TV TECHNOLOGY ISSUE

Information DISPLAY

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SID SOCIETY FOR INFORMATION DISPLAY

Nov./Dec. 2012
Vol. 28, Nos. 11 & 12

More Detail, Truer Color, Wider View From HDTV to 8K and Beyond

NEXT-GENERATION TV: SUPER HI-VISION

CHALLENGES WITHIN THE EUROPEAN TV MARKET

MORE POTENTIAL FOR HOLOGRAPHIC TVs

TOUGH TIMES FOR TV MANUFACTURERS

Plus

TV Trends for The Holiday Season

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ON THE COVER: *Illustrated is a representation of the color richness, high details of the world, and how each incremental improvement in television systems (represented by the corresponding labeled rectangles) opens up our view and enables us to experience the scene. In this scope, the original NTSC/PAL television would be like looking through a paper-towel tube. By including the red DCI (Digital Cinema rectangles), the cover properly represents what we would see in the theater today compared to the latest television standards.*

Cover Design: Acapella Studios, Inc.

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editorial

TVs under Pressure

by Stephen Atwood

As the year draws to a close, we once again turn our attention to the consumer television marketplace, one of the highest-profile and highest-volume segments of the display industry. The driving force of everyone's efforts since well before the beginning of the LCD and plasma eras has been achieving a large-screen flat-panel TV that can hang on a wall at a price everyone can afford. Well, here we are. Actually, we have been here for a few years now, but somehow it seems more like a total victory this year than ever before. Today, there are slim, bright, high-quality HDTVs in homes, businesses, public venues, and everywhere in between.

If you are shopping for a new TV this year, the choices are almost endless and the prices lower than at any previous time in history. Pick a size, pick a brand, pick a set of features, pick a store, decide what you are willing to pay, and your holiday shopping is done. It is safe to say that while there are many differences in features and performance among models, almost any set you find for more than $200 is capable of giving you a decent HDTV user experience. For less than $500, you can even find 50-in. 1080p LCD and 720p plasma TVs at retail stores. Just a year or two ago, these similar sets were selling for twice those amounts or more.

With these historically low prices, TVs should be flying off the shelves and manufacturers should be ecstatic, right? Well, not quite. The problem is two-fold. First, most consumers in many parts of the world have already recently made new big-screen TV purchases and there is nothing really wrong with the sets they have. So, demand is soft and sales are sluggish, pushing down prices and margins even further to the point where the ink on the bottom line is turning more red than green. Second, at these historically low prices, there is little or no margin left for the retailers, distributers, and manufacturers to make any profits. Downward price pressures brought on by intense competition and weak demand have wiped out traditional markups, and this has brought on waves of consolidation that are still under way.

The hope is that buyers will be tempted by the latest LED backlight version, or maybe decide to upgrade to a 3-D TV with "smart" features. In those cases, prices jump up fairly rapidly based on size and features, with most options priced between $1500 and $3500, which feels more like what we were seeing a couple years ago. Even hopes of selling large volumes of smaller-sized TVs for the kitchen, bedroom, and garage are not very high this year because of all the competition from tablets and smart phones and other so-called "second screen" devices. Sales of those devices have exploded and for many younger people a high-end tablet computer could actually become their "first screen." Plus, we should not forget that at least for North America and Europe the economy is weak and TVs, like many other consumer products, are discretionary purchases.

Author and industry analyst Pete Putman understands this well and explains how this has evolved into a really tough period for set manufacturers, who are facing downward price pressure and very little consumer demand for high-end features such as 3-D and Internet connectivity. As Pete explains in his Display Marketplace feature, "Now Is the Winter of Our Discontent," steep price erosion coupled with sagging consumer demand has driven some major brands to exit the marketplace and severely impacted the market share of many others. For those that persevere, the hope had been that new "bells and whistles" would convince consumers to come out once again for the

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Executive Editor: Stephen P. Atwood
617/306-9729, satwood@azonix.com

Editor-in-Chief: Jay Morreale
212/460-9700, jmorreale@pcm411.com

Managing Editor: Jenny Donelan
603/924-9628, jdonelan@pcm411.com

Sales Manager: Christine von Steiger
413/783-0473, cvonsteiger@pcm411.com

Large-OLED-TV Makers Face Manufacturing Challenges

Last June, the 55-in. OLED TVs from Samsung and LG were the most talked about items on the show floor at Display Week. They were big (but also thin), gorgeous, and scheduled for commercial availability in 2012. Six months later, with 2012 coming to a close, they are still not commercially available. Several publications, including *The Korea Times*,[1] have reported that the TVs will not be in mass production this year. And an unnamed LG official recently told *CNET* that late 2012 launch plans were still on target, but that the release would involve limited quantities.[2] At press time, a PR representative for LG did tell *Information Display* that plans for mass production this year had not changed. And a Samsung spokesperson said, "Samsung is still on track to launch OLED TVs this year." Neither company provided details on the situation.

Even if the TVs do become readily available, at about $10,000 per set, they are not likely to end up as many people's holiday gifts. Nevertheless, anticipation from those in the industry as well as videophiles has been high. Why aren't the big OLED TVs in mass production yet?

"Manufacturing OLEDs in large sizes has proven very difficult," says Paul Gagnon, Research Director for TVs at DisplaySearch. (DisplaySearch is also a major source of the OLED TV news cited in *The Korea Times* and other media.) "The equipment is just not there yet, and the materials used in large-format production are not as advanced."

The report from the supply chain, says Gagnon, is that yields for the large OLED panels are running at 20–30%, as compared to an average of 95% for LCDs. The exact reasons for the low yields are known best to the manufacturers themselves, he says, but have to do with the backplanes and the deposition process. Oxide backplanes, which are considered an enabler for large-area OLED-panel production, are somewhat new and still under development, and the process of depositing the OLED materials evenly and uniformly across the substrate is still being worked out. TVs can be made, but not efficiently and inexpensively. This is the main reason why the initial price for the OLED TV sets is so high.

Gagnon thinks that Samsung and LG will ship a small number of units – probably fewer than 1,000 by the end of the year – with more in 2013, but that he does not expect to see significant numbers until 2014. "They're closer but they're not there," he says, of the manufacturing processes. He does believe that OLED TVs will become a commercial reality and that the companies involved will overcome the manufacturing difficulties, "through force of sheer will if nothing else."

At a recent OLED World Summit, Jennifer Colegrove, DisplaySearch VP of Emerging Technologies, noted that the success of OLEDs in smaller form factors (less than 5 in.) bodes well for the technology and that she believes large-area OLED panels can become a success if manufacturers continue to focus their efforts on improving yields, extending lifetimes, reducing power consumption, and refining their manufacturing processes.

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– Jenny Donelan

guest editorial

A Look at Television Past and Future

by David Trzcinski

Why do you own a television? As a consumer, why would you buy another?

While a transformational wave continues to sweep over the television industry, providing more flexible communication channels in combination with greater information capacity, we can leverage some recent history to get a possible glimpse into television's future. For a brief review, let's journey back roughly 20 years to recognize the impact of a "big swap."

It was not so long ago that we all had our single-standard (NTSC, PAL, or SECAM) purpose-built television receivers, originally CRT-based but later yielding to thinner flat-panel displays, enabling larger screens that could still fit through home doorways.

In the early 1970s, NHK began research on high-definition television, and by the mid-1970s an 1125/60 HDTV production standard had the potential to replace all three existing standards with a single standard worldwide. Further, as documented in the RAND report on "Development on High Definition Television," backed by the ATSC (Advanced Television Systems Committee), the U.S. Department of State urged at a 1986 CCIR (Consultative Committee on International Radio) meeting that the 1125/60 standard be adopted as a worldwide standard. However, opposition from European countries prevented the recommendation from being adopted. After the meeting, European countries expedited the "Eureka" program for the purpose of developing a competing European 1250/50 standard.

During this period, other applications such as home PCs and video games began attaching to and leveraging the home-TV screen. In the 1980s, computers drove display resolutions higher – greater than 1 Mpixel for graphics and greater than 72 dots-per-inch (dpi) for text. Similarly, silicon-based imagers for video and digital still cameras dropped in cost and enabled much higher resolution toward replacing film. This electronic-imaging evolution created both the opportunity and demand for a new end-to-end motion-imaging system to produce and distribute higher-resolution television.

In the telecommunication and computer industries, a transformation in networks was also occurring and was accelerated not only by technology advancements, but deregulation and breaking up of monopolies. Communication is all about bandwidth efficiency and seems obvious in retrospect, but a "big swap" from wired to wireless telephones and wireless to wired television was at a tipping point, since a video channel uses much more bandwidth than a voice channel and wired networks provide this greater bandwidth at a lower cost. At the Columbia Business School during a speech for a Columbia Institute for Tele-Information's (CITI) program in 2010, Reed Hundt (who headed the FCC from 1993 to 1997), said, "[We] decided in 1994 that the Internet should be the common medium in the U.S. and broadcast should not be."

In the early 1990s, Japan had shown the world its fully operational HD-MAC system, and Europe had followed by defining its HD system, with both parties extending analog systems designed for direct-satellite broadcast. The HD wave was coming and couldn't be stopped. Support for the 1125/60 system in the U.S. weakened since the European opposition made adoption on a single worldwide standard unlikely, continuing technology advances provided alternatives, and terrestrial broadcast, not satellite, was predominant nationally.

In the U.S., questions were being debated such as: Why do we need HD? How will Japanese and European standards impact the U.S. economy? What will the HD

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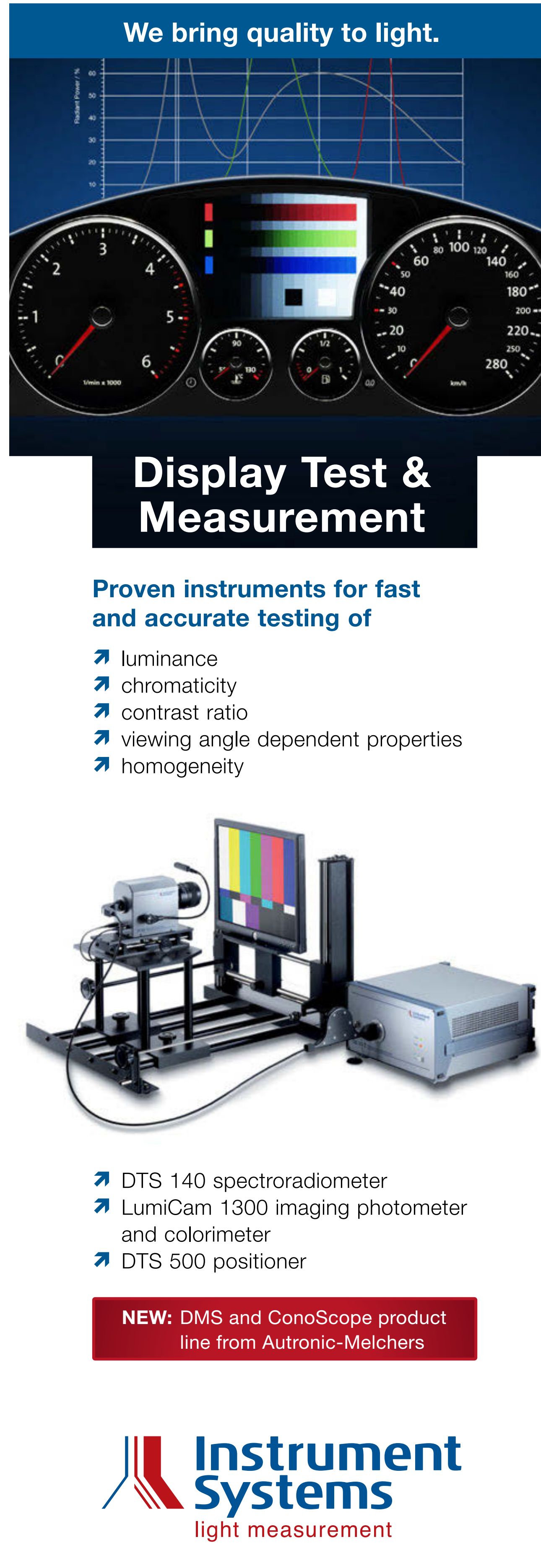
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Now Is the Winter of Our Discontent

Selling TVs isn't the profitable business it used to be. And it's only going to get worse.

by Peter Putman

EACH year, as the holiday season approaches, pundits pull out their crystal balls and issue the usual predictions of increased consumer-electronics sales, specifically focusing on display-centric gadgets such as laptop computers and televisions.

