FlexTech Alliance
for Displays & Flexible, Printed Electronics

FlexTech Trends

News from the world of displays and flexible, printed electronics

Volume 6 – Winter 2010

FlexTech Trends

Table of Contents

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Note from the President

by Michael Ciesinski

A harbinger of the year to come is often the Consumer Electronics show (CES), staged in early January. The show provides insights into the products that may drive consumer demand throughout the year ahead. It's a fairly safe assumption that any airplane headed to Las Vegas at that time is filled with management, engineering and marketing experts who provide the electronics industry's innovations. The results of their creativity and hard work are spread out over the Las Vegas Convention Center and hotel ballrooms.

3D technology and products were among the lead news stories at CES this year with notable companies including 3ality, HDlogix, Intel, Samsung, Sony, TDVision and Thomson announcing products that incorporate or support 3D viewing. Is this a real trend – and what does 3D mean for our member companies?

Recall that the transition from CRT-based displays to flat panel displays (FPDs) provided a significant jolt to electronics industry revenue in the last decade. Can this be repeated with 3D displays and related technology? Most experts agree that the primary markets for 3D are cinema (now more than 7,000 screens worldwide and increasing), gaming, and home entertainment. It's becoming increasingly clear that what is driving 3D is the match between available content – whether it is live, like an ESPN broadcast or a movie recorded on a blu-ray disc – and available technology. This has allowed DisplaySearch to forecast just prior to CES "that the total stereoscopic 3D display market will grow from 0.7 million units and $902 million in revenues in 2008 to 196 million units and $22 billion in revenues in 2018, a compound annual growth rate (CAGR) of 38% for revenues and 75% for units." At this level, 3D would be almost 25% of the total FPD market in 2010!

So, the opportunity presented by 3D for display-based member companies is significant as new displays are built requiring technology advancements from the supply chain. Firmly fulfilling our commitment to supporting the display industry, the FlexTech Alliance manages the 3D at Home Consortium. Comprised of leading CE and supply chain companies, the consortium's objective is to provide a great 3D viewing experience. For articles and insights on the 3D industry – including those of James Cameron, a leading proponent of 3D and director of Avatar – visit www.3dathome.org

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Plan on attending the annual the Flexible Electronics and Displays Conference, scheduled for February 1-4, 2010 in Phoenix, Ariz. The 2010 Flex Conference features business leaders and technologists in the emerging field of flexible, printed electronics and displays. Day 1 provides business strategies and markets forecasts, while Days 2-3 shift to invited and peer-reviewed technical presentations.

The conference is a tremendous value for your company as it includes 3 days of information-packed presentations, breakfasts, lunches and 2 networking receptions. A group discount is available for multiple registrations from the same company or organization – e-mail soya.clapp@flextech.org for more information.

Cordially,

Michael Ciesinski, President

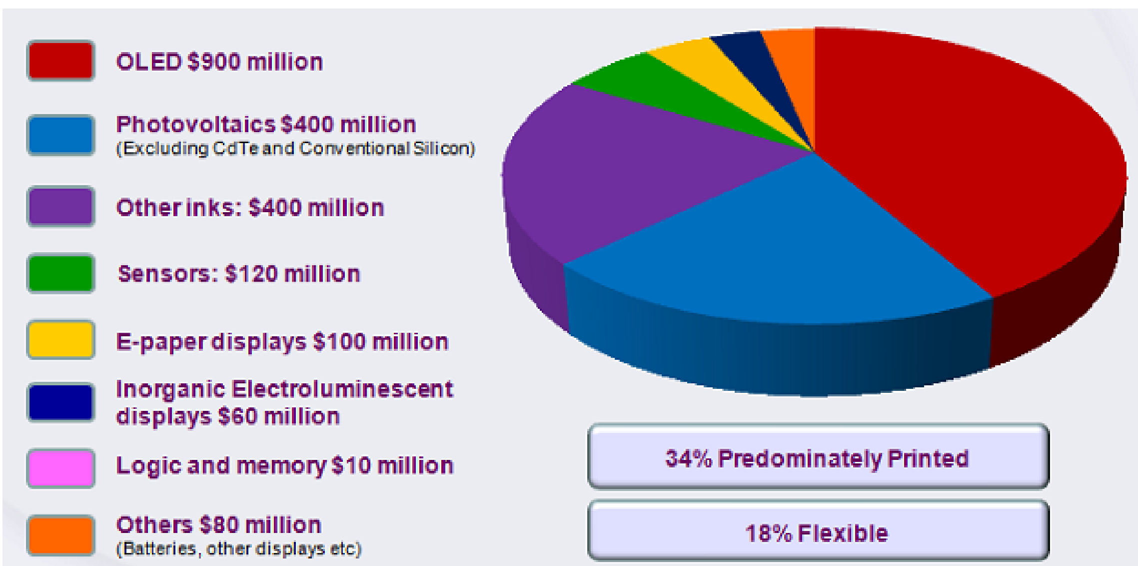
Market Update: Printed and Flexible Electronics
A view in 2010

by Raghu Das

Raghu Das is CEO/MD of IDTechEx. He has a BA Natural Sciences degree from Cambridge University, where he studied physics. He has been closely involved with the development of RFID and printed electronics for over six years, carrying out consultancy in Europe, USA, Asia and the Middle East. He has lectured on RFID, smart packaging and printed/organic electronics at over 200 events and conferences around the world and is author of several IDTechEx publications.

This year we enter the second decade since the first new printed electronics moved from academia to commercialization. The topic is now incredibly broad encompassing inorganic and organic chemistries that may or may not be printed and, judging by the many news sources now available, innovation is growing at a rapid rate. However, where are we in commercialization? What is needed? In this article we take a look at the business of printed electronics.

In 2010, IDTechEx see the size of the market as following:

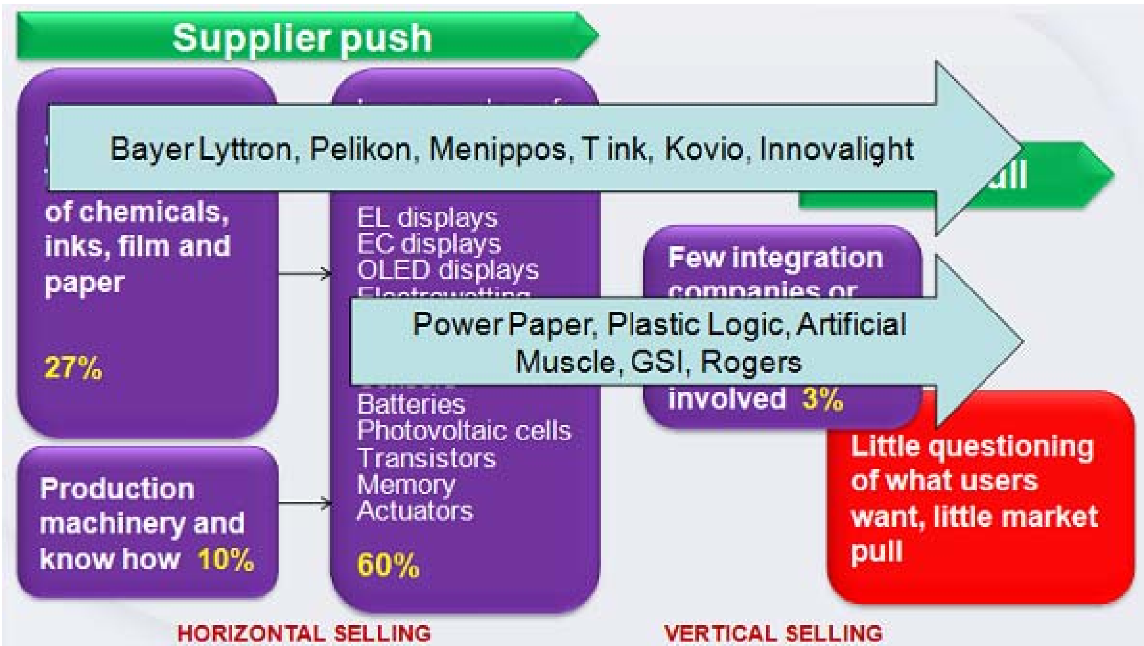


Source: IDTechEx

However, of the markets in 2010, less than 0.1% of the OLED market consists of flexible devices, flexible photovoltaics are 0.7% of the quoted market and only 10% of the e-paper display market is devices on flexible substrates. Flexible electronics is much more mature for the decades old AC electroluminescence (almost all is made by screen printing), and the many mature markets involving conductive ink printed for heating elements, membrane keyboards, flex connectors etc.

2010 sees the first commercial products involving the new flexible thin film transistor chemistries – from Plastic Logic for their Que e-reader using organic semiconductors and from Kovio that print nano-silicon onto stainless steel. This is the first commercialization of such chemistries despite over 500 organizations (academic and commercial) active in developing printed/flexible transistors. Like many other early stage technologies, both these companies, and many others in printed electronics that have been commercially successfully so far, have moved from the left of the value chain, i.e. being involved in materials supply, to the right, selling complete products. IDTechEx see the value chain as follows. The percentages shown are the number of companies involved in each part, according to the IDTechEx Printed Electronics Suppliers database.

