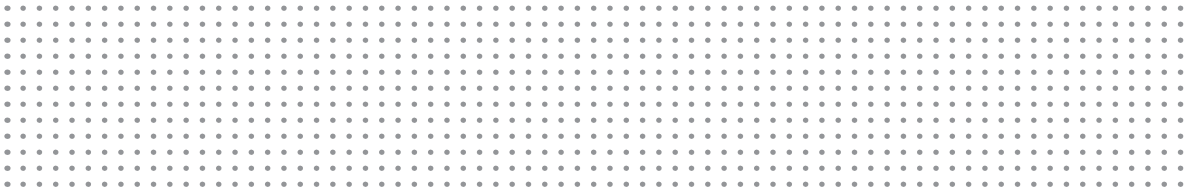


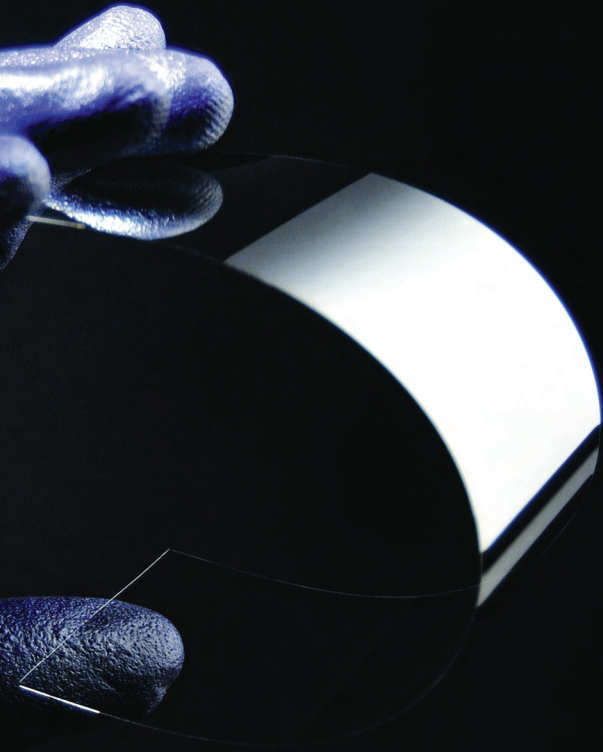
Bending



WORDS:
DAN ROGERS



the rules



CORNING IS DEVELOPING ITS GLASS FOR USE AS LAYERS FOR FLEXIBLE DISPLAYS
PHOTO: CORNING

Flexible displays are on their way

When Samsung announced plans to introduce flexible OLED displays in 2012, there was much excitement – and a little confusion – about what the first applications of these screens would entail.

The conclusions made in certain quarters of the media that Samsung was announcing plans to introduce bendable phones in the near-term – UK tabloid newspaper the *Daily Mail* announced ‘Your flexible friend? Samsung to release bendy-screened phones “in Spring 2012”’ – appear to be a little hasty.

Nevertheless Samsung’s plans to exploit more flexible OLED displays in 2012 indicate that the consumer electronics market is gradually moving in the direction of realising advanced concepts like bendable and rollable screens.

PC World reported that Samsung spokesman Robert Yi stated during an earnings call in September 2011: ‘The flexible display, we are looking

The flexible display, we are looking to introduce sometime in 2012, hopefully the earlier part.

to introduce sometime in 2012, hopefully the earlier part. The application probably will start from the handset side.’

Yi also suggested that flexible displays would be developed for use in tablets and other mobile devices.

FLEXIBLE?

‘Flexible’ is a term that covers a wide array of innovations in the field of displays – from conformable displays that can be bent occasionally during the design process for what is ultimately a rigid device; displays produced on flexible substrates that can be added to a rigid device without the need for glass; to screens that can be folded or even rolled without compromising performance.

Following the market success of OLED displays in smartphones – with tablets and televisions among the next targets for Samsung and LG – flexible displays have become one of the most exciting areas of commercial development for the plastic electronics industry.