But this year is different. Televisions are no longer the "must have" purchase on Black Friday. To be sure, there will be plenty of TVs sold between late November and early January, with another surge just before the Super Bowl.

The catch? Those sales will be driven by overly aggressive price discounting and not by 3-D, Internet connectivity, Skype, or any of the other bells and whistles that have migrated over to televisions in the past few years.

These are indeed tough times for TV manufacturers, with only two (Samsung and LG) showing a profit, and three legendary Japanese brands (Sony, Panasonic, and Sharp) struggling to maintain an increasingly smaller piece of the worldwide TV market while operating on the negative side of the ledger.

Other Japanese TV brands are also facing a tough future. After a well-needed reality check, Hitachi withdrew months ago from TV manufacturing and sales. Mitsubishi continues to sell small, ever-dwindling quantities of rear-projection TVs, while Toshiba maintains a low profile, advocating for autostereo 3-D and watching its market share evaporate.

How Did We Get Here?

This tectonic shift of gravity in the TV business started in the mid-1990s as upstart Samsung (yes, it was considered an upstart at the time) set its sights on becoming "the next Sony," a mission the company accomplished just over a decade later. The Samsung brand now appears on nearly 30% of all TVs shipped around the world, which is a mind-boggling turn of events.

According to NPD, Samsung's revenue share for Q4 '11 was 26.3%, a year-to-year (Y-Y) growth of 18%. LG Electronics finished far behind in second place with 13.4% revenue share, an increase of 2% Y-Y. The Japanese "big three" (Sony, Panasonic, and Sharp) captured 22.6% of TV revenue combined, an average decrease of 19% Y-Y.

These trends have only accelerated. For the record, Samsung's revenue share during the period April–July of 2012 was 28.5%, representing 18% Y-Y growth. LG managed to kick its share up to 15.2%, flat from a year previously. And the "big three" combined for a 20.1% revenue share, a drop-off of about 32% from the previous year.

It wasn't that long ago (early 2006, to be exact) when a Japanese manufacturer led the rankings. Back then, Sharp had well over 20% of TV revenue share all to itself. Today, the company wrestles with cash-flow problems and is struggling to keep its worldwide share at or above 5% (it's already below 3% in North America), is taking out more loans while its stock price continues to plummet, and has sold 46% of its Sakai Gen 10 fab capacity to Hon Hai Chairman Terry Gou, as reported by various news organizations' stories earlier this year.

Sony hasn't made a profit during the 8-year period that it has been selling flat-screen TVs and has ended its LCD manufacturing venture with Samsung (S-LCD) while also withdrawing its 7% stake in Sharp's Sakai LCD fab.

Panasonic has idled 50% of its LCD and plasma fab capacity as it finishes digesting the acquisition of Sanyo and is finally back on the road to profitability – that is, in businesses

> ***[Holiday TV] sales will be driven by overly aggressive price discounting and not by 3-D, Internet connectivity, Skype, or any of the other bells and whistles that have migrated over to televisions in the past few years.***

__Pete Putman__ is president of ROAM Consulting, Inc., based in Doylestown, PA. His company provides training, marketing communications, and product testing/development services to manufacturers of projectors, monitors, integrated TVs, and display interfaces. In addition, he maintains HDTVexpert.com, a Web site that covers digital TV, HDTV, and display technologies. He can be reached at hdtvpete@comcast.net.

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besides televisions. And it can only watch as market share for its signature plasma TVs continues to evaporate: NPD reports that plasma TVs accounted for just 6.1% of all TV shipped in Q2 '12, a Y-Y fall-off of 26%.

Retrenchment

The roots of this decline go back to the big digital-TV transition that started in the late 1990s. In the space of a decade, consumers abandoned tape-based video playback to digital optical disc, tossed out their bulky and small cathode-ray-tube TVs in favor of larger and flatter plasma and LCD screens, discovered the amazing image quality of high-definition TV, and reveled in the new widescreen aspect ratios offered by digital video formats.

The peak of this frenzy hit around the holiday season in 2005, when LCD and plasma TVs were literally flying off the shelves. Back then, a "good deal" on a 42-in. flat-screen TV was in the neighborhood of $2500, while 50-in. models were closer to $5000. High-end brands such as Pioneer (remember them?) could still command upwards of $7000 for its premium plasma TV sets, and rear-projection technology featured LCD, LCoS, and DLP technologies fighting for supremacy.

But things changed in 2008. By then, a majority of consumers who wanted a new flat-screen TV had purchased one. The entry of low-cost volume discounters including Vizio and the late Syntax Olevia and the popularity of buying clubs (Costco, BJ's, and Sam's Club) started pushing down TV prices, a trend augmented by excess LCD-panel inventory after overly optimistic sales forecasts prior to the 2006 football World Cup and 2008 Beijing Olympics.

The worldwide recession that started in late 2007 didn't help, as declining home values and ever-increasing oil prices put a crimp on big-ticket purchases. DVD sales (and later, rentals) started to drop off in 2005, replaced by the growing adoption of video streaming from YouTube and later Netflix and Hulu.

If At First You Don't Succeed, Part I

The TV industry fought back in 2009 with (of all things) 3-D. James Cameron's highly anticipated 3-D movie *Avatar* set box-office records around the world and stimulated 3-D releases at other studios. That, in turn, drove TV manufacturers to come out with 3-D TVs using active-shutter eyewear.

By all accounts, 3-D TV has been a non-starter. And manufacturers made matters worse by locking up the rights to 3-D Blu-ray discs for one or more years, adding them to exclusive "bundles" of 3-D TVs, Blu-ray players, and 3-D glasses. (The first 3-D bundle from Panasonic featured a 50-in. plasma TV, two pairs of glasses, a Panasonic 3-D Blu-ray player, and the *Avatar* disc for about $2800.) These locked-up deals meant a trickle of new 3-D releases to watch – hardly the way to kick-start a new viewing paradigm.

Not long after, LG announced it was abandoning active-shutter 3-D (where it wasn't competitive) for passive 3-D, using TVs with film-patterned retarders and super-cheap glasses. And Toshiba promptly responded that it was developing a line of "glassless" autostereo 3-D TVs. The usual coalitions and alliances were formed to promote each technology, but the net effect for most consumers was to drive them away from 3-D TV purchases altogether as they perceived another format war brewing *a la* HD DVD and Blu-ray, and opted to sit on the sidelines.

> ***"In the space of a decade, consumers abandoned tape-based video playback to digital optical disc, tossed out their bulky and small cathode-ray tube TVs in favor of larger and flatter plasma and LCD screens, discovered the amazing image quality of high-definition TV, and reveled in the new widescreen aspect ratios offered by digital video formats."***

Even 3-D movie releases have seen a decline in box-office revenue as the initial 3-D thrill has worn off, largely due to higher ticket prices for 3-D releases and consumer perceptions of minimal extra value for the additional dollars. The result? Fewer movies released in 3-D, meaning less content to watch in 3-D.

It didn't help that dedicated 3-D video channels were few and far between. DirecTV's venture into 3-D has largely been shut down, while the Sony/Discovery/IMAX 3-D offering continues. Panasonic's sponsorship of 3-D coverage of the 2012 Olympics was a bold move, but did not return enough eyeballs to stimulate interest in 3-D TV sales. As a result, 3-D has devolved into a built-in menu function to newer models of LCD and plasma TVs, some of which are now available for less than $1000.

If At First You Don't Succeed, Part II

The explosive growth of streaming video led to the introduction of so-called "smart" TVs about 5 years ago. These TVs could directly access popular Internet video content from YouTube and Netflix, with Hulu and Vudu added over time. Other popular services offered back then included USA Today, Pandora Internet radio, and a host of photo-sharing Web sites.

Some of these sets evolved into full-blown Internet browsers, capable of taking the viewer anywhere to watch Internet video. Additional "apps" and links were added to NBA TV, Major League Baseball, Facebook, Twitter, and specialized content delivery sites for 3-D videos. Wireless Internet connections were offered as an option and later became standard. Sales of Internet-connected Blu-ray players rose, but not for playback of optical discs: Buyers were using them to access Netflix on older TVs that didn't include these "smart" features.

All well and good, except for one major problem: Lack of standardization of the user interface. Every TV manufacturer had its own way to access Web content and streaming video (Panasonic's VieraCast, Samsung's Apps, *etc.*), and none of them were compatible; a flaw that resulted in negative consumer opinion.

Google decided to step into the fray and solve this problem with its own Internet video search engine (Google TV), which launched in 2011 and was an abject failure. Undaunted,

> *Among all geographic regions, China shows the strongest interest in 3-D and Internet connectivity. In the meantime, numerous studies on this side of the Pacific Ocean show that Americans just want big, cheap televisions.*

Google tried again earlier this year, partnering with Sony and LG and building the navigation interface directly into the TV. Consumers still rejected it, so Google TV looks to join other failures along the road to "connected" television.

It didn't help Google TV that 70% of all Internet video viewing comes from three sites – YouTube, Netflix, and Hulu. Plus, YouTube has its own video search engine, and it works quite nicely. Realistically speaking, if you had already purchased a new flat-screen TV in the past 5–7 years and just wanted to access Netflix, that $150 connected Blu-ray player with WiFi made a lot more sense than a new TV.

OK – Now What?

So here we stand, just weeks from Black Friday, wondering what (if anything) will kick-start sales of TVs. That task was further complicated by a September NPD DisplaySearch report that worldwide TV sales had declined 8% Y-Y in the second quarter of this year, led by a sharp decline in demand in Japan, of all places.

China, on the other hand, saw a 6% increase in demand. And among all geographic regions, China shows the strongest interest in 3-D and Internet connectivity. In the meantime, numerous studies on this side of the Pacific Ocean show that Americans just want big, cheap televisions and are largely disinterested in 3-D and Internet connectivity. (Same for consumers in Great Britain and Canada.)

Pricing trends show that discounts carry the day above all else. Back in January, it was possible to buy a 60-in. Panasonic plasma for $995. The year before, a 55-in. Insignia (Best Buy house brand) LCD TV was the ticket at $997. But that hasn't helped Best Buy, as the company continues to lose money and shut down stores in favor of a shift to mobile-device sales and services.

And therein lays the crux of the problem: Smaller screens are what's "hot' right now. People want the latest smart phones and tablets, and they're using these gadgets to stream video where they might have used portable TVs previously. (Any readers still have a combo DVD player/TV? Bet you haven't used it in a while….)

Remember all of those counter-top and under-cabinet LCD TVs that were attention-grabbers at the CEDIA and CES shows? They're largely being replaced by iPads, which can be used anywhere in the kitchen. Or the living room, or outside. Or in a plane, or on a train, or in the back seat of a car, or on a bus….

This "second screen" trend bears watching, for it will determine how display fabs will be best utilized in the future. Terry Gou's purchase of 46% of Sharp's Gen 10 Sakai output wasn't aimed at making TV sets, but to procure smaller LCD panels for Apple products. (Although the long-rumored Apple TV could also use Sakai glass, if and when the product ever comes to market.)

In the meantime, Sharp is making the best of a bad situation by concentrating on "mega" TV sizes, including a 70-in. LED-backlit design that has already been offered for $1999 earlier this year; an 80-in. TV that retails for $5000, and a new 90-in. monster that will sell (initially) for $10,999. The problem is, you can't sustain a TV business on such large TVs, which constitute a very small percentage of all TVs sold worldwide, as most people simply do not have the room for screens that large.

Panasonic, which formerly protected its plasma business by keeping its LCD TV offerings below a 42-in. screen size, has now accepted reality and expanded to 42-, 47-, and 55-in. sizes, with 60+ in. coming soon. Sony has announced an 84-in. 4K TV that will sell for $20,000. (JVC, a minor player in consumer televisions, will also sell the 84-in. 4K panel in its own product.)

And LG – who stirred up the pot by announcing at CES that it would begin shipping its 55-in. OLED TVs in the fourth quarter of this year – has quietly backed away from that announcement due to manufacturing yield issues and will instead promote the aforementioned 84-in. 4K LCD platform. (Never mind that there's no 4K content to watch on these TVs at present.)

For the Holidays

What are we likely to see for this year's holiday TV offerings? Pretty much the same thing we've been seeing for months – aggressive pricing, particularly in the most popular screen-size category (40–49 in.), incremental improvements in features, more bundles with Blu-ray players, cheaper active-shutter 3-D glasses (they've dropped in price from about $150 apiece in 2009 to less than $50 now), more WiFi connectivity, the usual Internet apps and links, and some new bells and whistles such as voice and gesture recognition (currently available on selected models of Samsung LCD and plasma TVs).

