TOUCH AND DISPLAY-ENHANCEMENT ISSUE

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In-Cell Pro-Cap Touch Comes of Age at Display Week 2012

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contents

For Industry News, New Products, Current and Forthcoming Articles, see www.informationdisplay.org

ON THE COVER: *Prior to Display Week 2012, it seemed as though in-cell touch wasn't making any significant progress. The number of shipping products with in-cell touch could be counted on just a few fingers. This year there was an increased number of p-cap module suppliers at Display Week focused specifically on meeting the needs of commercial applications in the U.S.*

Cover Design: Acapella Studios, Inc.

Next Month in *Information Display*

Novel Displays Issue
- I-Zone Prototype Winner's Tactile Layer Panel
- Holographic 3-D Displays
- Virtual Remote Controller
- The Cutting-Edge Display Market

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editorial

Choosing the Right Words

by Stephen Atwood

Welcome to the September issue of *Information Display*, featuring a focus on Applications and a continuation of our coverage of Display Week 2012 activities. This month we are highlighting Geoff Walker's review of all the touch technology shown at Display Week, including the many significant technical advances reported there. Touch has grown to be a large segment of SID's annual conference and Geoff has the best perspective on this technology of anyone in the industry. We're sure you will find it interesting and informative.

Along with touch, the buzz about reflective displays and their applications was significant both during and after the show. Our Industry News segment this month talks about an important change of direction for Qualcomm's mirasol displays and points to what we're seeing as consolidation in the low-power reflective display landscape. At the same time, we received some more mainstream validation that e-books and e-readers are here to stay, as both terms were recently added to the Merriam-Webster dictionary. These entries define the electronic instance of the books as "e-books," while they define "e-readers" as the physical devices. Of course, by this time people refer to applications as e-readers and I'm even told that on Facebook the term "e-reader" is applied to a person who reads books and similar material via an electronic format. So, the term refers to the user as well as the device itself. But this is nothing new.

We take lots of liberties with terminology in our industry. We call some LCD TVs "LED" TVs and we specify "brightness" when we really mean "luminance." In fact, the whole category of flexible displays is largely ambiguous because the "flexible" adjective can mean bendable, formable, moldable, or almost anything else. People often use terms like "readability" and "resolution" in ways that seem to make sense only to them. It can be a challenge to preserve the real meaning of well-known terms as well as decipher the meaning of new words that seem to appear overnight.

What matters is not the terminology itself, but how accurately we define it and how consistently we use it. That's one of the things we try to watch for here at *ID*. We carefully review our content to ensure the vocabulary being used is consistent with the standards in the applicable field and each uncommon term is explained well enough that the topic can be more easily appreciated. Such was the case with both of our applications articles this month. All of our authors did a great job not only explaining the nuts and bolts of their topics, but also helping to clarify the terminology and definitions of terms that may not be commonly used (or used correctly) unless you are more deeply involved with those subjects.

Our first application feature, "Front-of-Screen Display Components and Technologies," was written by a team of people from Qualcomm: Ion Bita, Marek Mienko, Rashmi Rao, George Mihalakis, Russel Martin, and George Valliath. A variety of methods and technologies are described for enhancing the high-ambient readability and performance of reflective displays, though many of these methods are commonly used on emitting displays as well. It's a set of recipes and a good primer that you will want to keep bookmarked for a long time to come.

Our second application feature this month is a follow-up to an earlier Frontline Technology article we ran on Cambrios's silver-nanowire transparent conductor technology in the January 2012 issue. This issue's article, titled "Laser Patterning of

(continued on page 31)

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Reflective OutLook: Shades of Gray or Colorful?

by Jenny Donelan

The summer of 2012 was an eventful one for the reflective, low-power industry. Two major players made announcements that may be difficult to interpret right now, but certainly indicate changes ahead. In July, Qualcomm, maker of the mirasol low-power MEMS (microelectromechanical systems) reflective technology, announced that it would begin licensing that technology. And in August, E Ink Holdings, which makes the E Ink on which the majority of e-Readers are built, announced that it planned to acquire SiPix Technology, Inc., a developer of microcup technology-based electrophoretic displays.

For some time, mirasol has been considered a possible contender to E Ink's ubiquitous electrophoretic technology. One of the main reasons that Qualcomm's announcement came as a surprise was that the chipset maker has been vigorously researching, developing, and promoting mirasol for several years and is currently building a mirasol-display factory in Taiwan. A quick survey of technology bloggers shows the general consensus is that Qualcomm may be going in a different direction with mirasol, which began appearing in e-Readers in 2011. mirasol can show color and video, but somewhat similar to color EPDs to date, the color is somewhat similar, not bright and crisp.

So what's going on with mirasol? According to *The Verge*'s Adi Robinson, who notes that Qualcomm CEO Paul Jacobs spoke of licensing next-generation mirasol display technology and directly commercializing certain mirasol products: "This doesn't necessarily mean the mirasol line will be discontinued, but it's clearly being scaled back, and it's possible that this is effectively the end for Qualcomm's own production." [1] At press time, Qualcomm representatives said they were not commenting on the announcement or plans for the factory in Taiwan.

E Ink and SiPix

Meanwhile, could color have anything do to do with E Ink's recent announcement of its intention to acquire SiPix, whose microcup technology does show promise in that area? E Ink will certainly utilize SiPix's color capabilities, says Sriram K. Peruvemba, Chief Marketing Officer for E Ink Holdings. Peruvemba characterizes that color as having "some of the same advantages as E Ink in that it is low power, sunlight readable, thin, light ... ."

Beyond a doubt, one area of interest for E Ink is SiPix's manufacturing capabilities. "SiPix's factories, equipment, and infrastructure are relatively newer, which gives us greater flexibility and additional capacity as we seek new markets," says Peruvemba. Among the markets that the potential acquisition will make more accessible, he says, are digital signage and smart cards.

When it comes to E Ink, it isn't necessarily all about color, notes University of Cincinnati's Jason Heikenfeld, who has served as a guest editor for *Information Display* (and is also a founder of e-Paper up-and-comer Gamma Dynamics, mentioned later on). "We should maintain excitement about the continued expansion of monochrome e-Paper products," he says. "A quiet revolution continues to take place there. Color-video e-Paper will also have its day, but today we should be impressed with E Ink's continued product growth and diversification."

Any way you look at it, with E Ink, whose share of the e-Reader market is more than 90%, poised to acquire AUO subsidiary SiPix, further consolidation in the e-Paper market seems inevitable. At press time, E Ink had reached an agreement to acquire 82.7% of SiPix's shares and was seeking to acquire up to a 100% stake, valued at approximately NT$1.5 billion. As DisplaySearch analyst Paul Semenza wrote in a recent blog, titled And Then There Was One – E Ink to Acquire SiPix, "Combined with Bridgestone's exit [earlier this year] from the electrophoretic display (EPD) business, this means that E Ink, the first company to mass produce EPDs, will be the sole manufacturer of the technology." [2]

Yet, the e-Paper story isn't all black and white. In the future, look for news from Liquavista (which Samsung acquired in January 2011) and Gamma Dynamics (a spin-off from the University of Cincinnati). Both companies have video-capable displays (Liquivista's is based on electrowetting and Gamma Dynamics's on electrofluidics) that are reported to show more vibrant color than previously available.

References

[1]http://www.theverge.com/2012/7/23/3178117/qualcomm-mirasol-screen-licensing-commercialization

[2]http://www.displaysearchblog.com/2012 ■

president's corner

SID's 50th Anniversary

by Brian Berkeley
President, Society for Information Display

I hope that everyone enjoyed Display Week 2012 in Boston. If you were able to attend, then you already know about the groundbreaking technologies that were presented in the technical program and shown at the Exhibition and the Innovation Zone. My personal favorite was the opportunity to compare 55-inch OLED screens from two different companies – but there were many outstanding things to see and experience at the show. If you didn't have a chance to get to Boston, then I encourage you to go to www.sid.org to learn more, or to read the extensive press coverage of the event. A photo of the exhibit's opening ceremony is shown below. Representatives of the largest exhibitors and sponsors were present at the ribbon cutting, and SID is very grateful for their support and help in opening the exhibition.

The Consul General of Germany is the person holding the scissors. To his right from SID is Brian Berkeley (SID President) and Helge Seetzen (Display Week 2012 General Chair). The others are representatives from the largest exhibitors at Display Week 2012. Photo courtesy Asahi Glass.

This month, SID is celebrating a very important milestone, its half century anniversary. On September 29, 1962, the Society for Information Display was founded in room 3400 of UCLA's Boelter Hall by Dr. H. R. Luxenberg. In addition to Dr. Luxenberg, 39 other representatives of major high technology firms attended that inaugural meeting. If Boelter Hall sounds familiar, it might be because it also served as the birthplace of the Internet. Seven years and one month later (on October 29, 1969), the first Internet message was sent from Boelter room 3420 to the lab at SRI International, known at that time as Stanford Research Institute, in Menlo Park, CA.

From SID's first meeting, fast forward 50 years later, and SID now has 28 chapters around the world. These chapters include SID Los Angeles, the founding chapter, 10 other U.S.-based chapters, and 17 chapters outside of the U.S. There are also nine student branches worldwide, including the UCLA student branch. More than half of SID's members are based outside of the U.S. now, and SID's influence and significance have spread as the display industry and worldwide research have experienced explosive growth. It is remarkable to think about how much displays have changed in those 50 years. I think back to being a young boy in 1962, watching our family's one and only monochrome TV, then am quickly reminded of today's interactive mobile devices and flat screen full-color high-performance smart TVs. These products have been enabled by the massive advancements in our field, and this rapid pace of change has only accelerated in recent years. Displays not only deliver electronic content to the human visual system; they also serve as the primary human interface point with input and sensing capabilities. Throughout it all, SID has been the place to report, learn about, and experience the latest technological advancements in our field.

In celebration of SID's 50th anniversary, an event is being held at the site of SID's founding at UCLA's Boelter Hall on the actual anniversary date. A one-day conference will take place on Saturday, September 29, 2012. Industry and research luminaries will reflect on the history, and more importantly will offer their perspectives on the future of displays. That evening, I will host a reception and we will all celebrate SID's golden milestone by placing a plaque at the site of SID's founding at UCLA's Boelter Hall. You are cordially invited to attend this event, and I hope to see you there.

Congratulations to SID on 50 phenomenal years!

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Display Week 2012 Review: Touch Technology

2012 was the year that in-cell capacitive touch became real. It didn't happen with big fanfare; in fact, you had to put together pieces from the Symposium, the Monday Technology Seminars, the Thursday Market Focus touch conference, and the exhibits to get the full picture. But it was there and it's significant.

by Geoff Walker

IF you missed Display Week 2012, you missed the most important event of the year in the touch industry anywhere on the planet. The amount of concentrated information about touch available at Display Week 2012 was and will be unsurpassed by any other conference anywhere this year:

- A 4-hour Short Course on Sunday
- Two 90-minute Technology Seminars on Monday
- Three presentations at Tuesday's Investors Conference
- Six presentations at the Exhibitors Forum on Tuesday
- 12 papers in the Symposium, mostly on Wednesday
- Seven posters in Thursday's Poster Session
- 19 presentations in Thursday's Market Focus Conference
- Almost half of the 195 companies exhibiting on the show floor (including suppliers of touch screens, controllers, touch-related materials and equipment, market research, and touch-related services such as bonding, optical enhancement, and integration)

As the likely result of projected-capacitive (p-cap) and resistive touch technologies accounting for more than 90% of the number of touch screens shipped in 2011 (according to DisplaySearch's latest 2012 data[1]), the total number of touch technologies exhibited at Display Week 2012 decreased. While 12 technologies were shown in 2011, this year there were only six [p-cap, single-touch and multi-touch resistive, infrared, embedded (in-cell/on-cell/hybrid), and optical]. If you looked closely, you could find one company that sells (but wasn't exhibiting) surface acoustic wave, another that sells (but wasn't exhibiting) surface capacitive, and a third that sells (but wasn't exhibiting) electromagnetic digitizers. Bending wave (from Elo TouchSystems and 3M) and force-sensing (*e.g.*, from F-Origin) were nowhere to be found.

Projected-Capacitive (P-Cap)

The key difference in the p-cap suppliers at Display Week this year was the number of touch-module suppliers focused specifically on meeting the needs of commercial applications in the U.S. The 15 suppliers in this group included 3M, AMT, Bergquist, Dawar, EETI, Emerging Display Technologies, Gunze USA, Mitsubishi Electric, NLT Technologies, Ocular, Panjit, RitFast, SMK, Touch International, UICO, and Zytronic (there may be others that the author missed). Prior to Display Week, it was not unusual to hear a p-cap touch-screen prospect say, "Well, who else IS there besides Ocular and Touch International?" Several of 15 are first-time exhibitors at Display Week; others have changed their product focus from resistive to p-cap.

There's beginning to be a significant amount of product differentiation between these suppliers. Some of their differentiation points include quick-turn prototypes, large screens (*e.g.*, 17 and 22 in.), a wide range of screen sizes, cover-glass decoration (printing, shaping, drilling, light pipes, *etc.*), lamination, extended operating temperatures, working with wet hands or gloves, stylus support, a large number of simultaneous touch points, operation in rain or saltwater spray, and embedded GUI solutions.

