SPECIAL REPORT

Display Monitor

Volume 12 No 38a
October 3rd 2005

EuroDisplay 2005

EuroDisplay Comes to Edinburgh

As the home of golf and whisky, Scotland was a popular choice for visitors

EuroDisplay is the European SID event and takes place every three years. As it is organised by regional SID chapters, it moves generally between the UK, Germany and France. In 1996, it took place in Birmingham, in 1999 we went to Berlin and in 2002, Nice in France was the venue. This year saw the event return to the UK. There was a very small exhibition that was quite a long way from the seminar sessions, but we were initially surprised at the senior level of a lot of visitors from Asia. Then we remembered that Scotland is the home of golf and whisky and our surprise disappeared!

On the day the seminar started, there was a business-style event which featured talks that were mostly from a more commercial direction.

The first speaker was Jyrki Kimmel of Nokia, (a very active member of SID in Europe in recent years and regional VP of SID in Europe), who spoke about the display requirements of mobile phone makers. To be successful these days, phone makers have to go beyond simply making good products and have to bring 'delight' to end users.

Digital convergence is driving new applications on mobile phones and the mobile phone market continues to grow, with a forecast of more than 700m which means more than 800m displays because of the subdisplays. Camera phones are driving the growth and 3G is finally beginning to pick up. The experience of 'end user delight' is the key to new technology adoption.

The display requirement tends to depend on the main target buyer of the phone. Displays for phones that include digital cameras of higher quality need 200dpi or more on the display. This kind of resolution has not quite become standard yet, but almost. High resolution is needed as a viewfinder and for controls, if for nothing else.

Phones that are intended to be used for the display of TV and video need larger and wider displays, while flip phones need very thin or integrated secondary displays on the outside.

Developing markets need cheap displays although the quality requirement will probably incrementally increase. New form factors will mean a requirement for flexible and bendable displays, even if this bending or flexing is only done once at the time that

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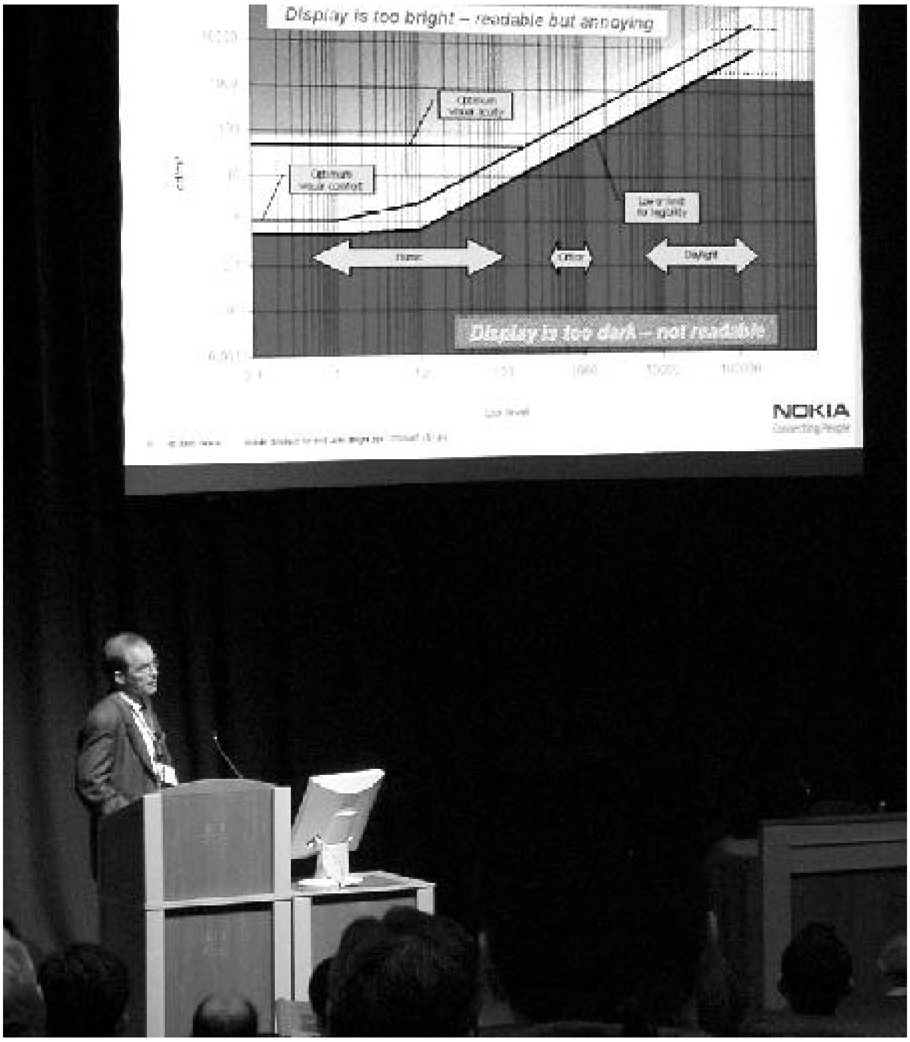

Nokia is looking to delight users with new displays

the handset is manufactured. According to Kimmel, mini-projectors are being seen as a 'no brainer' for business use, but they need much better brightness than is currently available. Furthermore, projector size needs to be dramatically reduced.

Good legibility is needed for a wide range of ambient light. If the data content is increased, bigger displays are needed, but this causes a problem with pocketability. Kimmel said that there need to be 'intelligent solutions'.

HDDs will move from MP3 players to phones and RFID will enable new applications, including traffic management and automated ticketing.

Displays are becoming more important again in phones partly because the display is a key part of the purchasing decision, so better visual quality is always worth looking at. However, reliability cannot be compromised to get a better display. Transflective displays are a good compromise to work in a wide variety of ambient conditions.

Phone interfaces need to be optimised for the key applications of the phone whilst other applications get mapped into the keyboard and display that are used.

