FLAT PANEL DISPLAYS - PHOTONICS NEWSLETTER

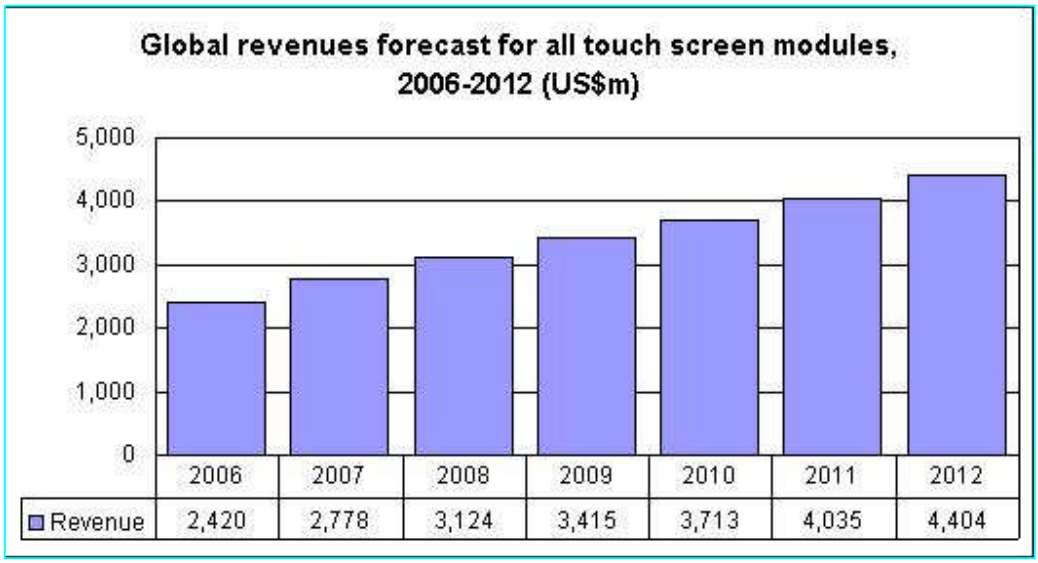
December 2007 - Ken Gilleo - www.ET-Trends.com

MARKET & BUSINESS INFORMATION

Opportunities Remain for LCD Display Alternatives - LCD display technology is dominant for most electronic products, including televisions, computer monitors, notebook PCs, ultra mobile PCs (UMPCs), MP3/portable media players (PMPs) and mobile phones. But there's still a market for emerging display technologies per iSuppli. These technologies include touch screen, bi-stable (like e-paper), near-eye, heads-up display (HUD) and miniature projection displays. For example, global shipment revenue for the leading touch screen technologies will rise to $4.4 billion by 2012, up from $2.4 billion in 2006. Bi-stable displays, those capable of presenting an image without using power, are expected to reach 350 million units by 2012, up from a mere 29 million units in 2007. Near-eye display revenue is expected to grow to $724 million by 2012, rising from $209 million in 2007 ***[I think this is an underestimate since the iPhone and video iPods will be strong drivers - eyewear displays are not quite good enough, yet].*** The global HUD module market is expected to reach $107 million by 2012, up from $26 million in 2006 ***[presumably this is for vehicles and doesn't include video eyewear].***

The release of Apple's iPhone has put touch screens into the spotlight [***the touch screen is at least 3 decades old technology but it's been revitalized. Most PDAs used it long before Apple].*** Demand for touch screen displays is being driven primarily by the mobile phone and consumer electronics industries, specifically portable game consoles, PDAs and portable navigation devices (PNDs). However, as the market matures, touch screen displays will find a role in nearly every aspect of life, from planes, to automobiles, to machine-control systems, to home appliances ***[Touch screens have been used for industrial gear since the 80's and probably earlier].*** Bi-stable displays are finally getting good enough to see some serious growth. Demand is rising for this technology as companies try to limit the power consumption of portable devices and always-on signage. Bi-stable displays' capability to sustain images without electricity also makes them well suited for smart cards, removable flash storage devices and e-book/e-paper. Other applications include electronic shelf labels (ESLs), point of purchase/point of sale (POP/POS) and mobile phones***. [Video in every gadget is coming, but who wants the "box" to getter any bigger just to enlarge the picture? The answer is the same as for audio. Use projection or wearable interfaces. Move to pocket/embedded projectors and near-eye displays. Such display solutions not only offer a larger viewing area, but also potentially lower costs, much less power consumption and reduced weight & size and privacy and stereo vision; they can hold the earphones - what are we waiting for? - this is obvious.]*** The near-eye display is designed to be placed on a helmet or visor close to the user's eye, providing a virtual image that is larger than the physical dimensions of the**.** HMDs can display a virtual image ranging in size from 20 inches to 100 inches,