In-Cell Touch: The Real Surprise at Display Week 2012

Prior to Display Week 2012, it seemed as though in-cell touch wasn't making any significant progress. The number of shipping products with in-cell touch could be counted on just a few fingers:

(1) The line of Samsung digital cameras that use pressed capacitive[2] – with a user experience significantly inferior to that of the typical smartphone.[3]

(2) The 21.5-in. monitors from Integrated Digital Technologies (IDTI) that use in-cell optical.[4,5]

*At the time he wrote this article, **Geoff Walker** was the Owner & Principal Consultant at Walker Mobile, LLC, a technical-marketing consulting firm. He has also been* Information Display*'s Guest Editor for Touch since 2007. By the time this article will be published, Geoff will be a Senior Touch Technologist at Intel. He can be contacted at geoff.walker@intel.com, 408/765-0056 (office) or 408/506-7556 (mobile).*

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(3) The Microsoft Surface 2.0 that uses Samsung's SUR40 LCD with in-cell optical – but requires severely limiting ambient light (*e.g.*, 50-lux maximum of incandescent light) due to the touch system's very high sensitivity to ambient IR.[6] While these products are all shipping, they cannot be seen as successful mainstream applications of in-cell touch.

What changed – and was reported in bits and pieces at Display Week 2012 – was that Synaptics made a breakthrough. Working with multiple LCD manufacturers (with the lead most likely being Sony) for the last year, Synaptics determined that the only way to create a smartphone-like touch experience with in-cell touch is to use the same mutual-capacitive sensor architecture that has become so successful in external touch screens, but move at least one set of electrodes into the LCD cell and find a way to significantly increase the touch system's signal-to-noise ratio (SNR).

Most of the papers published – mostly by the display industry – on all forms of in-cell touch (optical, voltage sensing, pressed capacitive, and self-capacitive) have reported SNRs in the range of 10:1 (3 dB) or 20:1 (10 dB). For example, there is a touch paper from this year's Symposium that claims an SNR of 10:1 is enough to meet the needs of a smartphone. That may be acceptable in the lab, but it's certainly not acceptable in the real world. Connecting a noisy AC adapter to a smartphone can raise the system noise floor by a factor of 10, causing that touch screen to become completely inoperative. The use of a fine-tipped passive stylus – which will become much more important with the launch of Windows 8 – requires a much higher SNR. Based on Synaptics' work, a realistic minimum SNR target for an excellent user-experience in the real world is 50 dB (a little over 300:1). Even higher is better for a passive stylus.

In order to accomplish a 50-dB SNR, Synaptics concluded that (a) the basic touch architecture must be "true" mutual capacitive rather than any of the existing in-cell capacitive variations, (b) the touch controller and the LCD driver must communicate with each other, and (c) the LCD driver timing must be modified to support both a display mode and a touch mode. The Distinguished Paper entitled "An In-Cell Capable Capacitive Touchscreen Controller with High SNR and Integrated Display Driver IC for WVGA LTPS Displays" by Synaptics is the key document that describes this technique.[7] Among other details, the paper describes segmenting the VCOM plane in an LCD to allow dual-purpose operation as drive electrodes for "true" mutual-capacitive touch sensing while still functioning as a proper VCOM plane for display operation. Repurposing the VCOM plane as touch-screen drive electrodes also produces a highly desirable advantage: it moves the (typical) ±10 V VCOM signal from the denominator of the SNR into the numerator; *i.e.*, instead of being considered noise that detracts from the operation of the touch screen, the VCOM signal becomes part of the touch-screen operation. Even better, higher VCOM voltages result in a higher SNR!

The sense electrodes are deposited in a single layer of ITO on top of the color-filter (CF) glass. This touch-sensor architecture is shown in Fig. 1, taken from the aforementioned Synaptics Distinguished Paper.

Note that technically this architecture is a hybrid of *in-cell* and *on-cell*, since one set of electrodes is inside the cell (the segmented VCOM plane) and one set of electrodes is outside the cell (deposited on top of the CF glass). However, the LCD industry is rapidly moving towards calling all forms of embedded touch "in-cell," on the grounds that it's all inside the LCD module. For example, Chimei Innolux announced at Display Week 2012 that it is going to brand all of its embedded touch products from now on as "Touch On Display" (TOD), intentionally obscuring the specific touch-sensor architecture that's used in a given product. After all, why should anyone care what touch-sensor architecture is used – other than the manufacturer, of course!

New Shipping In-Cell Products: The Next Piece of the Puzzle

On Monday of Display Week 2012, Bob Mackey, Synaptics's Principal Scientist, presented a Technical Seminar entitled "Innovations in Touch Sensing."[8] This presentation described with excellent clarity all the possible touch-sensor architectures that could be used in a smartphone (see pages 20–37 of "Innovations in Touch Sensing). In this presentation, Bob also stated that the Sony Xperia P smartphone (shown in Fig. 2) uses in-cell-touch electrodes configured as described on page 11 of the Distinguished Paper mentioned above (An In-Cell Capable Capacitive Touchscreen Controller…). In a Synaptics blog, it is stated that the HTC EVO Design 4G also uses the same in-cell configuration.[9] Both of these smartphones use a 4-in. 960 × 540 (QHD, 275 ppi) LTPS LCD. However, the LCDs are not actually identical; visual inspection of the phones reveals that the Sony Xperia P LCD uses RGBW pixels, while the HTC EVO Design 4G LCD uses RGB pixels.

These two shipping products use separate (but linked) touch controller and LCD driver ICs. Synaptics has announced that it has started manufacturing a single IC that includes both functions for 864 × 480 (WVGA) LCDs; it has named this new product TDDI (Touch and Display Driver IC). This integration reduces component cost, of course, but it also creates an IC that is unique for a particular LCD. If another LCD manufacturer wants the same functionality but is using an LCD with a slightly different resolution (there are no standards for LCD resolution in the smartphone market like there are in the PC market), then it requires a new custom IC. This problem was pointed out in a presentation entitled "Challenges and Opportunities in Touch Controller Semiconductors" made by Randy Lawson, a Senior Principal Analyst at IHS, during Thursday's Market Focus touch conference.[10]

In-Cell Touch in IPS-LCDs

In an IPS-LCD, the VCOM plane is located in the TFT array, and it's already segmented by design. Without changing the various metal

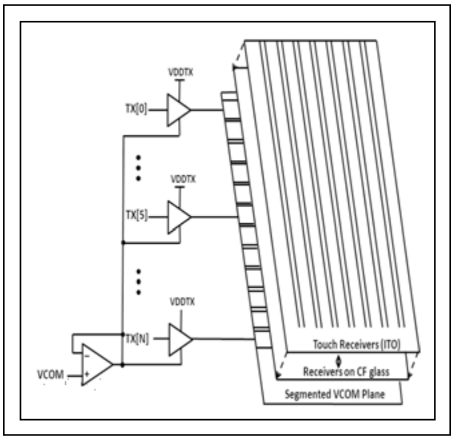

Fig. 1: *Synaptics's "true" mutual-capacitive LCD in-cell touch-sensor architecture incorporates a VCOM plane that is segmented to allow dual-purpose operation as drive electrodes for touch sensing while still functioning as a proper VCOM plane for display operation. Sense electrodes are deposited on top of the color-filter glass. Source: Synaptics.*

Fig. 2: The Sony Xperia P smartphone uses Synaptics's "true" mutual-capacitive in-cell touch-sensor architecture as described in the company's Distinguished Paper. Like most current mobile devices, this smartphone uses an IPS-LCD; the touch sensor is therefore configured as shown in Fig. 3. Image source: Sony.

and ITO masks used to create the VCOM plane, the VCOM segments can be grouped differently to form touch-sensing drive electrodes. In most IPS-LCDs there is also a grounded layer of ITO on top of the CF glass that functions as a shield and anti-static device; this layer can be segmented into sense electrodes. Since all sense electrodes except the one being sensed at any given moment are grounded, the ITO layer still performs its original function even though it's been segmented. The touch-sensor architecture of an IPS-LCD is illustrated in Fig. 3.

Adding in-cell touch to an IPS-LCD as described in the previous paragraph is sometimes referred to as "no cost" because it may require no mask changes. The author disagrees with this viewpoint, since it is likely that we are actually talking about creating a new display with embedded touch, which represents a new development cost that must be amortized. The reason it's a new display is that the existing non-touch display is unlikely to be made obsolete since the LCD maker probably has OEM customers buying it that use discrete or one-glass solution (OGS) touch-screen construction. In-cell touch in general is likely to add new products to an LCD maker's product line rather than replacing existing products. The management of this expanded product line adds yet another implicit cost.

The new development costs to be amortized include not only a new set of masks for the TFT array, but also the customization of the combined touch-controller and LCD driver (TTDI) IC and firmware to match the particular display resolution being used. Non-recurring engineering (NRE) costs such as the latter can be justified by the reduction in component cost achieved by the TTDI IC, but the primary factor that justifies the development of a new display with embedded touch is very high sales volume. In the author's opinion, it therefore seems unlikely that in-cell touch is going to spread into every LCD in an LCD maker's product line; it's more likely that it will be used only in the highest-volume models – at least in the next several years. Over the long term, as the overall penetration of touch increases, it is possible that the majority of mobile LCDs could include in-cell touch. Usable in-cell capacitive touch in larger-than-mobile LCDs is still under development; ITO-replacement materials such as micro-scale metal mesh or silver nanowires are probably the most significant enabler.

In-Cell Touch in VA-LCDs

The differences in touch-sensing architecture between an IPS-LCD and a VA-LCD are minor. The main difference is the location of the VCOM electrode. In a VA-LCD, the VCOM signal is applied to the ITO on the inner surface of the CF glass. Again, the ITO mask used to create the VCOM plane is changed so that the VCOM segments can be grouped differently to form drive electrodes. Since the inner surface of the CF glass and the top surface of the TFT array are only a few microns apart, there is little functional difference between the VA and IPS configurations.

VA-LCDs do not use a shield layer on top of the CF glass, so one additional ITO mask is required in order to deposit a layer of segmented ITO to form sense electrodes on top of the CF glass. The position of the drive electrodes in a VA-LCD is fixed by the VCOM mask, while the position of the drive electrodes in an IPS-LCD is determined by the LCD drive electronics. The touch-sensor architecture of a VA-LCD is illustrated in Fig. 4.

Chimei Innolux's In-Cell Prototype: The Final Piece of the Puzzle

The final piece of the puzzle came from the author talking with several company represen-

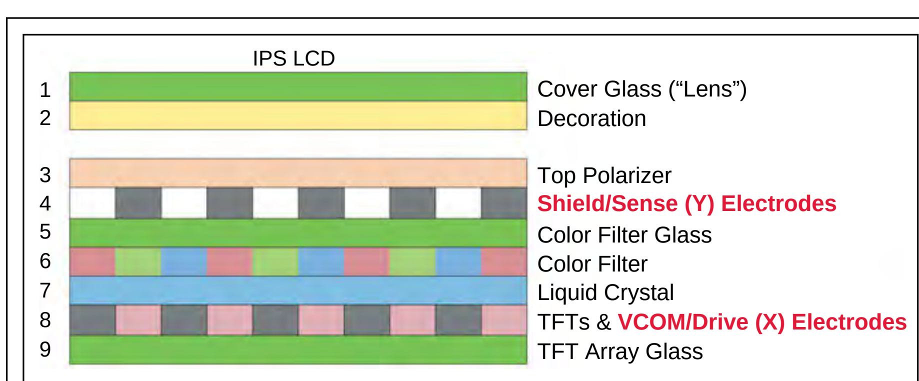

Fig. 3: Synaptics's touch-sensor architecture for IPS-LCDs uses an ITO shield layer on top of the CF glass (row 4 in the graphic). The shield layer is segmented to form sense electrodes while still retaining its function as a shield. Similarly, the segments of the VCOM plane in the TFT array (row 8 in the graphic) are grouped differently to form drive electrodes when the display is operating in touch-sensing mode. Source: Geoff Walker.

tatives in Chimei Innolux's booth on the show floor. The Chimei representatives said that they have recently prototyped in-cell touch in one of their IPS-LCDs using Synaptics's touch-sensor architecture and an early sample of Synaptics's integrated touch controller and LCD driver (TDDI) IC. The Chimei representatives said that their drive electrodes (VCOM segments) use existing traces on the TFT array; this is possible because the Synaptics TDDI IC allows each row and column of the LCD to be addressed individually. They also said that they had not yet measured the SNR of their prototype, but that they expected the value to be similar to that reported by Synaptics.

Other Chimei Innolux Embedded Touch Architectures

Chimei had the most extensive display of embedded touch products on the show floor. In addition to the IPS in-cell touch mentioned in the previous paragraph, the company was also showing or talking about the following:

- A self-capacitive set of electrodes on top of the CF glass, in a diamond pattern with true multi-touch (and as many as 300 pads!). A VP at Chimei told the author that they had started this project a long time ago when Chimei had a restricted manufacturing capacity. They did not want to add more machines to do multiple layers, so they challenged their engineering team to add touch using the existing equipment. From such challenges innovation is born.
- Standard on-cell mutual capacitive, which Chimei calls OTS (on-cell touch screen). This is a single layer of ITO with bridges, using the standard Synaptics controller. This configuration is not in volume production yet at Chimei because the yield is only 60–70% due to the "double-sided problem"; *i.e.*, whatever you do to one side of the CF glass is likely to damage or affect the other side. For example, if you do the CF side first, it can use organic material; when you anneal the ITO on the touch side, the high temperature damages the organic CF material.
- One-glass solution (OGS), which Chimei calls "window integrated sensor." (By the way, the term "OGS" seems to be slowly taking hold in the touch industry; more than a few booths on the show floor were using it.) Chimei's yield with OGS is also in the 60–70% range because it's a difficult process that the company hasn't done before. (Other vendors with more experience doing OGS have reported higher yields.) The touch sensor is a single layer of ITO with bridges (Chimei claims that this is lower cost than two layers with an insulator). One of the difficulties is the temperature limit of the black-mask (decoration) material; if the ITO needs to be annealed, the current black-mask material cannot handle the high temperature.