The 2012 Flexible Electronics & Displays Conference & Exhibition taking place on 6-9 February in Phoenix, Arizona, the US, will be one to watch, with so much activity expected in this space. Following the likely unveiling of flexible display technology at the 2012 Consumer Electronics Show (CES) in January, the FlexTech Alliance event will give the plastic electronics industry



IMAGES 2A AND 2B: SAMSUNG IS AMONG THE FIRMS TO HAVE DEMONSTRATED FLEXIBLE DISPLAYS AT PREVIOUS INDUSTRY EVENTS, SUCH AS THE 2011 CONSUMER ELECTRONICS SHOW
PHOTO: OLED-DISPLAY.NET

... flexible displays have become one of the most exciting areas of commercial development for the plastic electronics industry.

a chance to look in detail at what can be achieved in the near-term with the technology.

Having led the production and implementation of OLED displays in smartphones – now one of the primary hardware features that distinguish

FLEXIBLE DEFINITIONS

What is a 'flexible' display?

There seem to be some clear categories of device defined to varying degrees as flexible:

Conformable

A display that can be flexed or curved slightly during the manufacturing process, before being set into a rigid device.

The Galaxy Nexus smartphone boasts a curved OLED display, encased in glass.

Glass-free

A flexible display that can be flexed during the manufacturing process and also uses glass-free encapsulation.

These displays are thinner and lighter than rigid displays encased in glass. The removal of glass also makes the device less susceptible to breakages.

Flexible

A display that can be flexed or bent many times during use, without affecting the display's output.

Some e-paper displays are able to perform consistently despite repeated flexing, but consistent, high-performing OLEDs have not been publicly announced.

These devices would allow users to use and carry devices in new ways – for instance, wrapped around a wrist.

Rollable and foldable

A display designed specifically to sustain folding and rolling, often making them more portable.

Rolling a display requires devices to frequently undergo tight bend radii as they are retracted into a case or similar display holder, then rolled out for use.

Netherlands-based Polymer Vision has demonstrated rollable e-paper displays that can withstand hundreds of thousands of rolls without declines in performance, but OLEDs remain a long-term challenge.

a premium mobile device – Samsung has reaped the rewards of introducing new display technology that

offers valuable unique selling points. Earlier in 2011 the company's collaboration with Google on the Galaxy Nexus

– a smartphone with a curved OLED display – demonstrated that it was taking steps into conformable displays too.

MATURITY

So the South Korean company's latest announcement suggests that the various elements required to create a reliable flexible display – high-performing materials and layers, robust device structures, and scalable production processes – are reaching the level of maturity needed to make the step to the next generation of OLED displays.

... the South Korean company's latest announcement suggests that the various elements required to create a reliable flexible display ... are reaching the level of maturity needed ...

... a lot of progress has been made with barrier layers for OLEDs, which could allow you to get rid of a glass layer.

The move to flexible displays makes good sense. OLEDs are praised for the quality of the display's resolution and its wide viewing angle among other features that help differentiate an OLED-based smartphone from an LCD counterpart; but the characteristics of a flexible OLED display would help distinguish a device in the market even more markedly.

'The biggest advantage for flexible displays is that you can avoid glass breakages, as well as the lighter weight,' states Johan Feenstra, CEO at the Samsung LCD Netherland R&D Centre.

'A lot of products end up going back to the maker because of glass breakages. And a lot of progress has been made with barrier layers for OLEDs, which could allow you to get rid of a glass layer.'

While concepts like wraparound, wrist-worn smartphones and displays

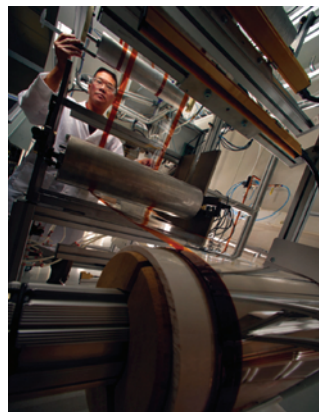
that can be rolled and put in a pocket get media coverage for flexible displays developments, it is these rather more practical advantages that will drive flexible displays to market in the near-term.

And it is possible these like-for-like replacements of glass-encased displays for robust, glass-free, lighter flexible OLEDs are what Samsung is aiming to introduce in 2012.

GLASS-FREE

One challenge that could inhibit the move to flexible displays is the barrier layers required to replace glass encapsulation. While Feenstra notes progress made in this area, glass remains the reliable material in commercial use for displays.

