TV TECHNOLOGY ISSUE

Information DISPLAY

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TV Technology: Options Abound for Consumers

TVs FOR THIS YEAR'S HOLIDAY SEASON

NEXT-GENERATION TVs

4K PROJECTORS FOR THE HOME THEATER

WHY SHOULD YOU BUY A PLASMA TV?

Plus

Journal of the SID November and December Contents

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ON THE COVER: *With all of the many options to chose from, along with a dizzying array of terminology and capabilities, it is difficult for even the most informed among us to make the right decision when buying a TV. Hopefully, this issue will lessen the confusion in time for the holiday season.*

Cover Design: Acapella Studios, Inc.

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editorial

An Optimistic Outlook

by Stephen Atwood

It's hard to believe we're at the end of another year already. I said in January that I was hoping this year would bring more investment and hiring within the industry, and fortunately that seems to have happened, to some degree. For example, we learned in May about the substantial manufacturing infrastructure investments being made in China over the next few years for both LCD and OLED panels. We saw global TV shipments rise 15% year over year in the fourth quarter of 2010 to a record 77.6 million units. That made for a nice holiday sales bump that everyone needed to see. However, in August we learned from our friends at DisplaySearch that by the end of Q2 '11, shipments of all large-area TFT-LCD panels had grown only 6% year over year, and the outlook had turned flat to even negative for the rest of the year. The momentum for LCD TVs, which now represent about 80% of the worldwide market, seemed to stall even worse. But, by the time we got to October, we learned that LG had shipped about 6.6 million units of flat-panel TVs in Q3 '11 which LG said in its press release was "more than the company has ever shipped in a single quarter."

In the industrial-displays marketplace, we saw numerous signs of improvement driven by expansion in retail, industrial automation, oil and gas exploration, and digital-signage activities. Planar Systems reported in May that its revenues increased 21% year over year, with the largest component being digital signage. e-Reader displays were red hot in 2011, with very strong sales of both the Nook and the Kindle. E Ink holdings reported year over year sales growth of 67% in the summer of 2011. Many major distributors also told us their total LCD panel shipments were up, with new commercial/industrial product developments coming on-line. And, of course, the demand for consumer hand-held devices such as iPhones and tablets was positively voracious.

We also saw significant investments in certain technology areas, including OLEDs, flexible backplanes, quantum dots, oxide semiconductors, electrowetting displays, and even a new type of laser-projection technology – just to name a few. It is this kind of long-range vision that builds the annuity for all of us to benefit from in later years, and as I've said before, the companies with the courage to invest during the downturns are likely to be the ones in the best positions as the markets recover. I believe we are seeing that recovery in process.

However, we also saw tragedy this year in the terrible events on March 11 in Japan. The combination of a 9.0-scale earthquake that lasted literally minutes and a subsequent tsunami that swept the low-lying region around Sendai produced a human and commercial catastrophe I doubt any of us had anticipated. The fact that the display industry was largely unaffected was a lucky break. That the aftermath did not cause a larger global tsunami on the world's manufacturing economies through disruption of supply chains was miraculous.

So, although the news this year was mixed, I think for the display business overall the recovery is firmly under way.

Our issue this month is focused on the landscape of TV technology and developed from a different point of view to appeal to the consumer in each of us. Ever get a call from a friend or neighbor with the question: "What TV should I buy?" Answering that question has probably never been harder, with all the options to choose: from 3-D

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Television News

Information Display *looks at TV licenses, viewing trends, and the new Energy Star standard in the U.S.*

TV Licenses Are a Global Norm

It may come as a surprise to citizens of the U.S., Canada, and a few other countries to learn that much of the rest of the world pays a license fee for the privilege of watching television. Countries that tax televisions include the UK, the Republic of Ireland, France, Germany, Austria, Japan, Israel, South Africa, and many others.

In the UK, residents must pay an annual fee of £145.50 for color and £49.00 for a black-and-white TV. Even if you catch all your shows on a smartphone, you are not exempt. TV licensing, the eponymous arm of the BBC, states on its Web site: "You need a valid TV licence if you use TV receiving equipment to watch or record television programmes as they're being shown on TV. 'TV receiving equipment' … includes a TV, computer, mobile phone, games console, digital box, DVD/VHS recorder, or any other device." [1]

Just because the license exists doesn't mean that everyone pays the fee. TV licensing uses penalties and a public-relations campaign to encourage compliance, as well as enforcement officers, hand-held detection devices, and specially equipped detection vans to discover scofflaws watching illegally behind drawn curtains. In the 2009–2010 period, collection costs came to 3.5% of the total collected.

The UK TV licensing fee may sound expensive to those unaccustomed to it, but consider that it enables about 14 advertisement-free BBC television stations in addition to ad-free radio and Internet programming, and it starts to seem like a bargain.

In the U.S., Average Person Watches Almost 5 Hours of TV per Day

According to the latest Nielsen State of the Media Fact Sheet, the average American watched 34 hours and 39 minutes of TV per week in Q4 of 2010, a year-over-year increase of 2 minutes. The heaviest users of conventional TV continue to be adults 65+ (47 hours 33 minutes per week), followed by adults 50-64 (43 hours per week). The group behind all others continues to be teens aged 12-17, who watch the least amount of TV (23 hours 41 minutes per week).[2]

Energy Star 5.3 Is Here

A revamped Energy Star standard for television went into effect in September. The latest standard calls for qualifying TVs to adhere to a "hard cap" of 108 W no matter what their size if they are to earn the well-known blue sticker. (For analysis of the new Energy Star standards, see the interview with plasma pioneer Larry Weber in this issue.) Among those sets that qualified for certification under the previous version, 4.2, 14% consume more than 108 W (mostly 2010 models).

Because Energy Star is not a regulatory program – it has no bearing on whether particular electronics can or cannot be sold; only whether they can bear the sticker – it remains for consumers who want larger TVs that consume more than 108 W to decide whether they will buy them anyway. Many experts think they will. Still, Energy Star has a "trickle over" effect. States such as California that traditionally seek to regulate these matters more aggressively often take their cues from voluntary compliance programs like Energy Star.

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– Jenny Donelan

Why Should I Choose a Plasma TV?

Taking another look at plasma technology? Curious about its endurance in a marketplace seemingly dominated by LCDs? Information Display *talked with plasma-pioneer Larry Weber about price, lifetime, contrast ratio, the new Energy Star standard, consumer confusion, and more to find out about the many advantages of plasma TVs and the reasons for their longevity.*

Interviews compiled by Jenny Donelan

LARRY F. WEBER is widely considered the founding father of commercial plasma television. At the University of Illinois at Urbana-Champaign, Weber studied under Donald Bitzer and Gene Slottow, who invented the first plasma-display prototype. Weber received his B.S., M.S., and Ph.D. degrees in electrical engineering from the University of Illinois and became a research associate professor there before going on to co-found Plasmaco, Inc., in 1987. In 2000, Weber received the Society for Information Display's Karl Ferdinand Braun Prize, "for pioneering contributions to plasma-display-panel technology and its commercialization."

Q: What are the advantages to plasma for home entertainment?
A: What I tell people about plasma is that you're going to get the highest quality image for the lowest price. It excels not only in response time but in high contrast ratio, particularly in a dark environment. That contrast is important when you're watching a dark movie at night in your living room.

Q: Has plasma found new life in part because of 3-D?
A: Being fast [capable of very-high-speed frame rates and fast pixel response times] is important for 3-D, and plasma is fast. It clearly does look better than LCDs in 3-D. But how important is 3-D? I don't know; it's hard to tell at this point.

Q: You've championed plasma most of your life, but LCD TVs dominate the market. How does plasma really compare to liquid crystal?

A: I have LCD TVs in my house, and I believe there are environments where LCDs really fit and do better than plasma. When people ask me about buying an LCD TV or a plasma TV, the first thing I ask is how bright is the room? If the room where you are going to be using the TV is really bright – the sunroom or the kitchen – you definitely want an LCD TV because plasma reflects the ambient light, just like a CRT does. It's one of the weaknesses of plasma.