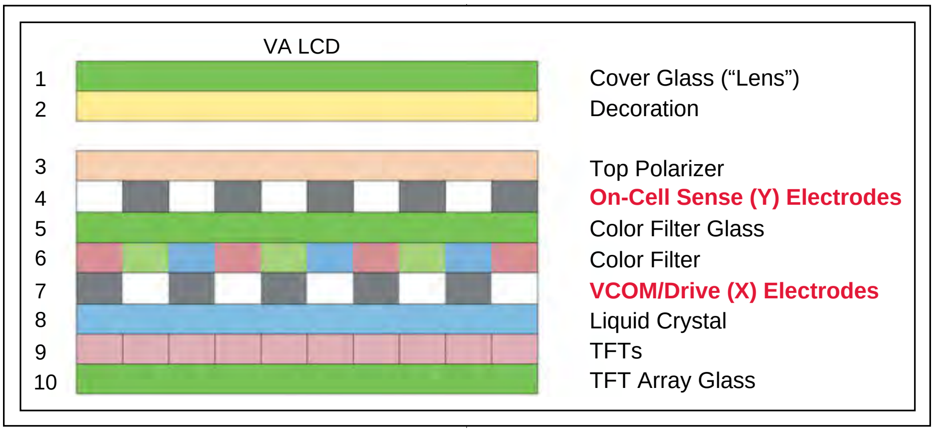

Fig. 4: *Synaptics's touch-sensor architecture for VA-LCDs incorporates an additional layer of segmented ITO (row 4 in the graphic) that is deposited to form sense electrodes on top of the CF glass. The segments of the VCOM plane underneath the CF glass (row 7 in the graphic) are grouped differently to form drive electrodes when the display is operating in touch-sensing mode. Source: Geoff Walker.*

Some Other Interesting Exhibits

The Display Week exhibition is so chock-full of interesting things to see that it's almost impossible to see it all. Here is a sampling of exhibit offerings that the author found particularly interesting:

- A very clever method of having touch buttons on a display without actually using a touch screen. This is accomplished by positioning long-range proximity sensors in the bezel below the display and controlling their sensing pattern. (Azoteq)
- A Specific Absorption Rate (SAR) proximity sensor with optimization for human detection (vs. inanimate objects). This is accomplished using two capacitive proximity sensors and digital signal processing. (Semtech)
- A curved touch screen (shown in Fig. 5) built on a 50-µm glass substrate with a 100-µm cover glass. (Nippon Electric Glass)
- A new method of making ITO invisible by depositing the ITO on top of a 3-D "moth-eye" nanostructure. The nanostructure makes the difference between the ITO-coated and uncoated surfaces' reflectivity (and also transmittance) almost zero. (Sony Chemical)
- A 3H hardcoat film with more abrasion resistance than an 8H hardcoat film. (Oike)
- P-cap touch screens that work well with water on the surface (several suppliers).

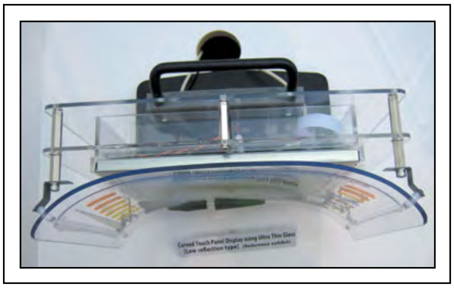

Fig. 5: *Nippon Electric Glass created this 10.8-in. curved p-cap touch-screen reference design on a 50-µm glass substrate with electrodes deposited on both sides and a 100-µm cover glass. The minimum radius of curvature is 65 mm. Nippon Electric Glass envisions applications (with a curved display) in automotive-navigation systems, tablet PCs, and smartphones. Source: Geoff Walker.*

- Extensive parameter tunability on Baanto's latest optical touch screens. Some of the parameters include touch-area detection, minimum touch time before a new touch is recognized, and shadow touch density.
- A new laser-cutting method for alumino-silicate (toughened) glass that loses only 10% of the glass's strength. (Asahi Glass)
- A plug-in for Adobe Acrobat that allows four users to simultaneously edit the same drawing or document on a multi-user touch table. (Circle 12)
- Re-designed spacer dots in a four-wire resistive touch screen that reduce the touch-force required for activation to only 2 or 3 grams – it feels the same as p-cap! (Fujitsu Components)
- PQ Labs's "high-finger-count" infrared touch algorithms licensed to IRTouch and used in a 10-touch 22-in. IR touch screen. A representative in the IRTouch booth said that there's a lot of interest in the product, but that it's not concentrated in any one market (*i.e.*, there isn't one common application).
- Stantum's latest digital-resistive touch screen (made by Nissha Printing and shown in Fig. 6) with Peratech's "quantum tunneling" pressure-sensing material in a layer only a few microns thick between the film and the glass.
- A p-cap mutual-capacitive sensor (in 3.5-, 5-, and 7-in. sizes) that uses a single layer of ITO without bridges or metal routing traces. This is accomplished by running drive electrodes vertically down the sensor and forming individual sense pads in a column beside each drive electrode. This layout also allows the sensor to be borderless on three sides. The sensor is built on a substrate of Corning's 0.1-mm "Willow" glass and laminated to a 0.5-mm cover glass with 0.1 mm of OCA for a total stack-up of 0.7 mm. This is about the same thickness as an OGS configuration, but without the associated yield problems. (TouchTurns)
- An ordinary 7-in. p-cap touch screen (shown in Fig. 7) that works very well with a passive 2-mm-tip stylus. (Emerging Display Technologies)

Touch at Display Week is Evolving

In the beginning of this article there was a mention of the increased number of p-cap module suppliers at Display Week this year that are focused specifically on meeting the needs of commercial applications in the U.S. It seems clear that the exhibition/conference portion of Display Week has become the number one place for U.S.-based commercial touch prospects to look for suppliers and new technology. The majority of the 31 presentations on touch in the bulleted list at the beginning of this article (presentations made in the Market Focus Conference, Investors Conference, Exhibitors Forum, Technology Seminars, and Short Course) were made by American companies.

In contrast, the touch portion of the Symposium is dominated by the Asia-centric display industry. Of the 19 papers and posters on touch presented in the Symposium, 10 were written from a display-industry perspective, reflecting the very strong interest of the display industry in embedded touch; five were written from a touch-screen-industry perspective; and four were written from an "other" perspective (glass-2, bonding, and proximity sensing). While this difference between the exhibition/conference and the Symposium parts of Display Week is not necessarily a problem, the author would definitely like to encourage the touch-screen industry to write more, higher-quality papers or posters for the Symposium. In that way, the touch portion of Display Week will become all it can be.

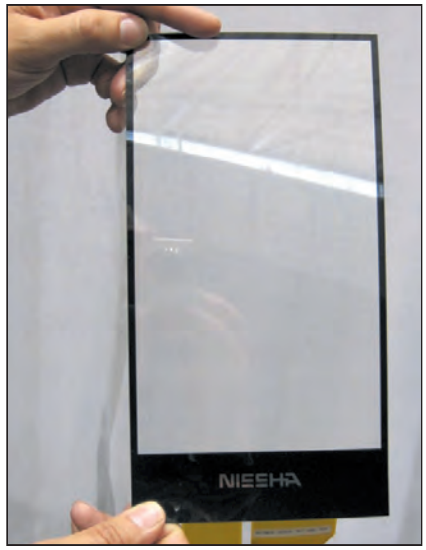

Fig. 6: Stantum's latest digital-resistive (iVSM) touch screen uses Peratech's "quantum tunneling" pressure-sensing material in a layer only a few microns thick between the film and the glass. Note the Nissha branding; Stantum and Nissha Printing have partnered to produce a line of "Fine Touch Z" touch screens in sizes 5–12 in. Source: Geoff Walker.

Fig. 7: A 7-in. p-cap touch screen from Emerging Display Technologies supports a passive stylus with a 2-mm tip. The author wrote his name on the screen with palm contact; there were no spurious points recorded and the ink was noise-free with normal stair-stepping that software could easily smooth. Source: Geoff Walker.

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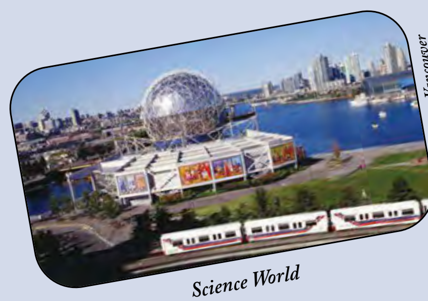
Display Week 2013

SID International Symposium, Seminar & Exhibition

Vancouver Convention Centre
Vancouver, British Columbia, Canada
May 19–24, 2013

Tourism Vancouver

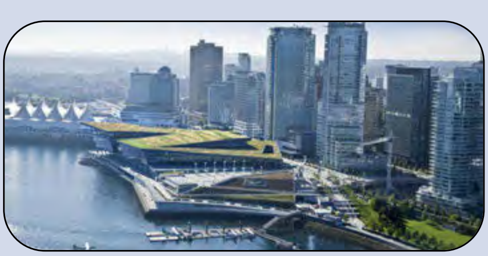
Grouse Mountain's Skyride Gondola



Tourism Vancouver

Science World

Display Week will be held May 19–24 at the Vancouver Convention Centre, with the exhibition open from May 21–23. Display Week is the once-a-year, can't-miss event for the electronic information display industry. The exhibition is the premier showcase for global information-display companies and researchers to unveil cutting-edge developments in display technology. More display innovations are introduced year after year at Display Week than at any other display event in the world. Display Week is where the world got its first look at technologies that have shaped the display industry into what it is today; that is, liquid crystal display (LCD) technology, plasma display panel (PDP) technology, organic light emitting diode (OLED) technology, and high definition TV, just to name a few. Display Week is also where emerging industry trends such as 3D, touch and interactivity, flexible and e-paper displays, solid state lighting, oxide TFTs, and OLED TV are being brought to the forefront of the display industry. First looks like these are why over 6500 attendees will flock to Vancouver, Canada, for Display Week 2013. Display Week 2013 will cover the hottest technologies in the display marketplace.



LMN Architects

Vancouver Convention Centre West

INNOVATION ZONE
"I-ZONE"

The I-Zone will give attendees a glimpse of cutting-edge live demonstrations and prototypes of the display products of tomorrow. Researchers from companies, startups, universities, government labs, and independent research labs will demonstrate their prototypes or other hardware demo units for two days in a dedicated space in the main Exhibit Hall. The "Best Prototype at Display Week," to be selected by the I-Zone Committee, will be announced at the Awards Luncheon.

SID DISPLAY WEEK
Vancouver 2013

Front-of-Screen Display Components and Technologies

Front-of-screen (FOS) display components are key to optimizing optical performance in displays as well as user experiences.

by Ion Bita, Marek Mienko, Rashmi Rao, George Mihalakis, Russel Martin, and George Valliath

A KEY ENABLER for designing and fabricating displays with the performance and functionality required by a target application is the ability to integrate the basic display panel with appropriately selected complementary components. Front-of-screen (FOS) display components, which are stacked on the viewer side of the display panel, play a major role in optimizing the display optical performance and user experience. Good FOS design enhances key image-quality metrics (FOS optical performance), surface robustness, and mechanical ruggedness. FOS architectures can also add functionalities such as touch sensing and illumination, to name just two. In this article, we survey a broad spectrum of FOS display components with an emphasis on highlighting the underlying technologies, the typical applications, and selection criteria where applicable.

FOS Components Overview

Generally speaking, front-of-screen refers to the components of a display module that are physically located between the display panel and the user, including all the layers above the display active area and the external surface of the display module (Fig. 1).

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The roles played by FOS components span a wide spectrum, from improving the mechanical robustness, optical performance, or environmental robustness of a display module, to providing added functionalities required by the particular end-product application. Last, but not least, when mapping out the range of FOS components and treatments, it is important to also consider module assembly strategies that will optimize the FOS component functionality within the new system-level constraints (electrical, optical, and mechanical). Table 1 provides examples of various mainstream FOS components and their respective applications.

Giving a comprehensive description for each of the items identified in Table 1 is outside the scope of this short article. Instead, we will introduce a few widely used components that are of particular relevance relative to current trends in the display industry.

Mechanical Robustness Improvements

A common requirement of display products is the protection of the flat panel during normal device use or in accidental events. Particular attention goes toward specifying the top surface of the display module to ensure adequate levels of scratch resistance, chemical compatibility, cleanability, and tolerance to mechanical load and/or shock. A popular solution in many of today's portable devices is the use of a strengthened cover-glass (CG) substrate placed above the display, replacing traditional solutions based on hard-coated plastics.

While the use of strengthened glass substrates has a long history of rugged display assemblies for industrial and military applications, we have seen far higher use of this solution in the consumer application space in the past 5 years. The trend for reducing the thickness of portable devices (smartphones and tablets) coupled with the large business opportunity created by more than a billion units shipped yearly, greatly energized the development and manufacturing of strengthened CG solutions.

Compared to plastic – which was originally the first material choice for the cover lens of

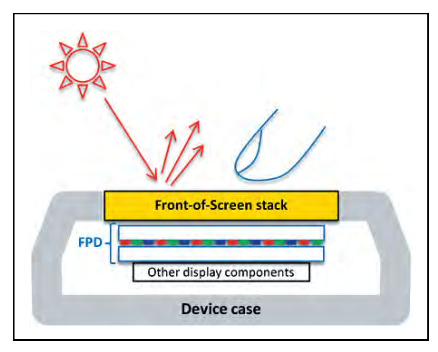

Fig. 1: The FOS stack, flat-panel display (FPD), and module interact with the ambient environment.

0362-0972/09/2012-012$1.00 + .00 © SID 2012

portable devices – the adoption of CG has been stimulated by advantages of superior hardness and scratch resistance, coupled with a higher perceived industrial design value. To increase the robustness of glass to required levels, a variety of strengthening methods are used. Chemical strengthening is the dominant approach, where a compressive surface layer is formed via a high-temperature ion-exchange process when sodium ions are replaced by larger volume ions such as potassium.[1] Significant robustness gains are

Table 1: (Left) Examples of FOS components and (right) their corresponding applications.

