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E-INK (ELECTRONIC INK)

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ABSTRACT

Electronic ink is a invention that combine all the desired features of a modern electronic display and sheer convenience and physical versatility of sheets of the paper. Therefore to create a dynamic high-resolution of E- display which is thin and flexible enough to become the next generation of papers. The E-Ink technology has been initialized and developed is well under way. Within next 5 years, it is envisioned electronic books that can display volume of the information as easy as flipping a page and permanent newspapers which update itself daily through wireless broadcast. They delivers the read-ability of paper under bio-virtually at any condition, without backlighting. Moreover E-ink displays are persistents without external power supply. It drawing current only when it take change, which means batteries are powerful and last longer.

KEYWORDS: Electronic Ink, Gyricon, OEM, TFT, LCD, Electronic Display

INTRODUCTION

Before 2,000 years ago normal ink on paper was the only way to display words and images, and it still beats computer displays when it comes to portability and price. Ink doesn't require an external power source or an expensive, fragile screen, and it doesn't suffer software and hardware glitches.

A book represents a fundamentally different entity than a computer screen in that it is a physical embodiment of a large number of simultaneous high-resolution displays. When we turn the page, we do not lose the previous page. Through evolution the brain has developed a highly sophisticated spatial map. Persons familiar with a manual or textbook can find information that they are seeking with high specificity, as evidenced by their ability to remember whether something that was seen only briefly was on the right side or left side of a page, for instance. Furthermore their haptic connection with the brain's spatial map comprises a highly natural and effective interface, when such information is embodied on actual multiple physical pages.

Another aspect of embodying information on multiple, simultaneous pages is that of serendipity and comparison. We may leaf through a large volume of text and graphics, inserting a finger bookmark into those areas of greatest interest. Similarly, we may assemble a large body of similar matter in order to view elements in contrast to one another, such as might be done to determine which of a particular set of graphical designs is most satisfying.

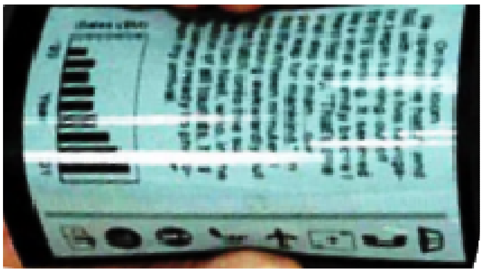
The problem, of course, with traditional books is that they are not changeable. Once words are printed on paper, those words cannot be changed without at least leaving some marks, and it is also difficult to carry around a large number of books.

Hence there is a need to construct a book that actually comprises several hundred electronic displays on real paper pages. For this, we need to conceive of a display technology that would save on power, money and be inherently amenable to the integration of a large number of displays.

One answer may be a hybrid display system that combines the flexibility and versatility of paper with the nature of a conventional computer monitor and the high capacity of electronic data storage. The key to such an innovation would be a new type of ink -- one that can change from black to white or white to black on command. The approach taken is to invent a new microfabricated material that is called Electronic Ink or e-ink. Electronic ink is a revolutionary technology that could replace paper. E-ink is an ink like material that may be printed by screen print or other standard printing processes, but which undergoes a reversible bistable colour change under the influence of an electric field.

Printed with such an electronic ink, a book would become a sheaf of high-resolution, high-contrast, electronically addressable displays. As with an ordinary book, a reader would be able to leaf through the pages, browsing the contents, making comparisons, and marking the required passages. In addition, however, a reader could adjust the format of the pages for readability, update the book's contents, or even download a whole new text.

This seminar report is about how electronic ink is made, how it will allow one to carry a whole library in one book and how it could be used for cheaper computer displays.



Electronic Ink

2. THE TECHNOLOGY

Mainly two companies are simultaneously developing similar electronic inks -- ***E Ink*** of Cambridge, MA, and ***Xerox*** in Palo Alto, CA. At first glance, a bottle of electronic ink looks just like regular ink, but a closer examination shows something much different. Although the two companies' products vary slightly, here are the three components of both electronic inks that give them the ability to rearrange upon command:

- Millions of tiny **microcapsules** or cavities
- An **ink** or oily substance filling the microcapsules or cavities
- **Pigmented chips or balls** with a negative charge floating inside the microcapsule

Electronic ink can be applied to the same materials that regular ink can be printed on. In the case of a digital book, the pages would be made out of some kind of ultra-thin plastic. The ink would cover the entire page, separated by cells that resemble the cells on graph paper. Each cell is wired to microelectronics embedded in this plastic sheet. These microelectronics would then be used to apply a positive or negative charge to the microcapsules to create the desired text or images.