providing a much more comfortable and compelling viewing experience than the as small as 2-inch displays typically used on mobile phones. The pocket projector will grow due to the high demand for portable presentation equipment. Projectors now weigh less than two pounds and have a size smaller than 60 cubic inches. Pocket projectors are preferred by businesses because be seen by small groups of people instantly, at any time, and in any place required; most can run on batteries. Displays have been used in automobiles for decades, as they can provide information for drivers and entertainment for passengers. Head-up displays (HUDs) enhance safety by keeping drivers' eyes on the road. Currently, there are many vehicle manufacturers offering HUDs including General Motors, BMW, Toyota, Nissan, Ford and Honda. The global HUD module market is expected to reach $107 million in revenue by 2012, up from 26 million in 2006. While there are big growth opportunities for miniature projectors, the rear-projection television market losing momentum. Source: iSuppli.



Film Materials Venture - Rohm and Haas and SKC Launch Display Films Joint Venture - SKC Haas Display Films, a new joint venture between Rohm and Haas and SKC Company, Ltd., began operations. Headquartered in South Korea, the company develops, manufactures, and markets advanced optical and functional films used in the flat panel display industry. The new SKC Haas represents a very important step in the growth of our Electronic Materials business and a major milestone for Rohm and Haas Electronic Materials and the growth of its Flat Panel Display Technologies business. Throughout 2007, the company has been investing to build a flat panel business that offers a suite of new products for LCDs and plasma displays. Earlier this year, Rohm and Haas acquired Eastman Kodak's Light Management Films business. They have been aggressively expanding their presence in the flat panel market and believe that the combination of our materials expertise, the deep pipeline of technology from the Kodak Light Management Films acquisition, and the manufacturing capability of SKC Haas will position them extremely well in this growing space. They appointed Dr. Dominic Yang as the president and business unit director for the company's Flat Panel Display Technologies business. He is currently the president and business unit director for Rohm and Haas's Microelectronic Technologies business, and brings more than 20 years of technical and commercial experience in the semiconductor industry to this new role. Dr. Yang was recently appointed a vice president of Rohm

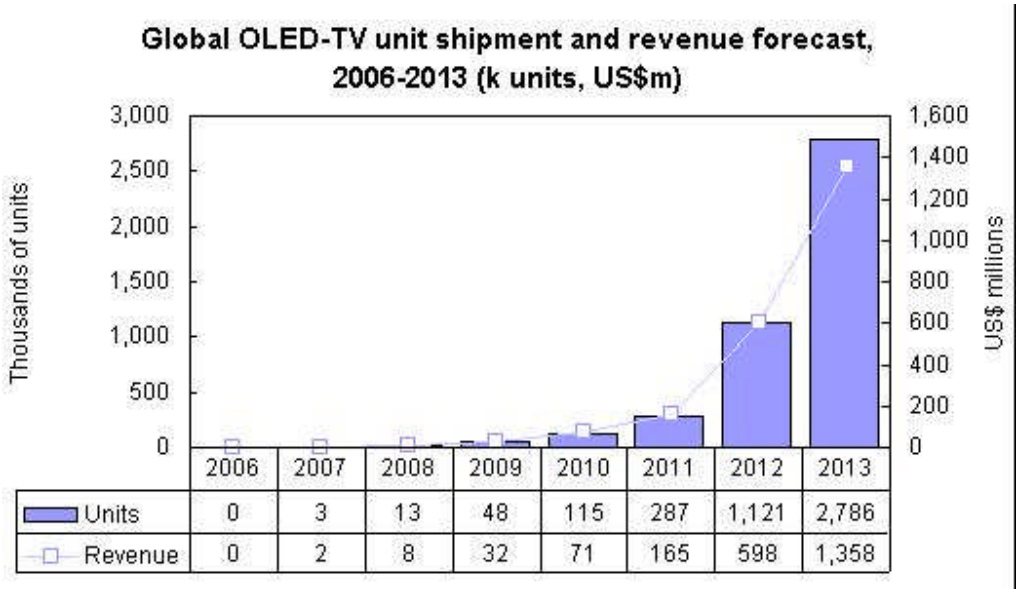
and Haas Company. Products developed, manufactured and marketed by SKC Haas Display Films include a suite of advanced specialty display films for liquid crystal (LCD) and plasma displays. The JV also will include dispersions of pigments, key ingredients used to manufacture LCD color filter resists. In addition to these films and materials, Rohm and Haas's Flat Panel Display Technologies business develops and manufactures a variety of products for the display industry, including TFT photoresists and color filter chrome patterning. Source: eMedia Wire.