Low ambient is where the plasma really shines because you can turn those pixels virtually all the way off. The LCD, on the other hand, has a very bright backlight; typically 20 times brighter than the peak luminance of the display, and so it is a challenge for the closed LCD shutter to completely block the backlight. When the LCD is used in a dark screen (which you do not see very often in store show rooms), the corners will often be brighter. This is because the sets are frequently built using edge-lit LEDs (light-emitting diodes). Very few TVs use the full array of LEDs on the back because you need a lot of LEDs to do that [and it increases the price]. With the edge-lit configuration, LED light comes from both the horizontal and the vertical edges of the display, which creates visibly more light in the corners. The plasma just doesn't have that; the light is generated from each individual pixel, so it is emitted uniformly across the entire screen.

It's also important to consider contrast ratios. What contrast ratio can you get at different viewing angles? Whenever manufacturers quote contrast for LCDs, they are measuring it straight on, and it's best straight on. If you go off-axis very much, the imagery starts to degrade, and you'll see dark blacks that look like grays along with visible color shifts. With plasma, the color and contrast ratio doesn't change with direction. So, the off-axis viewing angle of an LCD doesn't match the plasma, or its color imagery.

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Also, many people like the plasma because it has a softer, more natural look – a bit like the CRT that we are used to. The LCD has a harsher look, but some people like the super-sharp kinds of images that the LCD creates. It's all a matter of preference.

One relatively unbiased group that tells a story about LCDs and plasma is the movie industry – the people who work in post-editing. These guys are perfectionists. They want the best image possible when editing film. What's happening now in this industry is that the CRTs they've used are aging and can't be replaced. The movie-industry editors aren't moving to LCDs; they are using plasma. They consider LCDs insufficient due to the contrast and color change with viewing angle. Of course, these guys are looking for little nits. They need to find every last little error and get rid of it and for that they need a panel that will be able to perform by giving them the highest-quality image.

What the LCD does have is wonderful marketing. Consider those "LED TVs," for example. Of course, these are LED backlights in an LCD TV, but many people out there buying these sets think they're a completely new technology – "LED TVs."

So the distinct advantages of plasma are its contrast ratio, its viewing angle, its consistent color coordinates, and the speed of the imagery. These are all very important issues for the home user, but the last one I should mention is price. The price of plasma is lower than that for an LCD.

Last year, plasma sold 19 million sets worldwide; it actually took market share from LCDs. How do most people buy TVs? They get the cheapest one they can. There are some people who wouldn't do such a thing, but most buy on price. The plasma companies have been able to cut prices, while still making money. Plasma costs less to manufacture; it's really a simple device.

Plasma Manufacturers' Perspectives

Plasma Is Stronger than Ever

From Tim Alessi, Director of New Product Development, LG Electronics USA.

Plasma technology has always been appreciated not only for its fast response times and smooth motion, but for its ability to render the deepest black levels and rich, accurate colors. While the most recent advances in LED (light-emitting-diode) backlit LCD sets have closed the gap somewhat, plasma is still the natural choice for discerning home-theater enthusiasts.

LED-based LCD TVs will always have an advantage in power consumption due to the nature of the technology, but plasma has made significant advancements in reducing power consumption. For example, one of our current 60-in. plasma sets would cost about $15 more per year to operate than a 65-in. LED-backlit LCD TV (closest size match). For someone who appreciates the performance of plasma, this would not be a significant factor in the purchase decision.

There are tremendous values in plasma at every screen size. Generally speaking, a consumer could find a plasma TV for between 10 and 20% less than a similarly sized LED-backlit LCD, depending on the features. The great picture performance in plasma, coupled with the price advantage, offers tremendous value across the board. With regard to full HD *vs.* 720*p* panels, the market is about 3:1 in favor of 720*p*, due to the great values in 42- and 50-in. sizes.

Our plasma business has been stronger than ever in the U.S. and we're looking forward to introducing our new lineup at CES in 2012.

LG's PZ950 is the company's flagship 50-in plasma TV.

Best Image Quality

From Jim Noecker, Sr. Business Development Manager, Flat Panel Displays.

Our high-end customers agree that plasma continues to be the best in terms of image quality. For example, we sell to the production studios for movies and TV and they won't even let an LCD in the door. The viewing angle alone is where plasma is better. With LCDs, you have motion blurring. And the local dimming technology in LCDs can lead to "halo" effects.

There is still plenty of room for LED-backlit LCDs as well as plasma. In a bright-ambient setting, the LCD is better. That's why we sell a lot of LCDs for signage.

With regard to Energy Star and energy usage, plasma TVs are not energy hogs anymore. Our plasma models meet the Energy Star standards. We still see a lot of legs in plasma.

Panasonic's G10 plasma TV is a 54-in. 1080p model belonging to the company's Viera line.

Q: For years, plasma TVs have come under fire for using too much energy, even as manufacturers have lowered the required wattage. Do power-saving LED-backlit LCDs make it more difficult for plasma to compete?

A: Most plasma and LCD models right now meet the EPA Energy Star standard, which is getting to be pretty challenging. This has been a horse race in which one technology gets a little ahead, then the other catches up, and so on. Right now, I think plasma is slightly ahead of CCFL LCDs. And I believe the LED LCDs are probably a bit lower in power than plasma.

But they are all getting to be pretty low power. The new Energy Star standard, 5.3, which came out last September, was calculated in a new way. In the past, the authors acknowledged that power was going to scale with the area of the display. If you are putting out more lumens, you're going to dissipate more power – that's only logical. But for standard 5.3, they used a linear scale with area up to 108 W. Once you get there it plateaus and stays at 108 W no matter how big the panel is. A 65-in. panel is going to pull more than 108 W, so it's not going to get an Energy Star sticker. That's going to cause trouble for both LCD and plasma. I think in the plasma world, the 42- and 50-in. models will probably make the standard, but not a 65-in. model.

What is really of interest is the 108 W. In the early days, a 50-in. plasma used 550 W. There have been tremendous advances, and 108 W is remarkable.

So, to sum up, the LED backlit is a little better in terms of energy usage, but the differences may not be too important. Let's say the LED panel uses 88 W and the plasma panel uses 108 W – a difference of 20 W. When you go into the stores now you will see these yellow tags on the sets that indicate what the annual cost is going to be in terms of power. If you watch 4 or 5 hours of TV a day, 20 W may cost a couple more dollars a month. If you compare that cost per month with the overall panel cost, I still think you'll find the plasma will provide a lower total cost of ownership than the LCD.

Q: What about some of plasma TV's perceived disadvantages, such as maximum luminance, lifetime, burn-in, and weight?

A: For maximum luminance, you're going to do better on the LCD than the plasma. An LCD can have a backlight of any luminance you want. The plasma can't do that. It's constrained by what the plasma pixels can do and how fast they can pump out light pulses. Everything is done with the pixel. The LCD does everything with a systems approach; it uses the backlight as one part of the system, the liquid crystal as another part, the brightness-enhancement films as another, and so on. But do you need maximum luminance? The high luminance is useful if you have high ambient illumination, but you really don't need it otherwise. So that's a disadvantage to plasma but I don't think it's a large one.

Lifetime is not a disadvantage; it's a big advantage for plasma. Plasma's guaranteed lifetime to half-luminance is 100,000 hours. You won't find a number near that for an LCD; the highest you'll see is 50,000 or 60,000 hours. The backlights are made up of two possible technologies: CCFL (cold-cathode fluorescent lamp) and LED. CCFLs burn out at a certain age. LEDs also are not infinite life devices. They will fail and lose luminance and LEDs will shift color. They are very sensitive to temperature in terms of color.

With regard to burn-in, plasma was the first display out there with large screens, so a lot of them were put in airports and public places where they have the display on 24 hours a day and there might have been some number on in the corner all the time, which left a fixed-pattern image. Since then, the phosphors in plasma have gotten much, much better. That's why they have such a long half-lifetime now. I have a 50-in plasma TV [in my house] that's on much of the time, sometimes even in freeze mode when my wife pauses it and comes back 3 or 4 hours later. It's about 9 years old – I wrote an article on it in 2003 for *ID* magazine. That panel is still going and there's no sign of burn-in. The other panel I bought at the time for that very article was a 32-in. LCD. It has failed miserably. It has a big blob in it that's due to the liquid crystal. But there really isn't a plasma burn-in issue for TV images. If you put a fixed pattern image on any emissive display – CRT, OLED, plasma – yes, burn-in can happen. But TV images aren't that way. They move around.