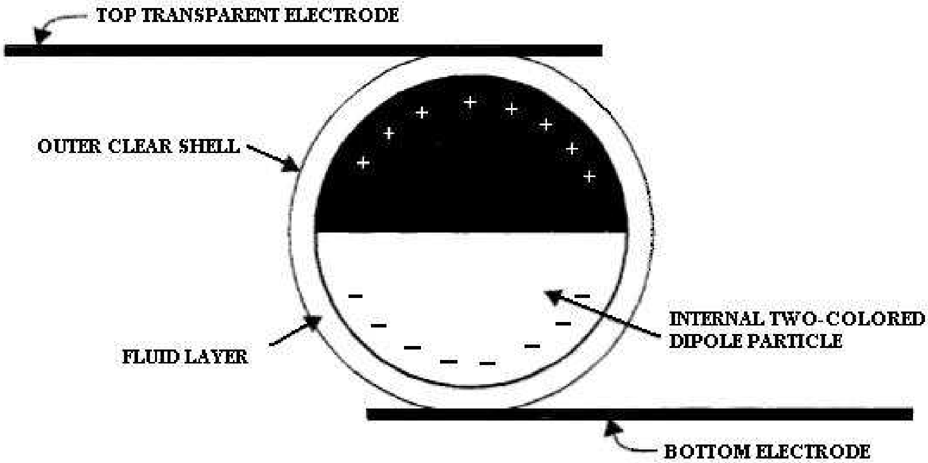


Figure 2.1: Schematic of an Electronic Ink Particle

The initial prototype of e-ink that was developed at the Massachusetts Institute of Technology Media Laboratory in Cambridge, Massachusetts, consisted of a microparticle system, susceptible to an electric field, which is then further microencapsulated in an outer clear shell that may be glued or printed onto an arbitrary surface. One such possible system that was fabricated is shown schematically in Figure 2.1 and as a micrograph in Figure 2.2. In this system a two-colored dipolar particle has a dipole moment associated with it along the color axis, as indicated by the plus and minus charges in Figure 2.1. A potential across the address electrodes serves to translate and rotate the two-color particle so that its top half or bottom half is made visible to the reader. An interaction between the particle and the inner wall of the clear shell makes the system bistable. Xerox and E Ink are using different techniques to develop their electronic inks.

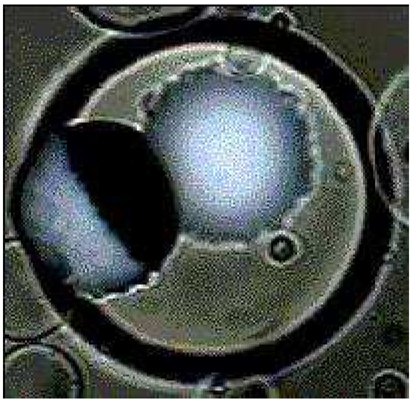


Figure 2.2: Photomicrograph of Electronic Ink

2.1 E Ink

E Ink uses electrophoresis – the characteristic of charged particles to migrate through a fluid under the influence of an electric field to attract light or dark particles close to the viewing surface to create an image.

The principal components of E Ink’s electronic ink are millions of tiny microcapsules, about the diameter of a human hair. In one incarnation, each microcapsule contains positively charged white particles and negatively charged black particles suspended in a clear fluid. When a negative electric field is applied, the white particles move to the top of the microcapsule where they become visible to the user. This makes the surface appear white at that spot. At the same time, an opposite electric field pulls the black particles to the bottom of the microcapsules where they are hidden. By reversing this process, the black particles appear at the top of the capsule, which now makes the surface appear dark at that spot.

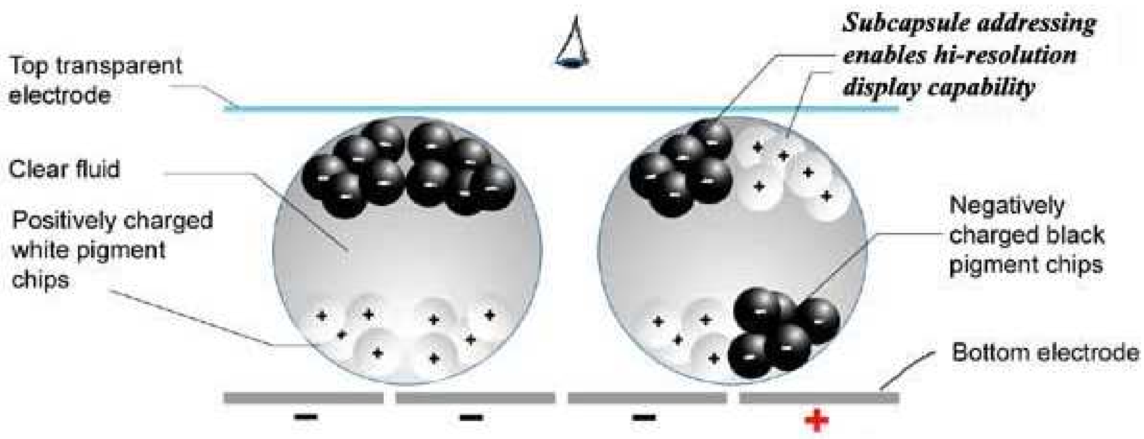


Figure 2.3: Cross-Section of Electronic Ink Microcapsules

To form an E Ink electronic display, the ink is printed onto a sheet of plastic film that is laminated to a layer of circuitry. The circuitry forms a pattern of pixels that can then be controlled by a display driver. To move the ink around, computer programs can be used to simply change the electric fields. These microcapsules are suspended in a fluid "carrier medium" and printed onto a flexible plastic film. The film is placed on a thin film transistor (TFT) backplane, which is controlled by a display driver. The carrier medium that the microcapsules are suspended in allows E-Ink to be printed using existing screen printing technologies. That means that E-Ink can be printed onto virtually any surface including glass, plastic, and fabric. This new potential for display devices on flexible surfaces can make display devices far more ubiquitous than they will ever be with current rigid display technologies.