We'll also see more wireless connectivity among cameras, phones, and set-top boxes as consumers want to stream content throughout their homes, including movies on Blu-rays and DVDs. However, none of these offerings is likely to kick-start TV sales in the fourth quarter, which may lead to more retrenching in Japan.

We may also see one or more Japanese brands finally give up as they recognize the halcyon days of TVs flying off the shelves will never come back, just as the legendary TV brands in the U.S. slowly disappeared in the 1980s as a result of Japanese competition.

For TV manufacturers, the period from Black Friday through late January may well be the "winter of our discontent… ." ■

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The European TV Market

Western Europe is a mature market for televisions and a challenging one for set makers who hope to entice consumers to upgrade for the sake of new features.

by Bob Raikes

THE EUROPEAN TV MARKET is at the same time very simple and very complex. The big brands are basically Korean and Japanese (Samsung, LG, Sony, Panasonic, Toshiba, and Sharp) with the addition of a local brand, Philips, which is now controlled in the European TV market by TPV of Taiwan under a joint venture with the Dutch company. Chinese brands are doing some business, and there is a range of smaller brands run by TV assemblers, traders, or retailers. The German market has a number of local companies – Loewe, Metz, and Technisat – that offer "Made in Germany" sets that are at the premium end of that market, and the Danish firm of Bang and Olufsen also has a very high-end niche presence.

There has been no new brand in Europe that has been able to achieve the kind of presence that Vizio has been able to achieve in the U.S. market. The particular conditions that enabled Vizio to scale so quickly have not been present in Europe, and the complications and high costs of operation in the market make it impossible to achieve high volume quickly unless you simply "buy market share." Many have tried and failed. Typically, they start well and then find that the cost base escalates faster than the revenues.

Technical Requirements

The displays used in TVs in Europe are, of course, the same as those used in the rest of the world. Sizes tend to be smaller than in some other areas, which reflects small room sizes compared to that for the U.S., some cultural issues about the importance of TV, and the relatively slow development of HD services, which have only really become widespread in most of the major European countries over the last year or two. Figure 1 shows an overview of TV sales by region in EMEA (Europe, Middle East, and Africa).

In addition, parts of Eastern Europe have a GDP per capita that is closer to the developing world than the rest of Europe, and consumers simply cannot afford a large set. Thirty-two inches remains the largest-size segment, although 40 in. and above is growing. Philips said at IFA (see sidebar for more about the IFA consumer-electronics show) this year that it believes that 46 in. will be mainstream in a couple of years.

Regarding the chassis of the TV, there is a big difference in the hardware and software requirements to sell in all the markets in Europe. As well as the challenges of language, the TV broadcast systems are different on a national basis. There are differences in the balance among terrestrial (DVB-T and DVB-T2), satellite (mostly DVB-S2), and cable (a mix of analog, DVB-C, and soon DVB-C2). There is also some IPTV, with France the most developed market. Codecs are either MPEG-2 or MPEG-4 and there are different

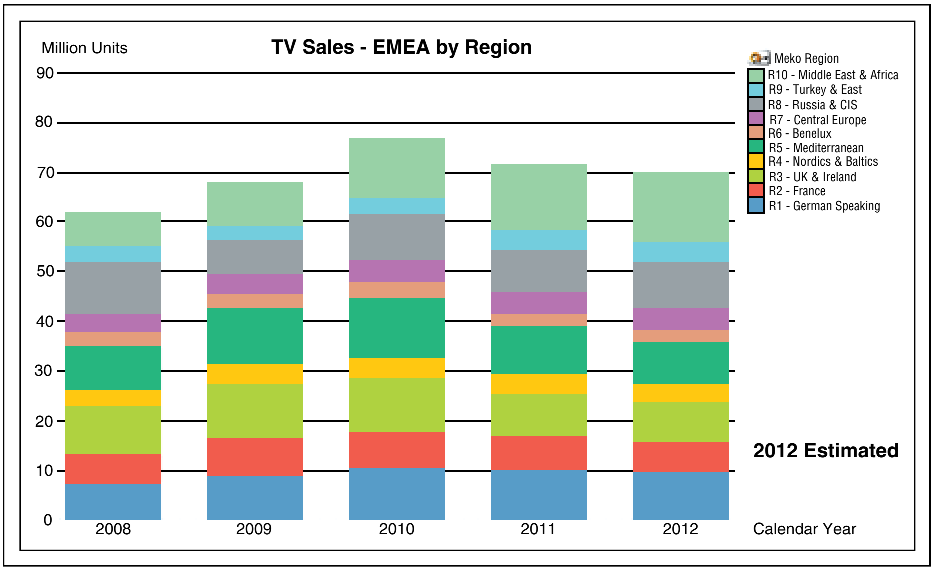

***Fig. 1:** Overall TV sales in Europe, the Middle East, and Africa (EMEA) appear to have peaked in 2010. (Source: Meko.)*

***Bob Raikes** is a principal analyst with Meko. He can be reached at bobr@meko.co.uk.*

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combinations of the broadcast standards and codecs for HD and SD in different countries.

Much broadcasting in Europe is government controlled and funded by mechanisms including licensing, advertising, and combinations of these two. There is plenty of pay TV, but the success of pay TV greatly varies from country to country, and the key service providers are basically different in each one, although some firms, including Sky and Canal Plus, operate in multiple countries. Liberty Global is a cable operator in multiple countries. Satellite is regional, and the broadcasting hardware is owned by SES and Eutelsat, but there are a number of different service providers using that technology.

Content protection is an issue for the pay-service providers and, again, there are a range of solutions, although for TV-set makers, the arrival of the CI+ slot specification can allow the use of a standard TV and tuner to receive encrypted content without a set-top box, providing the service provider decides to support the use of an appropriate decryption [Conditional Access Module (CAM)] card. Interactive technology is different around the region, with the UK and some others basing systems on the license-free, public MHEG5 middleware, which is used to control interactivity.

Broadcasters in France and Germany have developed a system for hybrid services, combining traditional broadcast sources with Internet content. That system, HbbTV (Hybrid Broadband Broadcast TV), is an open standard designed to provide a business-neutral technology platform to blend TV services delivered via broadcast with services delivered via broadband. HbbTV also enables access to Internet-only services for consumers using connected TVs and set-top boxes. The standard has rapidly developed support. However, despite the popularity of HbbTV, the UK has launched its own "YouView" hybrid digital-TV service platform.

These complicated local conditions make it very hard to develop a range of electronics and sets that can match the needs of the different markets unless vendors have a very large share of the market or simply focus on one or two countries. Getting a large share means a sales organization that can basically sell at country level, which is expensive. The technical and sales overheads make it hard for new and small brands.

European TV Supply Chain

The TV assembly and supply chain in Europe is based in the countries that are just outside Germany. There is a 14% duty rate on TV imports into Europe and this means that to be successful in anything but the smallest-sized sets, one has to assemble them in Europe. The factories have moved from the UK, Spain, Italy, and France to Hungary, Poland, Slovakia, and the Czech Republic. Some panel makers have established module assembly plants to support the TV business.

Turkey has a special deal with the EU to allow TVs to be imported from Turkey to EU countries without duty being levied, and Vestel of Turkey is a major player in the worldwide OEM business. Vestel makes millions of TVs a year in Turkey (it hopes to make 10 million this year) and supplies a number of the major brands for at least parts of their ranges. The firm also assembles LCD modules and uses the Finlux and Telefunken brands, among others. In 2011, it said that it had made a total of 100 million TV sets in its history. Beko of Turkey is smaller, but owns the Grundig brand and is more focused on its own brand.

Korea has a trade deal with the EU under which the duty on all trade gradually disappears over the 5 years to 2016. However,

IFA: Europe's Premier Consumer Electronics Show

The annual International Funkaustellung (International Radio Exhibition) or IFA in Berlin is the annual event for the TV set, consumer electronics (CE), and, in recent years, household appliance industry, in Europe. It has a similar status in Europe to CES in North America.

IFA also has a special place in display history. Since the 1920s, display-technology breakthroughs in the TV industry have been shown here, many for the first time. The show also has a place in German political history. In the period after 1945, when Berlin was occupied, and especially during the height of the cold war, making the journey to support the people of Berlin at IFA was seen as a matter of political support from the West for German brands.

Germany has a great tradition of trade shows, and more than 100,000 trade visitors attend the six days of IFA each year, along with more than 100,000 consumers. All the major brands in the consumer electronics world have significant presences. Most of the big ones have one of the 28(!) halls to themselves.

The global TV industry has a very clear annual cycle that is quite different from that of the IT world. At the Consumer Electronics Show (CES) in North America in January, companies show the products that they expect to launch on the market during the year. Shortly after that, they follow up with detailed launch events for their dealer networks and press.

In Q2, the brands start to change over their product ranges to "current year" models as they build toward the peak sales period – the day after Thanksgiving or "Black Friday" in the U.S. in November, and Christmas and New Year sales in Europe. The timing of the IFA consumer-electronics show in Berlin at the beginning of September is not great for TV brands in terms of showing new technology. Companies will do so, but they would prefer to focus in public on the products that are in the stores now rather than risk the possibility that consumers will defer their purchases until after the holidays.

As a result, many of the most interesting technology developments are not shown publicly at IFA and that was true this year. The main innovations were in 4K displays and in OLED TVs and these were the hot topics at CES back in January as well, although I thought that there was a lot more emphasis on 4K at IFA. (For more on the 4K and OLED TV market, see last month's Display Marketplace and Industry News articles.) Still, IFA remains a great place to get a sense of the industry and its trends.

– Bob Raikes

both LG and Samsung have developed strong vertical TV businesses based on local LCD-module assembly in Poland and Slovakia. Because of this local investment, it seems unlikely that these companies will change the structure because this would reduce their flexibility and increase their inventories. There are import duties from Europe and other regions into Russia, so Vestel is one of a number of companies that make TVs in that country.

At one time, NXP (previously Philips Semiconductors), Micronas, and others made lots of chips for TV sets, but those two companies were acquired by Trident of Taiwan, which itself went into Chapter 11 in January of this year. So, there is no longer any substantial European interest in the TV-set chip market, although STMicroelectronics makes chips for STBs and some TVs.

Market Forecasts

The market forecasts for Europe do not look very positive. Western Europe is a very mature TV market and most set purchases are replacements. The trend to increase the number of second sets has stopped, and second and third sets are probably on the decline because of the wide adoption of tablets and other devices for Internet-delivered TV viewing. Eastern Europe still has plenty of consumers who would like to upgrade and modernize their sets, but the economies need to get moving to enable this.

Although European consumers are very conservative, they can be persuaded to spend money on features such as 3-D, 4K, or smart TV if they feel that they need to be "upgrade proof." In recent years, the set makers have tended to drive innovation faster than some of the more conservative buyers can really absorb the new features and so have not maximized the value they could have achieved.

At last year's IFA, Meko's TV analyst described the kind of confusion over 3-D, smart TV, HD, and other TV features as the "Perfect Storm" that could allow a company that could offer a simple solution to make real inroads into the market. That might be an opportunity for Apple, or someone else, but they would have to deal with the complications of the broadcast environment. The TV is not going away as the central entertainment center of the home, but the economic success of TV brands will depend on the balancing of the simplicity and complexity that we have referred to earlier and in providing just enough innovation for consumers to feel that they need to upgrade the kind of set that they buy. ■

"Super Hi-Vision" as Next-Generation Television and Its Video Parameters

Future TVs, using a Super Hi-Vision system, will be able to deliver an enhanced and even unprecedented viewing experience in various environments.

by Takayuki Yamashita, Hiroyasu Masuda, Kenichiro Masaoka, Kohei Ohmura, Masaki Emoto, Yukihiro Nishida, and Masayuki Sugawara

HDTV (high-definition TV) has become popular all over the world with the spread of digital broadcasting. Japan Broadcasting Corporation (NHK), which has been developing HDTV for many years, began work on the development of ultra-high-definition television (UHDTV)[1] in 1995 and has contributed to ITU (International Telecommunications Union-Radiocommunications) standards such as Recommendation BT.2020 (mentioned later on in this article). This new format is expected to produce extremely realistic viewing sensations through the use of 4000 scanning line images and 22.2-multichannel sound. The Super Hi-Vision (SHV) design target is to achieve a total immersive experience providing realistic visual and aural sensations so that the audience feels they are present at the scene.

