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Epaper Central Talks With E-paper Inventor Nick Sheridon

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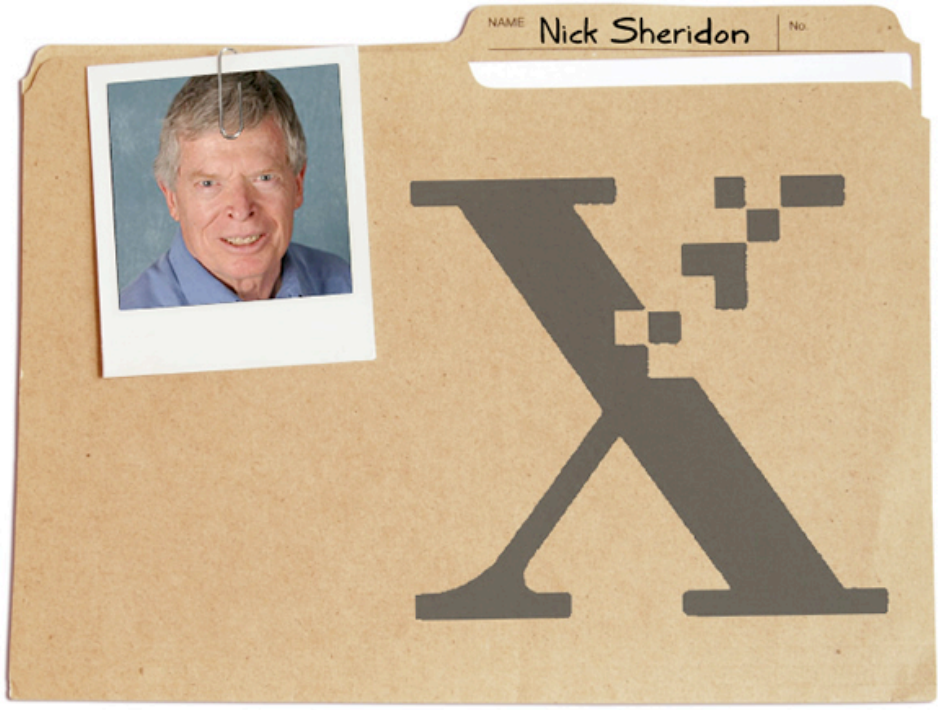

Timing is everything, especially with a new technology introduction. No matter how innovative the technology is, if the market is not ready, it does not take hold. E-paper was invented by Nick Sheridon at Xerox's Palo Alto Research Center (PARC) in the 1970s. However, it is only recently that the technology has found its niche. At the time of its invention, even Xerox had little interest in developing the technology. However, in today's society where consumers are demanding both digital information and portability of devices, e-paper has come of age. It is finding application as a

replacement for conventional display technology in many areas. There is a proliferation of e-readers, which may be the tipping point for mass commercialization of e-paper. With increasing crisis in the newspaper industry, e-newspapers are being developed and adopted at a rapid pace. It is in retail stores in the form of smart shelves. It has been tested as a medium for portable disaster information, as well as information signage in railway stations. Epapercentral.com recently had the opportunity to discuss E-paper technology with Nick Sheridon. Following are his perspectives on the early days, the status of the technology today and where it is going for the future.

Q. How did e-paper technology get its start?

Sheridon: It was the early 70's. Since I had established a reputation as a prolific inventor by this time, I was regarded as an individual contributor, with a lot of freedom. Palo Alto Research Center (PARC) had pioneered the ALTO computer, the first practical personal computer. The main drawback to these machines was their displays. The contrast was so low that users darkened their offices as much as possible when using the ALTO. With the agreement of my management, I set out to invent a display technology that would look good in a brightly lit room or on a beach.

Q. Can you explain the problems with early electrophoretic displays?

A: Electrophoretic displays at the time had serious image storage problems. In working with them I found that when they were held in the vertical position the image would self destruct within 2 or 3 minutes…unless the images were formed using high voltages. However, in that case it was extremely difficult to erase the images. By microencapsulating the electrophoretic particles in modern displays the fundamental mechanism for image destruction is eliminated, very successfully. These displays also had limited lifetimes, but enormous advances have been made more recently.