2.2 Xerox – Gyricon

Xerox, in partnership with 3M, has created an e-paper called Gyricon. Gyricon is a type of electronic paper developed at Xerox's Palo Alto Research Center (PARC). ‘Gyricon’ is Greek for rotating image. Gyricon differs from the E-Ink technology in a few ways. It is composed of a silicon rubber compound with the thickness and flexibility of a poster board. Gyricon consists of a double-sided plastic sheet almost as thin as a standard transparency. Within this sheet are millions of bichromal balls just 0.1 mm wide.

Gyricon also consists of microcapsules with black and white charged pigment. However, the pigment is applied to the surface of the microcapsule. One hemisphere is white, and the other is black. Depending on the charge in the TFT array, the visible area of the microcapsule will either be black or white. When the charge transitions, the microcapsules rotate 180 degrees to reveal the other color. They rotate fully to display a black or white, or partially to display a range of grey shades. Images and text are created by the combined display and are bi-stable. (They remain fixed in position until another electrical pulse is applied to change the orientation of the balls).

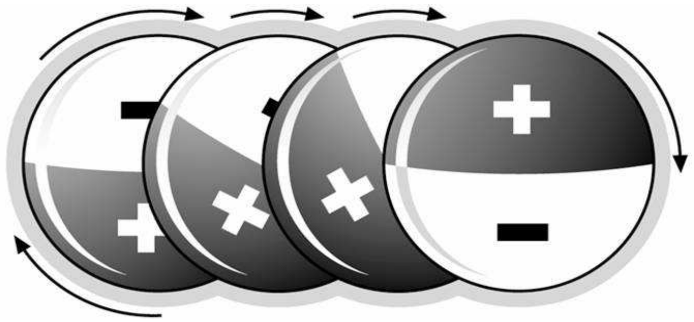


Figure 2.4: Rotation of Gyricon Beads during Charge Transition

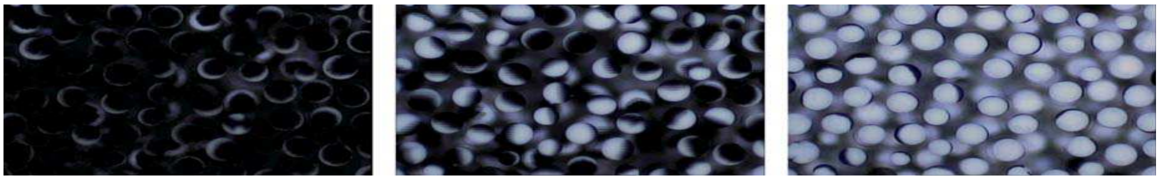


Figure 2.5: Gyricon - Microcapsules Switching from Dark Hemisphere to Light

3. KEY BENEFITS

With the explosive growth of broadband communications and wireless technologies, the world is rapidly becoming more connected – giving people access to vast amounts of information. However, current limitations in display size and readability are significant constraints to the dream of anytime, anywhere information. For enhanced ease-of-access, device users want larger displays with paper-like readability, ultra-low power consumption and thin, light form factors. The ideal solution: high-resolution, electronic ink displays.

Electronic ink moves information display to a new dynamic level, with dramatic benefits over traditional media.

- **Superior Look:** Because it's made from the same basic materials as regular ink and paper, electronic ink retains the superior viewing characteristics of paper, including high contrast, wide viewing angle, and bright paper-white background.
- **Versatile:** Electronic ink can be printed on almost any surface, from plastic to metal to paper. And it can be coated over large areas cheaply.
- **Paper-Like Readability:** The ultimate benchmark for displays is printed paper – this is especially true for reflective displays. Paper is easily readable over wide variations in lighting conditions and viewing angle. E Ink's electronic ink technology approaches printed paper in performance by incorporating the same coloring pigments often used to make paper white and ink black. Moreover, it eliminates the need for backlight. The key readability factors are white state reflectance and contrast ratio. To be readable, the display must offer both sufficient luminance and contrast. This will be explained in detail later.
- **Ultra-Low Power Consumption:** Electronic ink is a real power miser. It displays an image even when the power is turned off and it's even legible in low light reducing the need for a backlight. Once an image is written on an electronic ink display, it will be retained without additional power input until the next image is written. This can significantly extend battery life for portable devices.