Beyond simply delivering a wider field of view, important factors such as color/tone rendition and motion portrayal that could be crucial to delivering an enhanced visual experience with next-generation television (next-gen TV) systems will be investigated in this article, and system parameters will be proposed, including colorimetry and frame frequency for next-gen TV. The proposed colorimetry system is based on the real RGB color system and has a color gamut that includes 99.9% of real surface colors while using physically realizable RGB primaries. Further, a frame frequency of 120 Hz is pro-

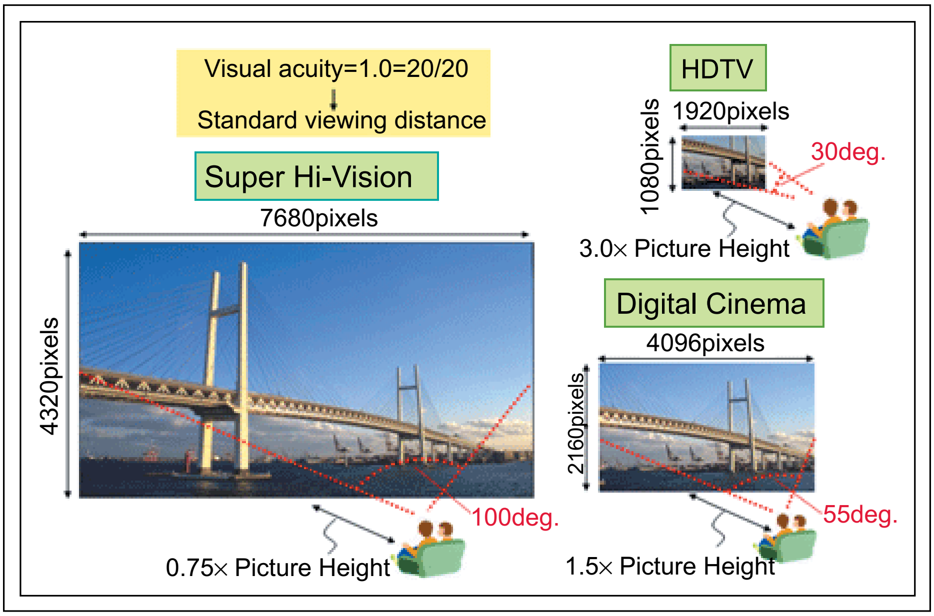

Fig. 1: The image format of SHV (left) is compared with HDTV and digital cinema formats (right).

Takayuki Yamashita (yamashita.t-hq@nhk.or.jp) is with the NHK Science and Technology Research Laboratories, Tokyo, Japan, and Hiroyasu Masuda (masuda.h-fg@nhk.or.jp) is with the Japan Broadcasting Corporation (NHK), Tokyo, Japan. Kenichiro Masaoka, Kohei Omura, Masaki Emoto, Yukihiro Nishida, and Masayuki Sugawara are with the NHK Science and Technology Research Laboratories, Tokyo, Japan. This article is based on a paper presented at the SMPTE 2011 Annual Technical Conference & Exhibition, 25–27 October 2011.

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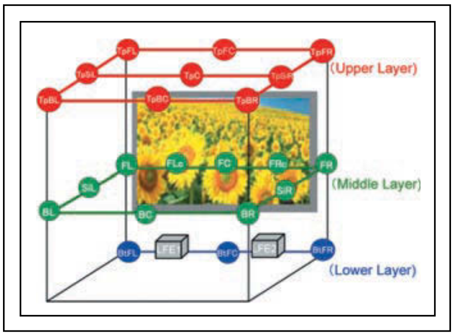

Fig. 2: This diagram shows an arrangement for a 22.2-multichannel sound system.

posed on the basis of subjective assessments of motion-picture quality.

Super Hi-Vision

NHK has been developing the SHV system as part of a project to deliver a viewing experience far beyond that possible with existing systems. Figure 1 shows the image format of SHV.

The SHV frame has 7680 pixels × 4320 lines with a frame rate of 120 frames/sec (progressive). The resolutions in the horizontal, vertical, and time vectors are the integral multiples of the HDTV format, to maintain compatibility with HDTV. The SHV system can accordingly be built on an HDTV base. The viewing distance in SHV is calculated as the picture height × 0.75 (~ 3 m/10 ft. in the case of a 500-in. theatre screen, or, in the case of a home application, a viewing distance of about 5 ft. for a 145-in.-diagonal 8K SHV) to ensure that all images are visible within 100° of the viewing angle and hence lie within the human visual field. It is a basic concept of SHV that the grain of the scanning lines should be practically invisible even at such close range so that the viewer can enjoy an extremely realistic visual sensation. Figure 2 indicates an arrangement for 22.2-multichannel sound speakers.[2]

NHK defines immersion as when the image on the screen is perceived as a real-world image. Sound effects are an essential factor in reducing the perception gap between the SHVscreen images and the real world. Whereas the 5.1-channel surround speakers are arranged in a plane to reproduce a planar sound field, the 22.2-multichannel immersion speakers are set up in three tiers (upper, middle, and lower) to reproduce a three-dimensional sound field: left and right, forward and back, and up and down.

Table 1: Parameter values for full-spec video for SHV include frame frequency and bit depth.

Parameters	Values		
Spatial sampling points	Horizontal: 7680 Vertical: 4320		
Frame frequency	120 Hz		
Opto-electronic transfer characteristics	$E'\begin{cases} 4.5E, & 0 \le E \le \beta \\ \alpha E^{0.45} - (\alpha - 1), & \beta \le E \le 1 \end{cases}$ $\alpha = 1.0993,\ \beta = 0.0181$		
Bit depth	12-bit		
Primaries and reference white chromaticity coordinates[3]		x	y
	R	0.708	0.292
	G	0.170	0.797
	B	0.131	0.046
	D65	0.3127	0.3290

In an early trial, select groups of people in London, Bradford, Glasgow, the U.S., and Japan watched the Olympic Opening Ceremonies last summer in Super Hi-Vision. The current target is to begin experimental broadcasts with this system in 2020 via satellite in the 21-GHz band. To achieve this objective, the focus has been on identifying the main video and sound parameters and on developing a complete end-to-end solution from the camera to the display, including media storage, compression, and transmission. For SHV, the specific goal is to meet the following fundamental requirements: worthwhile improvement in quality beyond high-definition television (HDTV); compatibility, interoperability, and commonality with HDTV; and technical feasibility in the foreseeable future. Thus, a number of studies on human subjects have been conducted to investigate the psychophysical effects of the several video parameters in

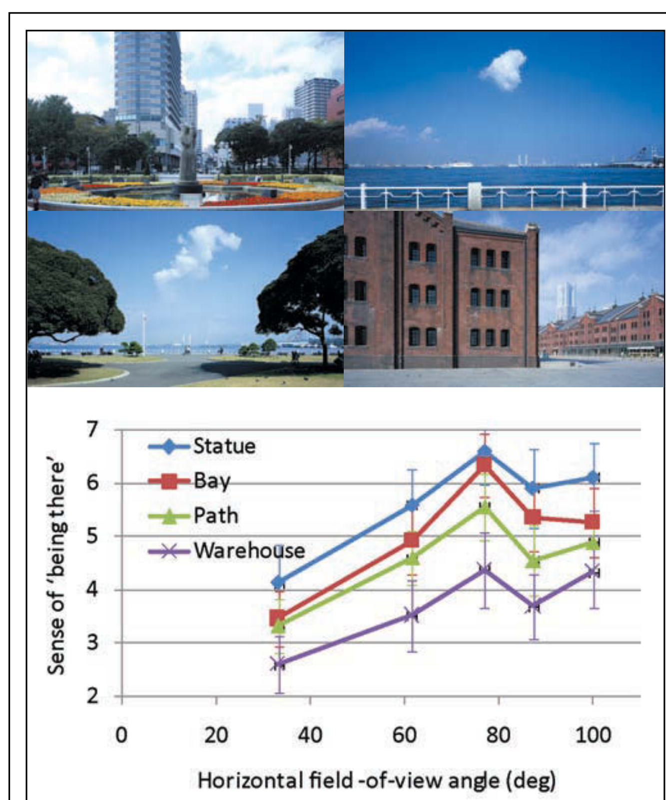

Fig. 3: A wider horizontal angular field of view provides a greater sense of "being there" (mean ± standard error).

order to determine suitable values, including the spatial resolution, temporal resolution, tone reproduction, and color representation.

Full-Spec Super Hi-Vision Video Parameters

The full-spec video parameter values suitable for SHV on the basis of intensive studies have been determined; the values are presented in Table 1. These studies will be discussed later in this article. Note that a new standard for ultra-high-definition television systems was established as Recommendation BT. 2020 by ITU-R.

Spatial Resolution

SHV has been designed to provide an enhanced sense of presence for a new visual experience. This requires a wider spatial resolution, which is expressed by the angular field of view (FOV) in degrees and angular resolution in pixels per degree of arc. However, the sense of presence could involve various subjective factors, among them the sense of "being there" and the sense of "realness." These have been identified as factors that should distinguish SHV from existing systems.

Sense of "Being There"

Subjective assessments were conducted using four images shot with a camera angle of 60° that were presented to participants at five different FOV angles. Each participant evaluated the degree of the sense of "being there" from the images on a continuous scale ranging from 0 (none) to 10 (extreme). In total, 200 participants were employed, and these were divided into five groups of 40 participants. Each group performed the evaluation for one of the FOV angles. As shown in Fig. 3, the results confirm that a wider FOV produces a stronger sense of "being there." [4]

From Fig. 3, it is clear that the sense of "being there" increases with the FOV but saturates at an FOV of around 80°–100°. Although this figure seems to peak at FOV of 77°, there is no significant difference statistically. Another experiment performed in the same study using images obtained with a camera angle of 100° showed a similar result. Thus, the target FOV for SHV was set at around 80°–100°. This corresponds to a viewing distance that is 0.75–1.00 times the picture height (0.75H–1H), at which point people with normal visual acuity are simply unable to discern the pixel structure.

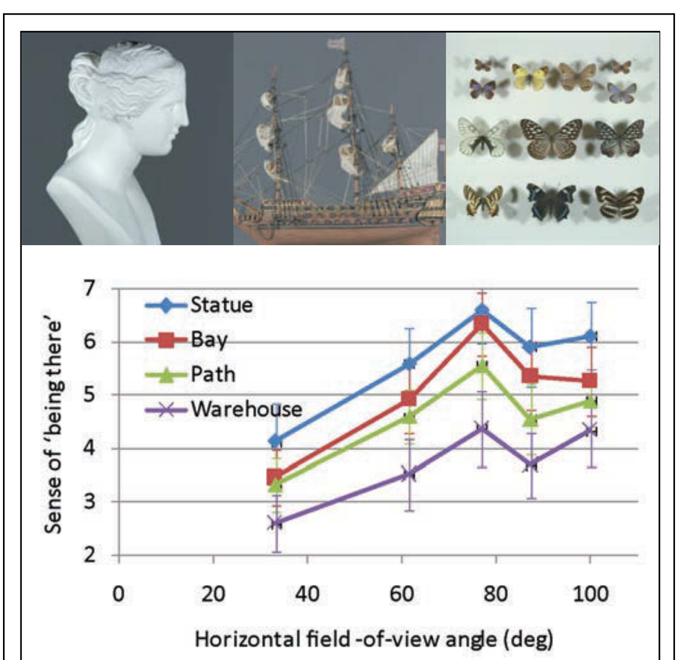

Fig. 4: The relationship between angular resolution and sense of "realness" (mean ± 95% confidence interval) is shown. The higher the angular resolution, the greater the "realness."

Sense of "Realness"

Another experiment was conducted using a paired-comparison method with images at six different angular resolutions that were presented along with real objects. Participants chose the image that they perceived as better resembling the real object. The experimental setup was such that the effect of factors (*e.g.*, binocular disparity, image size, perspective, luminance, and color) other than the resolution on the result was minimal.

As shown in Fig. 4, the results confirmed that the spatial resolution is responsible for determining whether viewers can distinguish images from real objects. The higher the angular resolution, the greater the sense of "realness" or visual fidelity.[5] However, the improvement gently saturates at about 60 cycles per degree (cpd), due to maximum human visual acuity, as mentioned above.

Spatial Sampling Parameters of Super Hi-Vision

The spatial sampling point for SHV has been set to 7680 × 4320 pixels – four times that of HDTV in both horizontal and vertical directions. Three video systems were compared with different spatial resolutions – a 2K system (HDTV), a 4K system, and an 8K system (SHV) – in terms of the sense of "being there" and the sense of "realness" for a range of FOV angles or viewing distances, as shown in Fig. 5.

It was shown that, as found previously, the sense of "being there" is influenced by the FOV. However, the sense of "realness" is influenced not only by the FOV, but also by the resolution; "realness" being low for low-resolution systems at wide FOVs.