Looking at technology developments, Kimmel said that mobile phone panels with 400dpi are now becoming available at 2" but improving the display quality only brings relatively small incremental benefits, so there will be important decisions to be made to optimise the cost/benefit ratio. Other developments will boost power efficiency and video capability and will add dual resolution displays that have a low power, low resolution section together with a higher quality, higher power section that can be powered on only when needed. LTPS panels are becoming more widely available and there are new backlights including OLEDs.

Looking more closely at the use of OLEDs in mobiles, Nokia thinks that there are some benefits of OLEDs if they can be made at a comparable cost to transmissive LCD, i.e. if OLEDs are thinner and have better colour. On the other hand, they would also be very attractive if they had the same performance as transflective LCD, but at a lower price. Nokia thinks that this is unlikely to happen.

OLED would have to go to positive rather than negative contrast and this is likely to be a problem. Kimmel said that there is a 'frightening momentum' in the glass-based economy of LCDs.

Flexible displays are an interesting concept and the idea of roll to roll is attractive but tolerances may never allow high resolution. Profit margins may be very small which may discourage investment in developing technology that is accurate enough. At the moment, the only parameter that is really a significant advantage for flexible displays is in drop testing.

Near to eye 'virtual' displays are a problem because monocular display use can cause eye strain in users, but there is some potential for microdisplays according to Kimmel.

Autostereoscopic displays could become important, not only in gaming, but also in improving the interface design. Cost up is small, and this could be critical in encouraging adoption of the technology..

In the question session, Kimmel was asked about flexible displays. The concept is interesting to Nokia, but you have to interact with them. Kimmel said that there has been no obvious way to interact with this kind of display, especially if you have to hold the display flat with two hands (perhaps the flexible display needs the success of voice processing - senior ed.).

Replying to another question, Kimmel said that for mobile phone use, 50% of NTSC is an adequate gamut for the moment. Multi-primary displays may help you get to normal TV gamut in the future without excessive power consumption.

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Comparative TV Performance*

Technology	Units	LCD	PDP	DLP RP	LCD RP	LCOS RP
Brand		LGE	Panasonic	Samsung	Sony	JVC
Size/Resolution		37" 1366 x 768	42" 852 x 480	50" 1280 x 720	50" 1280 x 720	52" 1280 x 720
Model #		37LP1D	TH42PWD7	HL-P5063W	KDF-50WE655	HD-52Z575
Full screen white luminance	cd/m²	534	50	319	302	842
Highlight luminance	cd/m²	271	254	311	394	842
Full black luminance	cd/m²	0.47	0.12	0.31	0.77	0.85
Full screen contrast (CR)	CR	1130	417	1040	392	994
Highlight contrast	CR	542	2150	1030	511	1000
Ambient contrast	@50 lux	393	48	190	160	430
Ambient contrast	@100 lux	242	28	105	101	278
Ambient contrast	@500 lux	60	6.2	34	26	72
Color gamut	% of NTSC	87%	96%	96%	96%	100%
White luminance variance	%	18	6.5	41	31.8	46.4
Contrast variance	%	15.1	9.8	28.7	34.2	27.6

*Highlight values refer to a 1% window. All measurements were taken in a dark room unless otherwise noted.

38 THE WORLDWIDE LEADER IN DISPLAY MARKET RESEARCH AND CONSULTING

Ross Young of DisplaySearch summarised the results of recent tests of TVs in the US

Ross Young went through the developments in the world-wide TV market and covered the material that we reported at the recent US and DisplayForum HDTV conferences. One comment he made that was interesting is that typically, the Chinese used to have apartment blocks with single TV viewing rooms, but now consumers are moving to having their own sets, so the market for very large sets is not increasing.

Greg Truman is managing director and COO of CRL Optronics which is based close to Edinburgh and makes microdisplays based on ferroelectric LCOS technology. These can be used in a single chip configuration to build TVs. Truman started by explaining the basics of a rear projection TV (RPTV).

The short answer as to why RPTV is needed is because it gives a large TV at a low price, according to Truman. The target is to make a large TV that can sell at $999, but the set has to have good image quality, attractive design and low lifetime cost.

Microdisplay RPTVs are either in three panel or single panel configurations, he continued. LCD and most LCOS sets (JVC, Sony, eLCOS, Spatialight, Brillian, TMDC, etc.) are three panel. While DLP is the main single chip technology, CRLO and MicroDisplay Corp. have LCOS technology that can operate in this configuration.

Three panel technologies are good for large TVs at 60"+ where higher brightness is needed. However, alignment of the LCOS imagers and optics is difficult, with an accuracy of 1μ needed across all temperatures. Single chip imagers are less efficient, but have simpler optics.

All current RPTVs use UHP lamps which have a lamp life problem, but have high output and are a point source. The balance of white is not great and UV and infrared have to be filtered out. It's also a continuous source, which is not necessarily an advantage.

LEDs will start to appear in 2006 and should be widespread by 2009. Thermal management and the fact that the LEDs have a large area source, making optics more complex, will both give rise to engineering challenges. By 2009, lasers may also be possible light sources for projectors. The advantages of lasers include the fact that they are point sources and also produce polarised light which assists LCOS and LCD sets by avoiding the loss from polarising filters. Problems such as speckle (*a kind of random pattern that makes the image look 'granular' - senior ed.*) will need to be solved to make the use of lasers acceptable to users.

MD RPTV has done better than analysts had forecast, with forecasts in 2003 showing expected sales of 600,000 to 1.8m units in 2005. Truman said that in practice it will be around 2.5m units this year for MD RPTVs (this is in line with the DisplaySearch forecast - senior ed.).

Sony dominates LCD RPTV, while Samsung dominates DLP. JVC is the leader at the moment in LCOS, but Sony has capacity in place for around one million sets per year, so they should be significant over the next year or so.