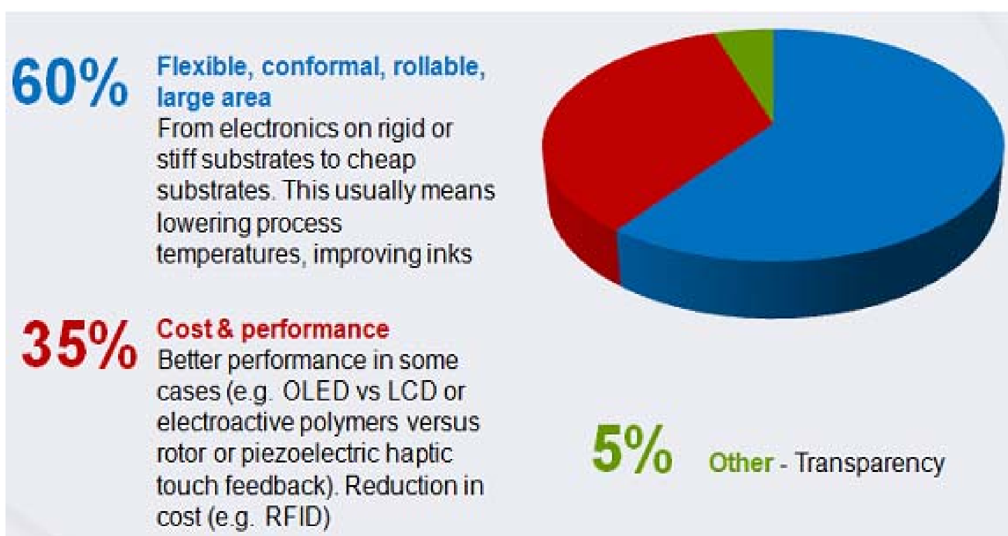
As with most other embryonic technologies, this industry is also very fragmented and there is an opportunity for consolidation. There has already been some shakeout in OLEDs over the last decade and more recently in organic semiconductors, but few are putting together complimentary technologies to build a strong value chain proposition. Companies in East Asia have been shrewd in consolidating some of the displays business, such as PVI, Sumitomo and LG.



Source: IDTechEx

The value chain chart above highlights several areas of undersupply. Almost by default developers, in the main, look to replace existing electronics or devices with the new electronics that they are creating. That is proving tough given issues with yield, R&D cost that needs to be recuperated and low starting volumes. The old silicon rules such as Moore's law may not apply here – many companies today are capable of cheaply making transistor circuits with a handful of transistors – but who is exploring the useful products that can be made that incorporate a dozen transistors? High volumes can only be created with modularity and basic building blocks – but this does not necessarily mean mimicking silicon ones.

Biggest driver is form factor: More so than cost or performance, IDTechEx research finds that the biggest driver of printed electronics is form factor – devices that are flexible, conformal, rollable or large area. In most of these cases, here the electronics are doing something that conventional electronics cannot do or struggle to do, and therefore are usually creating new markets. Competing on cost alone is difficult – many aspects of printed/flexible electronics promise to eventually be cheaper but can often start off at a higher cost base than the incumbent technology until manufacturing volume becomes significant.



Source: IDTechEx

In 2020, IDTechEx forecast the markets to be as shown below, with the value of the market that is predominately printed or predominately flexible also indicated.

So far, role models of success are companies such as T-ink that have used silver ink (where silver ink is in oversupply if we look at the number of suppliers versus demand) on 10 million McDonalds place mats, for example, or Power Paper that has created a cosmetic product using its thin flexible battery that is conformal to the body. Increasingly IDTechEx is asked by major consumer goods brands, consumer electronics and media companies for demonstrators of what the new printed/flexible electronics can do but it is surprisingly difficult to locate many. Over the next few years perhaps one indicator of success of the industry is the number of new demonstrators and products that are launched.

2020 Forecast Source: IDTechEx	**83% Mainly Printed**	**75% Flexible**
OLED $19 billion	30% (Displays) 97% (Lighting)	25% (Displays) 90% (Lighting)
Photovoltaics $17 billion (Excluding CdTe and Conventional Silicon)	85%	70%
Other inks: $2 billion	100%	85%
Sensors: $1.6 billion	98%	70%
E-paper displays $6 billion	100%	90%
Inorganic Electroluminescent displays $0.4 billion	100%	99%
Logic and memory $8 billion	90%	90%

Mission of the FlexTech Alliance

The FlexTech Alliance is the only organization headquartered in North America exclusively devoted to fostering the growth, profitability and success of the electronic display and flexible, printed electronics supply chain. Leveraging its rich history in promoting the display industry as the U.S. Display Consortium, the FlexTech Alliance offers expanded collaboration between and among industry, academia, and research organizations for advancing displays and flexible, printed electronics from R&D to commercialization.

1. To advance the growth, profitability and success throughout the flexible, printed electronics and displays manufacturing and distribution chain
2. To facilitate collaboration between and among industry, academia, and research organizations to share practical experience and develop solutions for advancing flexible, printed electronics and displays from R&D to commercialization
3. To foster development of the supply chain required to support a world-class, manufacturing capability for flexible, printed electronics and displays

FlexTech Alliance for Displays & Flexible, Printed Electronics

ALD Thin Films for Flexible Electronics

An Application Primer

by Eric W. Deguns

Eric Deguns is a Senior Research Scientist at Cambridge NanoTech. Eric received his PhD in inorganic chemistry from the University of California – Santa Barbara by characterizing surface species created from the deposition of volatile inorganics. He is currently a member of the technical team at Cambridge NanoTech, developing new ALD processes and conducting applied research. As the leading provider of Atomic Layer Deposition (ALD) solutions, Cambridge NanoTech has over 165 ALD systems installed worldwide. Cambridge NanoTech applies its expertise to solve unique coating challenges by collaborating on breakthrough research with customers and by offering next-generation thermal, plasma-enhanced and large-area ALD systems.

Executive Summary: Atomic layer deposition (ALD) is a low-cost, thin-film deposition technique capable of depositing flexible, multifunctional materials at low deposition temperatures. As these materials have useful electrical, optical and encapsulation properties, ALD is perfectly suited for integration into flexible electronics, displays and sensors.

ALD was first commercialized by Planar for thin film electroluminescent displays and has since been adopted into major technologies including as read/write heads in hard disk drives, DRAM trench capacitors and for high-k dielectric layers in microprocessor fabrication. Due to the superior properties of deposited films and the unique deposition process, ALD films are also ideally suited for incorporation into flexible displays, bio-sensors and organic/printed electronics. In this short article, an overview of the ALD deposition process will be given along with a summary of the manufacturing considerations and applications relevant to flexible electronics and displays fabrication, particularly those with modest deposition temperatures (i.e. under 200°C).

Principles and Properties of ALD Films: ALD is based on sequential surface reactions. Films are deposited by sequentially pulsing appropriate precursor material into the ALD reaction chamber, with purge cycles of an inert gas interspersed between precursor pulses. A key element of the deposition is the self-limiting nature of the process that allows repeatable monolayer-by-monolayer growth. Because of this unique reaction mechanism, films deposited via atomic layer deposition method have several unique benefits:

- Ability to coat inside pores, trenches and high aspect ratio features.
- Digital thickness control to atomic level since the film is deposited one atomic layer at a time.
- Pinhole free films, even over very large areas. Low defect density.
- Near 100% film density guarantees ideal material properties (n, Ebd, k, etc).
- Excellent repeatability (wide process windows: ALD is not typically sensitive to temperature or precursor dose variations).
- Ability to deposit films at low deposition temperatures, typically under 200°C
- Digital control of sandwiches, hetero-structures, nano-laminates, mixed oxides, graded index layers and doping.

ALD films have excellent adhesion as chemical bonds are directly formed with the substrate during the deposition process. ALD films exhibit high density, a low number of defects and have low stress due to molecular self-assembly during the deposition process. This allows ALD films be bent, flexed or twisted without cracking or delamination. [See for example: *Applied Phys. Lett*. 2006, *88*, 051907][1]

ALD Process Sequence: The general reaction sequence can be described in four steps. This can be best illustrated by examining the growth of alumina (Al_2O_3) using trimethylaluminum $Al(CH_3)_3$ and water, Figure 1.

- *Introduction and adsorption of the first precursor.* Precursor A, trimethylaluminum reacts with hydroxyl groups on the surface of the substrate, liberating methane. The reaction is self-limiting as the precursor does not further react adsorbed aluminum species.

- *Removal of the un-reacted precursor and reaction products via purge or evacuation*. Un-reacted precursor and gaseous methane (CH_4) liberated from the reaction are removed.
- *Exposure of the second precursor – or another treatment (such as plasma) to activate the surface again for the reaction of the first precursor*. Water reacts with the dangling methyl groups on the deposited aluminum atoms forming both Al-O-Al bridges, as well as new hydroxyl groups. The formation of hydroxyl groups readies the surface for the acceptance of the next layer of aluminum atoms.
- *Removal of the un-reacted precursor and reaction products via purge or evacuation*.

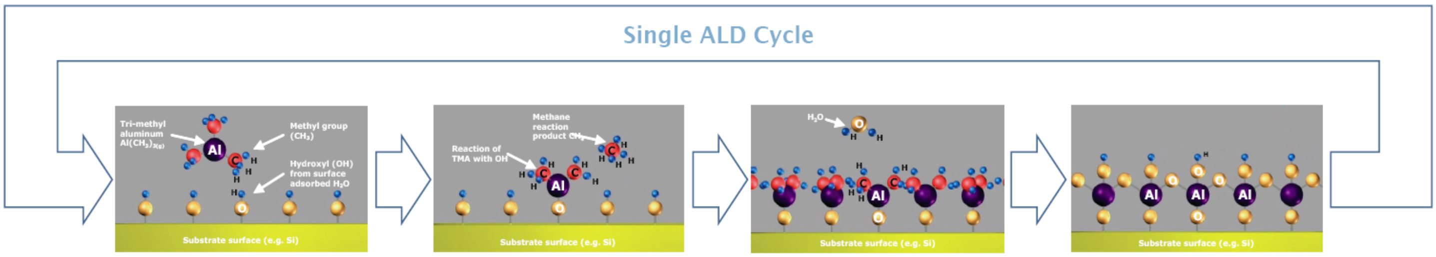


Figure 1: Sequence of ALD deposition of Al_2O_3.

The most common ALD films are oxides, but sulfides, phosphides, nitrides and metals can also be deposited, the latter two classes typically requiring temperatures above 200°C.

Film compositions: ALD offers unique options for creating films which are doped, graded or deposited in a nano-laminate of thin layers of different materials. Precise control of the level of doping of the material is achieved by simply substituting one of the precursor cycles with a dopant precursor cycle. Due to the self-limiting surface saturation, the dopant is uniformly incorporated into the film, without the need for post-deposition activation or annealing. Nano-laminates are easily deposited with ALD, in that stacks of specific thickness of material B can be layered between stacks of material A. This is particularly useful for preventing crystallization of materials by depositing layers smaller than the minimum grain size.