The sense of "realness" differs among the three video systems. In Fig. 5, the angular resolution has been transformed into FOV or viewing distance for the different spatial resolutions (see Appendix).

SHV can provide a strong sense of both "being there" and "realness" for a wide range of FOVs or viewing distances. This feature of SHV is expected to be effectively used in various viewing environments and for large, medium, and small displays. This is in contrast to the 4K and 2K systems, which are effective only under limited viewing conditions.

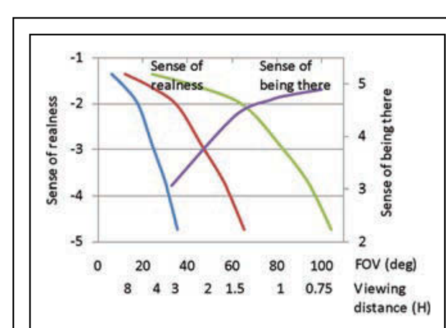

Fig. 5: Video systems with different spatial resolutions are compared in terms of the sense of "being there" and the sense of "realness."

Motion Blur, Stroboscopic Effect, and Flicker

Motion portrayal is characterized by the perception of motion blur, stroboscopic effect, and flicker. These factors are influenced by temporal video parameters, including the time aperture and frame frequency. The speeds of moving objects in the video also influence motion portrayal. Motion blur is caused by a moving scene accumulating light across multiple photo sites of the image sensor in the capture device and/or image update rate and response hold time of the display, which is associated with the motion-tracking response of the eye. For motion, the time aperture – that is, the capture sensor integration time or display response hold time – affects the dynamic spatial-frequency response, which decreases at high motion speeds. A short time aperture is required for both cameras and displays to improve the dynamic spatial frequency response.

Several experiments have been performed to understand the relationship between motion blur and time aperture. One was conducted to determine the quality of still images and moving images for different time-aperture–object-speed combinations.[6] As shown in Fig. 6, if we assume an object speed of 30°/sec, which is typical in HDTV programs, the time aperture should be in the range 1/200–1/300 sec. Note that only combinations of temporal aperture and object relative velocity to the camera (and display) that gave an observer an acceptable degree of motion blur are shown in the figure.

The time aperture can be shortened by increasing the frame frequency. Alternatively, the same effect can be achieved by using a shutter in the camera or by inserting black frames on the display without changing the frame frequency. However, these techniques may result in the degradation of the picture quality (called the stroboscopic effect or jerkiness), leading to motion being seen as a series of snapshots.

The subjective picture quality was investigated in the presence of the stroboscopic effect for varying frame frequencies using a fixed time aperture of 1/240 sec to determine an observer threshold for smooth motion that provides an acceptable motion blur.[7] As shown in Fig. 7, the results suggest that a frame frequency greater than 100 Hz is required for acceptable quality.

Flicker is a commonly encountered annoyance in moving pictures. A wide FOV on a large screen increases the perception of flicker because human eyes are more sensitive to flicker in peripheral vision. A short hold time on a hold-type display may also increase the perception of flicker. A plot of critical fusion frequencies (CFFs) for two different FOVs at a 30% time aperture,[8] as shown in Fig. 8, confirms that a frame frequency greater than 80 Hz is required for a wide FOV system.

Temporal Sampling Parameters for Super Hi-Vision

Taken together, these results suggest that the frame frequency of SHV should be at least 120 Hz to achieve a worthwhile improvement in motion portrayal. Naturally, a higher frame frequency would provide better quality, but the improvement tends to saturate. (This is assuming display technology capable of higher frame rates; for example, current digital cinemas use DMD projectors that are capable of operating at several times higher frame rates.)

Tone Reproduction

Discontinuities in tone reproduction, which usually occur as contouring artifacts, should be avoided. This means that quantization characteristics, particularly the bit depth, should be set such that it should not be possible to discern modulation corre-

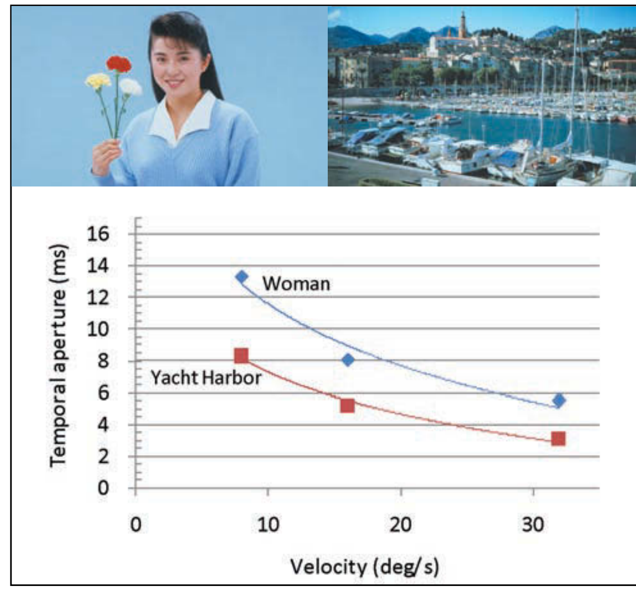

Fig. 6: Motion-velocity–temporal-aperture combinations correspond to acceptable degrees of motion blur.

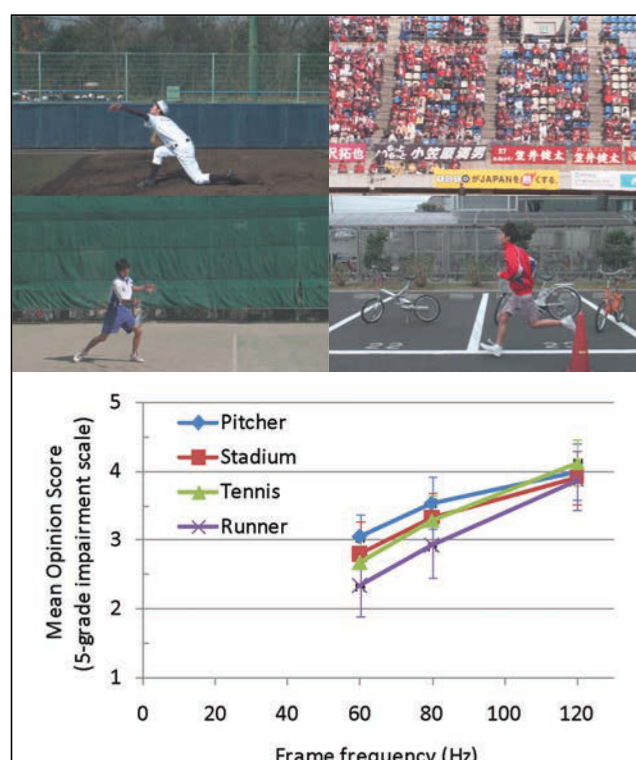

Fig. 7: Picture quality in the presence of the stroboscopic effect is demonstrated at different frame frequencies (mean ± standard error).

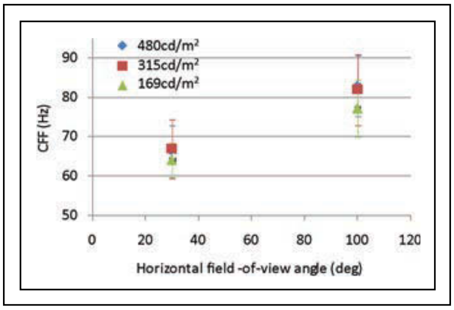

Fig. 8: This plot shows critical fusion frequencies vs. horizontal field-of-view angle (mean ± standard deviation)

sponding to a one-code value difference between adjacent image areas. The contrast sensitivity was measured in a dim environment with the modulation transfer characteristics of a gamma 1/2.4 transfer function for 10, 11, and 12-bit depths, as shown in Fig. 9.

The contrast sensitivity is based on Barten's equation,[9] which has been used to determine the bit depth of the D-Cinema distribution master.[10] It is observed that 11- and 12-bit encoding modulation lines are below the visual modulation threshold for the entire luminance range and do not show contouring.

Colorimetry

Real objects can have highly saturated colors that are beyond the color gamut of HDTV (ITU-R Rec. BT.709). Consumer-level flat-panel displays are quickly becoming capable of reproducing a wider range of colors; in fact, some non-broadcast video systems already handle a wider color gamut exceeding that of HDTV. Thus, for the observer to experience "realness" and the sense of "being there," SHV should cover a color gamut sufficiently wide enough to approach encompassing all colors found in our natural world, and an efficient and practical method should be devised for this.

To this end, requirements for developing a color representation method and determining parameter values have been defined in terms of target color, color-coding efficiency, program quality management, and feasibility of displays. After comparing several methods for widening the color gamut in terms of the requirements, the authors chose a colorimetry system with RGB monochromatic primaries on the spectrum locus that can be realized, for example, by using laser light sources in the foreseeable future.[11] Note that the reference white of D65 remains unchanged. As shown in Fig. 10 and in Table 2, the wide-gamut colorimetry covers the gamuts of HDTV, the D-Cinema reference projector, and Adobe RGB, as well as more than 99.9% of Pointer's gamut.[a] Experiments on the capture and display of wide color-gamut images have confirmed the validity of the UHDTV (ITU-R Rec BT.2020) wide-gamut colorimetry, demonstrating textures and highly saturated colors closer to those of real-world objects as seen by observers.

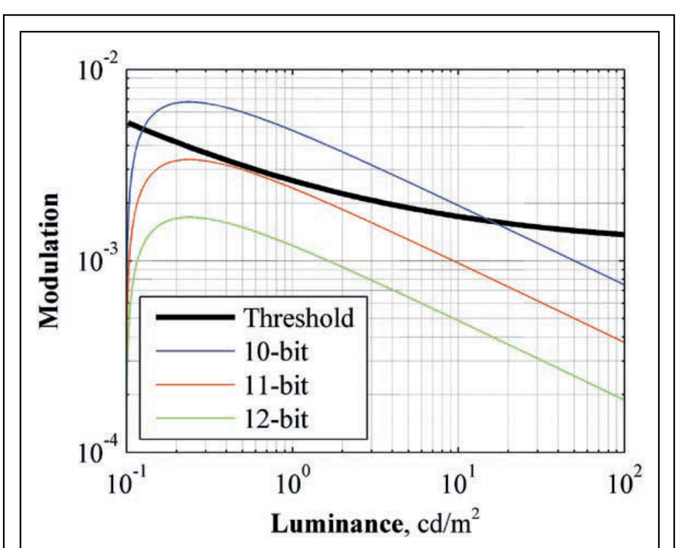

Fig. 9: Modulation threshold and minimum modulation are shown for different bit depths.

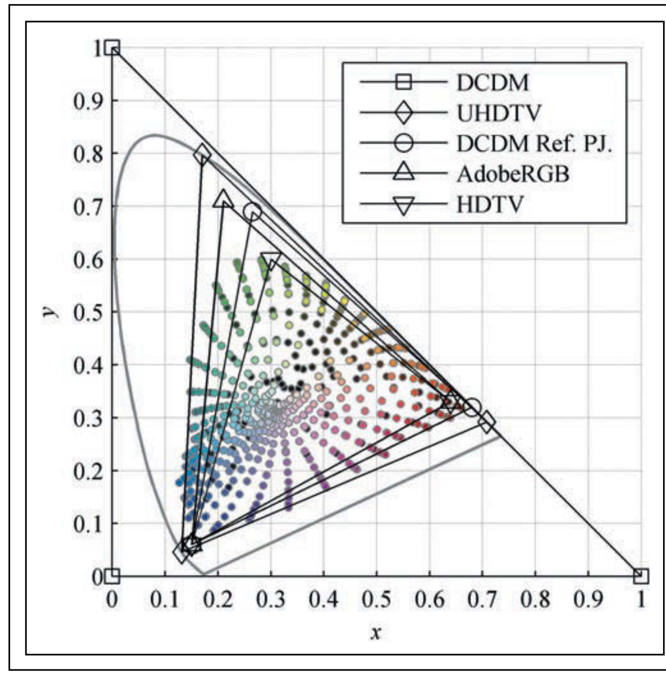

Fig. 10: Pointer's colors and primaries are shown for different video systems.

Device Development toward Full-Spec SHV

A full-spec SHV system based on these specifications is being developed. For practical implementation, several devices have been developed to realize full-spec SHV. On the capturing side, a camera system with the full-spec spatial sampling points and bit depth was developed.[13] This camera system consists of 33-Mpixel CMOS (complementary metal

[a] "Pointer's gamut" refers to work by Dr. Michael R. Pointer, whose frequently cited 1980 paper for Color Research and Application, "The Gamut of Real Surface Colors," considered the gamut of real surface colors in the CIE 1976 L*u*v* and L*a*b* color spaces for a typical dye set used in photographic paper and typical CRT displays, as opposed to the wider gamut that the human eye is capable of viewing, as described by the MacAdam Limits. (Useful Color Data, Munsell Color Science Laboratory, http://www.cis.rit.edu/mcsl/online/cie.php); and R. Heckaman and M. Fairchild "G_0 and the Gamut of Real Objects," Munsell Color Science Laboratory, Rochester Institute of Technology.