The emphasis in MD RPTV is in improving optics and light sources, rather than developments in the microdisplays themselves which have reached high levels of performance and relative maturity.

In questions, Truman said that, for a long time, the target was $999 for a 50" RP TV set, but with laser sources, brightness problems basically go away so he expects that even $700 may be possible at that size in the future.

Sharp Still Aims for 40-year dream of 'realistic feel'

Michiyuki Sugino is from Sharp in Japan and talked about large area TV and the Japanese quest for HDTV.

NHK started developing HDTV 40 years ago when the Tokyo Olympics took place. It has taken until now to deliver TV with a 'realistic feel', the definition of HDTV when the project started in the 60s. How can you quantify this, Sugino asked? Still nobody knows exactly, but experiments were made forty years ago to try to decide the information content that human perception can absorb. This included studies of the visual field and decided that the horizontal angle that the TV should occupy in the visual field is around 30 , while in the vertical plane, it's around 20 .

Another factor was viewing distance and room size. Between 2m and 3m seemed to be the best viewing distance in the early studies and calculations.

Sharp measured the view distance in 416 Japanese households as well as the viewing angle around four years ago. The average distance measured from the front of the set is

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Comparison between different approaches

H.Pan, X. Feng & S. Daly "Quantitative Analysis of LCD Motion Blur and Performance of Existing Approaches"

	Black Data Insertion	Backlight flashing	Frame Rate Doubling	Motion compensation Inverse Filtering
Requirement on LCD temporal response	High	Median	High	No
Requirement on backlight temporal response	No	High	No	No
Other requirement	No	Sync between LCD & backlight	Accurate motion estimation	Motion estimation
The ghosting artefact	Likely	Likely	No	No
The luminance reduction artefact	Yes	Yes	No	No
Flickering artefact	Yes	Yes	No	No
Reduction of motion blur (smaller the number is, the better)	50% (limited by LCD temporal response)	25% or less (limited by backlight temporal response)	50% (limited by LCD temporal response)	?

Sharp believes that doubling the frame rate is the best way to reduce smearing

around 2m although this varied with set size. Smaller sets of <=19" were viewed from 1.44m, 20"-29" sets from around 2.1m and 30"+ sets from around 2.4m

Sharp launched the largest commercially available LCD TV this year with a set of 65" diagonal. Why was 65" chosen by Sharp?

Sugino said that taking a viewing distance of 2.5m and with the optimum effective viewing angles decided before, the optimum size is 67". This was effectively the target from 40 years ago.

At this large size, artefacts such as mosquito noise become more obvious and even block noise artefacts from the MPEG compression and decompression become apparent so a lot of work needs to be done on the video signal and on the image processing.

To get a good image quality, there needs to be both post processing of the TV signal and further pre-display processing designed to exploit the properties of LCD such as larger gamut and higher bit depth.

True 10-bit drivers for LCD panels are still expensive, so Sharp is using bit depth expansion technology to convert 8 bit signals to 10 bits for pixel processing and then converting back to 8 bit for display. According to Sugino, the quality after this level of processing is very nearly as good as a true 10-bit panel, but the cost is much lower.

Sugino then looked at temporal artefacts. Black Frame Insertion and backlight flashing both have significant problems with side effects such as reduced luminance and also flickering. As a result, Sharp believes that frame rate doubling is the optimum technology. However, in order to avoid artefacts, there is a need for high quality motion compensation of the image during display and to generate the intermediate frames (*see comments on a new approach to this issue by* Samsung's R&D *team on page* 10 - *senior ed*.).

There is still a long way to go to understand fully how to measure and compensate for motion artefacts.

In questions, it was pointed out that according to the DisplaySearch measurements, PDP has better uniformity than LCD. Sugino said that Sharp would be able to match the uniformity of PDP by next year. The company is also working on new film technologies to match other features of PDPs such as improved viewing angles.

Weber Updates PDP Developments

Larry Weber, now effectively a full time freelance researcher and president of the SID, talked about new PDP TV technologies.

If you want to know about US TV, said Weber, you go to CES. At CES 2005, Panasonic had lots of new PDP displays and Samsung had a new 102" PDP. The 102" uses a transparent electrode technology that was originally developed in the US and avoids the need for ITO patterning. The real reason for the demo was to show that four 50" panels can be made on a single substrate.

Another big development was the arrival of 12 bit colour which eliminates colour banding. Furthermore, single scan circuits are reducing costs.

The technologies have got so good for LCD and PDP that it can be hard to tell them apart. For example, at CES, Philips had a lot of big displays in a cube, and half were LCD, the other half PDP. Even though Weber is one of the foremost experts in the world on PDP, he was unable to easily see which was which.

Weber went through the costing issues for PDP and LCD and is confident that PDP can maintain its cost position. He went over the competition between LCD, PDP and DLP.

One breakthrough in PDP has been the use of more Xenon which reduces the burn-in. From 5% a few years ago, this is now as high as 15% for some makers such as Pioneer. The use of more Xenon reduces the level of the UV light which is most damaging to the phosphors. The use of new phosphors has moved phosphor degradation down to the same kind of level as CRTs. If you don't have a problem with burn on your CRT, said Weber, you don't need to worry about PDP.

Weber went through the power arguments that he presented at IMID (Display Monitor Vol. 12 No 30).