NEW PRODUCTS

Sony has Launched OLED TV, **But…** OLED has a big challenge if it's to catch up to LCDs given the investments that have been put into the other technologies. But there a performance potential for the display technology, even if it's relegated to mobile applications. Sony is first with an OLED TV, its 11-inch just introduced in Japan at a price of $1,800; volumes will be very small, targeting a small niche of well-heeled, tech-savvy must-have consumers. And even at such a high price, Sony is probably taking a loss on the sale of each OLED set. A few other brands are likely to enter the OLED TV market in 2009, including Toshiba and Panasonic. Despite the obstacles, many are optimistic about the prospects and potential of OLED technology. However, there are a number of fundamental technology and market challenges that must be resolved before OLEDs can make a real impact in the market. For example, active-matrix OLED (AMOLED) panel **manufacturing is still an inefficient process**. As the size of OLED displays becomes larger, the yields and manufacturing losses also get larger. As a result, AMOLED products are going to be small-sized displays, for applications such as mobile phones and personal media players (PMPs) for a few more years. Furthermore, OLED material lifetimes are still an issue for products that require long lifetimes such as televisions. Add to this the fact that AMOLED suppliers cannot guarantee high volumes because the technology is coming from a single source.

However, **OLED TV has a number of great upsides**: OLED TVs use no backlights, so they offer potential power-savings benefits compared to other technologies. Because they have no backlights and use only a single glass substrate, OLED TVs can be very thin. The response time for OLED TVs is very fast, so there is no motion blur while watching television. OLED TVs have a much richer color gamut than competing display technologies. iSuppli forecasts the global OLED TV market will reach 2.8 million units by 2013, managing a compound annual growth rate (CAGR) of 212.3% from just 3,000 units in 2007. In terms of global revenue, OLED TV will hit $1.4 billion by 2013, increasing at a CAGR of 206.8% from $2 million in 2007. Because OLEDs already serve as small panels for mobile handsets, PMPs and other small handheld devices, it is safe to assume OLED TVs could be a natural fit for automotive infotainment, mobile television, kitchen televisions or other consumer electronics devices that want to add small-screen sets. The main challenge for the OLED TV industry is making large-enough panels that could be sold at reasonable prices in order to compete against the other television technologies. Still, iSuppli believes that OLED TV is promising in the long term. Reducing

power consumption, extending lifetimes, achieving larger sizes and attaining reasonable pricing eventually will help OLED TV to be competitive, but in the meantime, it will find a place in applications that require small sets. Source: iSuppli.



	2006	2007	2008	2009	2010	2011	2012	2013
Units	0	3	13	48	115	287	1,121	2,786
Revenue	0	2	8	32	71	165	598	1,358

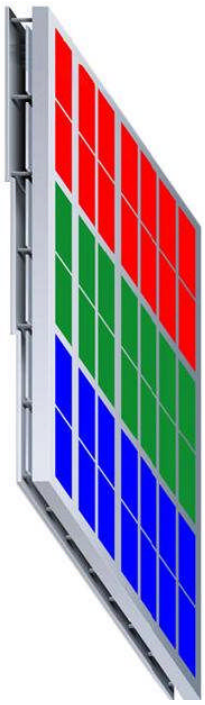
TECHNOLOGY BREAKTHROUGHS

DLP 3D Technology - Recently, Texas Instruments has introduced the first 3D-capable television solutions to its OEMs for 2007 consumer electronics televisions. These systems utilize the inherent speed advantage of the MOEMS-powered Digital Micro-mirror Device (DMD) to generate the left and right views required for stereoscopic imaging. Combining this with recent technical innovations in shutter glasses, the user will be able to experience a high quality high definition 3D image on their DLP' television set. The basis for DLP 3D HDTV is found in the SmoothPicture algorithm. DLP' 3D Technology utilizes the SmoothPicture sub-frames to generate independent views for the left and right eyes. A signal is generated for each sub-frame and transmitted optically to the LCD shutter glasses that are worn by the viewer. The LCD shutter glasses will process the signal and will control the shutter for each eye to ensure that the correct left and right views are displayed to the correct eye. ***[While it's not the old Polaroid deal, its still 3D glasses.]***