Table 2: This table compares HDTV, Super-Hi-Vision, and other ranges for Pointer's gamut (a well-known definition of the gamut of real-world color surfaces) and Optimal Color (based on the color space defined by the International Commission on Illumination (CIE)).

	Pointer's Gamut	Optimal Color[3]
HDTV	74.4%	35.9%
Adobe RGB	90.3%	52.1%
Digital Cinema	91.4%	53.6%
Super Hi-Vision	99.9%	75.8%

oxide semiconductor) image sensors, a 74-Gbit/sec bandwidth transmission device, and a signal processing unit. However, these camera systems do not achieve a frame rate of 120 frames/sec and do not have a sufficiently wide color gamut. To solve these issues, a CMOS image sensor that can capture 120-frames/sec[14] video was developed to meet the frame-rate specifications. For the camera operator, it is also a major challenge to make the size of the camera head more compact.

On the display side, a LCoS (liquid-crystal–on–silicon) projector with a resolution of 7680 × 4320 pixels was developed. And in 2011, a liquid-crystal display (LCD) with the same pixel count, called a full-resolution LCD, was devised, with details shown in Table 3.

These display systems also do not achieve 120 frames/sec and do not have a wide color gamut, which are the next development goals.

Table 3: Details of a full-resolution LCD developed in 2011 appear above.

Parameters	Values
Pixel count	Horizontal: 7680 Vertical: 4320
Diagonal size	85 in.
Frame frequency	60 Hz
Bit depth per color	10-bit
Luminance	300 cd/m^2

Closer to "Being There"

Video parameter values for SHV have been established, with the aim of delivering an enhanced, or even unprecedented, viewing experience to viewers in various environments. Some parameters contribute to an increased sense of "being there" and to the sense of "realness," while others help improve the picture quality by eliminating artifacts in motion portrayal and tone reproduction. Feasibility is also an important factor in determining the parameter values for application.

For further reading, Hiroyasu Masuda's article on "Ultrahigh-Definition Content Production Techniques and Their Broadcasting Applications," can be found in the November/December 2011 SMPTE Motion Imaging Journal.

Appendix

The viewing distance D (H) and the FOV θ(°) are written as follows:

$$D = 1/V \tan(1/2R), \quad (1)$$

$$\theta = 2\tan^{-1}(8/9D), \quad (2)$$

where V is the number of vertical pixels and R (cpd) is the angular resolution at the center of the screen with an aspect ratio of 16:9.

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Holographic Television at the MIT Media Lab

Several recent advances point the way toward real-time holographic television for telepresence, entertainment, and teleoperation. This article introduces the concepts and requirements for such systems, then presents the MIT Media Lab's work to make them practical and inexpensive.

by V. Michael Bove, Jr., and Daniel Smalley

THE NOTION of holographic television appeals to the popular imagination, figuring prominently in science-fiction movies and carrying enough cachet that the word "holographic" is often applied to systems that are not really holographic and sometimes not even 3-D, such as the "Pepper's ghost" illusions that have been used to re-create deceased celebrities onstage. Holographic TV also potentially provides some important technical advantages in that unlike two-view 3-D TV, it supplies in a consistent fashion all the visual cues to object shape and position, including focus ("accommodation") and motion parallax, increasing both viewer comfort for extended viewing and perceptual accuracy for precise tasks.

Research since the early 1960s has attempted to build true holographic television, but until very recently the prospect has seemed distant. The authors' group has for several years concentrated on developing holographic displays suitable for consumer applications, adding constraints of mass manufacturability, low cost, and compatibility with mass-market computational resources such as might be found in PCs or game consoles. A resurgence of consumer interest in 3-D displays, combined with several relevant technological developments, makes this an opportune time to explore re-imagining holographic displays as part of a home in the near future rather than in fictional spacecraft in the far-off future.

V. Michael Bove, Jr., heads the Object-Based Media Group at the MIT Media Lab. He is co-author with the late Stephen Benton of the book Holographic Imaging *(Wiley, 2008) and served as co-chair of the 2012 International Symposium on Display Holography. He can be reached at vmb@media.mit.edu. **Daniel Smalley** is a doctoral candidate in the Object-Based Media group at the MIT Media Lab. He can be reached at desmalley@gmail.com.*

Before we consider technical requirements for building such a device, it is important to define precisely what a holographic display is, namely, a system that uses diffraction of light to reconstruct light wavefronts (or lightfields) associated with a desired visual scene. It is sometimes added that the diffraction pattern should be generated by interference between a coherent reference beam and coherent light reflected by a scene (or at least by a computational simulation of the interference), but for a display designer the physical characteristics of the necessary diffraction patterns are what matters.

Like all 3-D displays, holographic displays are bound by the behavior of light and – despite cinematic special effects to the contrary – cannot create images in free space or project them across a room. As shown in Fig. 1, from the point of view of the viewer, all parts of a reconstructed object must have the display behind them.

Engineering Requirements

The realism of holographic displays and also the difficulty of building them can be traced to the physics of diffraction. A device is required – usually called a spatial light modulator (SLM) – that can change the amplitude (by varying its transmittance) and/or phase (by varying its index of refraction) of light waves passing through it with a fine enough pixel pattern that diffraction over a useful range of angles (which will be the viewing angle of the display) occurs. For typical display applications this means a pixel pitch of about the same size as the wavelength of visible light (or around half a micron).

Half-micron pixels may be smaller than the pixels in typical current microdisplays, but an even bigger challenge lies in the fact that physics constrains the pixel size to stay the same no matter the size of the display. Thus, such a display will need about 2 million pixels per scan line per meter of image width. It's

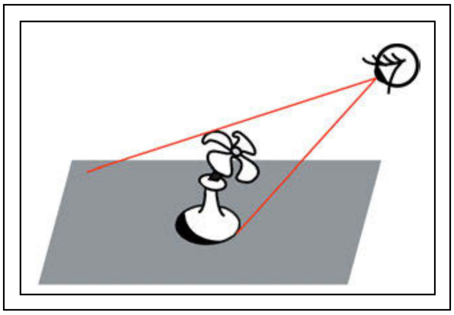

Fig. 1: From the eye's viewpoint, an object reconstructed by a hologram cannot extend past the edges of the display device.

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not too difficult to make a tiny direct-view holographic image by illuminating a microdisplay with a laser, but scaling this up to useful dimensions by tiling such displays together is a complicated proposition. Tiling of small devices nevertheless has been employed by several researchers to create larger images; if the device is fast enough, the tiling can also be done optically, where one device images in several positions sequentially.

A strategy that relaxes the need for such small pixels is to make a hologram with a smaller view angle (and thus larger pixel pitch in the SLM) and then use a steerable light source to direct the hologram where an eye tracker sees the viewer's pupils.[1] The pixel count and computational requirements reduce significantly if the hologram is made to have parallax only in the horizontal direction, as the vertical resolution then reduces to that of an ordinary television image, and the computation of each scan line can be carried out independently.

Diffraction

For clarity, the following diffraction discussion will be done in one dimension, with the extension to two dimensions straightforward (for a horizontal-parallax-only display, the process will happen in only one dimension). If a beam of monochromatic light enters a sinusoidal diffraction pattern, some will pass straight through (the undiffracted or zero-order beam) and beams will also come out at an angle to either side of the zero-order beam (the first-order diffracted beams). The resulting angle is a function of the ratio of the wavelength of the light to the spatial frequency of the pattern, while the amount of light that is diffracted is a function of the contrast of the pattern. Note here that the R/G/B illuminators will need to be monochromatic, as broadband illumination will diffract across a range of angles, leading to a blurry image.

Such grating patterns are created in optical holograms through interference, but the mathematics for synthesizing them from a three-dimensional model of a scene are tractable. This process can be carried out similarly for a computer-graphics model or for real imagery if sufficient information about the real scene can be captured.

If the spatial frequency of the sinusoid varies (a "chirped" grating), as in Fig. 2, and the pattern is illuminated with collimated light, beams at the higher-frequency end will be diffracted at more of an angle than those on the other end, giving the appearance that the light is coming from a point emitter.

Note that for this diffraction method to work, there must be a mechanism – which could be as simple as a barrier – for keeping the undiffracted and opposite-order light from reaching the viewer's eyes. It should be apparent that a 3-D scene could be built up by summing up chirped gratings corresponding to the points making up the scene. Such calculations are within the capabilities of modern PC or game-console graphics processors.[2]

Capture and Transmission

It is commonly assumed that the massive pixel count of display holograms makes transmitting real-time holographic television nearly impossible, and even if data compression could somehow reduce the data rate to something manageable, the requirement for coherent illumination of the scene and extremely short exposure times for moving imagery (because the scene has to be stationary to within a small fraction of a wavelength of light during the exposure) would still render the process impractical. Nevertheless, since the early days of holography, analysis and experiments have been carried out for coherent capture and real-time transmission.[3-5]

Recent advances in two areas have opened up an alternative approach: non-holographic capture and calculation of the holographic interference pattern at the receiving end. Ordinary cameras have become small and inexpensive enough to permit building dense arrays of them, while small lightfield and rangefinding cameras have also become available. The outputs of each of these image acquisition strategies are more compact and easier to transmit than the holograms that would result from capturing the same scenes at the equivalent image resolutions, and current graphics processors and digital signal processors provide enough processing to do the necessary diffraction-pattern computation.

Thus, researchers have recently been able to demonstrate scene capture for holographic displays using a camera array,[6] a lightfield camera,[7] or a rangefinding camera.[8] The authors' group at the MIT Media Lab has shown that the Microsoft Kinect can be used as the camera for a holographic television system, with Internet transmission of the resulting data and conversion to horizontal-parallax-only holograms at video rates on a standard PC with three graphics cards. Because the Kinect produces perspective views and the rendering algorithm needs an orthographic camera in the parallax direction, it is necessary to perform calibrated geometric correction as part of the process. Because a hologram captured with a single camera will have missing occluded regions visible from viewer positions far from that of the camera, for complex scenes or displays with large viewing angles it may be necessary to merge data from more than one rangefinding camera, requiring yet more calibration and correction. The resulting holograms have been demonstrated on both our display and a refreshable polymer display developed by the University of Arizona, College of Optical Sciences (Fig. 3).

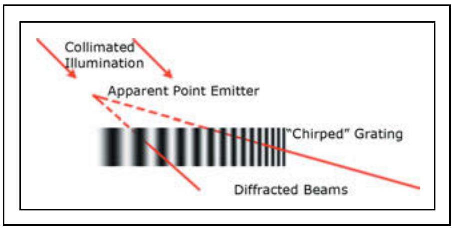

Fig. 2: *Because a "chirped" diffraction pattern bends light by varying angles, when it is illuminated by collimated light, the result appears to be a point emitter at a particular (x,y,z) position. A scene can be built up by superposing about as many of these as there would be pixels in an ordinary image of similar apparent resolution.*

Fig. 3: *This hologram was generated from a Kinect camera and displayed on a refreshable photorefractive polymer display. Courtesy University of Arizona College of Optical Sciences.*

Display Devices

Several generations of holographic video displays have been built at the MIT Media Lab since the groundbreaking Mark I display premiered by Stephen Benton and his students in 1989.[9] Our current display project continues with the Scophony geometry used in its predecessors, where instead of a common light-modulator technology, the diffraction patterns are created by acoustic waves in a transparent material; as the pattern moves with the speed of sound, such systems need a mechanical scanner to provide a stationary hologram. Recent systems in our laboratory have employed our own lithium niobate guided-wave light modulator in place of the earlier bulk-wave acousto-optic modulators. These devices – similar to surface-acoustic-wave filters – can be fabricated with a modest two-mask process. In a guided-wave modulator, a waveguide is created just under the surface of the material, light is coupled into the waveguide, and diffraction is created by surface acoustic waves. One of our prototype modulators is shown in Fig. 4.