The best PDPs have a luminous efficiency of 1.8 lumens/W which is reduced to 0.9 by the contrast enhancement filter (Pioneer claims 2.2lm/W - senior ed). Phosphor efficiency is pretty good, and could only theoretically be improved by 10% to 20%, but there's a lot of room to improve the discharge that creates the plasma. There are two kinds of excitation in the discharge and they are

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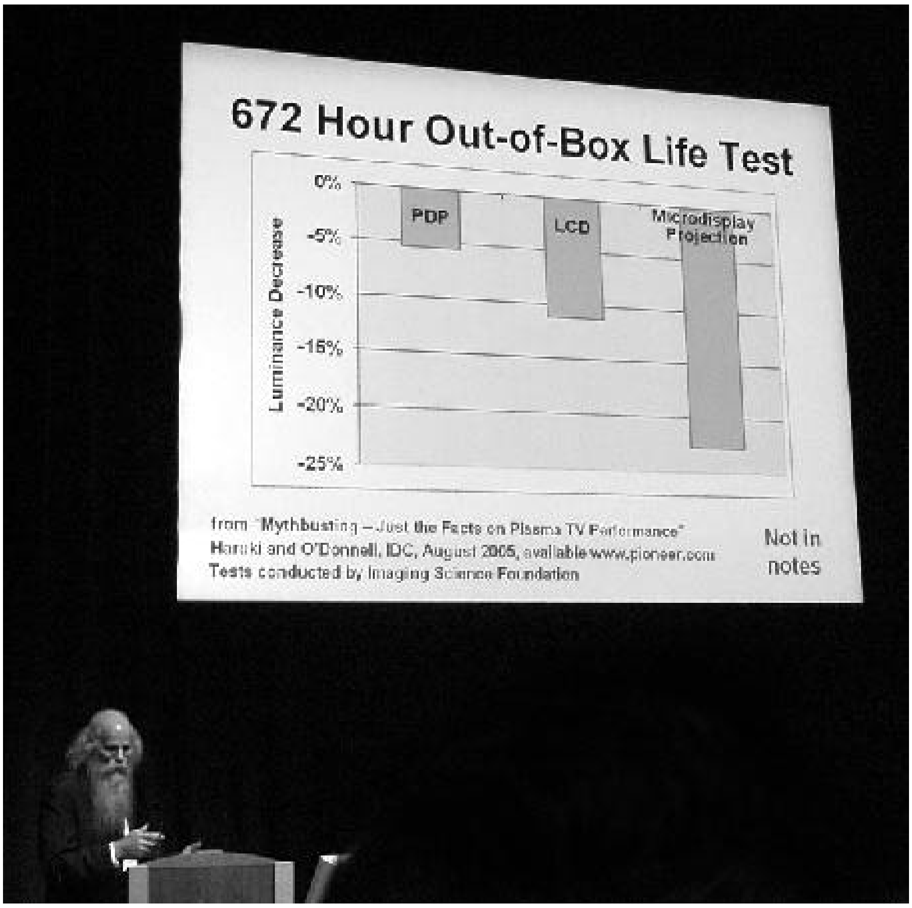


Larry Weber, now president of SID, can be relied on to support PDP

LETI Pursues CNT-based FEDs

Robert Meyer is from LETI in France and he talked about the development of FEDs that are suitable for TV applications. As FED is not in production for TV today, he gave a talk mainly about the technology.

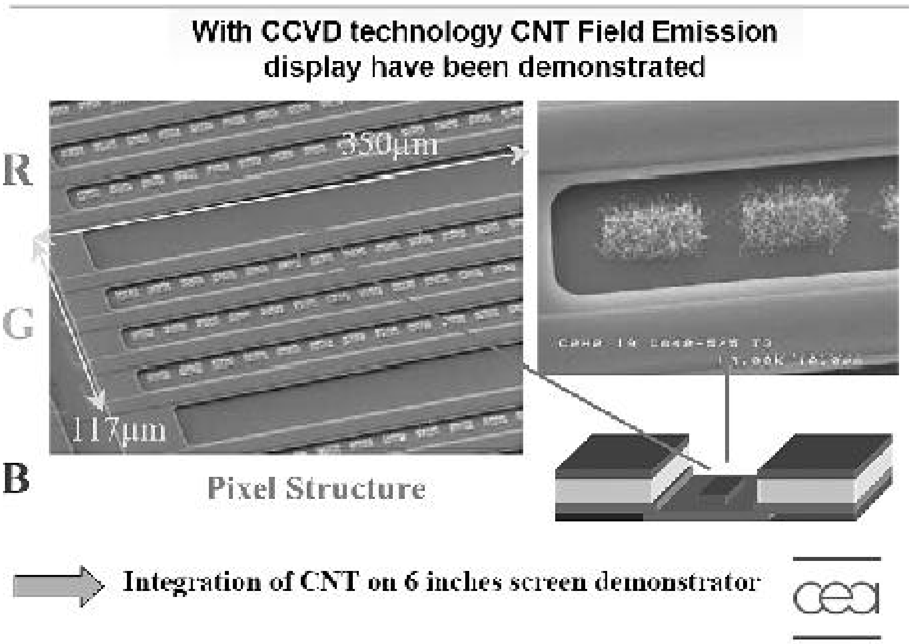
Although LCD and PDP have made an impact on the TV market, they still cost a lot and use too much power. Furthermore, visual performance is still not as good as CRT.

Microtip FEDs have really finished development for large area applications although Futaba will make small displays next year, according to Meyer. Meyer explained the basic FED technologies.

SED, which is a kind of special FED, is being developed by Canon/Toshiba and this will go into production in the near future (2007/8 in real volume, we think - senior ed.). Cell gaps are around 1.8mm and anode voltages are around 7kV-10kV. High voltage phosphors can be used and are quite efficient and the SED also uses a microfilter technology to improve contrast. SEDs can achieve good black level with only a small control voltage of around 10V to 20V. The biggest disadvantage is that perhaps only 1% of the electrons are used for light emission. This means a high

called negative glow and positive column. It's the positive column that is most efficient and the longer this is, the more efficient the discharge. That's why fluorescent lamps are typically very long - almost all the length of the discharge is the positive column, so you get high efficiency.

The negative glow is too big a part of the overall discharge in PDPs. Changing the configuration of the pixel electrodes helps to boost the positive column, but Weber is working independently to try to significantly improve the efficiency from around 2 lumens/W in the direction of the level of fluorescent lamps which are around 70 lumens/watt. Weber is working on this problem to try to get a breakthrough on his own account.