Yet the move to flexible displays may not mean abandoning glass for polymer-based encapsulation. Contrary to conventional wisdom, New



CORNING GLASS BEING PRODUCED IN A ROLL-TO-ROLL PROCESS
PHOTO: CORNING

York-headquartered Corning believes it has a solution that can reliably protect a flexible OLED display – based on glass.

The glass company, which produces the Gorilla Glass material used widely for consumer electronics displays, has created OLED layers like touch panels, colour filters and backplanes for flexible displays.

Its colour filter technology, demonstrated at high efficiency and throughput in a roll-to-roll process, uses a thin and flexible glass material.

The company will demonstrate the process for glass-based flexible layers at the CES and FlexTech conferences in Q1 2012.

'Working with glass spooling may seem a bit counterintuitive, because people tend to think of glass as being rigid and brittle. We've made glass material that is thin enough and conveyed flexible glass on a roll-to-roll process, then rolled the material back,' explains Dipak Chowdhury,

We've made glass material that is thin enough and conveyed flexible glass on a roll-to-roll process ...

Ten-year Forecast of Disruptive Technologies in Lighting and Displays to 2021



WHAT DO YOU GET?

- * The disruptive technologies that will have the greatest impact on the lighting and displays industries
- * Realistic how-and-when scenarios that look at the probability of success and impact of the top-25 disruptive technologies
- * Key end-use and technology trends in lighting and displays

REPORT SUMMARY

This major new report identifies and profiles the disruptive technologies that are most expected to affect the lighting and displays industries over the next 10 years to 2021. **Ten-year Forecast of Disruptive Technologies in Lighting and Displays to 2021** is the essential planning and strategy guide. It provides exclusive data and analysis, detailing how current and emerging trends will shape the future of the industry, along with realistic scenarios for how and when the disruptive technologies are likely to be fully integrated into the lighting and displays supply chains. This report is a must-read for anyone working in the lighting and displays sectors.

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DIPAK CHOWDHURY,
PROGRAMME DIRECTOR FOR
FLEXIBLE GLASS, CORNING
PHOTO: CORNING

programme director for flexible displays at Corning.

‘We’ve produced the material at dimensions such that the width of the printed area could go to gen. five.

‘We’re working with partners and enabling them to use our glass. Our target is that by the second half of 2012, supply chain implementation will have been executed.’

FLEXIBLE FUTURE

Chowdhury argues that companies looking to introduce flexible displays will need to use glass if they are to achieve commercially viable standards.

‘With OLED the challenge, other than the backplane, is encapsulation – particularly the flexible ones,’ he comments.

While it is difficult to establish the extent of Samsung’s

FLEXIBLE DISPLAY DEVELOPMENTS

While efforts to commercialise various forms of flexible displays are ongoing, some compelling proofs-of-concept have been presented by the plastic electronics industry.

Flexible rewritable e-paper

The Taiwan Industrial Technology Research Institute (ITRI) has demonstrated flexible e-paper that can be printed and rewritten around 250–300 times. The i2R paper is printed using a thermal printinghead, a technology found in many standard fax machines. The e-paper intended to replace the need to print multiple documents, such as in office use, or could be used to event tickets, point-of-sale displays and other printed media.

PaperPhone

The PaperPhone concept consists of a 9.5cm flexible e-paper screen that responds to bending and stylus input. The device was created at Queen’s University, Canada and unveiled in May 2011.

The ITRI has also demonstrated flexible displays for consumer electronics devices. One is the FlexUPD, a 6-inch OLED screen that the organisation claims offers good water vapour barrier properties. The technology was unveiled in December 2011 alongside a flexible touch panel.

readiness to deliver flexible OLEDs in 2012, progress by the likes of Corning suggests that wider use of conformable and possibly glass-free OLEDs could happen in the near-term. But what of fully flexible, bendable, or rollable displays?

The fortunes of Polymer Vision, the Netherlands-based developer of rollable display technology, indicate that this is a long-term effort that will require substantial investment in the coming years to be realised. The company was recently divested by its Taiwanese owner Wistron and is now looking for strategic investors (see **Looks good on paper**, p.4).

Fully flexible displays that can sustain repeated bending, folding or rolling appear to be far from realisation, despite progress on backplanes and other parts of the device.