The plasma is a little heavier than the LCD because the glass is thicker. The LED backlights can be pretty light and the glass for the LCD is usually lighter. But are you carrying these around?

Q: What about pixel resolution?

A: It's all the same now – HD [up to 1080*p*]. I should say that even though HD plasma is sold and you can buy it in full high resolution, a lot of people buy the 720*p* panels and they do that because they're $100 to $200 cheaper. The resolution is there; it's available, but many people want a bargain. The major choice you have today is size, which keeps getting bigger and bigger.

Q: Are companies closing their plasma lines or holding strong? How many plasma manufacturers are left?

A: Last year, the number of panel manufacturers was three. The players were Panasonic, Samsung, and LG. The year before, there were four, but Pioneer sold its operation to Panasonic. The year before that, Hitachi was in operation, but it sold its line to a Chinese company, so that this year we have a new plasma manufacturer, which is Changhong. They are a giant, well-established TV company in China. In addition to the old Hitachi plant, they just finished a new $1B plant in Szechwan. I went through it about a year ago when it was just in pilot production.

The Future of Plasma

Last year, 19 million plasma TVs were sold. This was a record, even though there have been a lot of market people predicting the demise of plasma for the last 10 years. The LCDs were going to take over! LCDs certainly did a great job of capturing market share, but it didn't put plasma out of business. Plasma continued to grow, although it didn't grow as much as it would have if the LCD wasn't there. So, LCD took the icing off the cake but didn't eat the whole cake. Last year, plasma even recovered some of the market share from LCDs.

The next competition will be OLED TVs (organic light-emitting diodes). But they are going have a hard time with price. They can't be as cheap to make as the LCD variety. And they still have to demonstrate their 100,000 hours of life, which is going to be difficult. But they sure look good! ■

Navigating This Year's Models

The average consumer who sets out to buy a TV has questions. The scene at the average electronics store, with its rows upon rows of TV sets all displaying identical flickering content, often leads to more questions. Since buying a TV can be overwhelming for anyone, Information Display *asked a knowledgeable retailer for answers to some of the most common TV buying questions. In addition, we highlight the kinds of products consumers can expect to see in stores right now.*

by Jenny Donelan

AN UNCERTAIN ECONOMY has been affecting manufacturers, retailers, and consumers alike, but if you do happen to be looking for a TV this holiday season, you are in luck. It is a buyer's market, with both plasma and LCD models packing more features for lower prices than ever before. It is true that November and December are not the best time to find the very latest TVs in stores. Most of the top TV makers introduce their new models at the Consumer Electronics Show in January, and those do not usually ship until the Spring. The flip side of this is that what's available now tends be mature and market-tested.

Information Display recently caught up with Robert Zohn, president of Value Electronics, an audio–video retailer located in Scarsdale, NY. Value Electronics is serious about TV technology, conducting an annual "shoot-out" in which flagship flat-panel HDTVs from different manufacturers are compared both out of box and after calibration. A panel of approximately 70 invited enthusiasts and experts vote for the winners.

The company has both a storefront and an Internet business. Its customers range from "regular" types, to well-informed and passionate videophiles, to ultra-wealthy residents of the area who, Zohn says, want the very best, but usually do not want to know about the details. Across the board, he says, the following are the most common questions that customers ask.

1. ***Can you explain the difference between LCD and plasma?*** According to Zohn, who sells both varieties, plasma provides a better picture for the money for most people. It has better off-axis viewing and better contrast. (Although be sure to see the results of his store's seventh annual shoot-out at the end of this story.) The LCDs, both the CCFL- and the LED-backlit variety, are definitely brighter. "LCD is gaining in popularity every year. People are drawn to that bright image in the store," says Zohn. "They definitely like the 'punchy' look of an LCD." They do not always like it as much when they get home, he notes. The newer LED-backlit LCD TVs with local dimming have better blacks than they used to, but they also have problems such as "blooming," with halo effects around some text and imagery. For a more detailed answer to this question, see the article "Why Should I Choose a Plasma TV?" in this issue.
2. ***What TV is better for what viewing environment?*** Plasma works best in darker environments, whereas LCD handles ambient light better. For a sunny room, where plasma's reflective attributes will make the picture harder to see, LCDs are great. In general, though, for a better overall TV viewing experience that includes plasma, "We recommend window treatments," says Zohn.
3. ***How can I mount this TV?*** "People have a lot of challenges with wall mountings," says Zohn. This has become increasingly frequent with the new, larger flat panels. "We've certainly tackled some unique custom mounting jobs – on the ceiling, in the corner, *etc.*," he says, adding that there is usually a way to do what the customer wants.

***Fig. 1:** Samsung's 55-in. LED Series 8000 ultra-slim-bezel Smart LCD TV.*

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4. ***What's the difference between models as you step up the prices?*** People often want to know what they do and do not need to pay for. According to Zohn, your money buys you a step-up from CCFL backlighting to LED backlighting for LCDs, then increased frame rates, from 60 to 120Hz and to 240 Hz, and also smart TV and wireless capabilities.
5. ***Do I really need 3-D if I'm not interested?*** Customers often hope to save money by dispensing with a feature they do not think they want, says Zohn, but most mid-range TVs are 3-D ready anyway. He's a strong believer in the technology "Most people are not into it but when they see it, they realize it's great." Zohn believes that active-glasses technology is the way to go for most consumers. "The off-angle viewing is much better [than passive], plus the price for the glasses has gone down a lot, from $180 a pair to $30–80 a pair." The second-generation active-shutter glasses are also much lighter, weighting less than 1 ounce. "You do not even know you are wearing them."
6. ***What about smart TVs?*** "People want to know what they can do with it," says Zohn. This feature seems to be a stronger selling point than 3-D.

One feature customers tend *not* to ask about is energy efficiency. "I would say 25–30% of customers have a modest concern," says Zohn, adding that TVs are becoming so energy efficient that there is not a great deal of difference between them anyway.

Fig. 2: *Sony's Bravia EX520.*

Surprise Results at the Shoot-Out

Value Electronics has been conducting its flat-panel shoot-outs for 7 years now. Every year, plasmas have won the top honors – until the most recent shoot-out, conducted in October of 2011. "This is the very first year that the LCD has won," says Zohn. The winner was a Sharp Elite LED-backlit TV with 300 zones of local dimming. Even the off-axis viewing, says Zohn, was very impressive. However, the 70-in. version retails for $8000 and the 60-in. for $5499, so this one may not find its way into everyone's Christmas stocking. To find out more about the shoot-out, visit Value Electronics' Web site at www.valueelectronics.com.

The following are some of the latest models you can expect to see in stores.

Samsung

Samsung is currently promoting three lines: LED-backlit LCDs, which it simply calls "LED TVs," CCFL-backlit LCDs, and plasma units. One LED-backlit LCD product line features ultra-slim TVs with ultra-slim bezels, as seen in Fig. 1.

Fig. 3: *LG's LW980S backlit TV.*

Fig. 4: *Panasonic's Viera with 3-D capability.*

Fig. 5: *Sharp's 60-in. PRO-60X5FD.*

Sony

Sony's Bravia series, introduced at last year's CES, represents the flagship LCD line for the company. The 2011 BRAVIA LCD HDTV series (Fig. 2) includes 16 3-D-capable models and 22 Internet-connected models, ranging in screen size from 22 to 65 in.

LG Electronics

LG Electronics is promoting the LW980S (Fig. 3), a top-of-the-line LED-backlit LCD TV that combines LG's CINEMA 3-D technology and smart-TV functions.

Panasonic

For the 2011 Viera Full-HD 3-D line-up (Fig. 4), Panasonic extended immersive 3-D technology to its LED-LCD units, with two models, the 37-in. TC-L37DT30 and the 32-in. TC-L32DT30.