Despite the problems with early FEDs, LETI continues to research using carbon nanotubes current is needed to drive the pixel, so the drive voltage drops a lot across the panel. This means very complex addressing because of the sensitivity of the drive voltage levels.

Indirect carbon nanotubes (CNT) are being developed by Samsung et al. This technology uses a composite paste of CNTs with a conductive binder. A pattern of pixels is made by putting paste on the display by screen printing, but there is a critical post activation process which allows the CNTs to protrude from the paste. The gap between the gate and paste is quite large, so the driving voltage needs to be quite high as the CNTs can be quite long.

Direct CNT is being developed by Motorola, LETI and others. This technique uses a triode structure created with proximity lithography. CNTs are grown directly on a nickel substrate at around 550°C and the growth takes around one minute. Lifetime depends on the thickness of the nanotube and the LETI process produces CNTs of a diameter of around 30nm. LETI embeds a ballast resistor and this means that CNTs that don't work properly simply don't emit electrons.

LETI has made a 320 x 240 display with 6" diagonal. The display produces brightness of 800cd/m² using an anode voltage of 2.5kV and a gate voltage of 85V. At the moment, uniformity is around 5% between pixels, up from 10% last year. The aim is to get down to 2% for commercial applications. The gate voltage should also be reduced to cut cost by allowing the use of lower voltage electronics.

Meyer contrasted the key features of CNT with other display technologies and highlighted the low power consumption because of the high efficacy of the device (around 3lm/W even with the filter included).

Looking at costs, CNT has lower circuit costs than PDP, although it has higher process cost because of the need for new CVD equipment. On the other hand, the investment and material costs are as low as PDP. Overall it could be a competitive display technology for TVs, in his view.

OLEDs may have a problem because of the high current needed to drive them at large areas. CNT lifetimes are not sensitive to oxygen as the spindt cathodes in the past, so LETI is confident of the possibility of long lifetimes from the displays.

MP3 Takes up OLED Slack

Kimberley Allen of iSuppli gave an overview of the market for OLEDs. Mobile phone subdisplays remain the main application for the technology. There are two personal media players with OLEDs but over fifty suppliers of MP3 players fitted with OLEDs. Overall, by value, the company expects to see CAGR of 29% to around $3 billion by 2011. Around 60-64m units are expected to be sold with a value of around $615m this year, so the ASP is around $10.

AMOLEDs are likely to appear in about Q2 next year (virtually all current production is passive matrix - senior ed.). Around 50% of all MP3 players use OLEDs and this market has taken up some slack that would have come from a drop in the adoption of OLEDs for mobile phone subdisplays.

There is still lots of research into OLEDs and applications are still being developed, including backlights. In the longer term, say ten years, general lighting could become a market. OLED manufacturing is characterised by low yield, long TAC time and slow production which has tended to mean expensive devices.

Unless PM OLED develops a lot, the value of the market will peak soon. While volumes will grow, prices are falling faster. The timing to switch to AMOLED is a difficult issue for companies. The longer you leave the decision to jump into the market, the lower the price points that you have to address.

Looking at flexible displays, Allen highlighted the applications that could be addressed. The best way for the market to grow is probably to look for completely new applications, but this will take time. Looking at applications that could use flexible displays, the sum of the value of those markets is around $22 billion, but it is not growing strongly. It's a large area to aim at, however, in her view.

Each of the applications has a different set of requirements and, as a result, technology developers need to target specific applications. For example, an ebook reader may need >180dpi, while this area of performance is not important for automotive or signage use. Plastic Logic is developing a small manufacturing line that can produce around 100 A4 sheets/week at around 150ppi of organic logic. Dimatix (the company that is behind the Litrex print head) has made a $30K 'tabletop' printer that can use materials such as Cabot's silver ink and allows low volume production of flexible displays for test and development.

Electrophoretic (i.e. E-Ink) is probably the best bet for commercial success in flexible displays at the moment. There are some OLED demos, but barriers remain the barrier! It's hard enough to make a rigid barrier that protects from air and water; to make a flexible one compounds the problem.

Active matrix substrates are still hard to make on flexible backplanes and generally have mobility below the level of current amorphous silicon.

Electronic signage seems to be the first real application for flexible displays.

One way that flexible displays may develop is to take flexible roll to roll processed displays and laminate them onto rigid substrates.

UDC Optimistic about OLED Efficiency

Julie Brown is CTO of OLED technology company UDC and she went through what the company is up to today, where it's been and where it's going.

Brown said that the TV market is splitting two ways, going larger as well as smaller. The World Cup in Germany is a target for mobile phone video. OLED has to solve its technical and manufacturing issues to get to a commercial market. Brown looked at the emission mechanisms for fluorescent and phosphorescent OLEDs. Phosphorescent OLEDs depend on molecules that have a heavy metal (such as iridium or platinum) atom in the centre. The higher efficiency that comes from using phosphorescent OLEDs may allow the use of amorphous backplanes, like those used for TFT LCDs.

UDC has been able to develop to 100% internal quantum efficiency equating to around 16% to 20% external quantum efficiency as it can be quite hard to get the photons to come out of the device! Red materials have now been tested at >10,000 hours lifetime with 90% brightness at 500cd/m² and at 60 C. Improvements in Hole Injection Layers have allowed the company to get to around 19% EQE for around 50 lumens/W.

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In the last year, the company has started to boost the colour performance of its blue materials from very light blue to more saturated blue colours with improved lifetimes.

Looking at manufacturing, UDC has investigated OVPD, inkjet printing, vapour printing and LITI.

Moving to flexible materials, if you have plastic substrates, you need amorphous backplanes and phosphorescent technologies. An alternative is to use a top emission structure on a metal foil. Because this is less temperature sensitive, it's possible to use polysilicon for the backplane. This concept has allowed the development of displays with lifetimes of 5,000 to 6,000 hours using barrier technology from Vitex.