Role in Display Module	FOS Component or Treatments	Description	Typical uses
1. Mechanical robustness	Cover lens (glass or plastic)	Substrate placed above all layers in the display stack.	Module surface protection. Strengthened glass is a popular choice for smartphones and tablets.
	Hard coatings	Materials deposited on plastics to improve scratch resistance.	General applications, most typical for plastic cover lenses and films.
	Anticrack coatings	Thin-film chemical passivation of microcracks.	Low-cost solution for improving glass robustness.
2. Optical performance	Anti-reflection coatings	Thin-film optical stacks or graded refractive index structures.	Sunlight readability (consumer, industrial, and military displays).
	Anti-glare coatings	Surface relief diffusive microstructures.	Disrupts specular reflection, reducing glare for applications indoors and outdoors.
	Circular polarizer	Plastic-film stack, combination of quarter-wave retarder and linear polarizer.	Blocks interface reflections generated below the front surface. Sunlight readability, popular with OLEDs and resistive touch.
3. Environmental robustness and reliability	Anti-fingerprint, anti-smudge	Low-surface-energy coatings, oleophobic and hydrophobic.	Reduces display surface contamination (fingerprints, other sources of residues, *etc.*).
	UV filters	Block UV from ambient and avoid chemical degradation of display layers.	Outdoor display uses.
	IR filters and hot mirrors	Block IR from ambient to reduce internal heat buildup from solar energy.	Outdoor display uses.
4. Added functionality *(application specific)*	Touch sensing	Detect finger- or pen-touch events (including gestures, *etc.*) for user input.	General applications, currently the preferred input interface for portable devices.
	Front illumination	Internal light source for reflective displays.	Enable devices with reflective displays to be used in insufficiently lit ambients.
	EMI filters	Conductive films that block EMI to/from display.	Military displays, as well as display noise reduction for projected-capacitance touch sensors.
	Heater film	Conductive films resistively heated to improve display performance at low temps.	Military and industrial displays.
	Night-vision (NV) imaging filters	Thin-film optical stacks that block IR and near-IR emission from display.	Enable use of military and avionics displays with NV goggles.
	Privacy films	Reduce display viewing angle (1 user scenario).	General applications.
	Anti-bacterial coatings	Inhibit bacterial growth on the display surface.	Medical displays.
5. FOS Assembly	Bonding adhesives & processes	Flexible film lamination and rigid panel bonding.	Integration of FOS components in the display module.

obtained by optimizing the built-in stress and thickness of this compressive layer (*e.g.*, by ensuring it is thicker than typical surface microcracks that could otherwise become fracture initiation points during a mechanical event). The glass surface can become so strong that normal scribe-and-break singulation processes become ineffective, thus strengthening is typically done at panel level so that all exposed surfaces and edges are strengthened. One of the mechanical tests used for quantifying the benefits of using strengthened CG is the steel-ball drop test, where the impact energy for causing CG or display-panel damage is determined by varying the ball mass and drop height, as described in a number of reports.[2]

As shown in Fig. 2, the mechanical benefits of the CG are significantly enhanced in a bonded configuration free of air gaps between the individual layers of the display module. With additional optical performance gains resulting from removing air gaps in the FOS stack (see next section), a number of materials and lamination and bonding processes have been developed[2,3] in order to enable an effective integration of the various FOS layers with the FPD panel.

Display Optical-Performance Improvements

One of the consequences of including multiple layers between the FPD panel and the user is the impact on the display performance, *i.e.*, the FOS optical performance (including brightness, contrast, color gamut, viewing angle, *etc.*). Key to minimizing the impact on the stand-alone FPD optical performance is to maximize the transmissivity through the entire FOS stack while minimizing stack reflections (transmission losses impact display brightness and luminous efficacy, while reflections cause degradation of the contrast and gamut in bright-ambient illumination conditions).

Two typical problems introduced by, and consequently addressed in the FOS architecture, are the front surface reflection (FSR) of the module and the reflections added by the interfaces between FOS layers. FSR properties are optimized by using anti-reflection (AR) and/or anti-glare (AG) treatments as described below. Interface reflection solutions include the use of circular polarizers, originally popular with resistive touch panels and more recently in OLED displays,[4] and the elimination of air gaps by lamination or bonding of the FOS components to the FPD panel.

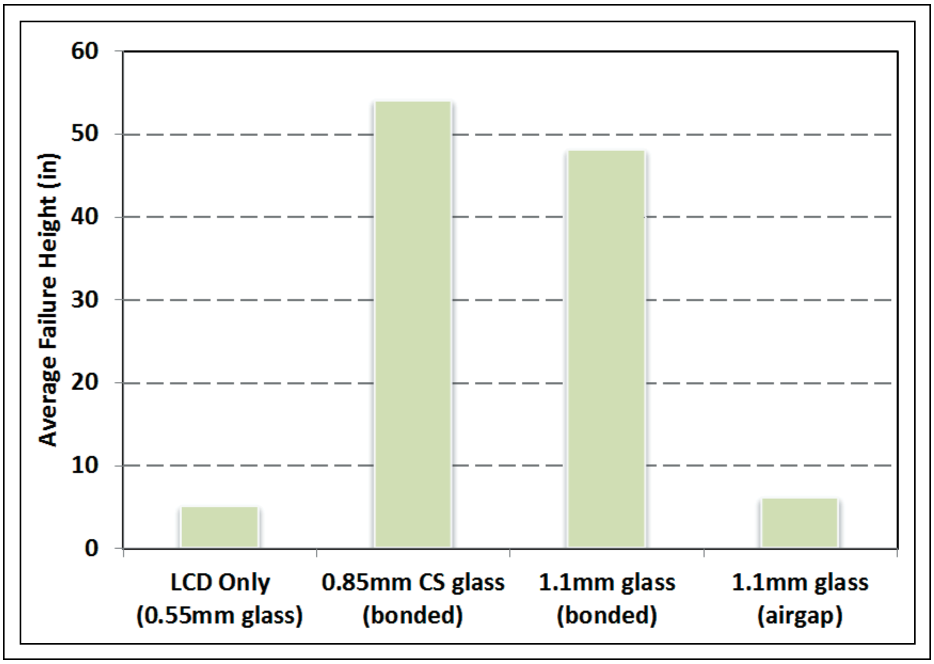

Fig. 2: *The chart depicts failure height and energy for 225-g ball-drop impact on 12.1-in. LCD modules protected by CG. Note the significant improvement when the CG is display bonded (DB) vs. separated by an air gap from the LCD, and the benefits of chemical strengthening (CS) when comparing 0.85-mm CS CG vs. 1.1-mm plain glass. (From Ref. 2.)*

Anti-Reflection and Anti-Glare Coatings

Reflections of ambient light at the front surface of any display can introduce a distracting glare to the user and degrade overall image quality. The significance of these reflections can vary based on the type of display and on the environment in which it is used.[5] The optical performance of reflective displays is influenced directly by the magnitude of the FOS stack reflections. Emissive displays are typically only sensitive in high-brightness environments, but there the user experience can be severely limited and the impact on power consumption becomes significant in order to maintain a minimum contrast. A well understood solution addressing these issues is to apply AR coatings and/or AG coatings/treatments on the front surface of the display. Figure 3 describes the optical properties for both of these coatings.

AR coatings find widespread use in the display field, with multiple technologies and integration choices available for implementation. In the majority of cases, AR coatings are created by stacking subwavelength thin-film layers, which cause a destructive optical interference across the reflected visible spectrum and consequently reduce the typical 4–5% FSR to < 2% for a single-layered AR, or < 0.5% for multilayered coatings as shown in Fig. 4. Besides the magnitude of reflectance, when choosing between various coatings one also needs to consider the trade-offs related to the reflection color tint, the perceived color variations related to process control or viewing-angle changes, and cost. Examples of typical reflectance spectra from representative AR coating designs are shown in Fig. 4.

AR coatings can be applied to glass and plastic substrates by established thin-film deposition methods, including vacuum evaporation and sputtering, as well as low-cost wet-coating processes. Another approach for creating AR coatings is to fabricate a graded-index layer, where the refractive index is gradually reduced from that of the substrate to unity matching the air ambient. A subwavelength nanoscale surface structure commonly known as "moth-eye" produces this effect and can be embossed in plastics using standard roll-to-roll processes. The resulting performance can reach very low levels of photopic reflectance (< 0.1%) with a neutral color and an optical performance that is stable across a large viewing cone.[6] Thus far, their use in displays has been limited by mass-production capacity, difficulty of surface cleaning, and reduced robustness compared to the more typical thin-film AR-coating stacks.

In all cases, AR coatings can either be applied directly to the cover glass and other FOS components or they can be laminated by using commercially available AR-coated plastic films. Given the display application and FOS requirements, suitable AR coating can be identified by careful consideration of all the above factors.

AG coatings are used to diffuse or spread out the specular reflections of ambient illumination sources by the display front surface.[7] These specular reflections appear to the user as "glare." The surface roughness of this layer diffuses the reflected light into a wider angular cone, causing a mixing and redistribution of the reflected light. This reduces the specular reflection intensity of the front surface and diminishes its image forming qualities.

Figure 3 depicts examples of the appearance of two linear light sources (fluorescent tubes) reflected from AG and non-AG surfaces. The texture of AG coatings can be achieved by subtractive processes, such as chemical etching and sand blasting, by additive processes including spray and dip coating and by molding or embossing processes on plastic film substrates. AG roughness can be created by random undulation of the coating or dispersing filler particles of different sizes within the coating. In general, the key challenge for optimizing AG layers for display applications is the trade-off between the desired glare reduction and the degradation of light-transmission properties. The texture of an AG surface diffuses the reflected light but will also diffuse the light transmitted through that surface, which can add unwanted haze and potential blur of the displayed image. Another side effect of adding AG coating can be the appearance of sparkle due to a random modulation of the transmitted image pattern passing through the AG coating.[8] This effect is related to the random nature of AG microstructure and strongly depends on the feature size and angular diffusion characteristics of its roughness. Optimized processes can tune these microstructures to yield desired AG properties with only minimal increase to haze and the perception of sparkle. Although visual perception properties of AG coatings are not typically quantified, quantitative metrics such as gloss, transmissive haze, and distinctness of image can be good indicators when evaluating and guiding the choice of AG solution for particular display applications.[9] The process choice for producing the AG coating will also be set by the intended application and substrate type. For example, in large-sized consumer displays where CG is not required, the simple lamination of plastic AG films from a wide range of inexpensive film solutions is sufficient. In other commercial, automotive, or military displays where mechanical robustness dictates the use of an AG layer applied directly on the front surface of the CG, the number of off-the-shelf solutions is more limited, so achieving the desired AG performance may require some level of customization for each application.

As shown in Fig. 3, AG and AR coatings can be combined to achieve a cumulative effect of reduced glare and reflection. Both plastic films and glass substrates with AG

(continued on page 18)

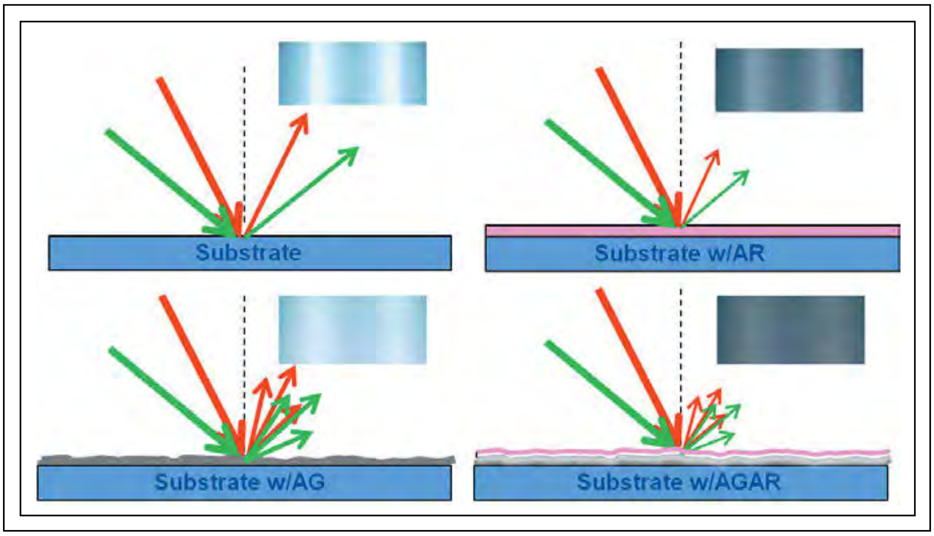

Fig. 3: *Optical properties of antireflection and antiglare coatings appear above. Inset pictures depict the impact of the AR and AG surface treatments on the reflected image of two fluorescent tubes.*

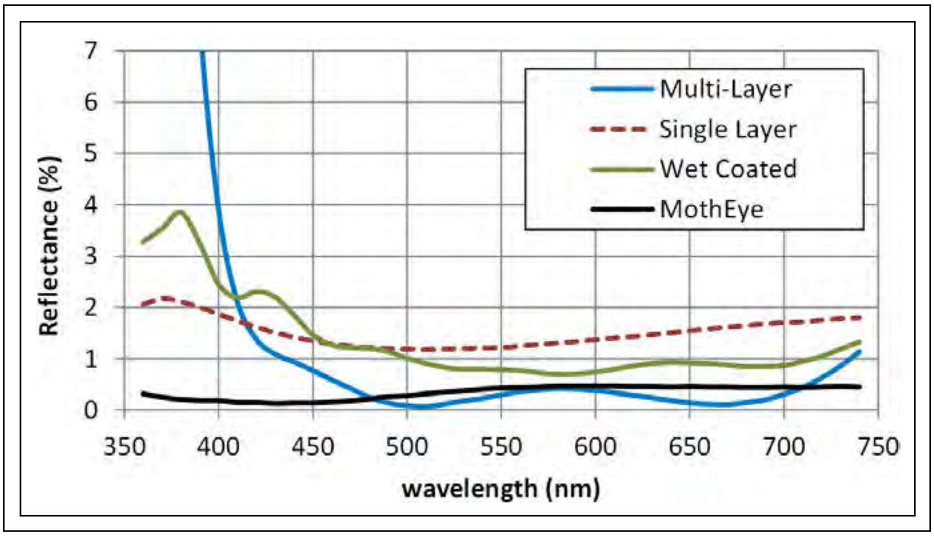

Fig. 4: *Spectral reflection curves are shown for various types of AR coatings.*

END-TO-END:
The Avnet Total Touch Solution

The touchscreen is often the first point of contact for a customer and the direct interface to gauge customers' first impressions of the product design and use. Therefore, it is absolutely critical to carefully select the right touchscreen technology for your unique application or design. Touchscreens are defined as a device that allows the user to interact with a display directly. There are more than a dozen touch technologies today. The demand for touchscreens, especially in the industrial and medical markets, continues to explode. The desire for interactivity for the users of LCD devices is now almost mandatory. The touchscreen industry, over the past 2 years, has grown from $4 billion to $13 billion, according to DisplaySearch, and reports have the market increasing to $36 billion within the next few years. This tremendous growth has also required additional capacity for the manufacturing of touchscreens and the actual utilization space will be 16.4 million square meters by 2014.