One technical hurdle in achieving cost effective stereoscopic displays is that stereoscopic displays require two times the imaging bandwidth of the standard 2D displays. For a 1080p television set, this means that two 1080p input streams are required. Current solutions to this hurdle are to either cut the horizontal resolution by ½ or cut the vertical resolution by ½. Using these solutions allows for the transmission of two images using the currently available bandwidth but sacrifices either the horizontal or vertical resolution of the image. The solution created by Texas Instruments maintains both the vertical and the horizontal resolution. This solution thus produces the highest quality and highest resolution displays available for stereoscopic viewing. Most TV display systems contain an On Screen Display (OSD) menu system. The OSD menu provides the user a feedback mechanism in situations where the user adjusts various parameters such as screen brightness and audio volume.

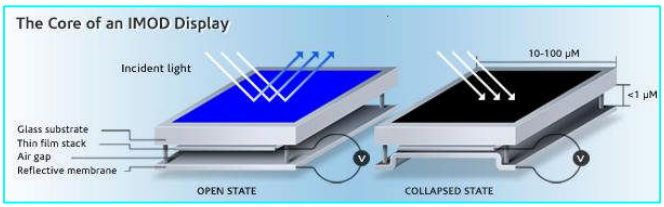
It is desirable for this menu system to work when the system is in 3D mode. The easiest way to achieve this is to display the menu at 0 depth (so it appears 2D). With some of the other formats, this requires placing the menu into two separate video streams adding complexity to the TV electronics design. With the offset sampling scheme used by Texas Instruments, OSD menus can be added to the stereo image using the same method as is used for a standard 2D image. As such, significant system redesign cost can be avoided. By utilizing the SmoothPicture architecture, Texas Instruments is able to supply a 3D-capable display with little additional electronic cost. The main cost to this solution is a modest cost in the eyewear. As such, consumers can purchase a 3D Ready television for the same price as the traditional 2D television. They can then choose to purchase the eyewear with the television or upgrade at a later time. The DLP 3D Image format makes use of how the DLP SmoothPicture algorithm displays an image onto the screen. The left and right images are sampled using the native offset diagonal sampling format of the DMD. The two views are then overlaid and appear as a left and right checkerboard pattern in a conventional orthogonal sampled image. This format preserves the horizontal and vertical resolution of the left and right views providing the viewer with the highest quality image possible with the available bandwidth. A cinema/projection version is also available. Source: Digital TV.

MEMS Display Advances - A novel electronic-paper display developed by Qualcomm (an acquisition, not home brewed) can deliver high-quality video images, making it more versatile than other e-paper technologies. The display employs microscopic mechanical switches that turn pixels on and off at rates more than fast enough to display video. The first versions of the display will be monochrome; one is featured in an Audiovox Bluetooth headset, released this week. A two-color display will be used in 2008 in a phone made by the Chinese phone company Hisense; full-color versions will follow. Like ordinary paper, e-paper displays are designed to be reflective, making them much easier to view in a range of different lighting conditions, such as bright sunlight, than are traditional displays, such as backlit LCDs. The other main advantage is that they are bi-stable, meaning that once they have been switched to a state, they will hold that state without requiring an electrical current. The benefit of this is that they use considerably less power. These features make them ideal for applications such as signs and electronic books, including Sony's eBook reader. In most e-paper displays, however, pixels switch on and off too slowly to display video. Indeed, other e-paper technologies can take longer than half a second to respond [***they are getting faster***]. Such slow switching can lead to "ghosting," in which moving subjects blur. In contrast, pixels in the new Qualcomm display can switch in just tens of microseconds--fast enough to produce sharp video images. This ability to use the displays for video could make e-paper less of a niche technology and suitable for more mainstream multimedia displays for mobile devices like cell phones. The new display technology uses a novel method for producing color. The method employs mechanisms that are similar to the ones that give films of oil on water a colorful sheen. When light hits a film of oil, it splits, with some reflecting and the rest passing through the oil before being reflected off the surface of the water. The light reflecting off the oil is slightly out of phase with the light reflecting from the water. As a result, light waves interfere with each other, with some wavelengths being reinforced and



others canceled out. The distance between these surfaces determines which colors are amplified and which are canceled. Films of oil of a certain thickness, for example, would amplify green light while canceling out red and blue light, making the oil appear green.

In the display, each pixel consists of several color-specific cells that mimic the film of oil on water.



