substrate.

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The following papers appear in the April 2009 (Vol. 17/4) issue of *JSID*.
For a preview of the papers go to sid.org/jsid.html.

SID
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continued from page 2

and appreciate all the amazing work that is taking place in the display industry.

While most of this issue is devoted to the upcoming Display Week events, we also have a very interesting article on current and future applications for lasers in display manufacturing. Laser technology is an integral component of many product processes and continues to enable new ideas and innovations. We appreciate the efforts of author Rainer Paetzel from Coherent GmbH in bringing this enlightening contribution to us. ■

In Memory of Joel E. Goldmacher

by Joe Castellano

Joel E. Goldmacher

Joel E. Goldmacher, 71, a pioneer in the development of liquid-crystal materials and displays, died on January 22, 2009, in Lakeland, Florida.

Born in Brooklyn, New York, Goldmacher earned his B.S. degree in chemistry in1959 from the City College of New York. He then attended Purdue University in Lafayette, Indiana, where he received his Ph.D. in organic chemistry in 1963.

Goldmacher started his career as a member of the technical staff at the David Sarnoff Research Laboratories of RCA Corp. in Princeton, New Jersey. He was the first organic chemist to be employed at this corporate research center. His early work involved the synthesis of organic semiconductors and insulators. Later, he developed materials for electro-optical devices and optical recording media. Goldmacher was a member of the team that developed the world's first liquid-crystal display (LCD).

In 1966, he and his co-worker developed the first room-temperature nematic liquid-crystal material, opening the way for practical LCD devices to be made. For this milestone achievement, he was a co-recipient of RCA's highest award, the David Sarnoff Team Award in Science, in 1969.

In 1970, Goldmacher left RCA to become one of the founding members of Optel Corp. in Princeton, New Jersey, one of the first companies to manufacture LCDs and digital watches. As Vice President of Research, he led the development of advanced liquid-crystal materials and electronic devices. Later, he became Optel's Vice President of Sales and Marketing. When Optel was sold in 1978, Goldmacher formed Springwood Associates with two other Optel executives to develop various electronic products.

During his career, Goldmacher lectured extensively around the world and was an author or co-author of numerous scientific publications; he also holds 17 patents.

He is survived by his wife, Judith; children Neil, Hope, Jonathan, and Tracy; and six grandchildren.

2008 SID Vehicles & Photons Symposium

by Robert Donofrio

The Metropolitan Detroit Chapter of the Society for Information Display hosted the 2008 SID Vehicles & Photons Symposium at the University of Michigan at Dearborn on October 16 and 17, 2008. The event proved popular; even though the automotive industry had already been hit with an increasing number of job layoffs and falling stock prices, 88 people attended. The majority of the attendees were from Michigan, but international participants from the United Kingdom, Germany, Switzerland, Canada, Taiwan, and Japan were on hand as well.

Twenty-four papers, including the keynote address, tutorials, and invited papers were presented in this two-day symposium, which was sponsored by Denso, Yazaki, Continental Automotive, and Futaba. This year's keynote was given by Michael Heimrath of BMW. He discussed automotive display integration and cost-reduction issues that addressed challenges faced by many in the audience.

Twelve companies had booths at the meeting. Two automobile demos showed new display implementations for automotive-industry applications. One demo involved a Ford Edge using a 3M screen-coating technology and the other was a Continental Automotive display in a BMW. Many of the attendees were able to use this opportunity to see in person how the various new technology improvements perform.

Symposium Co-Chair Mark Larry of Ford Motor Corp. (at left) delivers the opening remarks at the 2008 SID Vehicles & Photons Symposium.

Ben DiCicco of Chrysler receives a service award from Detroit Chapter Chair Silviu Pala of Denso America.

Another feature of the conference was the panel discussion on "Display Integration and Future Display Opportunities" in which participants from GM, Ford, and Chrysler Automotive, as well as from automotive supplier companies, discussed where the industry is heading.

Awards were presented to Ben DiCicco of Chrysler and to Mark Larry of Ford for their service as General Chair and Co-Chair of the Symposium, respectively. The Scholarship Awards Committee was also re-invigorated, with its new Chair Dr. Alan Sobel. These awards will be presented during next year's symposium.

Overall, the Symposium was both informative and enjoyable. The spacious facilities of the University of Michigan at Dearborn permitted many opportunities for attendees to discuss display issues with their peers.

The strong attendance would seem to demonstrate that the Metropolitan Detroit Chapter of the SID continues to serve its members through holding this annual symposium. ■

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continued from page 3

People have been saying that plasma is on the way out for years, according to Weber. But for now, he maintains, it not only still has its place but is continuing to evolve – much as LCD technology is evolving as well.

—Jenny Donelan

Seiko Epson and Sony Discuss LCD Businesses Alliance

Seiko Epson Corp. and Sony Corp. have begun discussions about an alliance in the field of small- and medium-sized liquid-crystal displays (LCDs), including the transfer of a part of business assets of Epson to Sony. The companies plan to enter into a legally binding definitive agreement by the end of June 2009.

To date, Epson Imaging, a subsidiary of Epson, has implemented a series of restructuring measures in its small- and medium-sized LCD business. At the same time, it has been working to shift its product portfolio toward developing original high-definition and ultra-wide-viewing-angle technologies based on its amorphous-silicon TFT and low-temperature-polysilicon (LTPS) TFT technologies. An alliance with Sony would enable Epson Imaging's LCD technology and amorphous-silicon TFT production capability to be more fully utilized.