Sharp

Sharp announced the return of the Elite brand with full-array LED-backlit LCD panels in 60- and 70-in. models (Fig. 5). ■

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4K Projectors Come to Home Theaters

Anyone who has seen 4K-resolution images on big-screen displays knows how detailed and impressive these images can be. Now it is possible to have 4K projectors for personal home theaters.

by Chris Chinnock

HOME-THEATER PROJECTORS, those with 1080*p* resolution and higher, represent a small but important segment of the display industry. With ever increasing performance and falling prices, high-quality 1080*p* home-theater projectors can now be purchased for as little as $1500. Other products span the range to over $100K, so it is possible to pay anything you want (or can afford) for a home-theater projector.

At CEDIA 2010, the big news was the introduction of the first 1080*p* 3-D projectors using LCOS and DLP technology. At CEDIA 2011, Insight Media saw the expansion of 3-D projector models with LCOS and DLP technology as well as the introduction of 3-D projectors using 3LCD technology. In addition, we saw the debut of 4K projectors from Sony and JVC – but using different technical approaches. Such innovations continue to make this segment interesting and relevant.

Sony Goes for Native 4K Approach

Sony Electronics has unveiled the VPL-VW1000ES4K projector, which uses a trio of 4K (4096 × 2160) native-resolution SXRD (LCOS) panels to create a beautiful image. The new projector uses 0.74-in. SXRD panels – half the diagonal size of previous 4K microdisplays from the company. That represents a pixel pitch of just over 4 µm – a state-of-the-art density.

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With 2000 ANSI lumens of brightness, the VPL-VW1000ES4K projector (Fig. 1) delivers nearly twice the output of previous Sony home-theater projectors, making it suitable for screen sizes up to 200 in. diagonally in 2-D mode and 150 in. in 3-D mode. The VW1000ES4K model also employs an entirely new SXRD 4K panel, which produces deep black levels. When combined with Sony's Iris3 technology, the projector can achieve a dynamic contrast of 1,000,000:1.

The VW1000ES4K projector includes an exclusive 4K "upscaler" that dramatically enhances all content – SD or HD, 2-D or 3-D – allowing viewers to see 4K playback, even from their existing media libraries. Other features include an integrated IR transmitter that drives the projector's TDG-PJ1 active-shutter 3-D glasses, dual triggers, a 2.1 motorized zoom, expanded throw distances, a RS232 interface, control over IP, and compatibility with leading home automation systems.

Sony acknowledges that there is no infrastructure for delivering 4K video to homes today, but the company hopes to see new Blu-ray players and AV receivers that can support 4K content and for Hollywood to release content in this resolution. The HMDI 1.4a standard does have provisions for delivery of 4K content, but to the best of our knowledge, no silicon solutions can support this data rate yet. The one source of 4K content available to consumers is still images that they can capture with imagers that have more than 8.8 Mpixels. These are readily available today and 4K consumer video camcorders are probably not that far off either.

We had a chance to see a demo of Sony's 4K projector *vs.* a 1080*p* projector with 4K upscaling. Identical 4K images were used with the native-resolution image fed to the VW1000ES4K projector and a downscaled 1080*p* image fed to the other projector. What was unclear is how this 1080*p* image was then processed to show the 4K image.

The side-by-side comparison did show a difference in image quality, with fine details being sharper on the native VW1000ES4K projector. Sony said the VW1000ES4K will sell for under $25K, but JVC's e-Shift 4K projector (described next) will be half the price, which will certainly be appealing to consumers.

Sony said the VW1000ES4K is the first in a new line of projectors the company will offer with native 4K panels. Mike Abary, Senior Vice-President of Sony Electronics' Home Division noted, "We're also adding resources to support our leading service programs and working with channel partners to provide dedicated support and training that no other company can match." The VW1000ES4K should ship in December, but it is unclear if this includes a lens or not.

JVC Debuts e-Shift QFHD Technology

While Sony has taken a native 4K panel approach to offering a 4K home-theater projector, JVC has taken a different path. JVC achieves 4K (actually QFHD resolution of 3840 × 2160) images by using a 1080*p* panel and electronically shifting it in space to create a 4K image at the screen surface. JVC calls this e-Shift technology, and it will proba-

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bly have a big impact on the home-theater and professional markets (see Fig. 2).

The concept of spatially shifting a projected image to fill in additional pixels and thereby increase the on-screen resolution is not new. Insight Media knows of at least three efforts that have produced higher-resolution images in this manner. One question that many are sure to ask is Who controls the IP around this issue?

We saw a demo of this e-Shift technology at CEDIA and found the resulting image to be excellent. JVC includes algorithms that focus on identifying and enhancing fine details – and they are apparent in the upscaled QFHD image.

JVC will offer the upconverting technology in four of its seven new 3-D-enabled projectors (see Table 1) that boast a wide range of advancements. However, the 3-D mode does not work with e-Shift, so 3-D content is shown in 1920 × 1080 resolution.

Earlier this year, NHK Science & Technology Research Laboratories, NHK Engineering Service, Inc., and JVC Kenwood Corporation collaborated in the development of a Super High Vision projection system that utilizes e-Shift technology. Now, that technology is available in the DLA-X90R/DLA-RS65 and DLA-X70R/DLA-RS55 projectors. These projectors replace last year's DLA-X7/DLA-RS50 and DLA-X9/DLA-RS60 pairs but add all the new features for the same pricing.

The paired models are essentially the same, but with different distribution channels. These models are also scheduled to undergo THX 3-D certification, which uses more than 400 laboratory tests to evaluate color accuracy, cross-talk, viewing angles, and video processing to ensure superior out-of-the-box 3-D and 2-D display performance.

These e-shift models include a new 1/16 pixel-shift function to precisely tune convergence via 121 adjustment points (11 vertical × 11 horizontal) and an increased number of screen-mode preset positions. There are also three xenon-lamp color modes that emulate the characteristics of high-end movie projectors.

Fig. 1: The Sony VPL-VW1000ES4K projector includes a 4K "upscaling" feature that enables 4K playback, even from pre-existing media.

Fig. 2: JVC's DLA-X90R projector incorporates the company's new e-Shift technology.

Table 1: JVC's new lineup of home-theater projectors are all available in time for the holiday season.

Model	Procision Series (Consumer Distribution)	Reference Series (Professional Distribution)	e-Shift Technology	THX Cert. & ISF Calibration	Native Contrast (wire grid polarizers)	3-D Glasses	MSRP Price
DLA-X90R	X		X	X	120,000:1	2 pair included	$11,995
DLA-X70R	X		X	X	80,000:1	Optional	$ 7,995
DLA-X30	X				30,000:1	Optional	$ 3,499
DLA-RS65		X	X	X	120,000:1	2 pair included	$11,995
DLA-RS55		X	X	X	80,000:1	Optional	$ 7,995
DLA-RS45		X			30,000:1	Optional	$ 3,499
DLA-RS4800		X		ISF only	55,000:1	Optional	$ 4,999

All seven of the above projectors are available now, are 3-D-enabled, and offer several 3-D performance and feature enhancements:

- A 2-D–to–3-D converter that converts 2-D program material to 3-D using technology derived from JVC's professional 2-D–to–3-D converter. Included are user adjustments for 3-D depth and subtitle geometry correction.
- JVC's 3-D anamorphic feature combined with an optional anamorphic lens make it possible to enjoy 3-D movies in the popular 2:35 scope format.
- Compatibility with a wider range of 3-D broadcasts, including 1080*p*/24 and 720*p* side-by-side formats.
- Brighter 3-D images than previous models through the use of an improved driver that keeps the shutter on the active-shutter 3-D glasses open longer, thus allowing more light to enter, while at the same time minimizing cross-talk.
- A cross-talk canceller further reduces cross-talk through analysis of the left-eye and right-eye signals and by applying appropriate correction (this sounds similar to "ghost busting" technology developed by RealD).
- A parallax adjustment allows the user to tailor the 3-D image effect.
- Direct access to 3-D formats and settings on the remote control.