The US Department of Energy has set a target of getting to 150lm/W from OLEDs. If this can be achieved, there will be a high potential for general lighting applications. UDC has developed a display with very large R, G and B pixels that can be integrated to white and it has now achieved 30lumens/watt with this display.

CDT Claims 100K Hours for Blue OLED

Nalin Patel is from one of the other main OLED technology companies, CDT, and he talked about the issue of building the infrastructure for commercialisation.

He started by looking at the status of CDT's polymer technology. He went through the traditional list of benefits of OLEDs, but highlighted in particular the potential cost savings of the technology because of the reduced material costs compared to LCD.

As we have previously reported, CDT has done a lot of work in developing inkjet printing to allow the development of low cost manufacturing.

CDT is now claiming 100K hour lifetime for their blue material to now reduce to 50% brightness at 100cd/m². Red and green have longer lifetimes. The company has been able to show that it can make prototype full colour displays using inkjet printers.

The last few months have seen a lot of consolidation in the supplier area for OLED materials. Major progress has been made in areas such as printer development, TFT backplanes and drivers.

Philips sees the need for applications that really need flexibility, like the Readius concept from Polymer Vision

Philips Looks for Killer Apps for Flexible Displays

Mark Overwijk of Philips Research group looked at developments in flexible displays.

Flexible displays allow rugged displays and products with increased display area. This kind of display could have reduced weight or improved safety (for example in cars). He pointed out that one way to develop the market is to look for applications where a flexible display can replace an existing display.

To compete with existing technologies, you need high specification displays and this is a challenge, but on the market side there are big opportunities. Looking at new applications, you don't need to match existing technologies so it may be easier to reach technology goals, but you do need to develop the market. Overwijk would like to see an emphasis on the new opportunities. LCD, for example, did not attack CRT initially, but concentrated on meeting the needs of mobile applications. Only when the volumes had been built by supplying the notebook segment were LCDs really set against CRTs in the monitor and TV markets. To be disruptive, you need an application where the unique features of the new technology are fully appreciated.

The main technologies for flexible displays are LCD, OLED or electrophoretic based on active and passive matrix arrays and using organic or inorganic materials.

In 1996, Philips demonstrated active matrix arrays on plastic and in 2003 it showed LTPS on plastic arrays so these are not future technologies, but are here now. Eventually, flexible displays will need to catch up with glass-based displays in performance if flexible displays are to be genuinely disruptive.

The transistor array that drives the display is an expensive component and makers need to get the cost down. Philips has worked on using existing manufacturing technologies for its flexible technologies.

Philips' EPLaR electrophoretic displays (EDs) are manufactured on a polymer layer that has been coated onto a glass substrate. After manufacture, the polymer including the display is released from the glass substrate. At SID, Philips showed a 2" array made on a 3µ layer of film.

EDs are, in his view, a natural fit to flexible substrates because consumers are used to buying flexible paper and this kind of display is best suited to applications that might otherwise have been on paper. Electrophoretics are the most flexible technology of the current range of options.

Smart cards could be an interesting application for EDs as they need to be flexible. Philips has demonstrated a fully flexible display for this application. The display has to be robust, but it doesn't need colour, high resolution or video performance. Low power consumption is also essential in this application.

Polymer Vision has a 5" diagonal product that is just 0.1mm thick with a weight of just 1.5g. The frame rate is 50Hz, but the update time is around 0.5s and driving voltage is around 15V. This product can be used in ebooks and other applications.

The Philips Readius is a prototype application to show how such a display could be used.

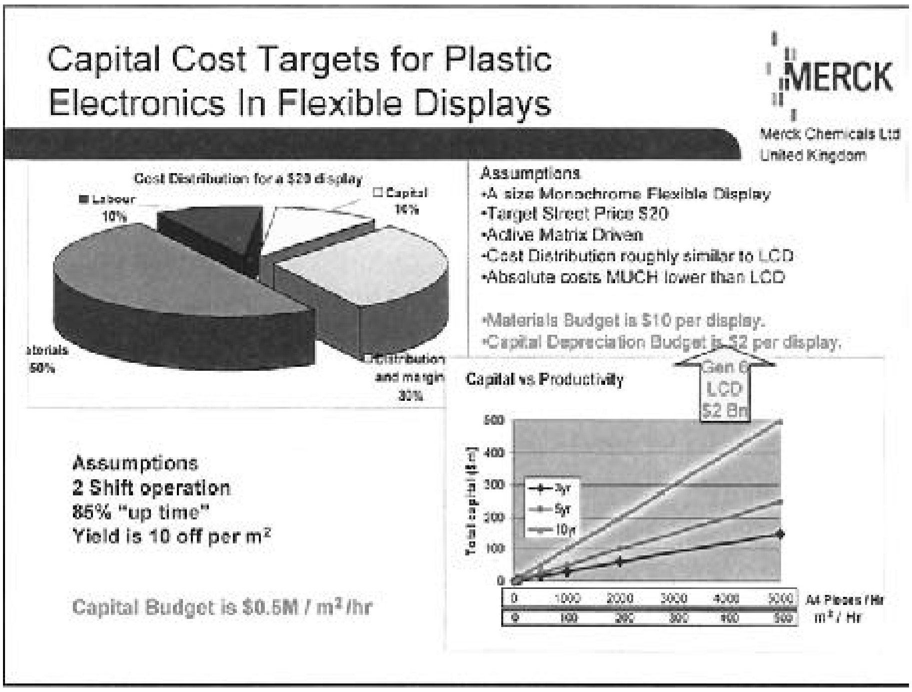
In conclusion, there's a market for flexible displays, but to be successful, there needs to be a 'killer app'. Polymer Vision is keeping its technology options open. The killer application may be an ereader or a smart card.

In response to questions, Overwijk said that video is not likely to be successful with electrophoretic technology which is simply too slow. In applications where video may be important, OLED might be a better long term solution if the encapsulation issues can be overcome.