- **Reduced eyestrain:** Since electronic ink does not require constant refreshing, there is no annoying flicker. Like a traditional piece of paper, the surface can be read from any angle, with a comparable contrast between the letters and the background.
- **Lightweight:** The display will have many of the qualities of paper thinness and portability. Not only is e-paper efficient to use, but also it is independent of a heavy, bulky power supply. Also, the fact that e-paper technology itself is thin and light, it shall make way for sleeker, lighter products.
- **Flexibility:** With the help of technologies such as that of plastic transistors, the electronic devices using electronic ink can be made so flexible that their displays can be rolled up.
- **Scaleable:** The ability to enlarge or reduce the size of an image is called scalability. E Ink's electronic ink process is highly scaleable, which makes it competitive against today's older technologies.
- **Low Risk Manufacturing:** E ink can be manufactured using existing infrastructure of conventional displays. In fact, electronic ink displays can be assembled with only minor modifications to the process equipment and with fewer, simpler process steps. A detailed explanation of the process is explained below.

3.1 Manufacturability

One of the major drawbacks of many new display technologies is the need to develop, capitalize and scale up new manufacturing processes to enable broad commercialization.

This can introduce several significant risks to the commercial launch of a new technology: the need for sizable capital investment, constraints in capacity, elevated manufacturing costs, and delayed time-to-market. E Ink’s electronic ink technology overcomes all of these potential problems by leveraging the existing infrastructure used in the manufacture of conventional active matrix liquid crystal displays (AMLCDs). In fact, electronic ink displays can be assembled with only minor modifications to the process equipment commonly used in AMLCD manufacture, and with fewer, simpler process steps.

Simple Ink Component: Display-makers are supplied with a simple ink sheet component. First, microencapsulated electronic ink is produced using batch chemical processes that can easily be scaled to meet volume requirements. The liquid ink is then coated onto an ITO-coated plastic substrate in a fast, efficient roll-to-roll process. The resulting ink film is combined with a thin adhesive and a plastic release sheet to form the complete front plane laminate (FPL). At this point, the FPL roll is converted into individual sheets and packaged for shipment to the display manufacturer. Given the economies and scale of these processes, large sizes can be readily made. This coating and converting process can be performed using methods well established in existing manufacturing operations.

Standard Process Technologies for Other Display Components: The other components required to make electronic ink displays are easily produced within the existing TFT display industry infrastructure. TFT arrays (thin film transistor arrays), driver ICs, controller ICs and other electronic components, and color filter arrays can all be readily produced by existing suppliers and process technologies.

Simple Display Assembly: For the display manufacturer, the E Ink process flow for display cell assembly is much simpler than that for AMLCDs. The process used to attach the FPL to the TFT panel is similar to polarizer lamination for AMLCDs, and uses similar equipment. Other steps, such as the scribe and break process, are identical to processes for AMLCDs. The similarity of the processes and equipment means that only minimal additional capital investment is required to convert an AMLCD manufacturing line for E Ink display production.

Manufacturing Cost Benefits: The simplified process to assemble electronic ink displays eliminates several steps and costly materials from the AMLCD manufacturing process, including alignment layer deposition and rubbing, cell spacing and filling, polarizer lamination, and the integration of optical enhancement films. This simplification brings two major cost benefits. First, the capital equipment, labor, materials and plant space associated with these steps are eliminated, resulting in direct cost savings. Second, the yield loss associated with each step is avoided, which should translate into higher overall display yields.

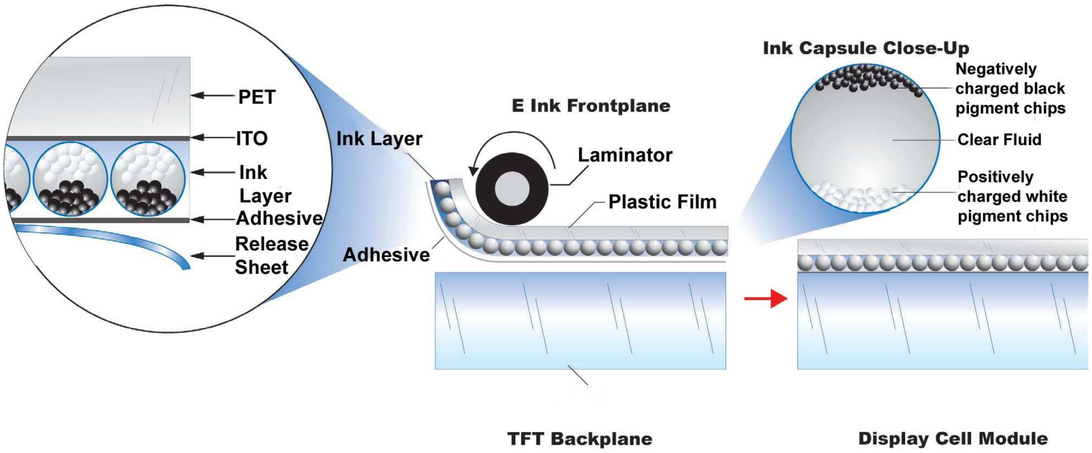


Figure 3.1: Manufacturing Electronic Ink

3.2 Display Readability

Readability is an important display attribute. With the emergence of reading-intensive applications such as web browsing, e-mail and electronic books, display readability has become one of the most important attributes in smart handheld appliances. In a survey conducted by Rocketbook (September 2000), over 90% of respondents stated that display screen readability was the most important feature for reader devices, followed by portability and ease of use.