While certainly some of the significant growth in the overall utilization of touchscreens is attributed to consumer devices, such as smartphones and tablet PCs – there is also a large and fast growing number of key non-consumer applications such as: ATMs, digital signage, fitness equipment, gaming, hospital bedside entertainment devices, human—machine interface (HMI), kiosks, marine, medical, mil/aero, point-of-sale, vending, and voting machines — to name a few. Each product application has unique technology requirements, value-added service needs, and financial targets to attain. This is why it is critical to gain an understanding of the key attributes available in touch technology.

Touch Technology

Resistive: Resistive touch sensors are simple and reliable. The primary types of resistive plastic overlays are in 4-, 5-, or 8-wire versions. They work via a mechanical function of the top layer being pressed against the bottom layer creating a voltage divider creating an X/Y point. Resistive touchscreens are single-touch products and work in most applications. They are able to receive inputs from almost any input type such as finger, gloved hand, stylus, etc. Resistive is the least expensive of the touch technologies but not the most durable.

Glass Resistive: Many manufacturers are now producing glass-front resistive touch sensors. By laminating a micro sheet of glass to the front surface of a standard resistive product, manufacturers can provide improved protection to the front surface of the sensor.

Resistive Multi-Touch: Resistive multi-touch is similar to standard resistive sensors. The advantage of this technology over standard resistive is the ability to detect dual-touch points. It does this by using a grid of smaller 4- or 5-wire touch sensors or cells.

Surface Capacitive: The majority of surface-capacitive touch sensors are made of glass. A transparent conductor is coated over the surface. When a conductor, typically a finger, comes into contact with the coating, a capacitor is formed which is measured by the touch controller and turned into a touch point. However, surface-capacitive sensors are only able to detect a single-touch point.

Projected Capacitive: Today's most popular, due to the release of multi-touch products such as smartphones and tablets, is the projected capacitive — a variant of surface capacitive. Although most typically designed with a glass front surface, a projected-capacitive touch sensor can also take advantage of screen protectors, stylized cover glass, as well as vandal or weather-proof glass. A projected-capacitive sensor is manufactured by either a single conductive layer forming a grid or etching two separate perpendicular layers of material forming a grid. Voltage to this grid creates a uniform electrostatic field projected out. A conductive object, usually a finger, breaks the local field at the point it's touching. The controller detects and measures those points along the grid. Based on the controller programming, a projected-capacitive sensor can detect two or more touch points.

Infrared (IR) Touch: An IR touch sensor utilizes an array of X-Y IR LED and photosensor pairs mounted opposite each other around the edge of the screen. This creates a grid of invisible infrared light. When an object crosses the beam the photosensors are able to measure a decrease of light which is utilized to create a touch-point coordinate. One of the flaws of this technology is the touch frame is above the surface of the display and therefore susceptible to early activation. Infrared is able to perform single touch or multi-touch, depending on the implementation.

Optical Imaging: Optical imaging is a relatively new touchscreen technology. It utilizes two or more imaging sensors around the edge (typically the corners) of a screen. IR backlights are placed in the camera's field of view on one side of the screen. A touch shows up as a shadow and each pair of cameras can then pinpoint the location of the touch and even measure the size of the touching object. This technology is capable of multiple touch points and is scalable to large-format displays.

Surface Acoustic Wave (SAW): SAW touch utilizes ultrasonic waves that pass over the touchscreen glass surface. When the glass is touched a portion of the wave is absorbed. This change registers as a touch event that the controller processes. SAW is capable of understanding nearly any touch object. The disadvantages to SAW technology are its inability to detect a stationary touch point, which is an advantage if resting objects on the screen are to be left undetected. Today, SAW is single-touch with some manufacturers, such as Elo TouchSystems, expanding into two-touch.

Dispersive Signal Technology (DST): DST is a proprietary technology from 3M. It utilizes sensors to detect a piezoelectric change in the glass surface to detect a touch. Similar to SAW, DST is unable to detect a motionless touch point after the initial touch, but is usable with nearly any touch object. DST is a good choice for large-format displays. DST is a single-touch device.

Acoustic Pulse Recognition (APR): APR is a technology introduced by Elo TouchSystems. When an object contacts the APR glass overlay an acoustic pulse is generated. The controller then matches the pulse to an acoustic profile for each location on the glass creating a touch point. Similar to SAW, APR is unable to detect a motionless touch point after the initial touch but is usable with nearly any touch object. It is only available today in finished Elo TouchSystems products. APR is a single-touch device.

Additionally, many of the world-class LCD-supplier partners on the Avnet Embedded line card, such as AUO, NLT, and Sharp, are offering factory-direct, mid-sized industrial display and touchscreen enhancement solutions, mainly around PCAP technology.

End-to-End Solutions

As shown in the illustration below, when selecting touchscreen technology it is important to also consider the entire system-application requirement(s) and needs. This includes evaluating the display requirements, the potential for a Microsoft Embedded O/S license, the embedded microprocessor (possibly Intel based) in a single-board computer product storage, and more.

At Avnet Embedded, we have streamlined the decision-making process by offering an out-of-the-box product that simplifies the evaluation and integration of system boards and LCDs. Performance Matched Kits (PMKs) are the technical alignment of displays and system boards and ensure compatibility between devices. The engineering experts at Avnet address the complex connectivity and firmware issues between these two product sets to deliver a fully vetted set of displays and system-board bill of materials. Related peripheral products and technologies such as touch sensors come complete and are easily adoptable as part of any PMK solution. PMKs, developed using products from industry-leading manufacturers, enable faster application development, speed time to market, and save time and money in logistics and the supply chain for purchasing groups.

Today, there are over 100 touchscreen suppliers in the market. Once the touch technology that closely matches your application requirements is selected, choosing the right supplier is the next step. At Avnet Embedded we work closely with our partners 3M Touch Systems, Dawar, Elo TouchSystems, Fujitsu, and Panjit. All of these touchscreen suppliers have a proven track record of success, high-quality standards, competitive pricing, and offer a variety of touchscreen technology options and from very small mobile products of the 4.3-in. range and upwards of 82.0 in. and above.

At Avnet Embedded, we are uniquely positioned to support most every display, touchscreen, or value-added service request. Our experienced staff of technical-marketing experts provides our customers with working samples, proof of concept, and demonstration units to meet most every display and touchscreen customer request. Our goal is to provide the exact working solution for our customers' applications and to turn these requests around in a very short period of time. The best way to determine what works best for your application is to utilize actual working solutions and to test within the same environment as the final product will be utilized.

How Can a Customer Learn More about Touch Technology and Avnet's Solutions?

Avnet Embedded has a team of regional display business-development managers and dedicated technical experts to assist customers during every phase of the design cycle. For more information on display products from Avnet Embedded, e-mail ask-lcd@avnet.com; visit: www.em.avnet.com/embedded; or contact your local Avnet representative.

Joe Fijak *is Vice-President of Display Solutions for Avnet Embedded Americas. With responsibility for the sales and marketing of displays and display solutions, Joe has a constant finger on the pulse of trends in the LCD marketplace. Joe is an industry veteran, with more than 30 years of experience in electronic distribution and 20 years dedicated to display and embedded product sales. Joe joined Avnet Embedded in January of 2010. For more information on display products from Avnet Embedded, visit: www.em.avnet.com/embedded.*

(continued from page 15)

layers can be used for this purpose, but applying AR coatings to a textured surface with good performance and uniformity can be challenging. The vacuum deposition of thin films lends itself better to this purpose but cost constraints can be a significant barrier for widespread implementation of these types of solutions.

Enhancing Environmental Robustness

Among the corresponding topics listed in Table 1, the topic of surface treatment for the reduction of contamination (fingerprints, smudges, *etc.*) is a good candidate for additional description given the CG, AR, and AG FOS treatments introduced earlier in this article. Two sets of approaches exist: in the primary one, the surface energy of the front surface is engineered to ensure that residues have a poor adhesion to the display surface and are thus easily cleanable, while in an alternate approach the surface optical properties are optimized to reduce the visible contrast difference between the clean and the contaminated areas.

While anti-fingerprint (AF) coatings cannot prevent fingerprint residue accumulation, they make the display surface readily cleanable by virtue of their oleophobic and hydrophobic surface properties. Fluorinated organic precursors are typical material choices, but the particular deposition process and film-thickness selection depends on the complete set of FOS requirements, such as compatibility with AR/AG, level of scratch resistance, *etc*. The AF coating thickness can range from a few molecular layers (no optical impact) to a few microns when AR/AG properties are desired, in which case it is possible to engineer the coating to provide multiple functionalities such as AF + AG + hard coating.[10] Note that the combination of AF with AG further helps reduce the visibility of the fingerprint residue, which can be further optimized by specific designs of the AG texture.[11]

Enhancing Display Module Functionality

As shown in Table 1, a diverse array of FOS components has been developed over time to add the functionalities required by various display applications. We show two examples below to add more perspective to the importance of FOS components and reiterate the need for a system approach when designing the module structure and the assembly strategy that optimizes the performance of all functional components.

Touch Sensing

Touch sensing has taken the center stage as the preferred user input method for portable devices, as evidenced by the explosion in popularity of smartphones and tablets in the past 5 years. Not surprisingly, a number of touch technologies have been developed and multiple display integration strategies exist for each of them. Projected-capacitive touch is now the dominant technology in mobile devices, displacing the other candidates, notably the originally more common resistive touch sensors. Leaving aside its touch-performance advantages, another benefit of capacitive touch is a superior FOS performance compared to resistive touch, which due to its high back reflection significantly limits outdoor usability. Among the multiple possibilities for implementing capacitive touch,[12] we are seeing configurations with better FOS performance becoming increasingly adopted (lower reflections, lower sensor pattern visibility, and reduced thickness) enabled by optimizations of the sensor design and architecture, material choices, and assembly strategies. Examples include replacing air gaps with bonding adhesives, elimination of the EMI shield layer between sensor and the FPD panel, preference for sensors with single ITO layers, and development of transparent conductive materials with low reflection (optically matched ITO,[13] alternative transparent conductors,[14] *etc.*).

Front Illumination

As an example of display-technology specific FOS components, we examine the case of front-lighting reflective displays, currently better known as "e-Paper" displays. As reflective displays are increasingly used in mobile devices, frontlights (FLs) become a key enabler for optimizing the user experience across applications. The integration of a FL in the FOS stack enhances the display brightness in environments with insufficient ambient illumination, and thus introduces a hybrid reflective-emissive usage model that eliminates the traditional usability limitations of purely reflective e-Paper applications.[15,16]

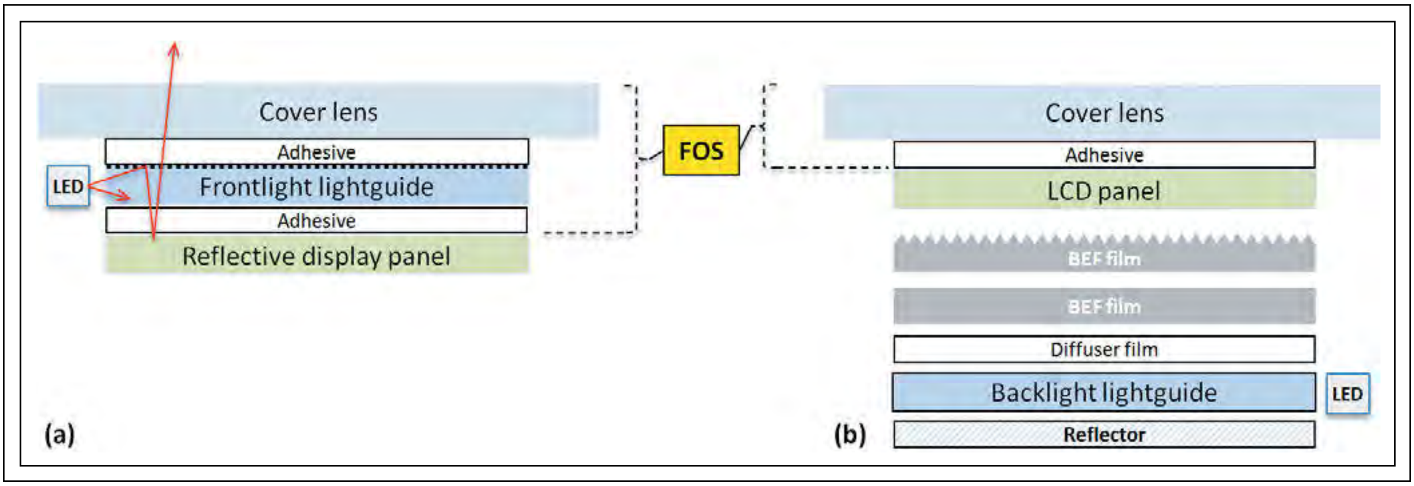

Fig. 5: Shown is a comparison of the FOS stack for (a) fully bonded frontlit reflective displays and (b) a backlit LCD, where the backlight stack has air gaps between all its components.

