# Display Week 2011 Review: E-Paper

*A year of robust investment in more mature technologies also offers a few new surprises.*

by Jason C. Heikenfeld

LAST YEAR was a breakthrough in visual terms for e-Paper at Display Week, as numerous color prototypes appeared throughout the 2010 exhibition and symposium. Sometime before the show, I wrote, with authors Paul Drzaic, Jong-Souk Yeo, and Tim Koch, a major overview of e-Paper (see Ref. 1). I was curious going into this year's Display Week about whether the rapid pace of e-Paper technology had already outdated our article.

While Display Week 2011 did not match the amount of new e-Paper technology shown at Display Week 2010, this year represented both increased product focus and firm investment from large display and electronics companies. What a great time to be involved in the technology or business of e-Paper. I find it absolutely amazing that there are so many unique horses (technologies) in the race. How long will they last? Maybe for a while, as the "perfect" color-video e-Paper has yet to be achieved, even in a laboratory setting.

It makes sense to start any e-Paper overview with E Ink Corp. At Display Week, the company showed a familiar array of excellent looking electrophoretic displays. Sony also showed a large 13.3-in. flexible module based on E Ink's Triton color technology (Fig. 1).

A couple of weeks before the conference, endgadget posted a blog (http://www.engadget.com/2011/05/04/e-ink-develops-flashing-displays-for-cloth-and-tyvek-experiment/) about possible full-motion video in the 2012 product update from E Ink. However, such a video module was not to be found at the E Ink booth – maybe next year… . To most of us, the resolution capability of E Ink at up to 300 ppi is completely satisfactory. E Ink continues to be on a roll, increasing production capacity, appearing in prototypes of numerous display companies, and, appropriately, winning the Society for Information Display's Gold Display Component of the Year Award for Triton film.

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## Comebacks

It was exciting to see a few of those companies that had previously exited e-Paper now back in the race and stronger than ever. Consider Samsung who just last August announced a halt to e-Paper production, and then this year strategically surprised many by acquiring Liquavista and therefore a global lead in electrowetting display technology. Samsung showed 6.3-in. color active-matrix electrowetting prototypes that appeared to have better gray scale and fewer defects than the Liquavista units displayed last year. One of the demo modules, and a symposium talk given by Liquavista engineer Andrea Giraldo, showed a low refresh rate of 1 Hz for power reduction (electrowetting displays are not bistable). Johan Feenstra, CEO of Liquavista, noted that with the acquisition by Samsung, electrowetting-display commercialization is




***Fig. 1:*** *Sony's 13.3-in. flexible prototype uses E Ink's new color imaging technology, Triton.*



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now more focused than ever before, with a clear product and production facility in sight.

If you visited the Solutia (Flexview) booth, you might have seen Edzer Huitema, CTO of Polymer Vision, showing a defect-free 6-in. SVGA rollable display. The display used SiPix microcup front-plane technology and exhibited 40% reflection. The fact that it was defect free is important because the display came off Polymer Vision's new Gen 2.5 R&D line in Eindhoven. Polymer Vision appeared to exit the e-Paper race in 2009 when it declared bankruptcy, but was acquired in 2010 by Wistron Corp. and is now once again pushing its technology forward.

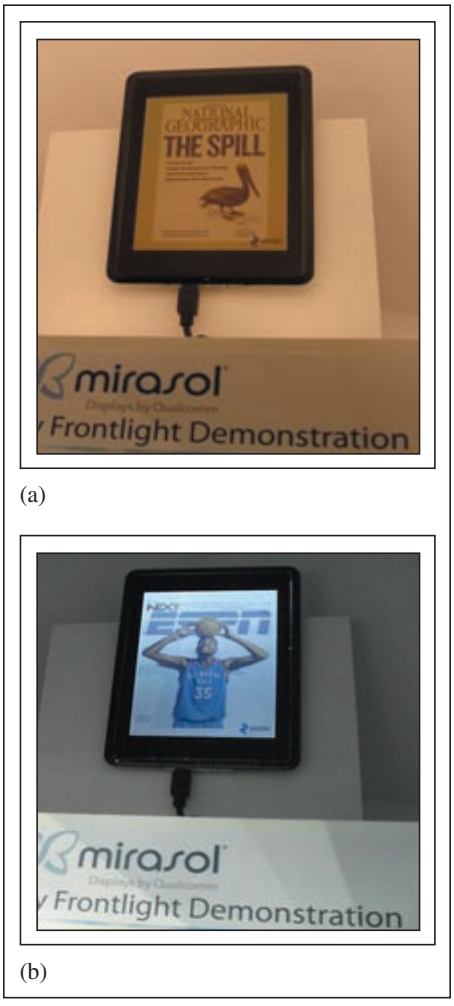



***Fig. 2:*** *(a) External ambient illumination is used (as it would be for standard e-Paper) and (b) the display in a dark environment with the front light activated.*

## New Offerings

So what was new? Actually quite a bit. There was a talk given by SiPix Imaging on its dual-mode display. It has now demonstrated prototypes with "dual color pixels," in which a single pixel can display a color or white or black. The big benefit is a possible boost in reflectance, but no strong supporting data were presented at this time. In the exhibit hall, you could find an HP electrokinetic active-matrix module (in the Corning booth), and if you were lucky enough to run into Tim Koch of HP, you were treated to a demo of a three-layered CMY prototype, which now nearly satisfies SNAP (Specifications for Newsprint Advertising Production; see Ref. 1) color standards such as reflectance and color gamut that we are all accustomed to from newsprint. This is a major advance for e-Paper.