Similarly, graded materials are possible with as the relative amount of material A versus B is changed over the thickness of the film by simple change of the recipe. A practical example of a graded film would be one that changes from conducting to insulating. The advantages of depositing a bi-functional film without the need for a separate process step are clear. As well, a wide variety of materials and properties can be quickly explored without the need for custom targets or changing deposition temperatures, otherwise required for sputtering, evaporation or CVD methods.

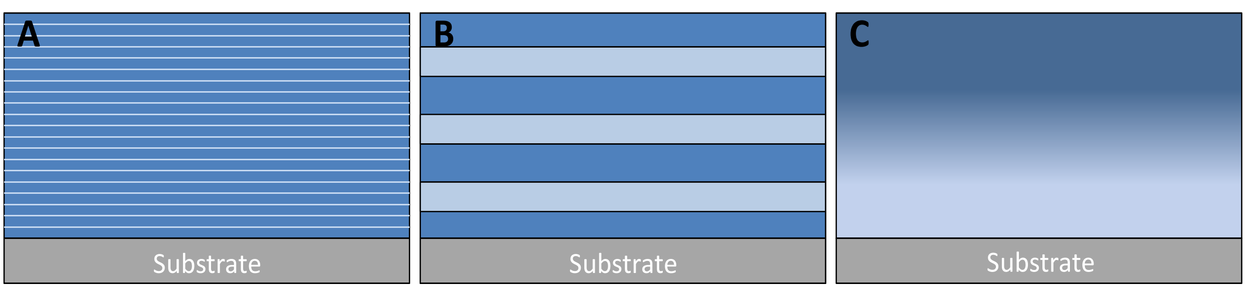


Figure 2: Profile of film compositions readily deposited with ALD: a) doped films; b) nano-laminates of two materials; c) graded film gradually varying from one material to another.

Organic-Inorganic Composites: Because of the nature of the surface reactions that occur during atomic layer deposition, ALD films can be successfully deposited on almost any substrate. ALD films have been deposited on top of flexible integrated circuits with challenging substrates/morphologies including polymers (PEN, PES, P3BT, etc.), organics (dye sensitized solar cells, porphyrns, etc.), carbon nanotubes and graphene, indicating the enormous potential of ALD as a functionalization technique. Generally, it is difficult to merge inorganics with organics/polymers as the deposition temperature is usually higher than thermal budget of the organic or T_g

of the polymer. Though dictated by precursor volatility and reactivity, most ALD process exist below 250°C with many below the T_g of common polymers (<150°C).

Adding inorganic components to organic structures and polymers serves to both increase the mechanical strength as well as protecting the polymer from damage from external sources. As ALD films do not suffer from line-of-sight or shadowing issues, films can completely infiltrate high-aspect ratio features or irregular topographies. Recent work has shown that modification of organic spider silk polymer with ALD coatings increases the carrying weight of the fibers up to four times and makes each strand up to 10 times more resistant to breakage [*Science* 2009, *324*, 388].[2]

Though ALD uses reactive precursors which can cause damage to organic substrates, several strategies exist for preventing such degradation. These include pre-treating the surface with alcohols or short hydrocarbons in order to prevent the precursors from deactivating double-bonds in luminescent, charge transfer or photonic dyes. Alterations to the precursor chemistry also afford great control over the reactivity and can preclude potential damage caused by the deposition. In most cases, any alteration of the organic component is minimal and is outweighed by the enhancement of the device functionality.

Applications: The drive towards low-cost electronics has spawned the use of organic materials as replacements for high-cost, metallic or rare-earth inorganic films traditionally used in the microelectronics and display industries. However, such inorganic materials are not as sensitive to damage or degradation that most organic components exhibit. Therefore, merging organic with inorganic components can serve to improve reliability and promote the early adoption of these novel processing steps. ALD is one such method to merge organics with inorganic materials. Several key applications, such as the use of ALD films for packaging, optical and electronic layers, have been demonstrated and will be briefly overviewed below.

Encapsulation/Moisture barriers: ALD films are deposited without cracks or pinholes making them excellent encapsulation layers. Research has shown that as little as 30nm of ALD Al_2O_3 is effective for preventing the degradation of OLEDs and organic solar cells. Organic electronics packaged with ALD films exhibit operating lifetimes of years, instead of seconds in their uncoated forms. Research has shown that nano-laminates, of ZrO_2-Al_2O_3 [*Advanced Materials* 2009, *21*, 1845][3] or HfO_2-Al_2O_3 [*Organic Electronics* 2009, *10*, 1300][4] are exceedingly effective at precluding the transmission of water and oxygen into organic electronic devices. These nano-laminates exhibit water-vapor transmission (WVTR) rates of down to 10^{-6} g-cm·day, near the value repeatedly implicated as necessary for organic electronics packaging. Such films are superior to paralyene, resin or thin glass layer encapsulation as they are not prone to pinholes or voids which can occur during the deposition or bonding process.

Surface passivation / optical layers: Thin films of Al_2O_3 act as excellent charge-recombination barriers and passivate surface defects on dye-sensitized solar cells even after the first complete ALD cycle [*J. Phys. Chem. C*. 2008, *112*, 19756][5]. Due to the ability to readily deposit nano-laminates or doped mater, finely tuned optical filters can be created with thin ALD films, enabling increased efficiency in multi-junction solar cells. Alumina ALD films can as a hole injection layer, greatly enhancing the performance of OLEDS, doubling luminous efficiency of devices. As well, films as thin as 10 Å act also have been shown to preventing the electroluminescent layer degradation during patterning/photo-lithography [*Organic Electronics* 2008, *9*, 667][6].

Dielectric/capping layers: When properly deposited ALD films form superior interfaces (minimizing interfacial layers), possess few impurities and exhibit a low number of defects making them ideal dielectric films. The low deposition temperature possible with many ALD oxides has enabled them to be used for dielectric layers in flexible and organic transistors, Table 1. For instance, ALD hafnium oxide has been used extensively for device integration of printed and organic electronics, Figure 3. HfO_2 films retain high capacitance and enable the use of low voltages, which are required in order to preclude the premature breakdown of organic components from high voltages. Work continues by us and others to explore binary and ternary combinations of ALD films in order to optimize the electrical properties of such films: un-doped TiO_2 and Ta_2O_5 can have high dielectric constants, but are inherently leaky and show little promise alone. Nevertheless, addition of these materials into other films, such as Al_2O_3, can greatly improve the dielectric constant and breakdown voltage.

ALD Film	Min. Practical Deposition Temperature °C	Dielectric Constant (*k*)
Al_2O_3	>25	6-9
SiO_2	>100	3.9
HfO_2	>80	>15
TiO_2*	>80	>20
Ta_2O_5	>100	>22
ZrO_2	>80	>14

* Deposition using titanium tetraisopropoxide, $Ti(O^iPr)_4$ and water.

Table 1: Dielectric constants for several ALD films capable of deposition under 150°C

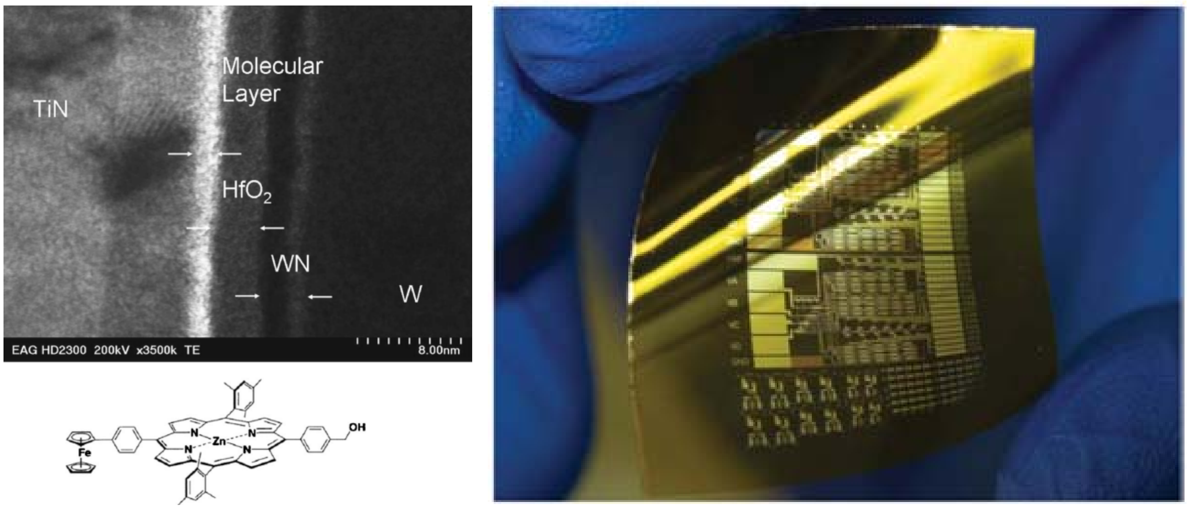


Figure 3: Devices integrated with ALD HfO_2 dielectric: (top) Metal-Insulator-Molecule-Metal (MIMM) devices using Zn-phorpyrins. [Applied Phys. Lett. 2007, 91, 173111][7]; (bottom) Flexible integrated circuits based on carbon-nanotubes [Nature 2008, 454, 495][8].

Transparent conducting oxides (TCOs). Transparent conductors are required for almost all applications in flexible displays, plastic and organic based electronics. Inorganic options can be appealing due their stability and robustness compared to organic counterparts. While ALD can deposit the industry standard TCO, Indium-tin oxide (ITO) with low resistivity (down to 3 X 10^{-4} Ωcm), the process window is above 200°C, limiting its use for organic electronics. A more cost-effective and attractive choice is ZnO. Zinc oxide is a multi-functional material and can be readily deposited even at room temperature. The electronic and optical properties can be finely controlled via doping with common ALD materials (including Al, Hf, Zr, Sn, etc.) using water as the oxidant. This enables materials with resistivities spanning four orders of magnitudes (down to 10^{-3} Ωcm) depending on the film thickness and doping concentration. Optically, doped ZnO thin films have transmissions of >90% for the majority of the UV spectrum when under 50 nm thick. Choice and concentration of the dopants also allow for further tuning of the optical band-gap and transparency at different wavelengths.