Q. Can you explain how the Gyricon technology works? Why did you feel that it would be easier to develop than the electrocapillarity display?

A: A Gyricon display consists of a highly transparent silicone rubber sheet in which a high density of 100 micron balls has been dispersed. Each ball is black on one hemisphere and white on the other, and the two hemispheres have different, permanent electrical charges. Also, each ball sits in an oil-filled cavity about 20 % larger than the ball, allowing the ball to rotate in response to an applied voltage. In one voltage polarity the rubber sheet appears to be white, in the opposite polarity black. The balls stick to the cavity walls after they have rotated, providing long term (months, years) image storage without the continued application of voltage (and thus power).

I pursued the technology because I was able to make early Gyricon displays using materials I could procure easily. Materials suitable for electrocapillary displays were not easily obtained at the time, and I spent some significant effort trying to develop them, with limited success (I was able to make displays that worked but would not be commercially practical). Such materials are much more readily available now.

Q. Xerox did spin off Gyricon LLC to market the technology, but it was not a success? Can you explain why?

A: Gyricon decided early on that they would use the technology to make wirelessly addressable point of sale signs for use in department stores. It turned out that department stores were unable to afford the displays at a cost Gyricon could sell them for. Despite sales in other application markets, Xerox closed the company because it felt Gyricon would take too long to reach

sustainability. The basic problem was that Gyricon decided it wanted to be a sign company. The successful e-paper companies, such as E Ink, set out to be display media companies that let the customers invent the applications.

Q. Xerox still holds the IP for the Gyricon technology, did it finally license the technology and to whom?

A: I understand that Xerox is very interested in licensing the technology, but has not found a licensee, yet. Interestingly, a Japanese company, Soken Chemical and Engineering Ltd., has recently announced a display product that is essentially identical to Gyricon.

Q. How does the current electrowetting technology differ from the electrocapillarity technology that you developed? What do you feel are the advantages of this technology and why?

A: The electrowetting technology is identical to the electrocapillary technology that I developed. Although I invented the technology in the mid 70's, I did not apply for patents on the technology until the mid 90's, because I always intended to get back to working on the technology. Shortly after my electrocapillary patent applications were laid open in Europe some people at a European university announced a new technology they called electrowetting. University researchers traditionally do not attribute ideas they obtain from the patent literature. Electrowetting allows dyed or pigmented liquids to be moved over the surface of a display using very low voltages and at very high speeds that are suitable for video. It is well suited for color e-paper.

Q. What about the other technologies currently being used for e-paper applications, such as electrophoretic, electrochromic, ChLCD, etc? What do you see as the competitive advantages/disadvantages of each of these?

A: The commercially dominant e-paper technologies today are electrophoresis (E Ink, SiPix) and cholesteric liquid crystals (Kent Displays). I define the perfect information display as black ink on diffuse white paper (drawback…can't be cycled). Most people seem to agree with this. Electrophoretic displays appear to be more capable of emulating the perfect display than cholesteric displays; indeed, they have been adopted for book readers.

Electrochromic displays can have excellent quality (as defined above) but traditionally require large electrical currents and have short lifetimes. There is an Irish company that may have solved these problems. None of these technologies has demonstrated a high quality color capability…the next frontier in e-paper.

Q. Which of the technologies do you see as having the most potential in terms of e-paper? Of do you see different technologies being used mainly for specific e-paper applications?

A: At this point there are many technologies being touted as electronic paper. Each has strong points for specific applications. For example, the E-Ink version is well suited to document reading in monochrome. The Bridgestone toner display can be expected to hold up well in outdoor advertising applications, also true of the Kent Displays and Magink Cholesteric displays.

Q. What do you see as the application that will offer the most potential for e-paper technology, i.e., e-paper newspapers, e-readers, information signage?

A: I believe the big application will be electronic document readers. Subsets are newspaper readers, book readers and ultra-light computer displays. The Holy Grail here is the highly flexible electronic paper medium that can be rolled up into a pen-like shape (that fits in a shirt pocket) and unrolled to provide a large, paper-like display. Information can be downloaded anywhere on the planet from satellites and cell phone networks.