FLs can share system characteristics with the much better known LCD backlights (BLs), such as the use of LED sources and light-guides; however, FL implementations are dramatically shaped by the requirements introduced when moving the illumination device from behind the screen to its front. Consider (arguably) the key FL requirement to be invisible in the off-state with minimal impact on image quality. While the same principles for optimizing FOS performance and mechanical and environmental robustness introduced above apply, it is important to account for the FOS requirements differences between emissive and reflective displays, given that reflective performance requires a roundtrip of the ambient illumination through the FOS stack (Fig. 5).

As a result of the stringent reflective-display FOS requirements, the emerging FL optomechanical system designs and manufacturing and integration strategies show a departure from traditional BL solutions in order to enable high emissive as well as reflective FOS performance.[16.17]

Summary

The rich ecosystem of FOS components is a key resource available to display module designers for meeting diverse and ever evolving application demands. We surveyed in this article a wide spectrum of FOS components and technologies and introduced in more detail a few select examples that are particularly relevant given current display trends. In particular, we showed through these examples the important role played by FOS in optimizing display performance (optical, mechanical, and environmental) and providing required functionalities (such as touch input or front lighting).

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Laser Patterning of Silver Nanowire

The use of laser patterning on silver nanowire enables reduced manufacturing costs and increased flexibility for touch-panel manufacturers.

by Terry Pothoven

SINCE the introduction of Apple's iPhone, the market for touchscreen displays has grown swiftly to $16 billion and is expected to double by 2018. With the much anticipated release of Windows 8, the first Windows-based operating system designed with a touchscreen interface, that trend will accelerate. Against the background of rapidly increasing demand, manufacturers of touchscreens, seeking an advantage over competitors, continue to look for ways to improve performance, reduce costs, and increase output of touchscreen displays. Laserod Technologies has developed a high speed direct laser patterning process for a new and unique material called silver nanowire that addresses all of those objectives. The silver nanowire used in this development work is proprietary ClearOhm film provided by Cambrios Technologies of Sunnyvale, California.

Silver Nanowire

Silver nanowire is a nanostructured inorganic material that produces a transparent conductor coating that has advantages in flexibility, conductivity, and cost over widely used indium tin oxide (ITO). The silver nanowire material consists of a wet processable dispersion of high-aspect-ratio silver nanowires. Starting from silver salts, twinned-crystal silver nanowires are grown via the polyol process. By carefully controlling the process parameters, high aspect ratio silver nanowires can be synthesized at high yield, with an average diameter in the low tens of nanometers and an average length in excess of 10 µm. Independent control of nanowire length and diameter is possible, allowing the tailoring of morphology-dependent optical and electrical properties for specific applications. These nanostructures are then purified and formulated into a coatable suspension that is compatible with industry standard coating methods such as roll-to-roll slot die coating or spin coating.

The transparent conductive layer is created by coating the formulated suspension of nanowires on the surface of a substrate such as glass or plastic. Upon drying of the solvent, the nanowires form an interconnected, two-dimensional mesh on the surface. Controlling the sheet resistivity of the layer of interconnected nanowires is accomplished by changing the number density of nanowires on the surface. The electrical properties of the interconnected mesh are well described by the theory of percolation, in which the number density of nanowires required to achieve a continuously conductive path on the substrate scales inversely with the square of their length ($N \sim 1/L2$). Thus, high aspect ratio nanowires are uniquely suited to achieve high electrical conductivity with a minimal amount of metal.

Similar to ITO, silver nanowire can be applied to glass, polycarbonate, and PET films and can be used for many applications as a

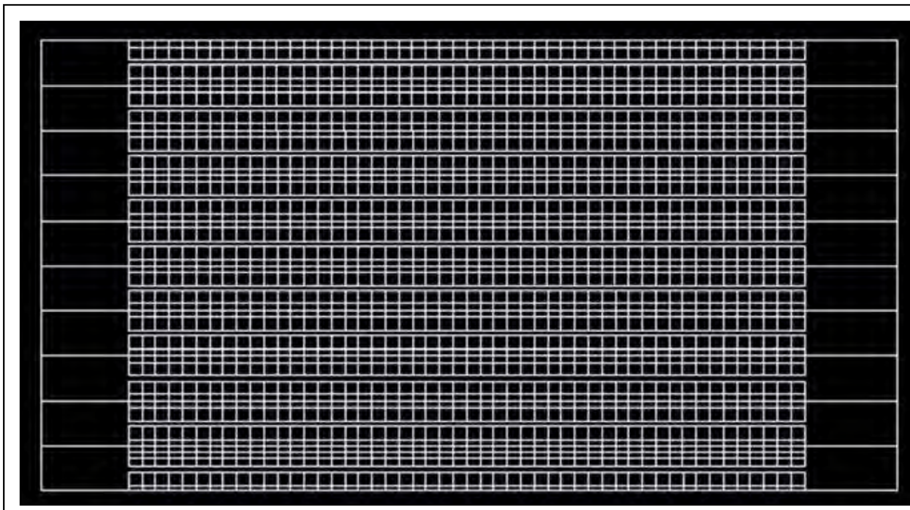

Fig. 1: *A typical smartphone touch panel electrode pattern would take 10 sec to create in ITO, but took 7 sec with silver nanowire.*

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coating material for transparent electrodes for touch panels, liquid crystal displays, e-paper, OLED devices, and thin film photovoltaics. The key advantages of silver nanowire over ITO are flexibility, improved optical properties, and reduced manufacturing cost. Although the unit cost of indium is comparable to the cost of silver, the conductivity of silver is far superior to that of indium, requiring a small fraction of silver relative to the amount of indium needed for the same surface area and resulting conductivity. Additionally, silver nanowire is applied to material using a wet chemical solution and does not require the expensive vacuum application required by ITO.

When applied to PET film, silver nanowire coatings achieve some optical performance advantages over similar ITO coatings. As reported in an article in the January 2012 issue of *Information Display* magazine titled "Wet Processable Transparent Conductive Materials," the transmission of these films can be in excess of 90% at 40 Ω/sq. or > 98% for the conductive coating itself. Comparing this to ITO film that includes a multilayered anti-reflection coating, the silver nanowire film had an equivalent transmission at 50 Ω/sq. as compared to ITO film at a 3× higher sheet resistance. For standard-grade ITO film that does not include anti-reflection coatings, the transmission advantage of this film would be significantly larger.

In the laboratory experiments described below, which were conducted on PET substrates, Laserod Technologies used a high speed direct laser patterning process to produce invisible patterns in silver nanowire. The combination of laser processing with silver nanowire results in lower costs and increased manufacturing flexibility when compared to the industry standard of wet chemical etching on ITO. Most significant is the fact that silver nanowire coatings can be modified quite effectively with laser ablation once cured. Compared to wet chemical etching, the use of lasers reduces the cost by approximately 50% and eliminates the environmental impact associated with chemicals used in the etching process.

Laser Ablation Process

Direct dry etch processing, which uses a laser instead of chemicals to remove material, has been around for many years. Similar to wet chemical etching, laser ablation can remove microscopic lines in ITO that create isolated conducting patterns in the remaining ITO for applications such as linearization patterns and quasi-invisible conductor matrices in touch screens. Dry etch processing does not require the toxic chemicals used in the wet chemical etching process and does not require expensive masks to make complex patterns in ITO. Historically, the laser beam in direct dry etch was directed straight down to a production part secured to an X/Y stage. A computer program moved the X/Y stage to scribe the desired pattern on the part. The process provided flexibility for research and development purposes, but lacked the throughput speed necessary for cost-effective volume manufacturing. The speed was typically limited by the power of the laser.

Advances in laser technology in the last 5 years have made it possible to increase production throughput with higher powered lasers and galvanometer beam-delivery systems. Modern lasers now produce per pulse energies and repetition rates that exceed the speed of the fastest X/Y stage. Laserod integrates high powered lasers with galvanometer beam-delivery systems to rapidly ablate complex patterns on glass and PET. The position of the part remains fixed. The galvanometer uses two overhead moving mirrors to direct the laser beam in the desired ablation pattern. The process avoids moving significant mass and only requires movement of the mirrors, thereby allowing the laser beam to move across the part at speeds as high as 12 m/sec. For typical touch-panel applications, increased production rates by means of laser patterning, combined with the elimination of expensive masks and chemicals, now enables a very cost effective and green production process.

Comparing Laser Wavelengths

Laserod used both diode-pumped and fiber-based laser systems to compare three of the most common laser wavelengths (1064 nm infrared, 532 nm visible, and 355 nm ultraviolet). Each wavelength was reviewed to compare laser patterning speed, electrical isolation, and visibility of the patterned material. Each of these three factors directly relates to throughput, yield, and transparency. Using an array of laser power, repetition rate, spot size, and speed, the company produced a test matrix to analyze the results. Several solid-state lasers (the Coherent Avia series, the SPI SM series, and the Lee Laser LDP series) were used to process the samples. Table 1 shows some of the test values.

Electrical Isolation

The team observed during the experiments that each wavelength easily obtains very high electrical isolation, the fundamental requirement of typical laser-based patterning applications. The absolute limit of isolation could not be determined because the equipment used at the time of processing was limited to a range of 1 GΩ. However, this isolation level is more than adequate for most patterning applications.

Process Speed

Based on the values obtained and those extrapolated from laser engines available, it is clear that using an infrared laser engine produces the highest processing speed. Using the IR laser, speeds in excess of 12 m/sec were achieved with good isolation. These extremely high speeds can typically only be used in simple straight-line laser processing applications. More complex patterns require the use of a lower patterning speed (3–6 m/sec), due to the limitations of current state-of-the-art laser patterning beam delivery systems. This represents a big change from past history. Five years ago, laser engines were not yet production tested or proven to produce sufficient

Table 1: These wavelengths all produce low-visibility patterns.

Laser Wavelength (nm)	Laser Power (W)	Laser Patterning Repetition (kHz)	Electrical Rate/ Speed (m/sec)	Isolation (GΩ)
1064	5.25	150	4	> 1
1064	12	400	12	> 1
532	0.57	15	0.3	> 1
532	1	100	1	> 1
355	1.2	220	4.5	> 1

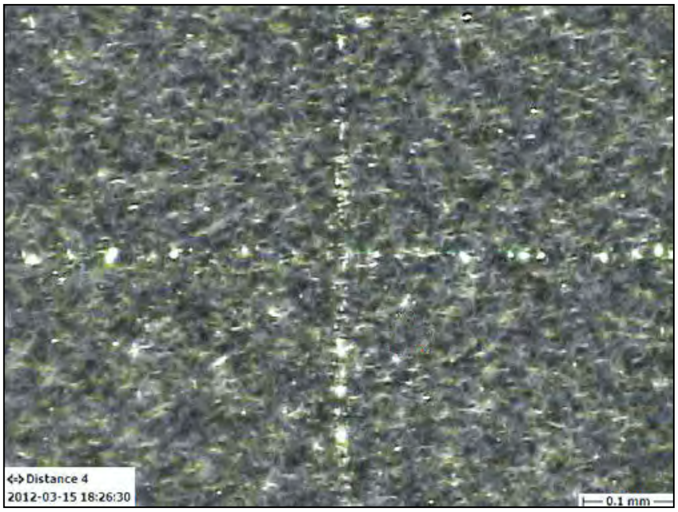

Fig. 2: The lines patterned using ultraviolet laser pulses tended to damage the topcoat.

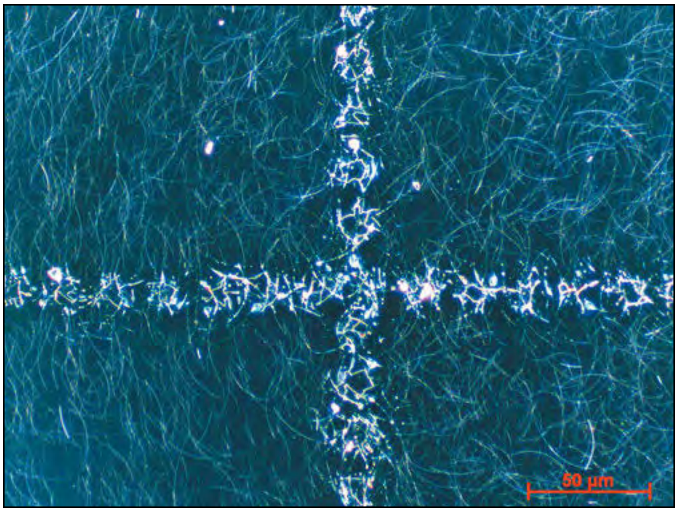

Fig. 3: The ultraviolet laser pulses also melted the silver nanowires.

laser energy at high repetition rates to support high speed laser-beam deliveries. After a big push from laser companies to increase power levels at high repetition rates, this problem has been resolved. Based on the beam delivery limitations for typical patterning applications, all three wavelengths were found to be capable of supplying sufficient power to create isolated patterns at speeds of 3–6 m/sec.

Figure 1 shows a typical smartphone pattern that the author has used to illustrate the speed of laser patterning. In the past, this pattern would have taken 10 sec to create in ITO. Maximum patterning speed is limited by insufficient absorption of the laser energy into the ITO, which results in substrate damage when using plastics. This effect limits the amount of laser energy that can be used and thus the maximum speed. Even with this limitation, laser patterning is still a very production-competitive process. Using silver nanowire, Laserod was able to reduce the process time to 7 sec and achieve electrical isolation with no damage. This was due to the higher absorption of the laser energy by the silver. A customized beam-delivery system could reduce this patterning time to 5 sec or less.