According to an analysis piece on Tradingmarkets.com (http://www.tradingmarkets.com/.site/news/Stock%20News/2221235/), Seiko is pursuing the business in order to shore-up efforts to compete with its South Korean and Taiwanese LCD rivals. A major weakness of Seiko Epson's LCD business, the article claims, is that Seiko Epson itself does not manufacture products that use LCD panels. In Sony, Seiko Epson would have a reliable customer for these panels because Sony makes a range of devices such as mobile phones that use them.

On its part, Sony is focusing on LTPS-TFTs for its small- and medium-sized LCD business. In order to accelerate the development and commercialization process, it is also consolidating its resources within its subsidiary, Sony Mobile Display Corp., which will result in a unified operation containing development, design, and production. Through the contemplated alliance, Sony says it aims to increase the competitiveness of its small- and medium-sized LCD business by incorporating Epson's wide range of technologies; in particular, Epson Imaging's amorphous-silicon TFT technology and LCD product designs and production capabilities.

According to analyst Paul Semenza, Senior Vice President with DisplaySearch, there is no one obvious underlying motivation for the projected alliance. A variety of factors may be at work. First, "Sony is looking for the next Trinitron," he says. And if Sony, which has been developing OLED as the future TV technology, wanted to expand its presence in OLEDs into mobile devices, the new TFT capabilities from Epson might bolster Sony's OLED as well as its LCD development. Or, Sony may just be looking to add to its LCD technology. Or, for both companies, he says, "Part of it may just be ongoing consolidation."

—Jenny Donelan

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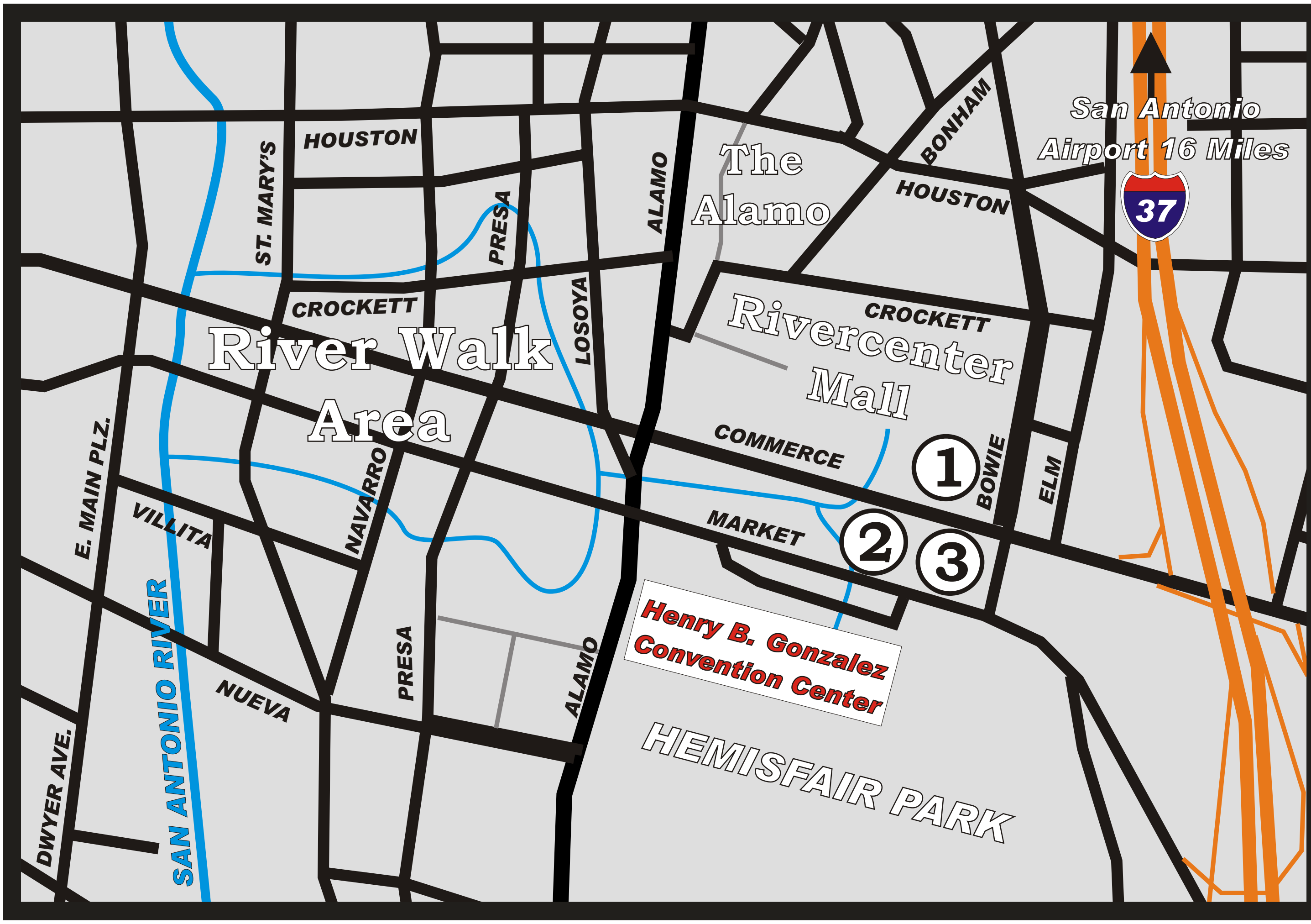

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