Deposition Considerations for Manufacturing: Enormous potential exists for the development of ALD processes for large-scale manufacturing. The superior features of films generated in research settings can be quickly reproduced over substrates with a large area. That is, ALD processes scale extremely well from research to batch type systems without a degradation or change in film properties. Once the ALD window for a process has been established, films reproducibly give outstanding thickness uniformity even over the largest area substrates.

As ALD is relatively insensitive to precursor flux and temperature, the relative simplicity of a production tool (when properly designed!) can translate to greatly reduced capital cost, maintenance frequencies and low cost per unit compared to traditional thin film deposition tools. Current large-scale batch ALD systems accept substrates of over square meter in size and can hold multiple substrates via stacking for high-throughput.

Figure 4 (left); research scale ALD system (200mm diameter reactor) integrated into MBraun glovebox; (right) dual-chamber batch production ALD system.

Ideal ALD precursors, such as trimethylaluminum (TMA) for Al_2O_3 and diethylzinc (DEZn) for ZnO have characteristics of being both highly reactive and highly volatile (with vapor pressures of >8 and >15 torr respectively, at room temperature). After coming in contact with the substrate, the surface reaction is nearly instantaneous. These properties can be exploited for practical purposes in manufacturing, including the ability to run processes at or near atmospheric pressures, eliminating the need for high-vacuum systems. Purging excess precursor and reaction byproducts is required before the introduction of the second precursor. The purity of the inert purging gas is dependant both on the precursors and the application (e.g. as TMA does not react with oxygen, sufficiently dry air is acceptable as a purging gas). These features allow for the development of technologies capable of performing continuous depositions on linear substrates. Indeed, roll-to-roll ALD systems are under development by several ALD equipment manufacturers, including Cambridge NanoTech.

Summary: Research into flexible and organic electronics is illuminating a path towards ubiquitous access to technology due to their low cost and increased performance and functionality. Atomic layer deposition is an enabling technology which can help to bridge the gap between cutting edge research and practical implementation of such novel devices.

[1] http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=APPLAB000088000005051907000001&idtype=cvips&gifs=yes&ref=no
[2] http://www.sciencemag.org/cgi/content/abstract/324/5926/488
[3] http://dx.doi.org/10.1002/adma.200803440
[4] http://dx.doi.org/10.1016/j.orgel.2009.07.008
[5] http://dx.doi.org/10.1021/jp807395g
[6] http://dx.doi.org/10.1016/j.orgel.2008.04.009
[7] http://dx.doi.org/10.1063/1.2800824
[8] http://dx.doi.org/10.1038/nature07110

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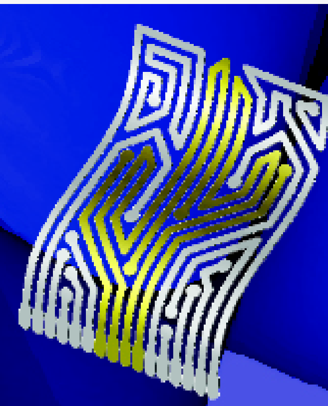

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A Discussion About Printable OLEDs

Interview with Matt Wilkinson from Add-Vision

Matt Wilkinson has served as Add-Vision's President & CEO since 2001, and is a co-founder of Add-Vision's P-OLED display business. Mr. Wilkinson directs the company's strategic direction and focus and manages all aspects of corporate planning. With over 10 years of experience in flexible display technologies, Mr. Wilkinson is one of the earliest pioneers in flexible printed P-OLED display technology for the low-resolution display and specialty lighting markets. Prior to Add-Vision, Mr. Wilkinson had successful engagements in the telecommunications and disk drive industries, and brings over 20 years of experience in Research & Development, New Production Introduction, and Operations Management. Mr. Wilkinson is co-author of several patents in printed flexible OLEDs and displays, and is a graduate in Physics from the University of California, Santa Cruz.

Please give us some background information about Add-Vision. Add-Vision's mission has always been to develop low-cost, flexible light emissive displays. Prior commercial experience in thick film, phosphor EL, keenly demonstrated the need for a new, higher performing technology platform that retained the same attractive manufacturing model and physical characteristics (thin, flexible, patternable). Our goal is to pick up where EL left off as well as enabling new market opportunity for fully printable, flexible, low cost LED's. It has never been our desire or intent to compete in the mainstream, high information content marketplace, but instead to develop and offer a solution for cost-effective, high-performance backlights, low information content displays, and specialty lighting. Applications include, smartcards or gift cards, promotional products, games and toys, consumer electronic devices, signage, white goods, and automotive. Add-Vision is a small company that has developed a unique IP portfolio consisting of process, materials (inks) and device structure. Our business model is to license our technology to manufacturing companies and sell our proprietary light emitting polymer (LEP) inks and cathode inks. Today we have licensed four companies including Alps Electric ($6B), Toppan Forms ($2B), Bayer Material Science ($15B), and CDT (Sumitomo Chemical).

Give us a short primer on Add-Vision's technology. A key characteristic of Add-Vision's technology is our fully printable, manufacturing process. There are no vacuum deposition processes; every layer of our simple three layer device is printed under normal atmospheric conditions. In order to achieve our low cost model, we required that the deposition of each layer of the device be accomplished with, fundamentally, ordinary printing equipment using standard methods. This required significant materials development, namely special LEP inks and cathode materials. In a standard OLED device careful selection of the electrodes is required in order to achieve efficient charge injection into the semiconducting polymer. In the case of the cathode this requires a low work function metal. The low work function cathodes in the standard OLED device are non-air stable and are deposited by vacuum deposition. Furthermore, the instability of cathodes make devices made from plastic substrates impractical due to moisture and oxygen ingress which rapidly causes black spot formation due to oxidation of the cathode. While plastic barrier substrate technology is improving, defect rates are still too high, with web based (high volume) produced material, to achieve device lifetimes suitable for most products in the case of devices with non-air stable cathodes. Add-Vision's air stable cathode not only allows us to deposit or print the cathode using screen printing, gravure, or flexographic methods, but also reduces the moisture vapor transmission rate requirement of the plastic barrier substrate. The development of doped LEP inks enables the use of relatively high work function metal cathodes in our device. Add-Vision uses ionic dopants in the LEP layer to create, in situ, a P-i-N device structure. This device technology is also known as electrochemical cell from the early work done by Dr. Alan Heeger and others at Uniax. Historically,

challenges with the electrochemical cell approach have included short lifetimes and long turn on time. Add-Vision has developed proprietary inks and simple device structure that has resulted in devices with lifetimes exceeding 10,000 hours (with 100Cd/m2 peak brightness) and turn-on times <0.5 sec. (Note: don't confuse "turn on time" with switching speed; switching speed is fast <<1msec, turn-on time in this case refers to "initial" turn on after the device has been off for >24hrs). This performance level exceeds most of our initial application requirements. A significant manufacturing cost advantage is a result of the very low cost tool set required to make Add-Vision's displays. In the case of the other display technologies, depreciation of capital equipment is a major cost adder to final cost of the display. In Add-Vision's case, the cost adder of depreciation of capital equipment is quite small.

Tell us about the nature of your relationship with CDT and now Sumation. Add-Vision has a very close and important relationship with CDT and Sumation. CDT/Sumation is now a shareholder, development partner, licensor, and supplier to Add-Vision. Our relationship with CDT began prior to the acquisition of CDT by Sumitomo chemical. In 2005 Add-Vision entered into a license agreement with CDT and CDT became a major shareholder of Add-Vision. In recent years Sumation has supported Add-Vision's effort by developing custom light emitting polymers suitable only for Add-Vision's unique device structure which has resulted in very impressive device performance.

In an interview we did about 3 years ago, in response to the question "Please tell us what you anticipate Add-Vision will look like as a company three years from now", you advised:

> *"Add-Vision wants to establish itself as the leading provider of flexible P-OLED display technology to the low-resolution display and specialty lighting markets. In three years, Add-Vision will continue to build out its IP portfolio and transfer this know-how to a growing base of manufacturing partners. In three years, Add-Vision will have validated the capabilities of the technology by having several manufacturing companies shipping products in high volume".*

- **First of all, have you been successful in meeting your goals from three years ago?** Yes, in many ways, with a significant exception; mass production and large scale commercialization has yet to be realized. Add-Vision has indeed established itself as the development leader in low-cost, flexible, P-OLED display technology in our target markets. Our IP position and technology has progressed impressively – in some cases beyond our expectations. While we have not yet seen large scale commercialization, we do have three licensees that are very active in process development, scaling activities driving towards commercialization.
- **Secondly, what have proven to be the biggest challenges for you in terms of bringing your technology to full commercialization?** Our major challenges have included material supply (specifically barrier/ITO coated plastic substrates), yields, process control, material utilization and a very difficult global economy. We are working very hard to overcome manufacturing issues and are now seeing good progress through the development of improved ink deposition techniques. These efforts have resulted in improved yields, higher quality and reduce cost. We have also put a lot of effort into developing our supply base and materials. As a technology developer, licensor and supplier of inks (and not a manufacture of displays) our commercial success is gated by our manufacturing (licensee's) rate of manufacturing and business development.
- **Lastly, what are you planning to focus on for the next three years?** Commercialization: scaling, process development, supply chain development, device qualification in expanded markets.

In the past couple of years, the focus of many OLED manufacturers seems to have shifted from producing high-information content displays to producing relatively low-information content displays, (including single-pixel solid state lighting solutions). Does this shift validate Add-Vision's original market position, or does it bring undue competition for what are still rather small, niche markets? At a very early stage I realized the incredible challenge for a new display technology to displace very strong incumbent technologies. I do not see competition as a problem for Add-Vision at this point in time. Add-Vision has a very unique technology approach and is very far ahead of would-be competitors. That said, we would be naïve to believe there is no competition or that no competition will emerge as we become successful in our markets.