Alongside OLED displays, there is also the market for flexible e-paper displays to consider.

E-paper, which has reached a greater stage of maturity as a flexible display medium than OLED, could provide flexible backplanes with the opportunity to prove that they can be bent and rolled repeatedly without losses in performance.



THE PLASTIC LOGIC 100 USES A FLEXIBLE BACKPLANE TECHNOLOGY FOR ITS E-READER DISPLAY
PHOTO: INTERTECHPIRA

The Plastic Logic 100 e-reader for the education markets, boasts a flexible organic semiconductor backplane to

complement its flexible E Ink display. The device has been trialled in schools in a number of countries and is now in

If someone can truly find a need for a rollable display then we can make it. The technology is there.

mass-production, according to E Ink's chief marketing officer Sri Peruvemba.

Although the device is framed in rigid plastic, the combination of flexible backplane and e-paper is likely to be seen more frequently in the near future.

USEFUL LINKS

- + 2012 Flexible Electronics & Displays Conference & Exhibition – www.flexconference.org
- + AUO develops solar-powered flexible e-reader – bit.ly/u4Ppfg
- + European project develops rollable displays – bit.ly/tfWljM
- + Flexible phone brings concept closer to reality – bit.ly/ve1Gbz
- + Google, Samsung unveil smartphone Galaxy Nexus – bit.ly/nkQDql
- + Plastic Logic e-reader to go into Russian schools – bit.ly/u3wZoi
- + Samsung Electronics to launch flexible OLED-based products in 2012, probably start with phones – bit.ly/v5IRmx
- + Truly flexible displays are not yet ready for market – bit.ly/spPGu7
- + Wistron to divest flexible displays firm Polymer Vision – bit.ly/vkGzMb

DESIGN NEED

However Peruvemba feels the benefits of a rollable or foldable display need to be defined first – and suggests that it is the design need, not the technology, that is holding flexible e-paper back.

'If someone can truly find a need for a rollable display then we can make it. The technology is there,' he remarks.

'The scroll disappeared for a reason: it's not practical as you have to roll it out every time you want to look at it. The same practical problems apply to plastic versions. People want a notepad, not a scroll.'

The advantages of flexibility are really felt in bigger displays. The iPad is quite heavy, for instance.

Peruvemba suggests that flexible backplanes could unlock other beneficial uses of flexible displays though.

‘In other applications there are possibilities, for displays that tend to be smaller – for instance, a wraparound mobile phone, or military use displays where there is definitely a need for a much more conformable device,’ he adds.

E Ink is working with partners on new drivers,

controllers, and systems to enable animation and video-rate displays. Other development work is focusing on colour e-paper displays, using flexible colour filters.

PRACTICAL USES

However it is likely that monochrome e-paper will help determine the appeal of more flexible displays, which in turn will validate efforts to develop more flexible – or even foldable or rollable – OLED displays in the long-term.

Aside from the appeal inherent in a flexible display-based device itself – the lighter weight, the ruggedness offered by eschewing glass, the thinness that can be achieved – there are potential benefits for processing on cheap, flexible substrates.

While some organic technologies are relatively immature – as Corning’s comments on flexible glass

layers suggest – the move to flexible substrates and lower-temperature processing could deliver significant production cost savings for display manufacturers.

‘It’s fair to say we’re seeing more interest in solution processing,’ says Michele Ricks, business development manager for OLED materials at Merck.

‘The industry as a whole has more confidence that it is viable, where previously there was skepticism that it would never be able to compete [with vapour deposition]. The question now is “What will be the right method?”’

IMPACT

If Samsung introduces new products in the smartphone market in 2012 using glass-free flexible displays, it could prove to be as significant a change as the original implementation of OLEDs – possibly even more so.

And the benefits of a flexible display have the potential to make an even greater impact in other, lucrative product categories in the coming years too.

‘The advantages of flexibility are really felt in bigger displays. The iPad is quite heavy, for instance: it would be a benefit to customers to have a lighter display in a tablet,’ Feenstra notes. +



FLEXIBLE OLED DISPLAYS COULD SIGNAL THE END OF THE USE OF RIGID SHEETS OF GLASS TO ENCAPSULATE A SCREEN
PHOTO: OLED-DISPLAY.NET