Epson and Panasonic Introduce 3-D Projectors Using 3LCD Imagers

Thus far, 3-D projectors based on DLP and LCOS technology have dominated the commercial and custom install markets. Now, 3LCD technology can offer 3-D images too. At CEDIA, Epson took the wraps off five 3-D projectors, while Panasonic showed its first 3-D 1080*p* home cinema model – all using newly developed 3LCD panels that operate at a 480-Hz refresh rate, which Epson calls "Bright 3D Drive."

This high-speed addressing allows 3-D images to be about 1.5× the brightness of 3-D images produced by 240-Hz HTPS panels. Note that Epson is not claiming the projectors are 1.5× brighter than DLP 3-D projectors, but that the drive scheme of a 240-Hz panel will enable this increase compared to a 240-Hz panel. This high speed of addressing is enabled by the use of the Epson D9 process for the high-temperature polysilcon (HTPS) backplane.

The increased brightness comes from the reduced blanking time required for 480-Hz addressing compared to 240-Hz addressing, as shown in Fig. 3. In 3-D HTPS systems, the image needs to be blanked while both the left and right images are on the screen. This can be done either by turning off the light source or by closing both shutters in a shutter-glass system or by using both techniques.

In 240-Hz addressing, portions of both images are on the screen for 1/240 sec or 4.2 mS for each image while for 480-Hz addressing, portions of both images only appear on the screen for 1/480 sec or 2.1 mS. Note that with either 480- or 240-Hz drives, one addressing cycle must be blanked when a 3-D image is displayed. The increase in brightness comes from the fact that this addressing period is significantly shorter with 480 Hz than with 240 Hz.

In either the 480- or 240-Hz case, however, the overall refresh rate seen by each eye is 60 Hz. While these panels are discussed by Epson in terms of shutter-glass 3-D systems, the polarized nature of 3LCD projectors would also allow the panels to be used in projection systems that employ passive glasses. The 1.5× brightness advantage of 480-Hz panels vs. 240-Hz panels would be the same regardless of whether active or passive glasses are used.

In its Home Cinema line, Epson introduced four new models: the 3010, 3010e, 5010, and 5010e. Perhaps the most interesting unit in this lineup is the entry-level Home Cinema 3010. This unit offers 2200 lm, FHD resolution, a dynamic comtrats of 40,000:1, split-screen mode for watching two pictures at once or watching TV and using the Internet at the same time, built-in 2-D–to–3-D conversion, and 3-D operation via shutter glasses for only $1600. The panel updates at 480 Hz, but 3-D images are refreshed at 120 Hz. The extra cycles are used for frame interpolation to reduce motion artifacts. The 3010e version is the wireless model ($200 extra). It uses the WirelessHD standard to send uncompressed high-definition video over short distances to the projector. Both will ship this fall.

The step-up 5010/5010e models offer the same features and functions (speced with a slightly higher brightness of 2400 lm), but with a much higher contrast of 200,000:1. The 5010 has an an MSRP of $2999; the 5010e goes for $3499. Both are available now.

The 6010 model is part of the Pro Cinema line with specs similar to the 5010, but it is distinguished by having ISF certification, two anamorphic lens modes, two pairs of glasses, color isolation, a ceiling mount, cable cover, and an extra lamp for installation flexibility. The 6010 is available for $3999.

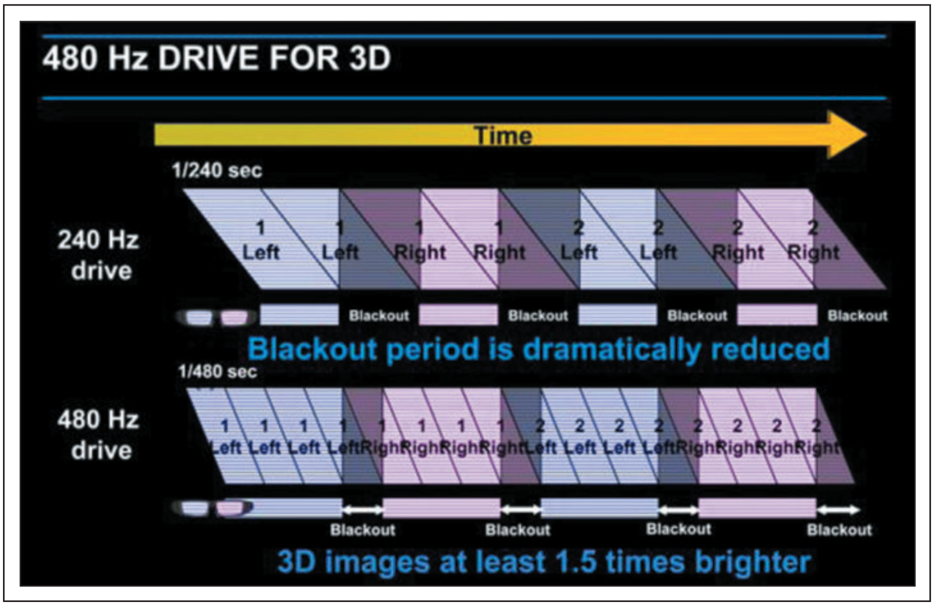

Fig. 3: Epson's 3-D timing diagram for its 480-Hz projector panel shows how 3-D imagery can be made brighter. Source: Epson.

We had a chance to see the 6010 in action at CEDIA, where the 3-D movie *Yogi Bear* was playing in Epson's theater. The colors and contrast certainly looked good, but there were some motion artifacts that were visible, plus some minor ghosting and cardboarding. A second demo featured Epson's 2-D–to–3-D conversion technology. The quality of this conversion was just fair.

Panasonic's new projector using these panels is called the PT-AE7000. The optical system features a new 200-W red-rich lamp and the new LCD panels offer a higher aperture ratio for increased red luminance and brightness output. The result is a 1080*p* projector with 2000 lm and a 300,000:1 dynamic contrast ratio. The projector is also equipped with a dual-core processing engine so that it can process 3-D signals with all of the benefits of 2-D image enhancements. It is a shutter-glass-based solution that also includes 2-D–to–3-D conversion and the ability of the user to adjust the disparity and color of the left- and right-eye images independently. The three HDMI inputs support x,v Color and Deep Color, and there is lens-shift capability for 100% vertical adjustment and 26% horizontal adjustment. This should be a pretty sweet home-theater projector. It is available now with an MSRP of $3499.

In conclusion, it is fair to say that innovation continues to drive the home-theater market. The projectors profiled here will offer some of the best images consumers can see – albeit at a price point that is much higher than a comparable flat-panel TV. But a market exists for these projectors and as long as it does, we should continue to see cutting-edge performance from this product area. ■

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The TV of the Future

Over the past few years, TV sets have incorporated numerous new technologies and features, in some cases providing more than consumers have been able to utilize or afford. At the same time, the need to improve profitability and tap into emerging markets has led to TV sets that make explicit performance tradeoffs in favor of lower cost. In the near term, this has resulted in a proliferation of choices. What does this tell us about the TVs that will be available in 2015 and beyond?

by Paul Semenza

SEVERAL different TV technologies – LCD, plasma, and OLED – are battling to become "the CRT of the 21st century," with the LCD currently in the lead. The TFT-LCDs have continued to expand their share of the TV market, having passed 100 million units shipped in 2008 and 200 million in 2011. DisplaySearch forecasts that LCDs will reach nearly 90% of the TV market by 2012. In addition to growing with the overall TV market, TFT-LCDs have also been taking share from the cathode-ray-tube (CRT) market, shipments of which fell below 100 million in 2008 and are expected to approach 10 million in 2012, as even emerging market households convert to flat panels or choose an LCD as their first set.

After growing rapidly in 2010 in response to a stall in LCD price declines, plasma-TV shipments are falling in 2011 and are expected to decline from 18 million units to 14 million by 2015. At that point, plasma-TV makers are expected to focus exclusively on the 50-in. and larger market segment, where plasma displays will maintain cost competitiveness with LCDs. But just as rear-projection technologies were driven out of the market by the economies of scale that flat-panel displays enjoy, the investment in Gen 7 and larger TFT-LCD fabs, combined with a lack of investment in plasma, make it likely that LCDs will eventually drive it out of the market.