Our ultimate target is to fabricate devices with 480 or more independent waveguides, providing sufficient bandwidth to support large displays, but our immediate goal is to demonstrate a full-color horizontal-parallax-only 100-mm-wide proof-of-concept desktop display of SDTV resolution with a bill of materials in the hundreds of dollars.[10]

Figure 5 shows the basic architecture: the light output from the modulator passes through a lens, horizontal and vertical scanners (where the vertical scanner will eventually not be needed when the modulator has as many channels as the display has scan lines), a parabolic mirror, and a vertical diffuser. Because the diffracted light has a rotated polarization from the zero-order beam, removing the latter can be done with a polarizer. We first verified the operation of the display optics with a bulk-wave modulator (Fig. 6 shows a small full-color image) and are now using our guided-wave modulator. Full details of our experiments will be presented in an upcoming publication, but the optical design has proven to work, and Fig. 6 shows a full-color (though not 3-D) image from the display system.

Holographic Television: A Work in Progress

A brief article such as this can just touch upon the basic principles; readers interested in exploring in depth the current state of display holography may want to look at a comprehensive recent technical overview by the author.[11] Much research and development remains to be done before holographic television is an everyday consumer product, but the practicality of real-time holographic viewing is being enabled by progress in a variety of technologies.

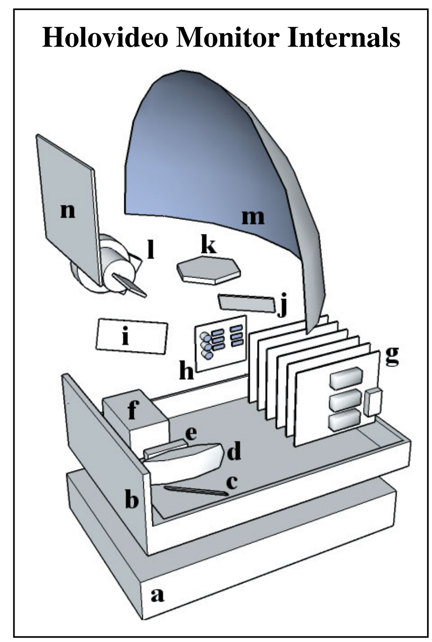

Fig. 5: This prototype display consists of a power supply (a), folded aluminum chassis (b), mirrors i and j (c), transform lens (d), light modulator (e), laser source (f), modulator driver cards with DVI-A inputs (g), phased-lock-loop control to drive the polygon (k), vertical scanner (l), parabolic reflector (m), and anisotropic diffuser (n). The vertical scanner will not be needed when the number of channels in the modulator increases to match the number of scan lines in the hologram.

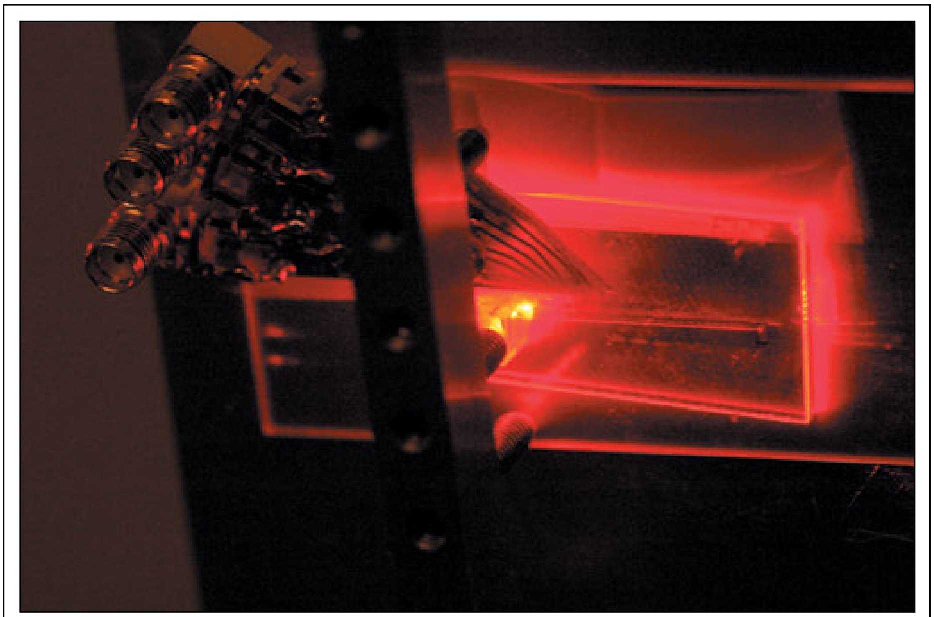

Fig. 4: In this photograph of a guided-wave light-modulator chip, laser light enters at left and diffracted light exits at right.

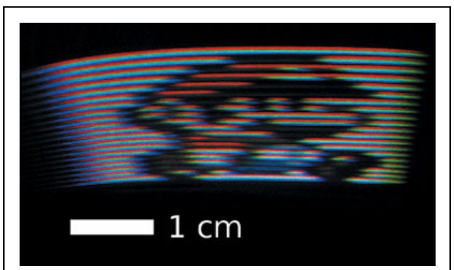

Fig. 6: This single view of a small holographic stereogram test image (only 26 scan lines, not full screen) was displayed on the system shown in Fig. 5.

For a Q&A with V. Michael Bove about the processing demands of holographic television, see the October 2012 issue of *Information Display*.

Acknowledgments

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Holiday 2012 TV Trends and Bargains

Last year, the holiday shopping period between Thanksgiving and Christmas offered deep discounts on televisions. This year, as manufacturers struggle to compete with each other for market share, shoppers will find even deeper discounts on better sets in a retail landscape that has altered subtly from the year before.

by Jenny Donelan

AT Value Electronics, an audio-video retailer in Scarsdale, New York, customers are replacing their existing TVs at a fairly brisk rate, according to president Robert Zohn. The driving factor behind many of these sales is not LED backlighting, or 3-D, or Internet connectivity, or any of the features TV manufacturers hoped would compel consumers to get rid of their old sets and buy new ones. It's design. "Customers are now demanding a thin bezel and an ultra-thin TV," says Zohn. They are completely willing and, in fact, eager, to jettison their older, thicker TVs for the sake of more streamlined ones.

Value Electronics admittedly has a somewhat rarified customer base, which includes passionate videophiles and very wealthy residents from the surrounding area. The latter are the ones generally wanting the streamlined sets. But Value Electronics also has customers with average incomes and average knowledge of TVs.

Last year, Zohn provided *Information Display* with a list of the questions customers commonly ask when shopping for a TV. These questions covered topics such as the difference between LCD and plasma, the best display technology for a given viewing environment, TV mounting options, features-to-price ratio, 3-D, and smart TV. A year later, these topics continue to come up frequently, says Zohn, but there have been changes in emphasis. The following buying trends are being seen at Value Electronics:

1. ***Greater awareness of but continuing confusion about LED backlighting.*** Some customers understand that an "LED TV" is an LCD TV with LED backlighting. Some know there is a relationship between LED and LCD but not what it is. A few others steadfastly refuse to believe that an "LED TV" is in fact an LCD at all, says Zohn.
2. ***Ambivalent attitude toward 3-D.*** As a feature to induce customers to buy televisions, "3-D is not as popular as I think we would all like it to be," says Zohn. However, he notes, people seem to understand that when they buy a 3-D-capable TV, they are generally getting a higher-end, more fully featured TV – a better 2-D TV, in fact.
3. ***Interest in smart TV.*** More customers are interested in smart TV than in 3-D. In the past, such connectivity meant Netflix and not much more, but the number of applications has skyrocketed. Says Zohn, "People are using it for exercising, Skyping, YouTube research and how-tos, and much more." While people may not get rid of their old TV just to have a smart TV, when they do buy a new set, they tend to want that feature, he says. Besides, with the addition of a Blu-ray player or Wii, existing TVs can become smart. "Even a CRT can be a smart TV," says Zohn.
4. ***TVs Going Where They Have Never Gone Before.*** This has been the year of the "designer friendly" TV, says Zohn. Due to the availability of the aforementioned slim panel and slim bezel, TVs are now being included in high-concept living rooms and other areas where interior designers would never have permitted them in the past. In some cases, they are even being used as a design element, with imagery chosen as a room accent.

Bargain TVs

For every customer who goes to an A/V specialty store such as Value Electronics, many more this holiday season will head to discount stores such as Target or Wal-Mart, to electronics chains such as Best Buy, or to Amazon and other online entities. What can they expect to find there?

"I would expect prices to drop significantly in the holiday period, but in a slightly different way than last year," says Ed Border, analyst for market research firm IHS. This year has seen a decline in sales for the formerly popular 32-in. TVs, he notes, but their prices are probably already close to bottoming out. "Instead, we'll see deals for middle-to-larger screen sizes, as companies look to encourage consumers by offering additional functionality such as smart TV for cheaper prices than have previously been available."

Border also expects the biggest discounts this year to come from the low-end brands. The real value, he says, will be seen above 32

***Jenny Donelan** is Managing Editor of* Information Display. *She can be reached at jdonelan@pcm411.com.*

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in. and below 55 in., with 40, 42, and 46 in. offering the best deals, and also 50–55 in. to some extent. “This is because 32-in. TVs and below are in continuous price decline anyway, while TVs 60 in. and above will be more difficult to push to consumers in the current economic situation,” he says. “Expect full HD/LED prices to continue to fall in smaller-screen-size models, and expect consumers who are opting for 50-in. plus models to use this as an opportunity to get discounted smart TVs.”

What about Plasma?

Plasma’s demise has been predicted for some time now, and even Zohn, who is a huge fan, believes this TV technology will eventually be phased out – “but not yet,” he cautions. In the meantime, plasma TVs continue to offer outstanding quality for the money. (See “Why Should I Choose a Plasma TV?” in the 2011 November/December issue of *Information Display*.) Value Electronics, which has conducted an annual large-screen TV “shootout,” for the last 7 years, saw an LCD rather than a plasma TV win for the first time last year. However, this year, plasma regained control, with the Panasonic VT50 winning by a large margin (Fig. 1).

Listing at $3600, it’s not in the range of bargain pricing, but Zohn describes it as a near-perfect TV. “The color accuracy is better than ever and it stands up to high ambient light in a way plasma hasn’t before,” he says. For more about the results of the 2012 shootout, see www.valueelectronics.com.

Gift List

No matter where you shop in November and December, you will not find the latest models. Most new TV technology is rolled out at CES in January and then commercially introduced in the spring. So by fall, what you get is mature technology at a good price. As far as bargain buys go, at press time, the Amazon Top 10 best-selling TVs (a list that is updated hourly) included two 32-in. LED-backlit LCD HDTVs for under $300, a 60-in. LED backlit LCD smart TV for $1000, assorted 40-in. LCD models in the low-to-mid three figures, and one 55-in. 1080p plasma TV for $634.

If you want to buy the best TV available, which will be better than what you could have bought last year, and even one your interior designer would approve of, you can do so for well under $5000. If you want a large TV with bells and whistles, such as Internet and 3-D, you can get one for under $1000. And if you just want a great-looking TV for a great price, look for bargains in those sweet spots, especially 40, 42, and 46 in. There is no doubt that this is a great time to buy a TV for the holidays. ■

Fig. 1: The Panasonic VT50 stands up to high-ambient light better than previous plasma TVs. Image courtesy of Panasonic.

continued from page 4

transformation cost? Why are we so behind Asia and Europe in HD? These questions indicated a sense of urgency and also outlined challenges that representatives from the computer, television, media production, and telecommunication industries needed to resolve. These entities were aided by academic labs and government agencies that were motivated by a goal of future global TV compati-

Television	Format reference	ITU-R Rec., Horizontal & Vertical Spatial Resolution Pixels	Mpixel	Temporal Resolution in Hz	Color Space	Approx. Horizontal Field of View in Degrees	Approx. Horizontal 'Acuity' in Pixels per Degree	Approx. Viewing Distance in Picture Heights	Approx. Viewing Distance in Picture Diagonals
SDTV	NTSC	BT.601 704 × 480	0.34	29.97p 59.94i	xW= 0.3127 yW= 0.3290 (D65) xR=0.63 yR=0.34 xG=0.31 yG=0.595 xB=0.155 yB=0.07 SMPTE RP145	11	64	7	4.2
SDTV	PAL SECAM	BT.601 704 × 576	0.41	25p 50i	xW= 0.3127 yW= 0.3290 (D65) xR=0.64 yR=0.33 xG=0.29 yG=0.60 xB=0.15 yB=0.06 EBU Tech.3213	11	64	7	4.2
HDTV		BT.709 1280 × 720	0.92	60p 59.94p 50p 30p 29.97p 25p 24p 23.976p	xW= 0.3127 yW= 0.3290 (D65) xR=0.64 yR=0.33 xG=0.30 yG=0.60 xB=0.15 yB=0.06	20	64	5	2.5
HDTV	2K	BT.709 1920 × 1080	2.1	60p 59.94p 50p 30p 29.97p 25p 24p 23.976p 59.94i 50i	xW= 0.3127 yW= 0.3290 (D65) xR=0.64 yR=0.33 xG=0.30 yG=0.60 xB=0.15 yB=0.06	30	64	3.3	1.6
UHDTV	4K QFHD	BT.2020 3840 × 2160	8.3	120p 60p 59.94p 50p 30p 29.97p 25p 24p 23.976p	xW= 0.3127 yW= 0.3290 (D65) xR=0.708 yR=0.292 xG=0.170 yG=0.797 xB=0.131 yB=0.046	55	70	1.7	0.8
UHDTV	8K SHV	BT.2020 7680 × 4320	33	120p 60p 59.94p 50p 30p 29.97p 25p 24p 23.976p	xW= 0.3127 yW= 0.3290 (D65) xR=0.708 yR=0.292 xG=0.170 yG=0.797 xB=0.131 yB=0.046	100	77	0.75	0.4

bility. It sounds like – "let's create world peace" – but, of course, economic competitiveness was at stake. For their part, these industry leaders, including satellite, cable, and broadcast network executives, were facing the challenge of transforming their businesses to grow in the future without going out of business in the process.