Merck Questions Economics of E-Paper

The final speaker of the day was Tom Mclean of Merck in the UK. The organic electronics group of Merck in Manchester was originally Avecia and was acquired by Merck along with Covion earlier this year (Display Monitor Vol. 12 No 6).

There has been some industry restructuring in organic electronics and the Merck group of 75 people from Covion, 25 from Avecia and 10 from Chilworth in the UK believes it is the largest group in any materials company looking at plastic electronics. Mclean said that those not watching the industry closely would not realise that the industry is getting to the position where it can supply materials at commercial volumes and costs.



The capital cost of making epaper has to be dramatically lower than current LCD costs

Key issues for materials are electrical performance, stability and processability.

The Organic Field Effect Transistors (OFETs) are made in the lab by Merck in air with no encapsulation at all. Until now most organic electronic materials have been very volatile, but there are now materials that are very stable.

PolyArylAmine was one of the first materials used as it is known to be very stable - it is used to coat rollers in laser printers where conditions are very hostile. The transistors using this material have low hysteresis and good stability. Device design is very different from silicon transistors, but switching can be achieved at voltages as low as 5V. 0.5cm²/vs is needed to match amorphous mobility and 1 to 10cm²/vs which is not dissimilar to LTPS. Others have had success with transistors made of pentacene.

There doesn't seem to be significant degradation from the environment or from repeated operation in the company's tests of PolyArylAmine. There can be failure from negative bias stress, as seen in amorphous silicon so further work needs to be done in that area.

Looking at process development, Mclean said that many different processes have been investigated including printing, laser deposition and others. However, process development for mass production manufacture can take a long time to get from the lab into a fully working factory.

Once products can be made in the lab, it can be three to five years before you see genuine pilot lines for developing manufacturing technology. It often takes another three to five years after the pilot lines to get to real volume manufacturing equipment.

Laser, photolith and some inkjets can get to around 1µ features now, so they may be ready to move towards manufacturing.

If we look ten years out, a target street price for an A4 epaper product could be $20. Of that $20, 50% is likely to be available for materials based on traditional business models of that kind of product.

If you work backward from this cost, you find that $0.5m/m²/hr is the likely capital

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budget that is needed to meet the overall cost target as the capital depreciation cost of each display is a maximum of around $2. He said that, in contrast, the capital cost of LCD fabs is much higher (assuming 45K per month G7 substrate inputs and a cost of $2.5 billion we make the cost around $10m/m²/ hour for Samsung's latest fab - Senior Ed.)

Mclean reviewed the state of the art in manufacturing processes for organic electronics. Surface energy inkjet looks expensive, but could meet the technology requirements. Laser transfer also looks interesting as it can meet the line width and registration accuracy needs, but traditional print may not be good enough, although it is cheap enough. Print probably cannot meet the accuracy requirements.

At the moment there is simply no equipment available that can be used to make volume production of plastic electronics and equipment that might could take up to five years to develop.

Novelty products could be an interesting area for driving new demand for low cost displays but Maclean agrees with Overwijk that the key is to find new applications that really need the flexibility of the display.

Papers & Exhibits Roundup

Unfortunately, we were not able to get to any of the papers at this year's EuroDisplay but we checked through the printed set on our return to the office.

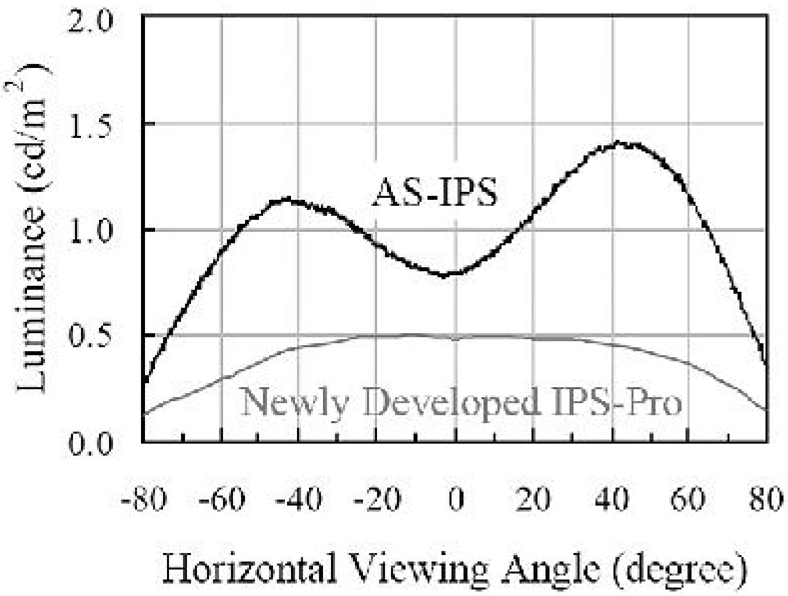
Papers that caught our eye included one from **Fujitsu** that described the concept of a PDP based on tubes. The final display would be 3m x 2m with 1000 x 700 format and 3mm x 1mm pixels, but would have an efficacy of as much as 5.4lm/W in tests. This is around 2.5 times the brightness of the state of the art of current PDPs and the authors believe that the level could get to 7lm/W. Another group from Imaging Systems Technology in the US have a system of using small 'plasma spheres' of around 3mm that can be embedded in a flexible substrate.

Scientists from **Tohoku University** and **Fuji Films** proposed a new Nematic Compensated Birefringence (NCB) mode that appears to offer the fast response times (5ms without overdrive) and wide viewing angles (160 all round) of OCB modes, but without the need for complicated driving and difficult cell structure.

Also in the LCD area, **Hitachi** proposed the next generation of its IPS technology which has a new pixel configuration, new polarisers and improved colour filter design that boosts brightness and significantly improves the problem of rising black level off axis. The company claims a black level of 0.5cd/m² for a wide range of viewing angles with 500cd/m² of brightness for a contrast ratio of 1,000:1 on axis. It claims more than 200:1 contrast at viewing angles of 160 , the point at which most of the existing LCD technologies are starting to get down to 10:1.