Visibility – or Lack Thereof

The research team next moved to a dark-field microscope. This instrument produced high quality images that enabled a comparison of the visibility of the lines. Those lines patterned using ultraviolet laser pulses tended to damage the topcoat (Fig. 2) at the power

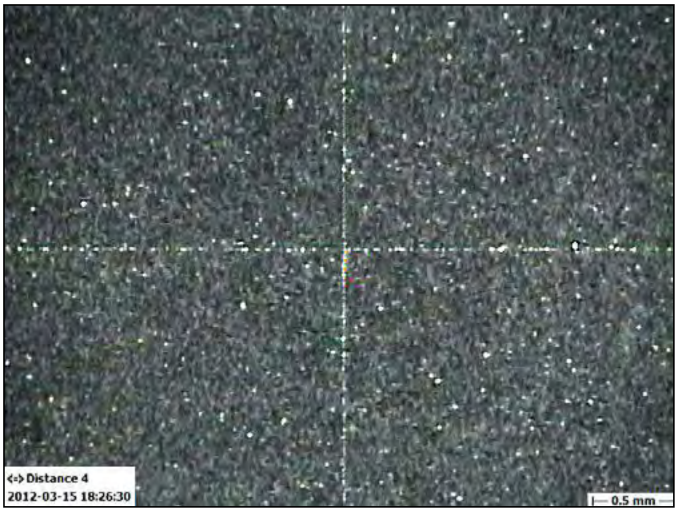

Fig. 4: Faint heat marks can be seen in this pattern due to energy absorbed in the PET substrate by the laser.

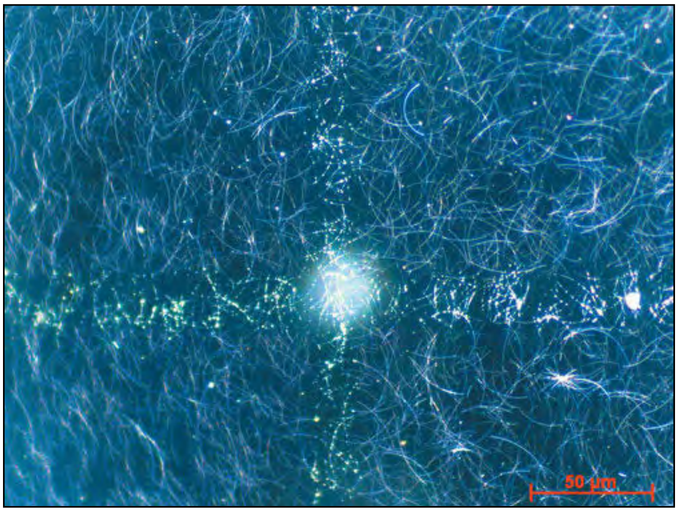

Fig. 5: Here, PET damage has been reduced to the point where it cannot be detected by the naked eye.

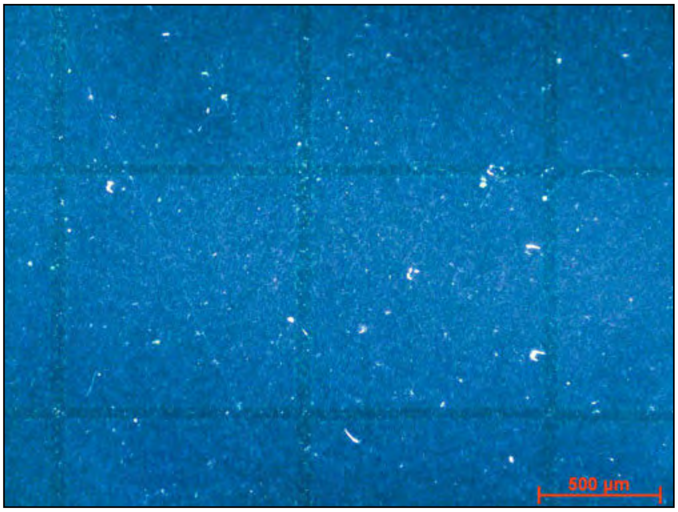

Fig. 6: A macro view of lines created through infrared laser light shows no observable substrate damage.

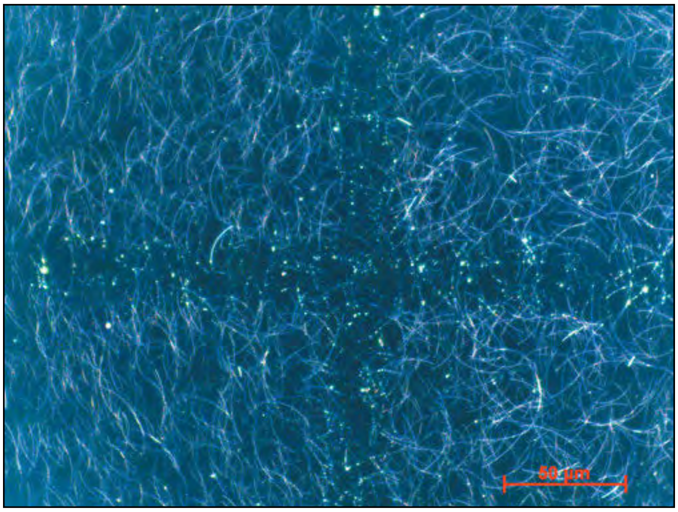

Fig. 7: A micro view of the substrate from Fig. 6 shows no observable features inside the laser-patterned lines.

levels required for good electrical isolation. They also showed more melting of the silver nanowire (Fig. 3), which creates very reflective surfaces. These two features made it very easy to detect the lines with the naked eye, once the sample was reviewed under dark background and bright lighting.

Once sufficient energy was obtained to create electrically isolated lines in the silver nanowire, using visible laser light, damage to the PET substrate in the form of heat marks was observed (Fig. 4). However, after several rounds of optimization of the optics to obtain the best energy density on the material, invisible lines with electrical isolation were produced (Fig. 5).

Infrared laser light was found to be ideal for producing invisible lines with no damage. Figure 6 shows a macro view and Fig. 7 a micro view. Note the lack of observable features in the laser patterned lines, which are 35 µm in width.

For comparison purposes, shown are photos of typical laser patterned ITO lines using both conventional bright-field viewing (Fig. 8) and dark-field imaging (Fig. 9). It is useful to note that silver nanowires are invisible when viewed through bright-field microscopes and almost invisible when viewed through dark-field microscopes.

A Promising Process

High speed laser patterning of silver nanowire

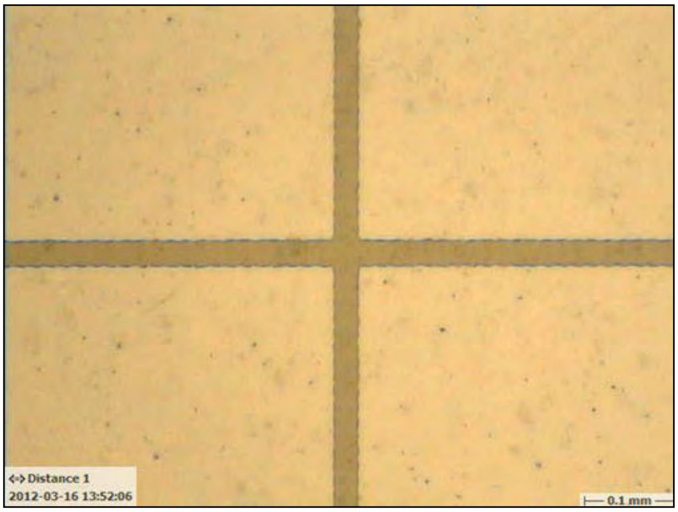

Fig. 8: This bright-field image of laser-patterned ITO clearly shows the lines.

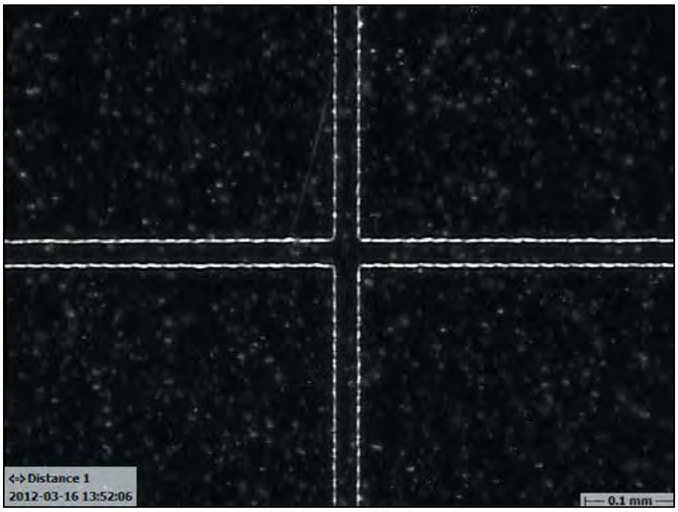

Fig. 9: This dark-field image of laser-patterned ITO shows lines as well.

is a very promising process. Silver nanowire has shown significant potential in all three major optical areas: light transmission, color, and haze. Since this material is applied using wet coating methods, the equipment cost is typically much less than that of conventional vacuum coating equipment. Further cost savings can be found in the amount of material required, due to the higher conductivity of silver compared to ITO. Moreover, by replacing conventional chemical wet etch with direct laser etch, manufacturers will reduce production costs and eliminate the need for hazardous and expensive chemicals. Most significant is the finding that the use of fiber-based infrared lasers achieves the highest speeds and offers the lowest initial capital cost and long-term maintenance cost of any of the lasers reviewed.

This convergence of technology provides new cost-effective possibilities for the production of touch panels. Laserod has produced an infrared patterning system that can pattern approximately 10,000 parts per day on silver nanowire. Touchscreen manufacturers could scale production capabilities based on the number of machines in use and maintain the flexibility to readily change the pattern designs in a matter of hours. The use of in-house capabilities to apply silver nanowire would add to the flexibility of production and eliminate the need for an oversupply of material and components. Manufacturers could produce products proportionate to market demand, be responsive to new design changes, and potentially generate greater profit.

Acknowledgments

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SID
SOCIETY FOR INFORMATION DISPLAY

Part II: A Brief History of the Society for Information Display

In Part I of our 50-Year Anniversary special article, we looked at the history of displays through parallel technology developments. Part II describes the history of the Society for Information Display.

Based on contributions from Robert Donofrio, Robert C. Knepper, Lawrence E. Tannas, Jr., Larry Weber, and others

IN THE FALL OF 1962, Dr. Harold R. Luxenberg, a Lecturer on Electronic Information Systems at UCLA Extension, called a meeting at the University of California Los Angeles that was the formative gathering of the Society for Information Display. The 39 individuals at that first meeting on September 29th learned that neither the Institute of Radio Engineers (IRE) nor the American Institute of Electrical Engineers (AIEE), then merging to form the Institute of Electrical and Electronics Engineers (IEEE), would create a new section devoted solely to electronic information displays. This was the pivotal event that caused SID founders to start their own society, a decision that was to be proven sound over and over again, through half a century of display development that progressed beyond the imagination of even the Society's founders.

Fifty years after that inaugural meeting, the Society's membership has grown from fewer than 100 individuals based mostly in the Los Angeles area to thousands of people all over the world. The first SID symposium was held in 1963 in Santa Monica, CA, with 92 attendees. In 2012, 49 years after that first symposium, nearly 6000 attendees visited Display Week in Boston, and the event has taken place in many different cities in North America. The LA Chapter, the first and founding chapter for the Society, has been joined by 27 additional chapters throughout the world (see the sidebar "The Founding of the UK and Ireland Chapter of SID" for just one of those stories.) SID today is an international engineering and scientific organization that promotes the business and technology of displays used in avionics, TVs, tablets, laptop computers, smartphones, digital signage, e-Readers, appliances of all sorts, and countless other products.

An Interwoven History

As SID Past-President Lawrence E. Tannas, Jr., observes: "The Society for Information Display and displays are interwoven as much as any technical component can be with an engineering society. Electronic displays are probably the most multidisciplinary components in the world and SID has a single objective: to advance electronic information displays."

In the earliest days of the Society, representatives from companies such as General Dynamics, IBM, and RCA participated in the meetings, as well as numerous individuals from the military and aerospace sector, including companies such as Hazeltine, Hughes Aircraft Company, and Lockheed. TV and aerospace continue to be key backgrounds for SID members, as are the automotive, industrial/medical, optical, and metrology industries as well as, of course, academia.

In terms of the evolution of both the society and the display industry, Tannas notes that a complete paradigm shift occurred between the late 1960s and the early 1980s, and this is demonstrated by three books published during that time. In 1968, Luxenberg and Rudolph L. Kuehn edited notes from "Lux's" electronic-displays class at UCLA Extension to

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create the first book ever published on the subject, "Display Systems Engineering" (McGraw-Hill). Among other early books was Sol Sherr's "Electronic Displays" (John Wiley and Sons, 1979). Tannas took over Lux's class in 1980, and in 1983, wrote a book with chapters from his lecturers entitled "Flat-Panel Displays and CRTs" (Van Nostrand-Reinhold). At SID's beginnings, wrote Tannas in Part I of this article, "displays such as galvanometers and CRTs were analog indicating transducers. Today, electronic displays such as plasma panels and LCDs are digital-matrix arrays of randomly addressable pixels."

As display technology evolves, so do the members and programs of SID. In years past, CRTs and field-emission displays were central to SID's agenda. Now LCDs, OLEDs, flexible technology, 3-D, touch and interactivity, and much more are key to the industry, and hence to the society. At the same time, SID and its members contribute in a proactive way to the evolution of displays by sharing information through presentations, publications, and exhibits, and by spotting and supporting trends, including those in nascent stages. In Part I of this 50th Anniversary article in the July/August issue, Tannas and other display-industry experts discuss the highlights of CRTs, projection technology, LCDs, OLEDs, and plasma.