This leaves the question of the potential for organic light-emitting-diode (OLED) based TV. In theory, OLED displays have the superior image quality (color gamut, viewing angle, and response time) of an emissive display, but at lower voltages, simpler structure, and far fewer materials than other emissive displays (CRT and plasma). At the same time, it is an active-matrix technology and can build on the TFT-manufacturing technology developed for LCDs. Instead of combining an active matrix with a complex system of creating and then shuttering light – as TFT-LCDs do – active-matrix OLEDs (AMOLEDs) can emit the color, brightness, and duration of light as needed. In theory, AMOLEDs should be able to compete effectively with TFT-LCDs and eventually take over the TV market.

In practice, bringing AMOLEDs into mass production has not been simple. Manufacturing TFTs that can provide the needed levels of current across a large substrate, and developing processes for depositing the organic materials at high density on such substrates, have proven to be difficult.[1] At present, there are more than two-dozen TFT-LCD fabs of Gen 6 or larger (factories that are optimized for 32-in. and larger panels), but there is only a single Gen 5.5 AMOLED fab. It will be many years before there will be anywhere near as many AMOLED fabs, even considering the possibility of conversion of existing TFT-LCD plants. Given the cost advantage from large-scale manufacturing, TFT-LCDs are likely to continue to be lower cost than AMOLED displays in TV panels for some time to come.

DisplaySearch forecasts that OLED-TV shipments will begin again (there were some shipments in 2007) in 2012 and will approach 3 million by 2015, which will account for approximately 1% of TV shipments. It is likely that 2015–2020 will be a key period for OLED TV to gain market share and represent significant competition for LCD TVs. However, in addition to the challenges of moving into high-volume manufacturing, OLED technology will have to compete with the ever-improving TFT-LCD technology.

In recent years, LCD performance has improved in the areas where OLED displays have been assumed to be superior. A key advance has been the development of LED backlights, which have enabled increases in color gamut and contrast ratio, as well as greatly reduced panel thickness. In conjunction with faster liquid-crystal materials and driving circuitry, LED backlights also enable higher frame rates. Another area of signifi-

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cant improvement has been wide-viewing-angle operation, enabled by advanced TFT architectures such as in-plane switching (IPS) and fringe-field switching (FFS).

Will "High Definition" Become "Medium Definition"?

An ongoing area of development in LCD TVs is in resolutions beyond full HD (1920 × 1080), with 4K × 2K and 8K × 4K sets having been demonstrated. Most demonstrations to date have utilized TFTs based on metal-oxide semiconductors, a promising approach that could also be utilized as an active matrix for AMOLEDs. There will be challenges for each of these technologies to realize such high resolutions: for LCDs the challenge is that the backlight brightness must be increased significantly; for OLED displays, there are no proven methods for depositing organic materials at such high densities.

In order for TVs with such high resolutions to become commercially useful, significant expansions in video capture, creation, storage, and transmission systems will be required. It is also important to realize that years into the transition to HD, most content is still in 720p or other formats below full HD, but it is likely that HD will not remain the highest – or even the standard – resolution forever.

3-D Will Need to Lose the Glasses

Another area of rapid development in flat-panel TVs has been 3-D, with intense competition between active- and passive-glasses-based systems. Active systems present left and right images in a time-multiplexed fashion and use switching glasses to select the image, while passive systems use spatial multiplexing in conjunction with polarizing glasses. Both approaches involve compromises – the switching in active systems can lead to flicker, crosstalk, and other effects, while passive systems avoid these issues but at the possible expense of resolution, a topic of some debate.

While the adoption of 3-D has been slower than many TV makers had hoped, it is likely that 3-D will become a standard feature in flat-panel TVs. Over the next few years, increasing availability of 3-D content will create a concomitant demand for 3-D capability, while the existing technologies will continue to improve.

It is clear that a significant barrier to broader adoption of 3-D has been the requirement for glasses. Thus, in the longer term, the most important development will be in autostereoscopic technologies, which do not require the use of glasses. Autostereoscopic displays developed thus far have not had the performance required for TV, but perhaps in conjunction with the emerging high-resolution displays, it is likely that such products will be available over the next 5–10 years.

TVs Need to be Connected – But How Smart Do they Need to Be?

With the proliferation of content beyond conventional broadcast, cable, or satellite access, connectivity of the TV has become an increasingly important feature. Connectivity has many forms, including the physical aspect (wired, wireless) and the scope (point-to-point, local network), as well as the location of the intelligence – in the TV or a connected set-top box, Blu-ray player, game console, or other device. It is clear that TVs must be able to connect to wired and wireless devices in the home, as well as the Internet, either directly or through an auxiliary device.

Through much of the history of the TV, the sets have been monitors – playback devices connected to a signal, set-top box, or video source. Often, new features are integrated into the set when first introduced, but soon move into a dedicated device that can be upgraded separately from the TV set. Connectivity is the latest example of the tension between embedding features in the set as opposed to an external device. The concept of Smart TV has been promoted by set makers as the way to provide the highest level of integration of content sources, from broadcast/cable/satellite, to media players, to content from the Internet, to content from mobile devices such as smartphones and tablet PCs.

The increasing use and integration of mobile devices to consume video and other "TV" content has led to increasing attention paid to the interactivity of the TV with other devices. Several TV brands, as well as Apple, have promoted interactivity between their mobile devices and TVs or set-top boxes. This can include sharing/streaming of video content, programming, and storage. Of course, these devices can, in some cases, supplant the TV, particularly in rooms where a smaller, secondary TV might have been used before the advent of mobile devices.

"Touch" TV Is Likely Impractical

In addition to the TV becoming more interconnected with networks and other devices, it is likely that more powerful and flexible ways for viewers to interact with and to control TVs will be developed. Due to the distances at which users interact with their TVs, it is not likely that touch screens will become prevalent. However, gesture recognition has already proven to be a powerful and intuitive user interface, as implemented in the Microsoft Kinnect for its Xbox game console. Surely, this technology will improve in the future, possibly using facial recognition to allow for customization of the user interface.

Another form of control that is currently available is to use devices such as smartphones, tablet PCs, or personal media players as remote controls, potentially allowing viewers to use the mobile device to monitor programming other than what is on the TV or to take the current programming with them when they are out of sight of the TV.

Too Many Choices?

Currently, there are two broad themes in TV development. On the one hand, the industry has pushed rapidly to drive adoption of full HD, high frame rate, LED backlit, 3-D, and connected TVs, with the hope that consumers will pay a premium for such features. However, perhaps due to high penetration and difficult economic conditions in developed markets, consumers have not embraced all these features enthusiastically, and price elasticity appears to have declined. In a study of over 14,000 TV owners in 13 countries, DisplaySearch found that the key drivers causing respondents to replace a TV over the last 3 years focused on improving the picture quality, getting a new flat-panel TV, and upgrading to a larger TV. New features such as 3-D, LED backlighting, and Internet connectivity did not drive consumers to upgrade, though they may be valued features if a consumer is already in the market for a TV. The study found a slightly larger, though still minor, impact of these features on purchases planned in the next 12 months.

At the same time, with the increasing share of emerging markets in the global TV business, a new set of designs, grouped under a term called EMTV (emerging market TV), are starting to have a noticeable and very different influence. Here, the idea is to make the set more affordable and provide a logical step up from existing CRT sets. Generally, these sets trade off the high-performance features in favor of simplicity of manufacturing and lower cost.

One approach is to eliminate much of the backlight unit in favor of a simple array of LEDs behind the panel. This lowers costs for light-management components; by reducing the brightness specification, fewer and/or lower brightness LEDs can be used, also saving cost. So-called "direct-type LED" sets can be sold for a modest premium over that of CCFL-based sets, with the tradeoffs being increased depth and reduced brightness. A variation in this design uses a single CCFL tube in a very deep case that is close to the depth of a CRT, leading to the name "chubby TV." This design seems to be targeted at current CRT owners who would like to move to flat panels but at a very modest premium. Another design seeks to approximate the performance of 120-Hz LCD TVs by using a cheaper 60-Hz panel in conjunction with a scanning backlight. This opens up the potential for a more-affordable 3-D TV.