Luminance and contrast are the two principal factors that determine readability for an electronic display. Luminance is the amount of light coming from the display surface - the light that ultimately reaches the user's eye. For an emissive display, luminance is generated by the display itself. But for a reflective display, luminance is determined by ambient illumination and the reflectance of the display's white state. Since ambient illumination varies widely, the key luminance metric for reflective displays is white state reflectance. Contrast is defined as the ratio of the white state to the dark state reflectance of the display - contrast enables the eye to easily distinguish between light and dark. To be readable, the display must offer both sufficient luminance and contrast.

Reflective displays are better suited to reading applications. Given that emissive displays produce their own light, they work well when there is limited illumination, such as in a darkened room. However, as ambient light increases, emissive displays can be washed out. This occurs because light reflected from the display surface increases the luminance of the dark state, thereby reducing contrast. This is why, for example, a laptop computer is very difficult to read in direct sunlight.

Reflective displays generate images using ambient light, and the luminance varies as the eye adapts to changing lighting conditions. In addition, the contrast is insensitive to variations in ambient lighting because both the white and dark states are equally affected. This makes reflective displays readable under a wide variety of lighting conditions, provided there is a basic minimum of ambient light; much like ink on paper.

In real-world reading applications, ambient light intensity varies greatly from a low light level in a home, to the intermediate lighting at the office, to very bright lighting outdoors. For an emissive display to be readable under this range of conditions would require a bright display, significant battery power, high cost, and substantial weight.

For this reason reflective displays are better suited than emissive displays for reading, especially in portable devices that will be used under a wide range of lighting conditions.

4. COMPARISON WITH OTHER DISPLAY TECHNOLOGIES

The current standard for flat panel displays familiar to notebook computer users is a 12.1-inch active matrix, thin-film transistor (TFT) display. Such screens can now have both high resolution and contrast. Unfortunately they have a number of serious deficiencies. The current original equipment manufacturer (OEM) price for such a display is approximately $1000. As larger substrate manufacturing technology is placed on line, this price will come down, but the asymptote price is still projected to be above $300. If integrated metal insulator metal (MIM) drivers become available, this price may halve again. One reason for the high price is that, in an active matrix (TFT) liquid crystal display (LCD), each pixel requires its own transistor latch to keep its state (black or white) fixed while other pixels are addressed. Further, since the display is transmissive, each transistor must be made as small as possible in order to let as much of the back light through as feasible. Manufacturing 106 such transistors to address a 1000 X 1000 display over a large substrate means that yields are poor. Another deficiency is power consumption. Typical power consumption for a 12.1-inch display is 2.5 watts split nearly evenly between the back light and the display drivers. Finally, such displays-which are built on glass substrates - are far from flexible and they are heavy.

There is much recent advancement in the area of organic light emitters that have the ability to be printed or spin-coated onto flexible substrates. Unfortunately, such displays, with fundamental input power to output optical power efficiencies of less than 5 percent, are power-intensive and, further, do not have archival properties.

Some of these deficiencies were attempted to be rectified using the guest host liquid crystal (LC) displays that do not require back light. In a standard liquid crystal display, liquid crystal molecules are rotated in an electric field that in turn rotates the polarization of light. Only when a top polarizer is put into place does the display actually turn into a black and white display (adding color filters yields color). The problem is that such polarizers have a very low coefficient of transmission for light (typically 20 percent transmission or less), thus requiring backlighting that consumes power. The guest host LC works without a top polarizer. It does this by linking a dichroic dye to the rotation axis of the LC molecule. The dichroic dye can be thought of as a cigar-shaped molecule. When viewed head-on, its cross-section to light is small and thus not visible, but if rotated it becomes highly visible. Such displays can be viewed fairly well in ambient light. However, they still require an active matrix to drive them, so there are still issues of cost and the power needed for the active matrix.

Other companies are pursuing displays that do not need an active matrix (thin-film transistor backplane). Such displays are possible if the pixel is “bistable,” meaning that after the pixel is addressed, it stays in the same state without a further field being applied. To date, these approaches have suffered from high power consumption requirements or slow address times.

But in the case of electronic ink, the overall display thickness may be eventually on the order of 200 microns, corresponding to about two and a half times the thickness of an uncoated sheet of paper (approximately 80 microns). The cost of a piece of 8.5 X 11-inch electronic paper is expected to be in the $1 to $10 range, with printing technology well suited for scaling up to larger sizes. The device is capacitive, and thus the only current draw is from displacement current. The current draw is about 500 nanoamps (A). A 12.1 inch electronic ink display would draw only about 12 milliwatts (mW). Although the switching time is dependent on the voltage, pixels with switching voltages below 10 volts have been created. Current particle size is approximately 250 microns, which corresponds to an addressable resolution of 100 dpi.