Since the OLED folks now seem intent on looking at low-information content solutions are you looking at all towards moving your P-OLED technology to higher information content levels? Not at this time. Our focus and plan remains primarily the same. There is a huge untapped market opportunity in low information content displays and our challenge is to resolve the handful of remaining issues that stand between us and commercialization.

Do you remain focused on deploying your technology strictly through a licensing model, or are you also considering ways to manufacture on your own? We are still primarily focused on a licensing/ink supply business model. However, we have not closed the door on the possibility of manufacturing. While manufacturing has its own set of challenges and capital requirements, I have at times wished that we had pursued this model at an early stage so as to eliminate the complexities of working with large multinational companies as our manufacturing partners. It may have been easier to commercialize sooner had we chosen to manufacture ourselves.

What sort of financial investment will it take for you or one of your licensees to bring up a production line? The equipment capital expense for a Gen 1 manufacturing line is between $1 and $2 million depending on scale and trade-offs between manual and automated processes. A production line of that scale would be capable of producing at least 2,000 m^2 per month on a single shift.

Three years ago, you indicated that it would cost approximately $0.26/in^2 for the material and production of one of your displays. What's happened to material/manufacturing costs in the interim? Our cost model has changed over the years as we have developed the materials and process but the net effect has resulted in little change to the cost of goods (material and labor) to produce our displays. We have much greater confidence in our cost model as our supply chain has matured and process/labor modeling has been verified by our manufacturing partners. There is some variation in the cost to produce displays related to the color (LEP type). For example, at this time, white emissive displays are slightly more expensive than yellow.

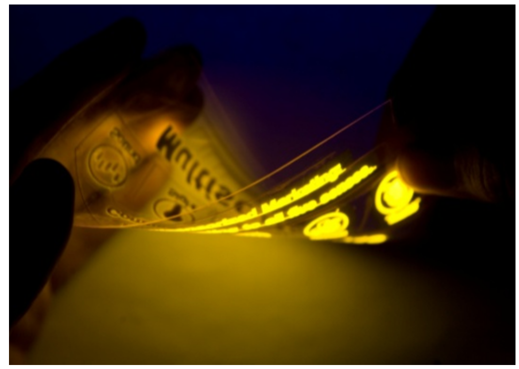
Is there one particular technological bugaboo that keeps you awake at night – something that would really help you to better commercialize your technology? I have some concern about the availability and quality of barrier coated plastic substrates in high volume While we are working closely with developers/suppliers of these films, and they are making very good progress, it remains a open question as to how the suppliers can guarantee a certain moister vapor transmission rate over 100% of 1,000 meter roll for example. Test methods are slow and can only be done on a very limited sample basis. It will take time and a lot of production, based on the available statistics, to have assurance the films meet spec. In the mean time we are at risk – not knowing if the film is good (with an acceptable level of defects) until displays are aged in the field. On a non-technical note, a more robust economy would help – that keeps me up at night!

Can you tell us about a couple of your favorite commercial implementations of your technology? Near-term favorite application concepts are in promotional products and premium packaging. Midterm applications include handheld consumer electronic devices. Our display technology brings unique value to these applications by its thinness, flexibility, pattern ability, and low cost.

Do you have any preferences as to what substrate materials are used with your technology, or can you print on most anything? We currently use barrier coated PET or PEN in varying thicknesses ranging from .002" to .007". There are some advantages to PEN, however we prefer the lower cost PET material. There are a number of companies developing barrier coated flexible films however, there are only a very few that have scaled manufacturing capability and can deliver reasonable quality consistently.

Do you develop and manufacture your own inks? We have developed our inks in house and we manufacture all of our LEP inks in-house. We work with a supplier under a special agreement to manufacture our cathode ink. As volumes increase we have arranged for our inks to be made by contract suppliers and drop-shipped with an Add-Vision label directly to our customers. The suppliers have the infrastructure and controls to meet global industry quality standards and distribution requirements.

Tell us about the lifetimes of your displays; are today's barrier technologies adequately keeping your displays alive? Our best "constant on" display lifetimes now exceed 10,000 hours. Shelf-life or total product life of our displays is greater than two years, approaching three, and is limited by the overall quality/capability of the encapsulation system which includes a transparent barrier plastic film, adhesives, getters, and other barrier films. Add-Vision's displays will degrade in the presence of oxygen or moisture but only when turned on (i.e. a voltage is applied). This is not true for standard OLED which degrade even in the off state due to the non-air stable cathode materials. Add-Vision has developed a relatively simple and process friendly encapsulation material set and process. Moisture and oxygen may enter the device package from pinhole defects in the transparent barrier film or from the edge by propagating through the adhesive layer. In order to extend our display shelf life, we will need to see increased quality of the barrier films as well as better moisture barrier properties of adhesives. We are working closely with the developers and suppliers of these materials to improve overall performance of our devices. Fortunately, there numerous near-term market opportunities for applications where a two-to-three year shelf life (or product life) is sufficient.



Any limitations regarding the size of the display? Fundamentally no, with the exception of limitations related to the resistivity of ITO without the use of buss bars. This may limit the size of any one individual pixel but not the total display size. In practice, the size of display is limited to the substrate size availability and capability of the printing and other handling equipment. We are currently focused on developing an A4 scale process.

You have the ability to make displays into unusual shapes – how important is this to your customers? This is one of the key differentiators of our technology from displays on glass. The ability to arbitrarily shape and cingulated displays with simple low-cost die-cutting methods is very attractive and an important characteristic of our technology.

In addition to P-OLEDs, you have patents related to the screen printing of EL Polymer Inks. Is this an area where you are actively doing any work? Screen printing has been the workhorse of our device manufacturing process. While screen printing is a very cost efficient and suitable method for printing some of the materials used in our devices we have developed alternative printing processes for our LEP ink's that are faster, more efficient, produce better layer uniformity and have higher material usage (less ink waste). This has been a driver in reducing cost and improving device quality.

What market segments are you most excited about with regard to you your technology? That has not changed much over the years. We are still very excited about promotional products, handheld consumer devices, toys and games. We are continually approached with good application ideas from end customers that validate our plans and expectations.

As the head of a new-technology start-up company in the display industry, what is the single biggest bit of advice that you can offer other people hoping to penetrate this market?

- Nothing is ever as easy as it sounds.
- There is no low hanging fruit.
- Plan on many important tasks taking longer and costing more than you had expected.
- Cost is king.
- Be ready to move quickly when opportunity knocks, but don't get too far ahead of yourself.
- Make sure you understand the entire value/supply chain as well as the end customer needs.
- Be sure to know who your competition is and where your strengths and weaknesses are.

A FlexTech Alliance Special Report

Flexible Solid State Lighting:

Technology, Manufacturing and Market Assessment

Summary:

This report is a complete overview of the technologies and market opportunities for print-based, flexible, solid state lighting (SSL). With new SSL technologies, novel form factors can extend and expand lighting applications. It is in this space that print-based, flexible, SSL technologies are poised to enter and change the market place.

Experts agree that new lighting technologies are needed to promote energy efficiency and help reduce the emission of green house gases. Introduction of light emitting diode (LED) and organic LED (OLED) light sources can contribute to accomplishing these goals because of their high conversion efficiency of electricity to visible light.

The 329 page report contains charts, graphs, cost of ownership analyses and many other means to visually depict the flexible SSL market's characteristics and dynamics. Interestsed in the market for OLED lamps? Device architectures? Materials? Manufacturing, and conversion processes? Then this is the report for you.

Member Price: $1995
Non-Member Price: $2,495

Visit www.flextech.org to download the executive summary and table of contents.

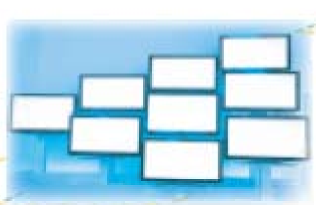
Report Features:

- The market opportunities for print-based lighting systems.
- How OLED devices manufactured for display applications need to be adapted for lighting applications.
- Identification and assessments of specific materials that meet the requirements for fabricating white OLEDs with high efficiency and long lifetimes.
- The manufacturing issues associated with producing cost effective light-emitting printed devices.
- Conversion operations required to turn a printed light-emitting structure into a product that can be sold to a consumer.

Produced and Distributed by:

FlexTech Alliance™
for Displays & Flexible, Printed Electronics





Summary of FlexTech's Quarterly Workshop
on Flexible, Printed Electronics
SEMI, San Jose, California
October 22, 2009

Experts Cite Need for Improved In-line Inspection and Failure Analysis Tools

by Paula Doe

Paula Doe does emerging technology programs and content for the micro-manufacturing trade association SEMI. She also works for the market research firm Yole Developpement, and previously tracked semiconductor and related technologies for PennWell's Solid StateTechnology and WaferNews, and the electronic materials market research firm Rose Associates.

The market for printed and flexible electronics was $500M-$600M in 2009, according to Paul Markowitz of NanoMarkets, potentially exploding to a multi-billion dollar market within a few years, once some technical issues get resolved. This was the analysis delivered to printed electronics makers and their suppliers at the October 2009 FlexTech Alliance quarterly workshop, hosted by Semiconductor Equipment and Materials International (SEMI) in San Jose, Calif.

The workshop highlighted the need for in-line inspection and failure analysis tools, and standard testing protocols, to move printed electronics products into volume production. Suppliers also stressed the need for workshops or roadmaps to communicate clear and common target specifications for barrier and encapsulation films, so they can focus their development effort on the right features for real markets.

Markowitz puts the flexible/printed market at $569 million currently, and projects 50%-60% growth for the next couple of years. But once more of the technical issues get solved, growth will really take off and pass $6 billion in 2014. OLED lighting will be the first big application, as its specialty design applications for unique sheets of lighting will allow premium pricing. But sales of flexible PV, displays, and sensors will follow, with these four sectors all becoming roughly equal markets going forward. Displays will do well because the overall display market is so large that even small penetration for flexible units can mean big demand. On the other hand, costs for printed RFID will have to be so low that even billions of units may still add up to revenues of only tens of millions of dollars.