The Founding of the UK and Ireland Chapter of SID

Around 1984, a small group of UK SID members set up a new UK chapter. It was realized that displays were becoming increasingly important and a professional body could have a significant influence on developments in displays in the UK. Success depended on attracting as many members as possible. A number of companies were approached for help and a positive response was received from IBM, GEC, Philips, Phosphor Products, Racal, RSRE, Sinclair, and Thorn-EMI Brimar.

The temporary committee was chaired by Professor Mino Green, Imperial College. Other members included Dr. Barbara Needham, STL, as membership secretary, Derek Washington of Philips Research Laboratories as secretary, Alfred Woodhead as chapter European representative, and Harry Ellis as newsletter editor. Laurie Allard, Simon Bliss, Steven Elmer, and David Marshall were committee members. They prepared a set of by-laws and arranged for the first two technical meetings to be held on September 1, 1985.

Alfred Woodhead attended the European Steering Committee meetings, which discussed the development of SID activities in Europe. It was recognized that Europe had been poor at creating opportunities for the display business, and that SID had an important role to play in stimulating the European display community to make the most of opportunities in the market. The UK was the first European country to set up a chapter and it was hoped that others would soon follow suit, particularly France and Germany.

A message from the SID President appeared in *Information Display*, reporting that at the SID Board meeting on January 7, 1985, the formation of the UK and Ireland Chapter had been approved. He congratulated the UK members for their hard work in setting up the chapter and in particular Alfred Woodhead, who had taken up the chapter formation from start to finish. He also congratulated Dr. Andy Lakatos, who had coordinated the formation process and confirmed the appointment of Dr. Tuomo Suntola, who was appointed European Regional Director.

At the end of the first year of the chapter, there had been five technical meetings, with subjects including LCDs, applications, large-area displays, and an evening devoted to venture capital. The quality of the presentations had been high and attendance good, with most meetings oversubscribed. The chapter's existence had met with success beyond the dreams of its founders.

– John R. Mansell

Chapters: Underpinnings of an Organization

As has been noted, from that one meeting at UCLA in 1962, SID evolved into an international organization with thousands of members, numerous publications, and a world-class symposium and trade show. From one chapter in 1962, four chapters were operating by 1963: Los Angeles, San Diego, New York, and Washington. Between 1965 and 1967, four more chapters were added: New England, Bay Area, Delaware Valley, and Minneapolis/St. Paul. The UK and Ireland Chapter was operational by 1977. In 2011, there were 250 members in SID's Beijing chapter alone and a total of 28 chapters. Much of what is vital to SID goes on at the chapter level; it is there that members can come together regularly and share ideas and insights (as well as dinner and the occasional beer). Chapter participation is vital to the health of SID; a chapter meeting is after all how the organization began.

Display Week

It is often said that the technical program is the heart of Display Week, SID's annual Symposium, Seminar, and Exhibition. Without a doubt, the information presented in the symposium sessions is invaluable and cannot be matched elsewhere in terms of depth and breadth of content. Originally, SID held two symposia a year, one on the east coast and one on the west. That format changed in 1966 to one per year. The early symposia were run by their local chapters, but in the early 1970s, professional conference organizers were hired to assist with the growing event. An early technical symposium program from 1963 lists about 15 papers, including one called "Aims and Purposes of the SID." The annual Symposium now includes over 400 papers.

Over the years, Display Week (which began life simply as the SID symposium and exhibition), has been the scene of many exciting display developments. Among these are the DMD (Digital Micromirror Device) optical semiconductor from Texas Instruments. In 1995, TI's Digital Light Processing (DLP) engine for projection technology, which incorporated the DMD, won a Display of the Year award.

Plasma technology had many firsts at Display Week, including a 21-in. color panel

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shown during the last 2 hours of the 1994 exhibition. As inventor and SID Past-President Larry Weber explained, "It was not working before that and I was frantically working on the panel in a garage about 10 blocks from the San Jose Convention Center. If we had missed that deadline then the bank would have closed Plasmaco [Weber's company] for good the next day." (This story is recounted in "The Perils of Plasmaco" in the December 1997 issue of *Information Display*.)

In 1999, a 60-in. plasma panel was shown for the first time publicly during a Monday seminar lecture given by Weber. "It created quite a stir even though some people thought it was too big," says Weber." I think the key to its appeal was that up till then most people had not realized that the eye's visual acuity was limiting the perceived quality of the HDTV image. An HDTV signal on that 60-in. panel allowed the full quality of the HDTV signal to be easily seen by the eye and appreciated."

In a more recent time frame, Display Week milestones in 2012 alone included a 5-in. 440-ppi LCD from LG Display that used an a-Si backplane, a 32-in. 4K × 2K LCD with an oxide backplane from Sharp, and 55-in. OLED TVs from both Samsung and LG Display.

As display technology evolves, technology tracks for the symposium are created or eliminated to reflect the changes. In recent years, for example, special topics on 3-D, Touch and Interactivity, Oxide TFTs, OLED TV, Lighting, and more have been added. In-depth short courses and seminars on particular areas of display technology also provide a knowledge boost to those new to the display industry as well as to seasoned veterans looking to learn about a new area. Display Week has grown over the years to include a three-day exhibition with hundreds of companies, and several days of conferences delivering specialized information in the areas of marketing, investing, and business. This year, SID added the Innovation Zone, a designated area on the exhibit floor where startups and other researchers could present prototypes and other cutting-edge research. Twenty-three companies' applications were accepted for the inaugural I-Zone and each received a free table on the Display Week exhibition floor. Traffic was brisk, as show goers flocked to see what technologies might become the displays of the future.

Awards

The Society confers annual awards on outstanding members of the display community, with prestigious prizes given in various areas of technical as well as education and service achievement. Awards for products as well as individuals have been established in order to promote and recognize industry innovation. The Display Industry Awards (formerly Display of the Year awards) have been presented at Display Week since 1995 in categories that now include Display of the Year, Display Application of the Year, and Display Component of the Year. In 2011, Best-in-Show awards were added to complement the DIAs (which are for shipping products) by honoring the most exciting products and displays on the show floor, whether they are commercially available yet or not. This year, a Best-Prototype award was added to honor the most outstanding product in the Innovation Zone.

Publications

Publications have always been an important activity and information-sharing vehicle for members. Following the initial organizational meeting in 1962, the *SID Newsletter* first appeared and eventually was replaced by *Information Display* magazine in 1964. The *SID Symposium Proceedings*, now called the *SID Digest of Technical Papers*, is issued after each symposium. And the monthly *Journal of the Society for Information Display* is a peer-reviewed publication founded in 1963 for original works dealing with the theory and practice of electronic information displays. (Before *JSID*, the journal was referred to as the *Proceedings of the SID* from 1963 through 1991 (issues 1–32)). From 1992 to the present, it has been referred to as the *Journal of the SID*. Recently, SID has begun hosting technical webinars as well.

Honoring Its Beginnings

With half a century under its belt, SID has a history that members have been increasingly acknowledging. At Display Week 2011 in Los Angeles, founding and charter members of the Society for Information Display came together to celebrate the society they helped create nearly 50 years earlier at UCLA. This year, for the 50th anniversary of the inception of SID, the SID Los Angeles Chapter is installing a plaque at UCLA honoring the society. For its birthday on September 29, 2012, SID will also hold a one-day symposium at the location of its founding, exactly 50 years later.

The Society for Information Display began when individuals involved in the business and research of displays realized that the technology was deep enough to merit its own society.

> *From that one meeting at UCLA in 1962, SID evolved into an international organization with thousands of members, numerous publications, and a world-class symposium and trade show.*

> ***It was not so very long ago that conventional wisdom had it that a large-area LCD was not 'feasible.' Who knows what 'unfeasible' developments will be made real during the next 50 years of the Society's existence, thanks to the spirit of innovation and cooperation fostered by SID?***

Those individuals, and their successors, encouraged continuous progress in terms of both cutting-edge research and commercial availability. Fifty years later, the Society continues to promote innovation and the sharing of information among members. It was not so very long ago that conventional wisdom had it that a large-area LCD was not feasible. Who knows what "unfeasible" developments will be made real during the next 50 years of the Society's existence, thanks to the spirit of innovation and cooperation fostered by SID?

Acknowledgments

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Upcoming Event: Vehicle Display Symposium, October 18 and 19

Vehicle displays are an exciting and demanding area of display applications. Sunlight readability, ruggedness, and interactivity, as well as safety, aesthetic, and ergonomic factors are just some of the special design considerations needed for these applications. The Annual Symposium on Vehicle Displays was created nearly 20 years ago to bring together scientists and engineers from the display technology, photonics, and vehicle systems communities. This year's 19th Annual Symposium, organized by the Detroit Chapter of SID and sponsored by Continental Automotive Systems U.S., Denso International America, and Yazaki North America, will take place October 18 and 19, 2012, at the University of Michigan-Dearborn. This year also marks the 25th anniversary of the Metro Detroit Chapter of SID.

This year's Symposium will feature a keynote address by Dr. Cem Saraydar, Director of Innovation & HMI, General Motors; and a panel discussion titled "How to Achieve High Performance Automotive Display Systems and Low Energy" and will feature papers in the following areas: The Automotive Market, Display and Lighting Technologies Applicable to Vehicular Applications, Application Issues with Vehicular Displays and Lighting, Human–Vehicle Interface (HMI), and System Solutions and Touch Screens. The event will also include an exhibition with leading display industry companies such as Konica Minolta Sensing Americas, Microvision, Nanofilm, Osram Opto Semiconductors, Sharp Microelectronics of the Americas, SMK Electronics Corp., Sun Innovations, Westboro Photonics, and more. For the first time, the Vehicle Symposium will include exhibitor presentations as part of the technical program. These 5-minute presentations will provide a valuable snapshot of the exhibiting company's major technology, products, and services.

According to Silviu Pala, chair of the 2012 Vehicle Symposium, "The symposium is an international open forum for automotive manufacturers, suppliers, and academia involved in HMI/visual manipulative interfaces. It's a platform that enables valuable engineering and marketing dialog related to new technologies and trends."

For additional information and to register, visit www.vehicledisplay2012.org. ■

continued from page 2

Silver Nanowire," delves into the details of laser-ablation processes and provides some very promising process results. Author Terry Pothoven from Laserod Technologies provides a good summary of the pros and cons of both ITO and silver-nanowire materials and demonstrates the potential throughput and manufacturing process advantages of silver for both display substrates and touch-screen applications.

We also continue this month with our celebration of the Golden Anniversary of SID with Part 2 of our History of SID series, written by long-time SID members and compiled by Jenny Donelan. By looking back at the original formation of our Society and tracing its expansion across the world, as well as noting some of the most important technical milestones first displayed at SID exhibitions, the article shows how significant SID's impact has been to the larger engineering and technology community. The authors also describe the key contributions made by early SID founders and how far-reaching their early vision has become.

We're fortunate in this industry to have a lot of 'eye-candy' associated with what we do. I noted in an earlier editorial that one of the benefits of this is that I can show my family what I have been working on and they can appreciate the value of it. We all spend countless hours at our jobs, usually much more than we do in any other aspect of our lives. In many technical endeavors it's hard for outside observers, including families, to fully appreciate the impact and challenges of the things being developed. And, while there are certainly lots of esoteric concepts and challenges in the world of displays, the ultimate success can almost always be appreciated visually by all of us – whether in the form of tablets, HDTV, or 3-D movies. I'm proud to be a member of our fine Society and a contributor to our industry. I'm looking forward to the next 50 years, which I can only imagine will be even more groundbreaking and exciting than the last 50. ■

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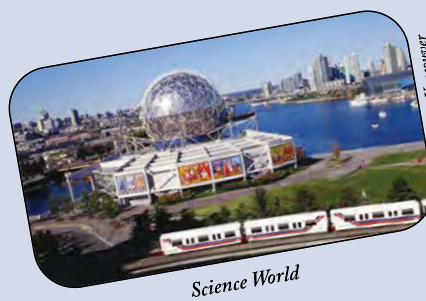
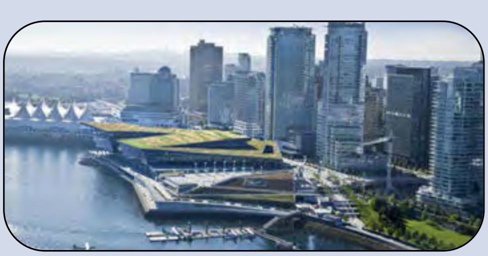


Tourism Vancouver

Science World

Display Week will be held May 19–24 at the Vancouver Convention Centre, with the exhibition open from May 21–23. Display Week is the once-a-year, can't-miss event for the electronic information display industry. The exhibition is the premier showcase for global information-display companies and researchers to unveil cutting-edge developments in display technology. More display innovations are introduced year after year at Display Week than at any other display event in the world. Display Week is where the world got its first look at technologies that have shaped the display industry into what it is today; that is, liquid crystal display (LCD) technology, plasma display panel (PDP) technology, organic light emitting diode (OLED) technology, and high definition TV, just to name a few. Display Week is also where emerging industry trends such as 3D, touch and interactivity, flexible and e-paper displays, solid state lighting, oxide TFTs, and OLED TV are being brought to the forefront of the display industry. First looks like these are why over 6500 attendees will flock to Vancouver, Canada, for Display Week 2013. Display Week 2013 will cover the hottest technologies in the display marketplace.



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The I-Zone will give attendees a glimpse of cutting-edge live demonstrations and prototypes of the display products of tomorrow. Researchers from companies, startups, universities, government labs, and independent research labs will demonstrate their prototypes or other hardware demo units for two days in a dedicated space in the main Exhibit Hall. The "Best Prototype at Display Week," to be selected by the I-Zone Committee, will be announced at the Awards Luncheon.

SID DISPLAY WEEK

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