Q. There has been a flurry of announcements lately about color e-paper. What do you see as the most important challenge/obstacle to color e-paper at this time? When do you think color e-paper will become a mainstream technology in the industry? Which technology do you think has the best potential for color first and why?

A: Color e-paper is difficult and I have seen no good quality color e-paper technologies. The basic problem is that e-paper is a reflective display that uses ambient light for visibility. As printers have long known, images with bright colors are obtained by the use of subtractive color techniques (requiring cyan, magenta, yellow and black layers, each image-wise addressable). Attempts to use additive color (red, blue and green sub-pixels comprise a full pixel) produce "muddy" images because they waste light. An exception to this statement is found with electrowetting, in which red, blue and green dyed liquids that act as color filters can be individually moved to fully cover a pixel. E-paper cannot reach its potential without high quality color. At the moment it appears electrowetting has the best potential here.

Q. Many of the larger electronic display companies are working heavily on OLED technology. How will OLED and e-paper technologies coincide?

A: OLED is an emissive display technology that requires significant power on a continuous basis. E-paper is a reflective technology that requires power only to change its image. OLED works best in low ambient light situations, e-paper works best in well lit situations. They will co-exist nicely.

Q. Do you see e-paper devices improving to become multifunctional devices or will the e-reader/e-newspaper device only offer book/newspaper reading?

A: An e-paper document reader will be very useful for reading all documents, including newspapers and Magazines (Magazines require high quality color). In previous discussions with newspaper people I found they prefer a format size fully comparable to that of an actual newspaper in order to accommodate advertising. They are highly interested in such a reader.

Q. It was interesting to see the E Ink developer kit tested with the Google Android platform. If the devices are capable of becoming multifunctional, when do you see the commercialization of such products happening? Will such devices replace current multifunctional devices such as the iPhone, or will the products co-exist?

A: As I am sure you are painfully aware, the biggest problem with these multifunctional devices is power consumption…battery life. E-paper burns far less power than any other display device. Another problem with multifunctional devices is display size…no one wants to carry around a big display but everyone wants to have one. Because e-paper is capable of being rolled up when not in use it solves this problem. E-paper will greatly enhance the capabilities of these devices.

Q. Would you comment on e-paper as a green technology?

A: My observation at Xerox was that almost everyone read short memos on the computer screen, but printed any documents longer than a half page and read the printed version on paper. Paper provides a much better reading experience. To the extent e-paper fully emulates printed paper a lot of trees will be saved. E-paper also consumes much less power than any other display modality.

Since its time has come, the major question is what will be the direction that e-paper will take for the future. The first step which is already underway is mass commercialization of e-readers. Although there are debates as to whether consumers will pay for an e-reader rather than a multi-functional device such as an iPhone, there are obvious advantages to a dedicated reader, such as the larger screen and readability in ambient light. Sheridon has noted that this is the "killer application" for electronic paper. Along with e-readers will come e-newspapers and e-magazines. In addition, e-paper in any form uses substantially less power than traditional display technologies. Sheridon does not feel that OLEDs would replace e-paper technology for the future. Each technology has its own advantages and will complement each other rather than compete for applications.

Color is Critical

Critics and proponents agree that color e-paper despite its challenges is critical for future expansion. Sheridon agrees, adding that the reflective advantage of e-paper is a disadvantage in regards to colors. Because it uses an additive concept rather than the subtractive process used in traditional printing, the color has a tendency to be muddy. Regardless, there have already been significant steps in towards the direction of color. The Flepia is but one example. In addition, LiquiVista, the only firm using electrowetting technology, which Sheridon feels is the best bet for color, is finally starting to move towards commercialization. There has also been development in other technologies from QualComm, which have definite potential to break the color barrier, as well as that of faster switching speeds.

E-paper has also found increasing application in other areas. ZBD Display has encountered considerable success in Europe in implementing e-paper technology for smart shelves. It is currently aggressively targeting the U.S. market. In Asia, there have been signs of e-paper for advertising signage and for portable disaster information. So it would seem that e-paper technology is moving in several directions. Which will become the main roadway may be a question mark, but its future success is a definite positive.

By Linda M. Casatelli

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