One key need is in-line real-time inspection tools, concluded Dan Gamota, principal of startup Printovate, Inc., and formerly director of Motorola's printed electronics effort. He and other producers of printed electronics products who spoke at the FlexTech workshop noted that rolls of flexible substrates and barrier films they were receiving from suppliers were not uniform enough for producing consistent results for their devices, as subtle difference in surface chemistry both within a roll and from roll to roll turn out to have significant impact on electronic performance. Current testing methods can't make these spatial distinctions, so the films may meet the specifications macroscopically, but not be uniform across all areas.

The sector is also aiming to start a collaborative effort on advancing understanding of failure mechanisms and yield killers in printed electronics, by specifying the common kinds and densities of defects that matter in its products, and then looking for what kinds of tools and solutions already exist in university labs and in other sectors, from the IC industry to the high speed film processing world. "Other industries may have already looked at these issues," noted Gamota, "and transferring solutions from those industries would probably be an easier option for bringing things over faster, since universities can take considerable time to develop tools." As chair of the large area flexible electronics section of the iNEMI electronics industry roadmap, he's looking for input from metrology suppliers in all sectors for the next edition.

Both users and suppliers argued that better testing standards and systems were also needed, including testing after integration and processing, not just on flat lab samples, as inks on the surface and rolling through presses change performance. Testing also needs to be done with conditions that reflect real conditions of product use, like flexing. Products for solar applications need to be tested under exposure to light and impure water spray, not just the typical heat and humidity. Some suggested a central standard testing lab would be useful for testing films, barriers and adhesives, since different labs tend to get different results even with the same test equipment without standard protocols.

Application/Substrate Properties			Smoothness	Barrier Properties	Optical Transparency	Dimensional Stability	Thermal Stability	Mechanical Strength/ Flexibility
RFID tag	Antenna		2	3	3	2	2	2
	Circuitry		1	2	3	1	2	2
OLEDs			1	1	DS	1	1	APS
Display Backplanes	Inorganic	Passive	2	3	DS	2	2	APS
		Active	1	2	DS	1	1	APS
	Organic	Active	1	1	DS	1	2	APS
Organic Photovoltaics			2	1	DS	2	1	2
Batteries			3	2	3	2	2	2

1 – very important, 2 – medium and 3 – less important,
APS – application and product specific and DS – design specific

iNEMI identifies substrate properties requirements depending on application

Key role for materials, starting with low-end and hybrid products: Most flexible electronics are currently made on metal foil, with heat-resistant foils accounting for 84% of the substrate market in 2010, stated Markowitz. He estimates that polymers will grow to 26% of the market by 2013, as processing temperatures come down, and other materials like paper and flexible glass will become a significant 20% portion by 2016.

Konarka presented about some of the applications for flexible organic photovoltaics

Advances in functional inks mean that simple, relatively low resolution electrical circuits can now be produced with existing off-the-shelf printing equipment with minor customization. These tools, however, are not easy to use for small volumes or prototyping.Like most radically new technologies, printed electronics are creeping into the industry around the edges. Most first applications are either hybrid approaches that combine new solution processes or organic materials with a more conventional electronics process flow, or very simple devices that do something not otherwise practical without unreasonable cost.

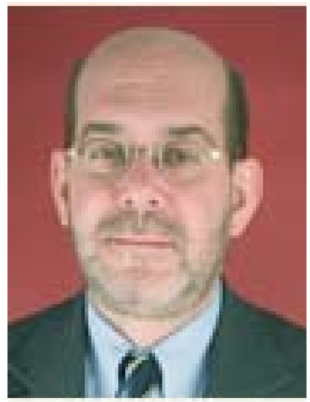
In one key application, flexible and solution processed photovoltaics have the potential to bring solar costs down low enough to be viable without government subsidies, but most printed or flexible products so far use hybrid solutions. Creative options include vacuum deposition on flexible substrates from Unisolar/Global Solar or solution-coating on flexible substrates covered with glass sheets for encapsulation from Nanosolar.

Partner update from the CAMM

CHA Industries high vacuum deposition system accepted at Binghamton University's CAMM for continuous web coating processes

Web Coater Built Under Development Contract to Flex Tech Alliance

by Mark Poliks



Mark Poliks is the Electronic Components and Technology Conference (ECTC) Materials/Processing Section Co-Chair, a Research Associate Professor at Binghamton University, Northeast Regional Program Chair for the American Chemical Society, Advisory Board Member of the Integrated Electronics Engineering Center (IEEC) and Technical Director of the Center for Advanced Microelectronics Manufacturing (CAMM). The CAMM was sponsored by the FlexTech Alliance and the ARL.

The Binghamton University based Center for Advanced Microelectronics Manufacturing (CAMM) and The Flex Tech Alliance, announced recently the acceptance of the CHA Industries Web Coater. The CAMM is an integral part of Binghamton University's New York State Center of Excellence in Small Scale Systems Integration and Packaging (S^3IP). The CAMM, a microelectronics manufacturing R&D center, is focused on the development of manufacturing technologies in a flexible, cost-reduced, roll-to-roll format. The CAMM was founded by Binghamton University in partnership with Endicott Interconnect Technologies and Cornell University, and has a growing number of partner companies from around the world.

CHA Industries was chosen by the Flex Tech Alliance to develop a knowledge base on the intricacies of web handling in a process tool. This partnership represents CHA's unique ability to customize design and engineering to fit unique application requirements, such as those specified by the Flex Tech Alliance. The $6M project was cost-shared between CHA, Flex Tech Alliance, and Binghamton University, using Army Research Laboratory funding that was appropriated to advance the capability of U.S. industry in the burgeoning flexible microelectronics market.

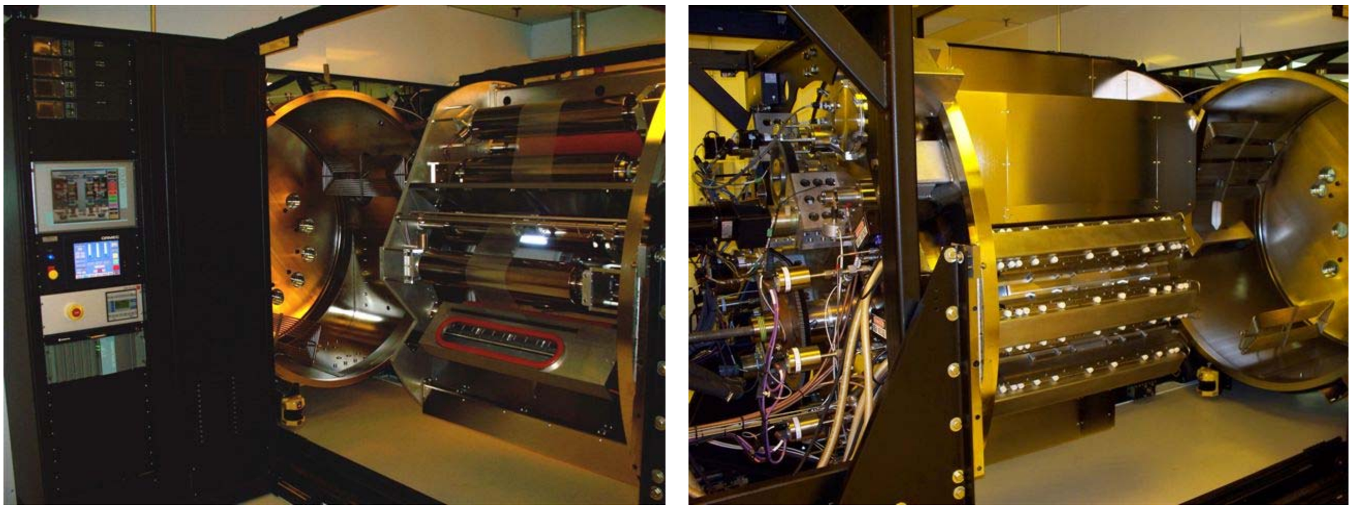
The web coater was built under contract to the Flex Tech Alliance, which is working with its member companies and the CAMM to commercialize flexible display technologies and other flexible electronics products for military and commercial applications. The contract commissioned CHA to develop and characterize a production web/roller coater to understand requirements and characteristics of handling plastic substrate films for the manufacturing of flexible electronics on a continuous web.

"The delivery, installation, testing and operation of the CHA high vacuum deposition system represent a major milestone in the capabilities at the CAMM. Many individuals made a long term commitment to make this happen; we especially thank Steve Kaplan and his talented technical team at CHA," stated Dr. Mark Poliks, Technical Director of the CAMM. "The combination of the CHA, the Azores photolithography tool and the Bobst/General Vacuum Optilab equipped with a variable temperature drum and an EITI linear plasma etch (RIE) source will create a truly unique resource for roll-to-roll fabrication of electronics.

"The CHA web coater, a unique, one-of-a kind system, will be an integral part of the CAMM's prototype line to develop process methods for manufacturing electronic components on a roll-to-roll basis," stated Dr. Peter Borgesen, Director of the CAMM. "We are excited to accept this tool from CHA Industries and the Flex Tech Alliance and to put it to use on behalf of our industrial partners and the academic R&D community to develop new applications across many application areas."

This three-phase project involved the following components: Phase I focused on a design stage evaluation to identify potential causes of defect generation prior to tool construction; Phase II (underway) included tool construction, testing and process development designed for sputter deposition of the necessary materials to fabricate TFTs and TFT precursors on a flexible web up to 24 inches wide; and Phase III will focus on future tool reconfiguration with an OLED source for testing film deposition in a Roll-to-Roll process.

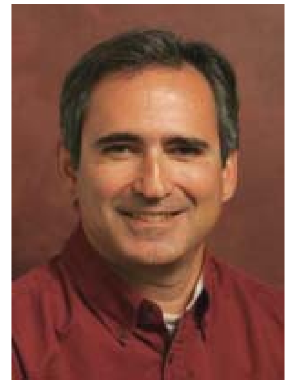
Process development work with the CHA's Al, Si and ITO targets is already well underway. Both sputter and reactive sputter is being used to make prototype semiconductor grade multilayer coatings on PET, PEN and PI films. These films will be used for a variety of applications including the fabrication of TFTs on unsupported flexible plastic films. The CAMM staff and its corporate members have created an aggressive plan to meet both short and long term objectives.