These opposing trends are resulting in a proliferation of LCD-TV designs, as can be seen in Fig. 1. When all possible combinations of the performance attributes at the bottom of the table are combined with the wide variety of screen sizes, there are over 50 different set types possible.

The Ultimate TV

Today, the "ultimate" TV is a flat-panel set with high frame rate (at least 240 Hz), 3-D capability, and Internet connectivity. What might the ultimate TV look like in the future? By 2015, we can expect much higher resolutions to be available (at least 4K x 2K), enabled by new backplane technologies. Some of the additional resolution will likely be utilized to implement glasses-free (autostereoscopic) 3-D. The TV will likely be "smart," meaning that it can operate on the open Internet, network with devices including fixed sources (pay TV and streaming set-top boxes, game consoles, and PCs), and mobile devices (smartphones and tablet PCs) and run apps, widgets, and other software providing advanced user interfaces and programming discovery and recommendation functions.

This TV set will likely use an LCD panel made with a lower-cost TFT technology such as metal oxide, with advanced LCD modes enabling wide viewing angle and high transmittance, as energy efficiency will continue to be a requirement. The set will benefit from continued developments in LED devices and color-conversion materials. Looking past 2015, we can expect OLED TV to have made noticeable inroads into the TV market, and to start to compete for the "ultimate" TV by exploiting its inherent ability for wide viewing angle, high color gamut, and high-frame-rate operation in a thin form factor. In order to be successful, significant gains will have to be made in large-area deposition of organic materials at high densities. But OLED TVs could also offer features that would be very difficult for LCD TVs to match, such as

Fig. 1: Current LCD-TV designs vary widely; many possible combinations are shown. Source: DisplaySearch.

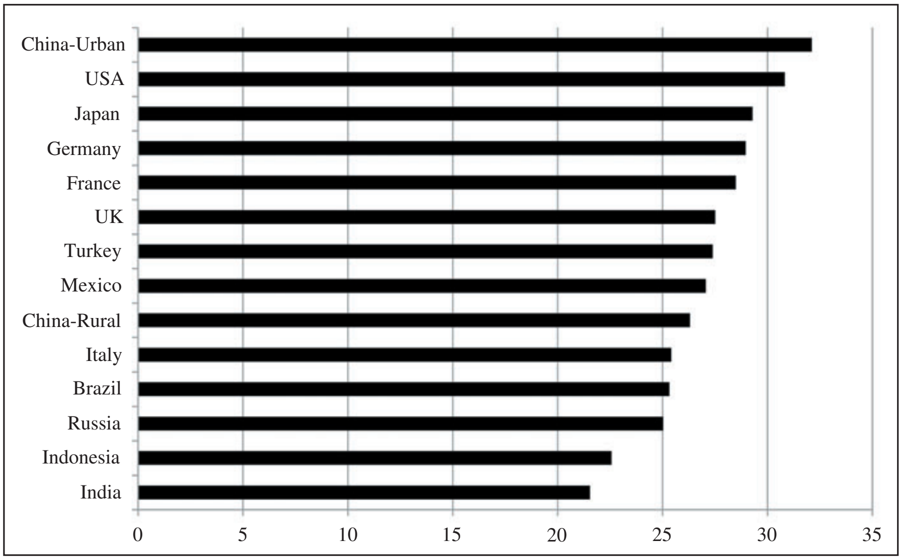

Fig. 2: The average screen size of TVs as reported by a multi-nation consumer survey shows viewers in urban areas of China enjoying the largest sizes and viewers in India the smallest. Source: DisplaySearch, Global TV Replacement Study.

paper-thin form factors – and even flexibility – if processes such as plastic or metal-foil backplanes and thin-film encapsulation can be brought into mass production.

One aspect of TV sets that seems destined to change less than many expect is screen size. While average screen sizes will certainly increase as the cost of 40+ and then 50+ in. flat panels falls, and as higher resolutions mean that larger screens will not necessarily imply longer viewing distances, the ultimate limit on screen size is not technological. Rather, it will continue to be limited by things such as architecture and living patterns. As shown in Fig. 2, there is a wide range in the average size of TVs in households across different countries and within countries such as China. Additionally, the availability of alternative devices, such as tablet PCs, for viewing TV content could indicate a trend toward "personal" TVs sized for single-user viewing from a short distance.

While display technology will continue to evolve, it will become increasingly important for the TV to allow for customization by the viewer. The definition of the "ultimate TV" will likely differ with the type of consumer (age, income, and lifestyle), the region in which the consumer lives, the location of the TV in the home, and other factors. If TV sets do not evolve with the changing ways in which content is accessed, it is unlikely that consumers will value them highly, raising the possibility that they will continue down the path of commoditization.

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[1]For a discussion of developments in AMOLED manufacturing, see, P. Semenza, "Can OLED Displays Make the Move from the Mobile Phone to the TV?" *Information Display* **7&8** (2010). ■

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Special Section on Green Technologies, Design, Manufacturing and Operation

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Contributed Papers

Special Section on Progress in Solid-State Lighting

Four SID Members Receive Major Awards

Society for Information Display members Thomas Peter Brody, Bernard J. Lechner, and Fan Luo recently received IEEE Jun-ichi Nishizawa Medals for their pioneering contributions to TFT-LCD technology. Member Ching Tang received the Wolf Prize in the field of chemistry for his work with OLEDs.

IEEE Jun-ichi Nishizawa Medal Winners

The IEEE Jun-ichi Nishizawa Medal was established in 2002 in honor of Japanese Engineer Jun-ichi Nishizawa and his lifetime of achievements, including work with fundamental semiconductor materials and devices, optical communications, and power systems. The medal is awarded for outstanding contributions to material and device science and technology, including practical application.

According to IEEE's announcement: "Hundreds of engineers have contributed to the innovations responsible for the current success of TFT-LCDs used in today's televisions, laptops, and mobile phones. However, it was the pioneering contributions and persistent efforts of Lechner and Brody in the 1960s and Luo in the 1970s that set the stage for the technology we see today. The trio overcame the initial limitations of using liquid crystals to display complex moving images to make the dream of being able to hang a television on the wall a reality."

Thomas Peter Brody

Thomas Peter Brody

SID Fellow Thomas Peter Brody was a pioneer in the field of thin-film transistors (TFTs), especially their application to active-matrix displays, which became the foundation of a major new industry. For more than a decade at Westinghouse R&D Center in Pittsburgh, PA, Brody developed many uses for thin-film transistors, including flexible circuits, aircraft power controls, industrial timers, and others. Recognizing that the active-matrix array was an ideal vehicle for driving any display medium, he dedicated his life to the development and commercialization of active-matrix displays. His department in Westinghouse built the world's first working TFT-EL displays in 1973 and the first working TFT-LCDs in 1974. Later in 1974, the team demonstrated real-time video imagery using both types. Brody coined the term "active matrix."

In 1979, he founded Panelvision Corporation, the world's first AMLCD company, which introduced AMLCD products to the U.S. market in 1983. In addition to consulting, Dr. Brody founded a series of companies including Magnascreen Corporation, Active Matrix Associates, and Advantech US.

Dr. Brody was a Fellow of the Society for Information Display and a recipient of many awards, including a SID Special Recognition Award and the SID Karl Ferdinand Braun Prize. During his lifetime, he published over 70 scientific papers and received more than 60 patents. He was born in Hungary and received his bachelor's and doctorate degrees from the University of London, U.K. (Note: Dr. Brody passed away in September 2011. His obituary appears in the October 2011 issue of *Information Display*.)

Bernard J. Lechner

While working at RCA Laboratories in the 1960s, Bernard J. Lechner became the first researcher to analyze the limitations of early liquid-crystal cells, which had poor responsivity in handling complex images. As an alternative to simple matrix addressing, Lechner pursued addressing schemes that later became known as "active-matrix" addressing. He conceived the basic idea of associating a field-effect transistor (FET) and a capacitor with each cell of an LCD panel to selectively store and control the brightness of the cell. In 1968, using a 36-element LCD and discrete FETs, he demonstrated moving gray-scale images at full NTSC television rates, thus showing that the active-matrix concept had the capability for television displays of the future. It could not be built as an integrated structure at the time, but Lechner's transistor-capacitor addressing circuit is what is used in today's active-matrix LCDs. He first published this concept in 1969.