Each cell is made up of two reflective layers, one on top of the other. The top layer is only partially reflective, allowing some light to pass through it and bounce off the second surface. In each cell, the gap between these surfaces is spaced so that constructive interference occurs for only one specific range of wavelengths, causing them to amplify a single primary color while canceling out other colors. To create a full-color display, each pixel is made up of three different types of cells, each having a different-size gap between the layers that reflects red, green, or blue. Each cell can be turned off by bringing together the two layers using an electromechanical switch. (When there is little space between the layers, no visible light is amplified, making the cell appear black.) The switch moves after a pulse of voltage and stays in place until another pulse moves it back. As a result, the display is bi-stable, using little energy except to change the image. By combining different sets of colored cells as sub-pixels, researchers can get any color of the spectrum. These MEMS devices are very robust, he says, and have been demonstrated to be reliable for more than 12 billion cycles. But because of the fabrication processes used to create MEMS devices, there is a constraint on how big such displays can be made, he says, which is the reason that Qualcomm is targeting small mobile displays. What's more, the energy savings will only apply when the display is used to view static, not video, images. Source: Technology Review.

MORE OLED

Displays and Energy - Although the adoption of LCD TVs can halve the electricity consumed by traditional CRTs, LCD TVs still account for about 70% of the electricity used by household appliances, according to Sony. Sony's desire to reduce the consumption of energy was a contributing factor in its drive to develop OLED TVs, as OLEDs have the potential to reduce electric consumption by 40% compared with LCD TVs. However, they admit that it is still too early to say OLED TVs can replace LCD TVs, and Sony is still focusing on its Bravia brand LCD TV business. Sony still highly values the potential of OLED TVs primarily because of its ability for energy saving, as well as its thin and high-definition features. But if Sony wants OLED TVs to become more popular, the company has to consider how to make OLED products that are larger and less expensive to produce, Ihara added. Source: DigiTimes.

AM-OLED - Samsung Electronics has introduced its first handset model equipped with its SDI 2.2-inch active-matrix organic light emitting diode (AM OLED) panel. Only 1,000 units of the W2400 Special Edition are being sold for now. Adopting a swing design users can make video calls on the slider phone through Bluetooth headsets, and enjoy multimedia games and digital multimedia broadcasting (DMB) services, according to the company. Separately, Japan's Toshiba, Hitachi and Sony Ericsson have been selling the phones armed with Samsung SDI 2.6- and 2.8-inch AM OLED panels. Source; Digital TV

More on Samsung AM-OLED - Samsung released AM-OLED earlier than the initial plan of early next year. Mobile phones with AM OLED show very clear images but the biggest problem is their high price. As the company released only 1,000 phones at the price as limited edition, the price can be higher. New models which will be mass-produced next year can be cheaper. AM OLED is two times more expensive than LCD. But the price of display is only a part of total phone cost. Therefore, the price burden on consumers is not that high, according to Samsung. Some say mobile service providers can promote AM OLED as a marketing tool for 3G as AM OLED is superior to LCD in display, which means cost burden would not have much negative impact and the sales could skyrocket. Also, Nokia and LG Electronics will shorten the release of AM OLED phones, which means more AM OLED phones on the market. The world's biggest mobile phone maker Nokia will release AM OLED phone this year. So hopefully Samsung-SDI can expand its production capacity of 1.5 million. Samsung SDI already announced the expansion to 3 million next year and 6 million in 2009. Source: OLED TV.

Mass Production of OLEDs - Samsung SDI plans to mass-produce 14-inch AM OLED panels probably from the Q1-08 to meet growing demand for profitable IT-related products, including notebooks. The suggested retail price for the 14-inch AM OLED TV is likely to be around $3,000 when it is commercialized. Both 31-inch and 14-inch panels will be exhibited at the Consumer Electronics Show to be held in Las Vegas from Jan. 7-10. Samsung SDI said that it has successfully developed the panel by using advanced active matrix organic light-emitting diode (AM OLED) technology and a low temperature poly-silicon (LTPS) manufacturing process for the first time in the world. Despite power and life span advantages compared to the a-Si method, the LTPS process has widely been considered a much tougher method to make larger-sized panels, resulting in wide adaptation to smaller electronic gadgets such as car navigation and high-end cell phones. Samsung SDI will develop 40- and 42-inch full high-definition AM OLED panels in 2010.' Source: OLED TV.