CHA's web coater for use at the CAMM

Partner update from the FDC

by Nicholas Colaneri, Center Director, Flexible Display Center



Nicholas (Nick) Colaneri, Ph.D. is the Flexible Display Center Director with primary responsibility for strategic vision, member recruitment, new business development, and funding acquisition. Nick has been involved in organic technologies since the discovery of polymer electroluminescence during his work as a Post Doctoral Research Assistant in Cambridge in 1989. He received his Ph.D. in Physics in 1987 from the University of California at Santa Barbara under the supervision of the 2000 Nobel Laureate in Chemistry, Professor Alan Heeger. Following post-doctoral research in the laboratories of Cavendish Professor Sir Richard Friend, FRS at Cambridge University, England, he became a founding employee of UNIAX Corporation in 1990. Over the following ten years, UNIAX became a global leader in the development of light emitting polymer technology. During that period, Nick served in a variety of technical and business roles, eventually being named Vice President of Business Development in 1998. He was a member of the executive team that arranged and completed the sale of UNIAX to the DuPont Corporation in 2000, and subsequently became Director of Strategic Planning for the DuPont Displays SBU until 2003.

Flexible Display Center at Arizona State University: The newest members at the FDC are the Printable Electronics Technology Center (PETEC), QD Vision, Sharp Laboratories of America, and dpiX. PETEC, a leading development center for printable electronics technologies with an extensive facility in the UK dedicated to the development and productization of printable and plastic electronics, will collaborate with the FDC on high-performing organic thin film transistors (OTFTs) for both reflective and emissive flexible display applications. QD Vision headquartered in Watertown, MA will be collaborating with the FDC to demonstrate an emissive display demonstrator. Collaboration with dipX located in Palo Alto CA will be in the area of transistor array test & repair and work with Sharp Labs will be in the area of higher performing transistor channel materials and flexible substrate processing.

The FDC and Universal Display, a charter FDC member since its founding in 2004, demonstrated a 4.1-in. monochrome quarter video graphics array (QVGA) amorphous-silicon (a-Si:H) PHOLED display on DuPont Teijin's polyethylene naphthalate (PEN) substrate early last year. Universal Display and FDC have now developed a new strategic relationship to demonstrate flexible OLED display prototypes with enhanced performance for the U.S. Army. The FDC will fabricate a-Si:H thin-film transistor (TFT) arrays on flexible plastic substrates using our low-temperature (low-T) backplane and proprietary bond-debond manufacturing technologies. Universal Display will then use its Universal PHOLED materials and technology to build full-color AMOLED displays. For prototypes to be delivered under an U.S. Army SBIR, the company will also use its proprietary encapsulation film technology to create permeation barriers on the display.

The FDC just completed the FY10 annual planning process with highest technical priorities to be mixed oxide TFT development, GEN II scale-up of bond-debond technology and GEN II scale production of reflective and emissive displays. Collaboration with HP in the area of alternate photolithography processing and flexible color filter arrays for reflective display technologies is also high on the list. FDC development of low-T transistor processes is also enabling the Center to develop a higher research profile and leverage other highly-successful ASU research programs to broaden our flexible electronics capabilities and integrate additional functionality on flexible substrates with projects to develop flexible imaging arrays, operational amplifiers and sensors, power conversion circuits, antennas, and solar applications.

ASU Flexible Display Center

News and news links from the FlexTech Alliance

excerpted from Veritas et Visus newsletters

Keith Rollins and Robert Tulis selected for FlexTech Alliance positions

Keith Rollins, Global Plastic Electronics Business Manager for DuPont Teijin Films has been elected to the FlexTech Alliance Governing Board. Robert W. Tulis has been appointed to the newly created position of Director of Technology and Business Development. Keith Rollins, a 25 year veteran of the chemicals industry, had previous assignments at Imperial Chemicals Industries (ICI), DuPont, and DuPont Teijin Films. http://www.flextech.org

FlexTech Alliance releases technical conference agenda for Flex 2010

The 2010 Flexible Electronics and Displays Conference & Exhibits is scheduled for February 1-4, 2010 at the Pointe Hilton Squaw Peak Resort in Phoenix, Arizona. 2010 conference will include 85+ presentations divided into 21 sessions with 3-6 speakers in each session. http://www.flexconference.org Among the hot session topics this year:

- End User Applications & Requirements: Procter & Gamble, MeadWestvaco, Avery Dennison, MC10
- Printed Electronics Processes & Technologies: Electrox, FUJIFILM Dimatix and Western Michigan U.
- Sensor Technology & Applications: DARPA, PARC, NextGen Aeronautics, IST, NanoSonic
- Energy Storage: Solicore, Paper Battery Co., BlueSpark Technologies
- Future Display Products & Applications: Touch Technologies, Kent Displays, BizWitz, JFMagic
- Market Analysis and Strategic Outlooks: PARC, ARL, NanoMarkets, IDTechEx, Lux Research
- *Plus many more…*

FlexTech Alliance awards contract to South Dakota School of Mines to develop materials registry

The FlexTech Alliance announced a contract award to the South Dakota School of Mines and Technology to create a user-friendly database for accessing technical information on functional materials. The registry will enable more timely, efficient and accurate selection of the most appropriate material-sets for flexible, printed electronics industry product developments and serve all manufacturing platforms. The project is being funded in response to an identified critical industry need for more reliable performance and applications data on the variety of materials used in flexible, printed, and organic electronics. http://sdmines.sdsmt.edu/sdsmt

QD Vision raises $10 million in financing

QD Vision, developer of Quantum Light nanotechnology-based products for solid state lighting and displays, announced it raised $10 million in financing from North Bridge Venture Partners, Highland Capital Partners and In-Q-Tel. This new round of funding will support the expansion of the first QD Vision Quantum Light products into the global solid-state lighting market, and continued advancements on a new generation of quantum dot-based LEDs and materials for high-resolution displays. Founded in 2004 by a research team from MIT, the financing brings to $30 million the total venture investment in QD Vision. Since announcing its first product earlier this year – a Quantum Light optic for a new LED lamp developed by Nexxus Lighting that combines the warmth and color of incandescent bulbs with the efficiency of LED technology – QD Vision has seen a significant increase in interest from the lighting and display industry in its quantum dot technology. The Nexxus lamp featuring the Quantum Light optic is scheduled to ship in Q1 of 2010. http://www.qdvision.com

Showa Denko and UDC announce OLED license agreement for white lighting applications

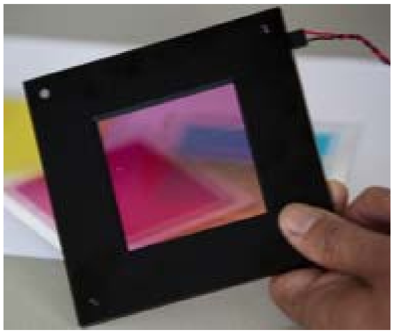
Showa Denko and Universal Display Corporation have signed an OLED Technology License Agreement. Under the agreement, Showa Denko will be able to integrate Universal Display's proprietary PHOLED phosphorescent and other OLED technologies into Showa Denko's white OLED lighting products fabricated by solution-processing methods. Showa Denko has been developing polymer-based white OLEDs for use with coating-type manufacturing equipment that may enable the cost-effective production of large-area lighting panels. http://www.universaldisplay.com http://www.sdk.co.jp

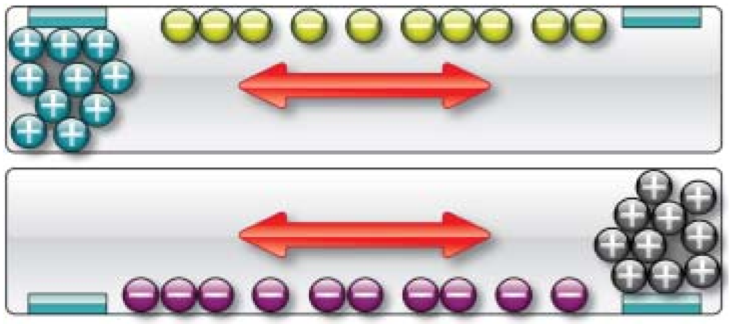
Liquavista receives strategic investment from Applied Materials

Liquavista announced that it has received a strategic investment by Applied Ventures, LLC, the venture capital arm of Applied Materials. The investment will enable Liquavista to further the commercialization of its unique display technology for future electronic products. Liquavista's technology offers a new type of paper-like display with vastly improved usability, content compatibility and cost comparisons. Aimed initially at the fast growing electronic reader market place, Liquavista's first active-matrix technology platform, LiquavistaBright, offers a unique combination of outstanding brightness and high contrast in all lighting conditions, coupled to an intrinsic video capability, excellent legibility and functional freedom. http://www.appliedmaterials.com

Philips introduces electronic skin technology

Philips Research developed a novel color e-paper technology that opens up new design opportunities for personalizing electronic devices. The technology has the potential to be used in the future for 'e-wallpapers' where users can adjust the color of the wall or smart windows to regulate the daylight coming through windows. Philips' technology allows different colors of ink to be built into one layer with each color controlled separately. This means the layer can be transparent, the same color as any one of the inks, or a mixture of multiple colors. Moreover, the saturation of each individual color can be controlled accurately – so any shade can be produced. In ambience-creation applications, reflective e-skins are the perfect complement to the emissive ambience-creation technologies that use LEDs and OLEDs to create colorful light. http://www.research.philips.com





Similar to paper, Philips e-skin has a paint-like appearance. A full-color e-skin could be created from two layers, each with two colors of ink. Here, only the yellow and magenta inks are showing making the pixel appear red.