Philips Research presented a paper on a backlight system that uses a grating structure that is filled with a birefringent material. The grating polarises and separates the light into its component colours. Unlike the system proposed by IBM at SID in 2003, the separation is not complete, but it should mean that existing CCFLs can be used, whereas LEDs were essential for the IBM system. On the other hand, the filters would need to be much less saturated than currently, so the amount of light transmitted could increase from 30% to 50%.

Sharp presented a paper on a new 2.4" LCD using the company's Continuous Grain Silicon (CGS) polysilicon technology that integrates an audio driver into the display using the polysilicon on the display. It takes around 150mm² of glass area. The device is intended for mobile phones and can produce



Hitachi's new IPS-Pro technology dramatically improves off-axis black level in LCDs around 150mW of power in a piezo-electric speaker.

A group from **Kyoritsu Optronics** in Taipei said it had developed a new MVA LCD that is claimed to be cheaper to make than existing TN displays and with much higher performance.

We got to the author interviews on the first day and also attended the poster session. As usual, there was lots to look at.

We were especially intrigued by an idea for solving the problem of dead pixels from **Barco** and we spoke to Tom Kimpe about the concept. Kimpe has modelled the diffusion of the light from individual pixels on medical displays. The image from each pixel is slightly diffused by the lens in the eye and some of the light falls on the area where an adjacent pixel would be. By controlling the intensity of the light from the pixels around a dead one, so that some extra light is emitted by each of the pixels, Kimpe can manipulate the actual image that falls on the retina to eliminate the dead pixel from the image. The processing is relatively simple, but is important in medical displays where a non-uniformity as small as a single pixel could be an indicator of a very early stage cancer.

Jun Someya of **Mitsubishi** talked about the development of the MPRT system that is being developed to allow better specifications for image blurring on LCDs and which takes into account both the response time of the crystal and the effects of any scheme designed to reduce the smearing effects of the hold addressing. The MPRT measurement is being built into the VESA Display Measurement standards and there was some discussion at the event as to whether it made sense to include MPRT as a metric in some proposed SMPTE standards for broadcast monitors.

On the same issue of hold addressing, we were intrigued by a great idea from **Samsung**'s research labs. One way to eliminate the smear from hold addressing is to use black frame insertion or backlight blinking to add an impulse type of drive to the LCD. The danger is that this may cause both a loss of brightness and contrast and may also start to cause large area flicker. Samsung realised that the movement is only apparent from the high resolution/high frequency data in the image. They are proposing, therefore that the image is split into low and high frequency portions and that only the high frequency data is treated with impulse driving. As a result, there will be little or no loss of brightness and contrast and no large area flicker. This seemed to us to be a very clever idea and could exploit the work that has been done to develop chips which can easily split image data this way as it is a step in the operation of the JPEG2000 codec (see IFA and US HDTV conference reports). Samsung is calling this technique SFI or Smooth Frame Insertion.

There was a small exhibition at the show, but there were not a lot of new products on display. We were intrigued by a new inverter developed by **Zippy Technology** of the US that uses a piezo electric ceramic transformer instead of a coil. There is no production of magnetic flux, so there is a reduction in shielding needed and 90%+ efficiency means simple thermal management and low power. There is a very wide range of dimming available and the transformer works on CCFLs, EEFLs, flat FLs and even neons, which are difficult to dim by other means. The technique is claimed to lead to longer lamp life and lamp brightness can be maintained until end of life. Finally, the inverter is 1/3 to 1/2 of the thickness of traditional inverters. In the past this kind of technology has been too expensive, but Zippy claims that it now very competitive with traditional approaches.

http://www.zippy.com

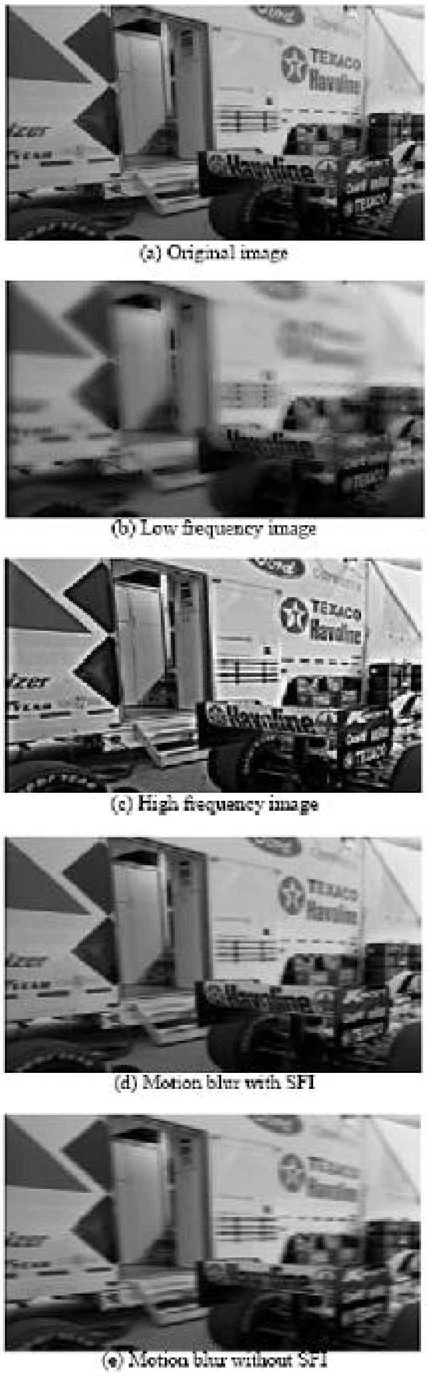


Figure 3: Motion blur simulation.