After months of meetings during which these industry giants presented their often-competing traditional business models and argued passionately about their visions of the future, I recall a defining moment for the U.S. television industry when a colleague pronounced boldly, "I WANT MY DTV!" Next-generation television, as a progressive standard, is primarily about converting to an all-digital system, which then provides the mechanisms for compatibility with existing standards and the new higher-resolution 16:9 formats to nearer emulate and harmonize with cinema.

From this early group, a digital-image architecture was described by setting the conditions for image systems that are:

- ***Open:*** The modules and interfaces forming the architecture are fully defined and in the public domain.
- ***Interoperable:*** Images and related equipment may move freely across application and industry boundaries.

Such systems would be based on a hierarchy that is:

- ***Scalable:*** Supports a wide range of image capabilities.
- ***Extensible:*** Future proof to the extent possible.
- ***Compatible:*** Supports existing television practices and standards when possible.

For further details, the reader is encouraged to refer to "Report of the Task Force on Digital Image Architecture," in the December 1992 *SMPTE Journal*.

Future Viewing

Fast-forward 20 years to 2012 and a digital-image architecture is apparent, with HDTV now being positioned as "2K", and recent ITU standards describing "4K" and "8K" ultra-high-definition television, bringing us to this ID issue on television. This issue's cover depicts the relative steps in the evolving scalable, extensible, and compatible architecture with increasing information capacity. The borders on the cover depict the slightly larger 2048 (2K) Digital Cinema Initiative (DCI) and 4096 (4K) DCI specifications. The table associates central system parameters for the reader's comparison. (The "viewing distance in the picture diagonals" table column may come in handy for estimating display sizes while holiday shopping.)

Since 1995, NHK has persisted to lead the development of next-generation television beyond HDTV. NHK continues to be an important contributor to UHDTV standards and is currently developing television toward the year 2020. For this issue, Takayuki Yamashita and his colleagues describe some of the new ITU Rec. BT.2020 system parameters derived from human-factor studies to elevate a consumer's sensory experience of "being there."

Beyond UHDTV, what could the future bring … holographic television? V. Michael Bove of MIT's Media Lab provides an update in this issue on a next-gen holographic system as well as a new guided-wave modulator that strives to address consumer-television constraints, so we can all one day own a holo-TV.

In a Washington D.C. airport, fresh from one of the many 1991 Digital Image Architecture Task Force meetings, an MIT professor and I were sharing a plane back to Boston, recounting the day's events. After discussing digital-coding transforms and the robustness of the latest transmission methods for terrestrial broadcast, he asked me simply, "So what is going to replace my 13-in. color portable TV that I carry from room to room to watch a ball game?" Neither of us had the definitive answer. Today, the answer is clear. It is as portable as a magazine, wireless, has high-resolution color, and is battery powered. Recent market numbers point to the iPad introduction as driving the explosion in streaming television. Could it be that we consumers will experience HDTV and UHDTV Over-the-Top (OTT) broadband Internet first on a handheld display? When it comes to a television purchase this year, will a new 84-in. 4K UHDTV as covered in last month's *ID* magazine, or perhaps a smartphone or a tablet, be on your holiday list? It's a choice that would have been difficult to comprehend just a few years ago.

In any event, during the colder, darker winter months, television viewing is up, and this is traditionally a great time to find holiday deals. My sincere appreciation to the contributors of this special television issue who considered the marketing aspects of the television industry, including industry veterans Bob Raikes and Pete Putman. Raikes covers the IFA show and the European TV market, while Putman describes the outlook for the U.S. market. *ID*'s own Jenny Donelan takes a look at the retail landscape for consumers this holiday season. I hope you enjoy this collection of articles on television technology, which continues to converge with digital telecommunications and computing. ■

***David Trzcinski** is president of Precision Consulting, based in Londonderry, NH. His company provides market development, product development, program delivery, and general management services focused on profitable client solutions for manufacturers of electronic imaging and telecommunications systems. Currently, David is a Senior Manager in Broadcast Engineering at Avid Technology, which creates the technology that people use to make the most listened to, most watched, and most loved media in the world. He is a member of SID, SMPTE, OSA and IEEE, and can be reached at davidtrzcinski@gmail.com.*

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holidays and make new purchases, but the data so far is not encouraging. To be fair, there will still be a huge number of TVs sold this holiday season, just not as many of the right mix to bring widespread profits back to this industry in the short term.

Unfortunately, the marketplace in Europe is well in line with North America and the rest of the world. We hear from author Bob Raikes in his Display Marketplace feature on the European TV market that the situation is essentially the same there, with the trend to increase the number of second sets in households declining mostly due to the wide adoption of tablets and other second-screen devices for Internet-delivered TV viewing. However, as we learn from Bob, the infrastructure of the TV marketplace in Europe is very different than that of North America and Asia due to several factors including trade regulations in the European Union. I think this demonstrates that regardless of how a marketplace is structured, supply and demand will still ultimately dictate the outcome.

Looking beyond this year, we wanted to know what was in the future for TVs and we found a couple of hot topics. The first involves a somewhat ad-hoc push to ultra-high definition (UHD) as the next new format for very-large-sized TVs. I talked about this last month in the context of Paul Semenza's article on the two major trends people hope will revive the TV marketplace. One trend is OLED and the other is UHD.

Solidly in the UHD camp are this issue's NHK authors Takayuki Yamashita and Hiroyasu Masuda. In their Frontline Technology article titled " 'Super Hi-Vision' as Next-Generation Television and Its Video Parameters," they propose a new system that not only addresses increased panel/content resolutions but also colorimetry, all-surround sound, and viewing-angle requirements. This is a very complex subject with many technical and logistical facets that NHK has been considering for some time now. It's safe to say that the authors' complete treatment of this subject shows it is a serious future endeavor but something very long-term focused – it's not going to result in a new wave of products in the near term, though there are some manufacturers that are starting to build 4K-resolution large-screen TVs for sale as early as next year. We thought this was so fundamental to appreciate that we asked our guest editor David Trczinski to develop the graphic concept you see on the cover showing the dramatic increase in content resolution from old-world NTSC to the latest proposed UHD format.

David not only helped us put together the NHK article; he also arranged to get the MIT Media Lab to report on their research work into holographic TV technology. Authors V. Michael Bove and Daniel Smalley describe the technical foundation, background, and latest developments in their efforts, which date back to 1989 and earlier. Their latest development, which they refer to as a "holovideo monitor," uses acoustic waves in a transparent medium to create the diffraction patterns necessary for image reconstruction. Their immediate goal is to demonstrate a full-color horizontal-parallax 100-mm-wide proof-of-concept desktop display of SDTV resolution with a bill of materials in the hundreds of dollars. While this is basically a 4-in.-wide holographic display that appears three-dimensional only in the horizontal axis, it's still an incredibly promising leap of technology. I talked a lot about the possible future for holographic TV in my editorial from last month where we also featured an interview with Dr. Bove on this subject. Now you can read the rest of the story and see more of the reasons for my continued optimism. Also, please take a minute to read David's guest editorial and hear his perspective on holographic TV and other related topics.

Meanwhile, you are probably wondering about OLED TVs and how they fit into the context of reviving the marketplace. Well, here again there have been some changes since we last reviewed this coming off the very successful product demonstrations by Samsung and LG at Display Week 2012 in June. The manufacturing-process maturity needed to make high volumes of these panels has not yet been achieved, and yields are apparently too low to support full-scale launch plans for this season. It's too bad because the demonstrations were so compelling that I'm sure there would have been sufficient high-end consumers ready to be first adopters. However, there's always next year. Jenny Donelan addresses the current status of the OLED TV launches along with other aspects of the retail landscape in her Enabling Technology feature and Industry News roundups.

It's worth noting that back in September 2009, for the OLED Technology issue of *ID*, I talked about the very long and arduous road that OLED technology developers had travelled so far. In 2009, it appeared as though several players were just on the cusp of commercialization. Several significant technical and manufacturing process milestones were still required to make the business models work, but for handheld devices as well as TVs the groundwork was in place. A lot more progress has been made in the ensuing 3 years and yet not as much as I expected. It's encouraging that in small formats, OLED displays have achieved significant volumes and are widely sought after by consumers. Therefore, I still stand by my 10-year horizon prediction. You might want to take the time to go back and see what the baseline was in 2009 compared to where the industry is today.

I want to thank our guest editor for this issue David Trczinski for his dedicated efforts to help create this year's TV Technology issue. I hope you enjoy reading it and we always welcome your comments and feedback. You can reach us by email at jdonelan@pcm411.com. ■

Second Annual I-Zone Calls for Cutting-Edge Technology Demos

The first-ever I-Zone in 2012 was a great success, both in terms of attracting new technology and in drawing crowds of attendees at Display Week. The Innovation Zone at Display Week 2012 featured 23 exhibitors in a designated I-Zone space on the show floor. Each was chosen to participate on the basis of cutting-edge research and the ability to demonstrate a working prototype at the show. Members of the I-Zone committee chose the best prototype from the I-Zone, announcing the winner, Tactus Technology, on the show floor for its next-generation tactile touchscreen interface.

At Display Week 2013, under the sponsorship of E Ink, SID will once again provide this forum for live demonstrations of emerging information-display technologies and related areas. The I-Zone will take place May 21 and 22, the first 2 days of the exhibition. This special exhibit offers researchers space to demonstrate their prototypes or other hardware demo units for two days free of charge at Display Week and gives attendees a chance to view best-in-class emerging information-display technologies in a dedicated area on the show floor.

The I-Zone committee is now actively seeking participation by small companies, startups, universities, government labs, and independent research labs. Proposals to demonstrate new displays, input technologies, and innovations in related fields such as lighting and organic electronics are being solicited. Technologies should be in the pre-product stage, and demos that will be shown for the first time in a public forum at I-Zone are especially encouraged.

Submissions are due by **Friday, March 15, 2013.** Please address any questions regarding I-Zone 2013 to Prof. Jerzy Kanicki at kanicki@eeds.umich.edu.

For more information, including a list of the 2012 winners, visit http://www.sid.org/About/Awards/IZone.aspx ■

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Building 77 Chungsing Road, Sec. 4
Chutung, Hsinchu 310 Taiwan
+886-3-591-6939
fax: +886-3-582-0217
jiamingliu@itri.org.tw

Sales Office – Taiwan

Jie Tsai, Project Manager
ACE Forum, Inc.
10F-1, No. 180, Sec. 4
Nanjing E. Rd.
Taipei 105, Taiwan
+886-2-2570-6960 x302
fax: +886-2-2570-2305
jie@aceforum.com.tw

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12 Park View Court
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Christine von Steiger, Sales Manager
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fax: 413/783-0474
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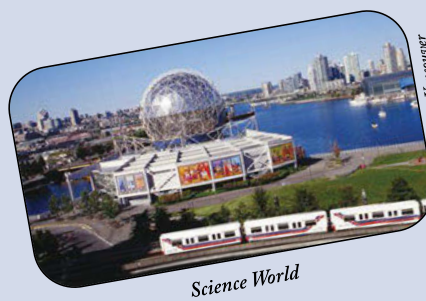

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Display Week will be held May 19–24 at the Vancouver Convention Centre, with the exhibition open from May 21–23. Display Week is the once-a-year, can't-miss event for the electronic information display industry. The exhibition is the premier showcase 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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INNOVATION ZONE
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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.

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