A very interesting e-Paper adaptation was shown at the Qualcomm booth, where there were two mirasol demos that were front lit for nighttime readability. The image quality for the front-lit units was good [Figs. 2(a) and 2(b)].

This front-light concept is quite intriguing because a bright front light could possibly allow e-Readers to have a "saturated" color mode. For instance, with RGBW, if the red is turned on, the front light illuminates the red creating better color saturation than achieved with R&W pixels in the reflective-only mode. Qualcomm is not the only company working on advanced front lights, although it is the only one thus far to publicly disclose it. Regarding product launches of e-Reader/tablet-sized mirasol displays, the target date has been pushed back to late 2011. This seems to represent a strategic shift for Qualcomm, from mobile phones to larger-sized displays. Also based on optical interference, but not requiring micromechanical pixels, is the improved photonic-crystal electronic ink that Opalux CTO André Arsenault presented at the Symposium. This "P-Ink" has 60% reflection across the visible spectrum. Unlike mirasol, this technology currently can create any saturated color across the visible spectrum inside one pixel (see the article from Opalux, "Photonic Crystal Display Materials," in this month's issue of *Information Display*).

Arguably one of the most exciting presentations at the SID Symposium was Ricoh's three-layered CMY electrochromic display. In electrochromism, colorants undergo an oxidation change that shifts them between a clear or colored state. First, the white-state reflectance was 70% (although the black state was not fully black yet). Second, the color gamut was vastly improved through the use of CMY stacking as opposed to RGBW. Third, the stacked display used a common electrolyte that coupled all three layers to a single backplane. This eliminates many of the optical losses in CMY stacking. Only two substrates were used, a first ever for stacked e-Paper. Although slow (it took seconds to refresh), the gray scale was striking for a first demo (see Fig. 3).

I was impressed by how the three layers were stacked and addressed between just two substrates. Ricoh reported that each layer is only ~ 2 μm thick, and when questioned in the session, company representatives claimed 20,000 cycles of operation. Akira Suzuki of Ricoh has been seen at every display conference for as long as I can remember, assessing what technologies Ricoh should pursue. It looks like the company's first major bet may now be played.




***Fig. 3:*** *Ricoh unveiled a three-layered (CMY) electrochromic display capable of 70% white-state reflectance and, amazingly, driven with a single backplane.*

ADT and Gamma Dynamics reported on the progress in their variations of displays using electrowetting, not to change surface wetting, but to move (transport) colored fluids inside microfluidic pixels. The ADT booth showed a first-ever medium-sized droplet-driven prototype (Fig. 4). ADT's Frank Bartels also noted the availability of evaluation kits late this year, with initial products in 2012.

Last but not least, a resurgence in traditional liquid-crystal displays (LCDs) was seen throughout the exhibit hall. Sharp displayed two polymer-network LCDs. Also, the new Chinese startup company Halation showed numerous smectic LC products (see Fig. 5).

I ran into display industry expert Mark Willner, who is knowledgable about smectic-A displays and Halation in particular. He was impressed by how far the company had come in just 2 years in developing both smectic-A liquid-crystal materials and displays for production in China. Mark said "If Halation is able to improve performance and meet ESL market requirements, they could become a significant player." None of these LC technologies look superior to E Ink or other more optically diffuse displays, but the infrastructure for LC technology is strong, so the costs for such displays could be quite low, even in the short term. Kent Displays did not exhibit, nor were there many cholesteric demos, except for several papers and demos presented by ITRI.




***Fig. 4:*** *ADT showed, for the first time, a highly pixelated and bistable droplet-driven (electrowetting) display.*




***Fig. 5:*** *Halation's smectic-A e-Paper displays exhibit good e-Paper performance with the potential for low-cost manufacturing.*

It is not possible to cover all the e-Paper seen at Display Week 2011 in this short review. Almost every major company has reflective technology in production or development. However, e-Paper is still only widely available in monochrome formats. After approximately 1 year, the major technologies reviewed in our *JSID* paper are still in play. None of us knows all the true challenges and benefits for all the competing technologies. Presentations, demos, and review articles such as this will soon give way to the ultimate judge of commercial success or failure – the marketplace. Looking forward to next year, will we have color E-Ink (electrophoretic), Bridgestone (liquid powder), Qualcomm (mirasol), and Samsung (electrowetting) modules in the marketplace? The demos look ready to go. Some now already have video, which pushes e-Paper into closer competition with LCD and OLED tablets. Next year should be a critical one for accessing the ability of e-Paper to move beyond signage and e-Readers.

## References

[1]J. C. Heikenfeld, P. Drzaic, J-S. Yeo, and T. Koch, "Review Paper: A critical review of the present and future prospects for electronic paper," *J. Soc. Info. Display* **19**, No. 2, 129–156 (2011). ■