4.1 Readability Comparison

To quantify the improved readability of electronic ink displays, a comparison of reflectance and contrast ratio for E Ink’s display material relative to several commercial LCDs as well as newspaper is shown in Table 4.1 below.

These measurements were taken at a 0° viewing angle (as if a user is looking straight at a handheld display), with direct overhead lighting illuminating the display at an angle of 45°. The viewing angle and illumination angle are approximate to what one might find in a typical office situation.

As can be seen in the table, under equivalent conditions, the E Ink display sample with touchscreen is nearly three to six times brighter and has more than twice the contrast of the LCDs measured. In fact, the contrast of E Ink is notably greater than that of a printed newspaper. As can be seen from its high reflectance and contrast the E Ink display is much more readable than any of the LCDs shown in Table 4.1.

Table 4.1: Comparison of Reflective Display Media

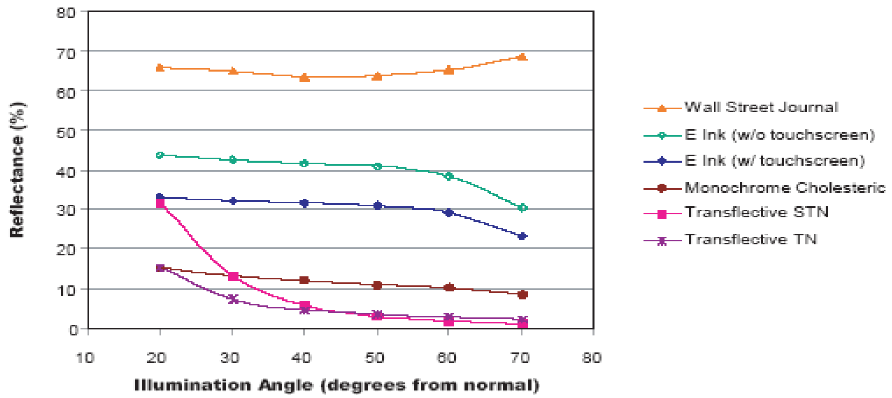
Display Technology	White State Reflectance	Contrast Ratio
Transflective Mono STN LCD (common PDA with touchscreen)	*4.2%*	*4.1*
Transflective Mono TN LCD (common e-Book with touchscreen)	*4.0%*	*4.6*
Monochrome Cholesteric (with touchscreen)	*11.5%*	*3.5*
E Ink (with touchscreen)	*31.7%*	*10.8*
E Ink (with no touchscreen)	*41.3%*	*11.5*
Wall Street Journal Newspaper	*64.1%*	*7.0*

Because the direction of lighting cannot always be controlled, we also compare a range of lighting angles in Figure 4.1, where the reflectance of these same displays is plotted at illumination angles ranging from 20° to 70°. An illumination angle of 20° would occur when the light source is positioned just over the viewer's shoulder; a 45° illumination angle would be experienced by a person sitting in the aisle seat of an airplane; while an angle of 70° might represent the most extreme illumination angle encountered when reading at home with a table lamp off to one side. As seen in the Figure, the reflectance of LCDs drops off rapidly with angle of illumination, while the E Ink displays compare closely to newspapers in their insensitivity to angle.

These results demonstrate the paper-like readability of E Ink displays. Unlike LCDs, where the user is forced to constantly adjust the display and reading location to find a position where display reflectance is maximized, E Ink displays, just like ink on paper, are easily readable under virtually any condition with a basic amount of ambient light.

Human factors studies have shown that paper produces less eye strain and affords the reader better, faster comprehension of material, as compared to emissive displays. This is believed to be due in part to the scanning frequency, or rate at which a conventional LCD is being updated. In the case of E Ink's electronic display material, it not only affords high contrast and reflectance, but also possesses an image stable "memory effect" where an image on the display remains static until a new image needs to written. This feature eliminates any need for rapid update during reading applications, thereby eliminating some of the key contributors to eye strain and reduced reading performance.

High reflectance and contrast, combined with paper-like viewing angle characteristics and paper-white appearance, make E Ink displays the ideal technology solution for reading intensive handheld devices such as electronic books and PDAs, as well as for other alphanumeric display applications requiring a high degree of display legibility in dynamic lighting environments. For these applications, E Ink displays are unmatched by either emissive or reflective LCD technologies.



Note: Reflectivity measurements were taken with the detector at the display normal (0°) using a collimated source positioned at angles ranging from 20° to 70°.

Figure 4.1: Reflectivity of Displays at Varying Illumination Angles

4.2 Comparison of Power Consumption

Electronic ink displays offer greatly reduced power consumption as compared to transmissive LCDs as well as newer emissive technologies (OLED, FED, PDP). Lower power consumption translates to longer battery life, and perhaps more importantly, the ability to use smaller batteries in electronic ink devices – reducing device weight and cost.