Uni-Pixel announces first Opcuity film product roll out

Uni-Pixel announced the launch of its fingerprint resistant film as protective cover products for a variety of touch screen devices in collaboration with the Company's first licensee and business partner, Targus. Branded under the Targus name and introduced under the co-owned trademark of Clear View Technology, Uni-Pixel's Opcuity fingerprint resistant film (FPR) technology is being introduced as products for multiple touch-enabled devices. http://www.unipixel.com

DuPont Teijin Films joins Holst Centre research program on Systems-in-Foil

DuPont Teijin Films joined the Systems-in-Foil program of Holst Centre, a research initiative of the Flemish and Dutch research centers IMEC and TNO. By getting a major substrate vendor on board, Holst Centre gathers the entire ecosystem of industrial players around its Systems-in-Foil program line. The aim of this Holst Centre program is to design and optimize OLED device concepts and processes that are compatible with roll-to-roll fabrication for lighting and signage applications. By bringing together equipment and materials suppliers with system integrators and device manufacturers around a well-defined roadmap, interactions originate that would not be possible in a scenario where each party sticks to in-house R&D. http://www.holstcentre.com

Merck expands Advanced Technologies Center in UK

Merck KGaA inaugurated the expansion of its Advanced Technologies Center at Chilworth near Southampton, United Kingdom. For around ten years, the Chilworth site has served as a chemical research and technology center focusing on reactive liquid crystals, organic electronics and materials for flexible displays. Around three million Euros have been invested in technical facilities for research and product development. At the same time, up to 20 new jobs have been created for highly qualified scientists and technical experts in the fields of chemistry, physics, application technology and analysis. http://www.merck.de

AIXTRON participating in German OLED research project – So-Light

A new national R&D project has recently been started in Germany focusing on the development of OLED displays and lighting applications. AIXTRON will participate in this 14.7 million Euro project together with ten other partners with the target to strengthen Germany's leading position in the fast growing OLED market. Funded by the German Federal Ministry of Education and Research (BMBF) for a total period of three years, So-Light (Special organic Light) will focus on specific OLED applications, such as special lighting systems and displays. The technological focus will be on novel materials (transport materials, triplet emitter, redox dopants and matrix materials), improved optical systems and on process technologies for small molecule based OLEDs. As part of the latter element, AIXTRON will take the lead in this area through the optimization of its proprietary OVPD (Organic Vapor Phase Deposition) technology. Other project deliverables will be application studies and demonstrator devices for specific applications such as automotive or architectural lighting and backlights for large displays. AIXTRONs partners in the So-Light project are Novaled AG Dresden, Sensient Imaging Technologies GmbH, Westfälische Wilhelms University of Münster, Fraunhofer IPMS Dresden, Symboled GmbH, Fresnel Optics GmbH, Hella KGaA Hueck & Co, Siteco Beleuchtungstechnik GmbH, AEG-MIS mbH and the University of Paderborn. http://www.aixtron.com

Applied Materials, Merck and Braunschweig University Awarded Funding for OLED Research

Applied Materials, Merck, and the Braunschweig University of Technology (TU-BS) announced that they have been awarded a grant by Germany's Federal Ministry of Education and Research (BMBF) to develop processes to lower the cost of manufacturing OLED lighting for general illumination applications. Applied will spearhead the three-year project, named Light InLine (LILi), joining forces with Merck and TU-BS. Work on the LILi project will be centered at Applied Materials' advanced development facility in Alzenau, Germany. http://www.liliproject.com.

eMagin OLEDs enable Soldier Training Systems

OLED microdisplays from eMagin Corporation continue to enable new simulation and training systems. Attendees at this year's Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) were able to see eMagin's OLED-XL displays in prototype products at the booths of premier suppliers including Atlantic Cyberspace, Cubic Defense Applications, Drive Square Inc., Intelligent Decisions, Intevac Vision Systems, NVIS Inc., Quantum3D, Rockwell Collins, and Sensics. http://www.emagin.com

Vitex Systems expands barrier film development

Vitex Systems announced that it has expanded its thin-film barrier capability with the qualification of its new state of the art, 2nd generation deposition equipment. The new equipment will be located in Vitex's facility in San Jose and will allow the company to further enhance its moisture barrier film technology as well as service its customers. Vitex has also elected to join the Flexible Display Center located at Arizona State University (ASU) and to donate its previous generation tool to the Center. http://www.vitexsys.com

Energy Conversion Devices announces 3 Megawatt rooftop solar project in Spain

Energy Conversion Devices announced it has signed an agreement with Endesa in Spain to install 3.0 MWp of *UNI-SOLAR* photovoltaic (PV) laminates on the rooftops of two Coca-Cola Company buildings in Seville. Through its wholly owned subsidiary, United Solar Ovonic, ECD will oversee construction of the rooftop system, which will consist of *UNI-SOLAR* laminates bonded to the Giscosa waterproofing system and applied directly on the roofs. The completed system will be owned and managed by Endesa. Construction will be completed in the first half of calendar 2010. www.energyconversiondevices.com

Prime View and E Ink revise merger agreement

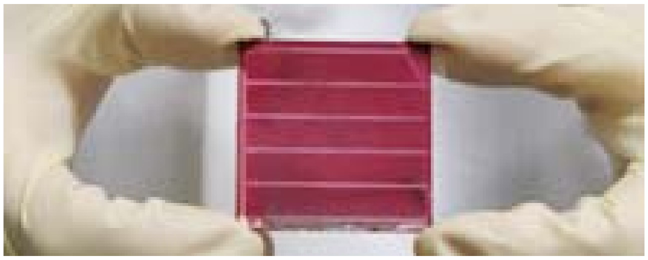
Prime View International announced in late September that it has amended its merger agreement with E Ink Corporation. In addition to the $215 million cash consideration unveiled on June 1, 2009, the revised agreement includes consideration for E Ink shareholders based on the combined company's stock performance over a three-year period. The consideration will be granted in the form of 120 million convertible preferred shares that can be converted into common shares as the stock climbs from NT$50 to NT$80. At the end of the three-year period, any unconverted preferred shares will be cancelled. http://www.eink.com

Unidym and Nano-C enter exclusive license agreement for Fullerene derivatives used in solar cells

Unidym announced that it has entered an exclusive license agreement with Nano-C for patents covering fullerene derivatives. The license provides Nano-C exclusive rights to U.S. Patent No. 5,739,376 and foreign counterparts in the field of photovoltaics. In recent years, researchers and companies seeking to commercialize novel thin film Organic Photovoltaic (OPV) solar technologies have focused on using fullerene derivatives as the n-type semiconductor in bulk heterojunction organic solar cells. The use of fullerenes as the electron acceptor and transporter results in higher quantum efficiencies of the cells. Unidym will also cooperate with Nano-C to supply a variety of patented derivatives to customers for uses beyond Photovoltaics. This cooperation will expand the market for devices that use this family of patents. Terms of the agreement were not disclosed. http://www.unidym.com http://www.nano-c.com

Solarmer breaks organic solar PV cell conversion efficiency record, hits NREL-certified 7.9%

Organic photovoltaics developer Solarmer Energy has achieved the highest conversion efficiency recorded so far for a plastic OPV champion cell – 7.9%. The aperture-area test results, recently certified by the U.S. Department of Energy's National Renewable Energy Laboratory, represent an improvement over independent exams conducted a few months ago at Newport Corp.'s Technology and Application Center's PV Lab, where cell efficiencies of 7.6% and module efficiencies of 3.9% were recorded. The company's roadmap calls for the achievement of 10% conversion efficiencies on its OPV cells by the end of 2010. The company is also working to improve device lifetimes and performance, with focus on the identification of key degradation mechanisms, the development of advanced moisture encapsulation methods, the creation of standard OPV test methods, and the evaluation of the modules in indoor and outdoor testing scenarios. http://www.solarmer.com



Fyfe and Friend awarded the 2009 Institute of Physics Business and Innovation Medal

Dr David Fyfe, CEO of CDT, was awarded the Institute of Physics' Business and Innovation Medal together with Professor Sir Richard Friend of Cambridge University for "guiding the company Cambridge Display Technology (CDT) to a pre-eminent position in the development of light-emitting polymers and in the development of the technology for flat-panel displays and lighting." The prize is one of four gold medals awarded annually by the Institute of Physics (IOP), and is for outstanding contributions to the organization or application of physics in an industrial or commercial context. The discovery that certain polymers can emit light when an electric current is passed through them was made by Jeremy Burroughes (Chief Technology Officer for CDT) under the guidance of Professor Richard Friend with assistance from Professor Donal Bradley at the University of Cambridge in the late 1980s. Realizing the potential for the technology, Friend and colleagues promoted the spinout of the intellectual property into CDT which was initially funded by the University, business 'angels' and local venture capitalists. Sumitomo Chemical of Japan purchased the company in September 2007 after forming a joint venture for materials development in 2005. CDT has licensed its technology to eleven companies including Panasonic, Seiko Epson, Dai Nippon Printing and DuPont. http://www.iop.org

Kodak sells OLED business to LG

Eastman Kodak announced that it will sell substantially all the assets associated with its OLED business to a group of LG companies. Financial details were not disclosed. Kodak has been a pioneer in developing technology associated with OLED displays. In the 1970s, Kodak scientists developed the world's first viable OLED material. Kodak will have access to its OLED technology for its products. http://www.kodak.com

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Industry Research – FlexTech research reports provide valuable insights into economic and technology trends of the electronic displays and flexible electronics industries and its primary markets. Providers include DisplaySearch, Fuji Chimera, Insight Media, Toray Research Council, and Veritas et Visus. *Collectively, the reports are a $27,000 value!*

R&D Program – FlexTech's R&D Program has two elements for members:

- Gap analysis and technical roadmapping that identifies and resolves key technical challenges
- Pre-competitive R&D funding to provide funds for projects defined by member interests.

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- Technical Conferences & Workshops – led by our flagship event, the *Flex Conference*
- Regional Meetings – great networking events at member locations
- Business Conference – connection with potential investor and partners

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- Advocacy – industry voice with the media and federal and state governments
- Demo Creation – FlexTech facilitates the development of product demonstrators

To schedule a company meeting,
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