Sony's Plans - Sony will exit the micro-display business in the U.S., effectively immediately, prompted by the growing popularity of flat-panel TVs. The focus will be on Bravia brand liquid-crystal display (LCD) sets. The popularity of flat panel TVs and their desire to put all our resources into development of LCD and OLED necessitated the move. Sony recently started offering an 11-inch OLED TV called the XEL-1 in Japan, and the company demonstrated a 27-inch 1080p resolution prototype at the 2007 Consumer Electronics Show. Rear-projection TVs (RPTVs) have traditionally had the upper hand over flat panel models because they offer large screen size at affordable prices. But steadily increasing capacity and efficiency of flat panel manufacturing has resulted in declining prices that RPTVs will likely have difficulty competing with over the long term. Source: OLED TV.

Big OLED - Samsung strikes back against Sony and claims that they has succeeded in a 40-inch AM OLED screen for the first time in the world. Active matrix organic light-emitting diodes are often cited as the next-generation displays that could replace other flat panels. They emit their own light with no need for back lighting, while consuming less electricity and can be produced slimmer than liquid crystal displays. But manufacturing yield and high costs have plagued the technology. Samsung Electronics said it plans to showcase the latest TVs in the International Consumer

Electronics Show to be held earlier in 2008 in Las Vegas; the prototypes are already running. It is the first time in the world that such a large AM OLED TV was produced. Samsung will also show off their 31" OLED, still a prototype, and their 14" TV - probably the real product for sale. Currently, Japan's Sony sells TVs equipped with an 11-inch AM OLED screen. No word about the production costs, mass production, selling goals**.** ***[Their 31-inch model that could actually be affordable to some, but probably few. Their 14-inch AM OLED TV will also be at the show and is probably the actual "for sale" product.]*** Source: OLED TV.

Phosphorescent OLED Development - Universal Display Corporation, a major force behind today's evolving displays and lighting with its PHOLED phosphorescent OLED technology, reported significant progress in the development of P^2OLED printable, phosphorescent OLED materials for use with solution-based manufacturing processes, which display manufacturers, consider a prospective solution for the cost-effective production of large-area OLED displays. Reported jointly with Seiko Epson Corporation (Epson) at the recent International Display Workshop (IDW) Conference, these advances are the result of a 3-year joint development program during which the two companies focused on the successful demonstration of Universal Display's P^2OLEDs for application to Epson's proprietary ink-jet printing process technology. The efforts to develop P^2OLED materials and technology for use with Epson's ink-jet printing technology have been highly productive and they have accelerated progress toward our commercial targets to enable the production of OLED displays that are low-cost, high-efficiency, thin, bright, and beautiful for a variety of consumer markets including large-area TV's. Most appreciate the potential of printable OLEDs, but the challenge for commercialization has been significant. The two companies reported progress in red, green and blue P^2OLED device performance in spin-coated devices and ink-jet printed devices. Demonstrating the high luminous efficiency of PHOLED technology, the team made significant progress in extending the operating lifetimes of its red and green material P^2OLED systems: Red with CIE (0.66, 0.33), luminous efficiency of 9 cd/A and greater than 50,000 hours of operating lifetime to 50% of initial luminance (at 500 cd/m (2)) and green with CIE (0.33, 0.63), 35 cd/A and greater than 50,000 hours (at 1000 cd/m (2)). The team also reported data for a new sky blue P^2OLED with CIE (0.19, 0.40), 18 cd/A and greater than 3,000 hours (at 500 cd/m (2)). In addition, results with ink-jet printed P^2OLED devices were reported which demonstrate the excellent film-forming ability of the small molecule layers. Ink-jet printed green P^2OLED devices were also demonstrated to have the same efficiency as those of the spin-coated control P^2OLEDs following an in-depth study of solvent selection and process optimization. Source: OLED TV Tech.

Delays from Others - Toshiba Corp has it had shelved plans to sell ultra-thin TVs with organic light-emitting diode (OLED) displays in 2009/10 because of the cost of mass production. Toshiba will stick to its plans to commercialize smaller OLED displays for cellphones next year, and will watch markets and technological developments to see whether making OLED TVs is commercially viable later. Home electronics rival Sony Corp began sales of 11-inch OLED TVs in November, but the development costs have limited its shipments to 2,000 units per month. Display and TV makers see OLED displays as a possible growth driver, as they produce brighter images, use less power, and are thinner because they do not need the backlights used in liquid crystal displays. In April, Toshiba had said it aimed to market 30-inch OLED TVs in the business year to March 2010. Source: OLED TV.