Lechner is a Fellow of the Society for Information Display as well as a Fellow of the IEEE and the Society of Motion Picture and Television Engineers (SMPTE). His many honors include the SID Frances Rice Darne Award in 1971, the Advanced Television Systems Committee Outstanding Achievement Award (now called the Bernard J. Lechner Award), and the SMPTE Progress Medal. He received his bachelor's degree in electrical engineering from Columbia University. Lechner is currently a consultant residing in Princeton, New Jersey.

Fang-Chen Luo

Working at Westinghouse during the 1970s, both Peter Brody and Fang-Chen Luo extended Lechner's active-matrix work, and, based on CdSe TFT technology developed by Brody during the 1960s, produced the first LCDs employing an integrated array of TFTs. Brody led the research group for which Luo fabricated the displays.

In 1973 and 1974, Luo and his team at Westinghouse made working 5 × 5-in. 100 × 100-pixel TFT-addressed panels. The results were reported by *Time* magazine in a 1974 issue with a picture of Luo holding a working panel. The article described a "picture on the wall." Notes Luo, "It was a little far-fetched to think of going from a 5 × 5-in. panel to a picture on the wall. At that time, I never dreamed that TFT-

Fang-Chen Luo (second from left) and Bernard J. Lechner (second from right) receive their IEEE Jun-ichi Nishizawa medals.

LCD panels could reach 80 in. on the diagonal, with contrast ratios over 1,000.000:1 and with more than 1 million colors. The ubiquitous applications and the over US$10 billion market value of TFT-LCD panels were beyond our imaginations at that time.

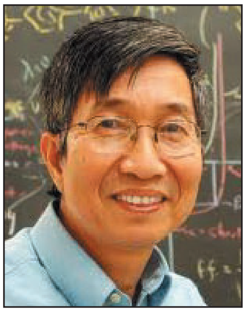
"All of these achievements were primarily due to the efforts made by TFT-LCD engineers all over the world in continuously improving the performance and manufacturability of TFT-LCD panels. I particularly express my gratitude to Dr. Brody for hiring me, assigning me the TFT-display projects, and being a mentor to me at Westinghouse."

An IEEE Life Member, Luo is also a Fellow of the Society for Information Display. His honors include a SID Special Recognition Award and an Outstanding Industrial Innovation Award and Gold Panel Award, both from the Taiwan's Ministry of Economic Affairs. He received his bachelor's degree in electrical engineering from Cheng Kung University and his master's and doctorate degrees from Northwestern University. Luo is currently Chief Intellectual Property Officer and Vice-President at AU Optronics Corp., Hsinchu, Taiwan.

Wolf Prize Winner Ching Tang

Wolf Prizes are awarded by the Wolf Foundation every year in four out of five categories: agriculture, chemistry, mathematics, medicine, and physics. A total of 262 scientists from around the world have been honored with this prize over the past 33 years. One out of every three Wolf Prize Laureates in chemistry, physics, and medicine has later received a Nobel Prize.

Ching Tang



Ching Tang

SID member Ching Tang recently received the 2011 Wolf Prize in Chemistry. He shares the prize with Professor Stuart Alan Rice of the University of Chicago and Professor Krzystof Matyjaszewski of Carnegie Mellon University.

Tang is the inventor of the organic light-emitting diode (OLED). When he published his seminal paper on the technology in 1987 (along with Steve Van Slyke) in the journal *Applied Physics Letters*, he was employed by the Eastman Kodak Company.

In addition to the discovery of OLEDs, Tang has been credited with a number of key innovations leading to the commercialization of new flat-panel display technology, including the development of robust luminescent materials, novel color pixilation methods, fabrication processes for the manufacture of OLED displays, and the adaptation of technology for high-definition OLED displays. Tang also is widely recognized for his early work in photovoltaics.

Prior to joining the University of Rochester in the fall of 2006, Tang was a Distinguished Research Fellow at Eastman Kodak Company. He is a member of the National Academy of Engineering and a Fellow of the American Physical Society and the Society for Information Display. He holds more than 70 U.S. patents and has published 70 papers.

– Jenny Donelan

continued from page 2

vs. 2-D, plasma *vs.* LCD, LEDs *vs.* CCFL backlights, DLP *vs.* LCD projectors, plus Energy Star ratings and what they mean. It's a dizzying array of terminology and capabilities that make it hard for even the most informed among us to keep up. Fortunately at *ID* we knew the right people to call and were able to bring together an array of features that we think will clear away some of the fog, just in time for holiday shopping.

We began with a very basic question that comes up time and again across our industry "Why Should I Choose a Plasma TV?" To answer that, we went straight to the founding father of plasma TV technology, Dr. Larry Weber, and posed this question along with some others. His candid and straightforward answers became the substance of the first Enabling Technology article in this issue. Plasma TVs have a lot to offer and I think after reading this you will take a second look at plasma when you go shopping.

We continue with our "Holiday Roundup" of various TV technology topics and answers to the most common consumer questions, compiled by Jenny Donelan after speaking with Robert Zohn, the owner of Value Electronics, a specialty audio and video retailer in Scarsdale, New York. Value Electronics has not only been selling TVs for almost 20 years, it has run a performance shoot-out among the latest high-end models for the last 7 years.

If home theater is more your thing, and a new projector is your dream, author and industry analyst Chris Chinnock brings us a thorough survey of the very latest in his Enabling Technology article titled "4K Projectors Come to Home Theaters." Needless to say, if you plan on putting a big screen in your home today, you need enough resolution to take you far into the future. The newest "4K" format, embodied in various sizes such as 4096 ˘ 2160, is the way to go to if you want to have multiple options for up-scaling of HD content as well as be ready for future content sizes and formats that are surely coming. Many of these offerings also support 3-D formats and some have frame rates as high as 480 Hz. Once you read Chris' survey, you will be even more ready to make your dream into reality.

Maybe you are not ready to buy this year, but you are looking to plan your next purchase and need to know what is coming? In our monthly Display Marketplace feature we asked analyst Paul Semenza to help us by not only discussing the current marketplace, but also by looking into the future and telling us what is coming. Paul accepted the challenge enthusiastically and gave us his perspective on "The TV of the Future." If you were wondering when the much heralded OLED TVs will arrive, Paul addresses this and many other topics, including 3-D without glasses, 4K and higher resolutions, Internet connectivity, touch screens, backlights, and much more.

In addition, we also have our regular SID and Industry News features, including a few interesting tidbits about TVs you may enjoy.

Before I close, I just want to thank everyone who works so hard to put *ID* magazine together throughout the year. Our team of Guest Editors for this year is listed on our masthead and I can't thank them enough for their tireless work. Our editorial staff consisting of Jenny Donelan and Jay Morreale did an outstanding job managing the production process and producing numerous in-house articles. Our sales and marketing team consisting of Christine von Steiger, Sharae Johnson, and Michele Klein brought a variety of new advertisers to the magazine as well as helped refine our overall strategy. Our cover designs this year were more creative than ever thanks to Jody Schramm and her Acapella Designs Studio. And finally, I want to extend a special thanks to editorial advisor Allan Kmetz, who month after month, tirelessly reviews all our articles and alerts us to numerous details. It's an honor to work with this outstanding team and I truly hope you enjoyed reading the results throughout the year. ■

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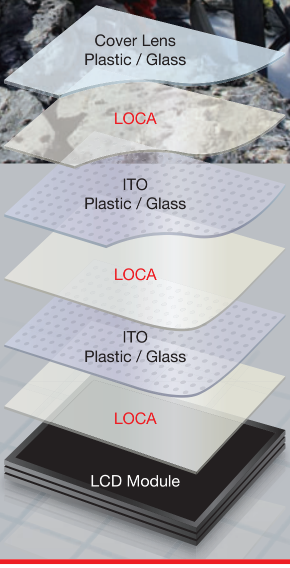

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