The reason for the reduced power consumption offered by electronic ink displays is two-fold: (1) they are completely reflective requiring no backlight (unlike high performance transmissive LCDs) and (2) they have an inherently image stable “memory effect” for extended periods of time requiring no power between image states. In contrast, LCDs and newer emissive technologies require continuous addressing, and hence power to maintain an image. Once an image is written on an electronic ink display, it will be retained without additional power input until the next image is written. Hence the power consumption of an electronic ink display will ultimately depend upon the frequency at which the displayed image is changed and not how long a display is read.

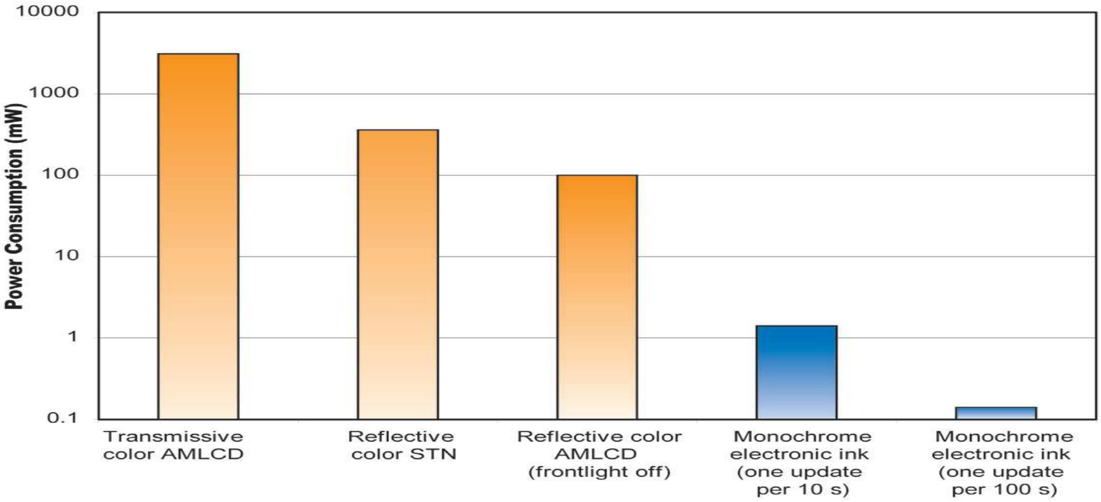


Figure 4.2: Comparison of Display Power Consumption LCD and Electronic Ink Display Technologies for Two Display Formats

As shown in the Figure 4.2, a significant reduction in power consumption is gained by moving from transmissive to reflective displays, as the need for power-hungry backlights is eliminated. However, in both cases, a reduction in power consumption by several orders of magnitude can be achieved by using electronic ink with its image stable “memory effect” for reading intensive applications.

4.3 Portability Comparison

Electronic ink display modules are thinner, lighter weight and more robust than conventional LCD modules. These benefits, coupled with the ultra low power requirements of electronic ink displays, translate directly into thickness and weight savings for smart handheld devices, where portability is paramount.

Complex, Bulky LCD Cell Structures: A typical LCD cell comprises a thin liquid crystal layer sandwiched between two glass substrates, each typically 0.7 mm in thickness. In addition, two polarizing films, each about 0.25 mm thick, are laminated to the outside surfaces of the substrates, resulting in a total display cell thickness of at least 2 mm. Often, additional film components are assembled onto an LCD cell to enhance optical performance, making the cell even thicker and heavier.

Simple, Thinner Structures of Electronic Ink Displays: The first active matrix electronic ink displays consist of front plane laminate (FPL) structure - comprising a thin film of electronic ink coated onto an ITO-coated plastic substrate – laminated to a conventional glass TFT backplane. This simple structure uses a thin polymer film for the

front plane, while eliminating one glass sheet and all polarizing films. This hybrid substrate structure, shown in Figure 4.3, is approximately half the thickness and weight of a typical LCD cell. The electronic ink film stack can be further customized to include such features as touch screen, anti-glare, anti-reflection, or hard coating layers.

Further Gains with Smaller Batteries: Significant gains in thinness and lightness can be further realized in handheld device construction when using electronic ink displays. Compared to other so-called ‘low-power’ displays, such as reflective or transflective LCDs, electronic ink displays require 10- to 100-fold less power. Use of electronic ink displays can translate to a reduction in battery bulk in a handheld device, which can be particularly dramatic in some applications.

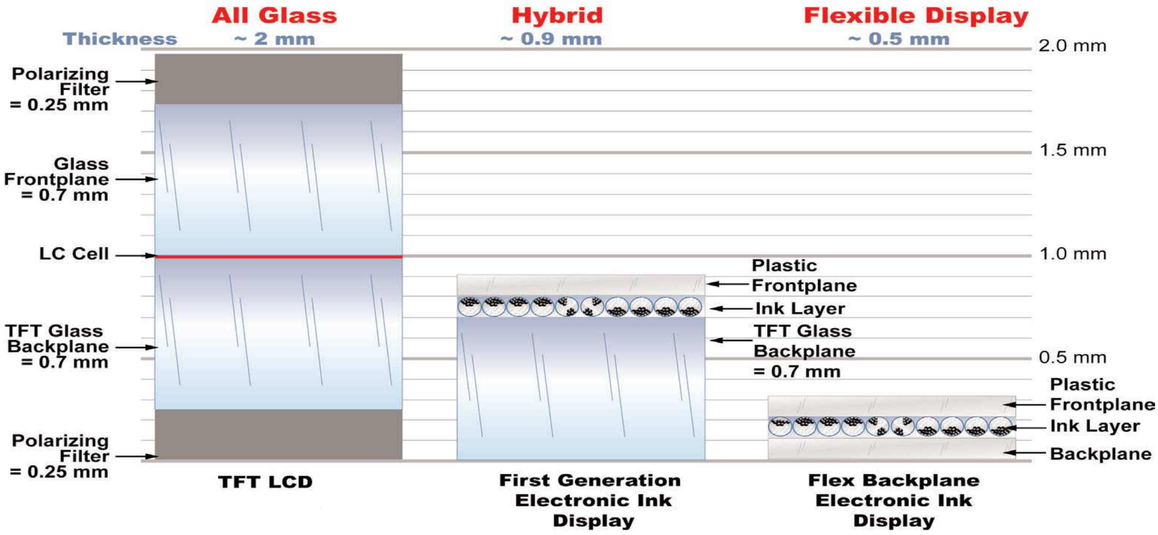


Figure 4.3: Comparison of Display Cell Structure between Conventional LCDs and Electronic Ink Displays

Flexible Displays Using Electronic Ink offer Further Benefits: E Ink’s electronic ink can be laminated or applied to virtually any substrate, which offers a new level of design versatility for applications requiring rugged, conformable or bendable displays. Unlike liquid crystal technologies, which are highly sensitive to variations in cell gap, electronic ink maintains a uniform image even when flexed.

Compatibility with flexible substrates makes electronic ink well suited for applications that require a level of ruggedness that can’t be met by glass-based displays. E Ink is actively working with partners to develop flexible TFT backplane technology, which will enable design versatility, display ruggedness, and ultra-thin form factors. E Ink has already demonstrated high resolution active matrix displays with TFT’s built on plastic and metal foils.

By eliminating both glass substrates used in conventional TFT’s, these future electronic ink display cells will be less than 0.5 mm in thickness – perhaps as thin as 0.3 mm (see Figure 4.3). This translates into a nearly 10-fold reduction in cell thickness, and an even greater reduction in weight.

Ultra-Portability in Size, Shape & Flexibility: Electronic ink technology offers immediate benefits over comparable LCDs, cutting weight and thickness in half. Future generations will provide even more dramatic improvements in weight and thickness, as well as enabling truly flexible, conformable displays. For smart handheld devices, where portability is the key, these are compelling advantages.

5. APPLICATIONS

Since the invention of the Electronic ink, its different properties have found uses a wide range of applications. Here I have listed out some of the application which has come out as prototypes in our market today.

5.1 Electronic Paper Watch

Seiko Epson Corporation and Seiko Watch Corporation demonstrated the world’s first watch to utilize an electronic paper display. This ‘Future Now’ design incorporates an easy-to-read, ultra-thin, low-power display integrated into an eye-catching curved band. The unique electronic paper display module in this Seiko watch is the result of a joint development effort, bringing together E Ink's 'electronic ink' technology and Seiko Epson's advanced display manufacturing and electronic circuitry techniques. When combined, these technologies offer a wide range of display design possibilities - including flexibility. Seiko expects to commercialize this 'Future Now' watch in Japan by the spring of 2006. Plans for the international launch are under consideration, along with other design interpretations.

Figure 5.1: World’s First Watch to Utilize an Electronic Paper Display

5.2 Paper-Thin Digital Clock

Utilizing the electronic paper display technology, Citizen Watch has created a digital clock that is as thin as paper. This easy-to-read, low-power display component is fully conformable, allowing product designers more creative freedom than ever before. With its exceptional readability - roughly twice the contrast of a reflective LCD, EPD’s can be easily read in bright sunlight or in dimly lit environments and at virtually any angle. Power consumption in 1/100 that of traditional display options because of stable ‘memory effect’ which requires no power to maintain an image and no backlighting is required. These benefits allow the clock to be installed in locations that would otherwise be difficult. Especially in the case of using Battery, this Clock is “Mobile”.

Figure 5.2: World's First Curved Clock to Utilize an Electronic Paper Display

5.3 E-Newspaper

Electronic ink could change the way one would receive his daily newspaper. It could well bring an end to newspaper delivery as we know it. Instead of delivery people tossing the paper from their bike or out their car window, a new high-tech breed of paper deliverers would simply press a button on their computer that would simultaneously update thousands of electronic newspapers each morning.

The IBM e-Newspaper is a design concept that explores a possible future method of news and information delivery. It takes into account what people actually do with newspapers — the way they read them, fold them and carry them. Readers would connect the e-Newspaper to the Web to update it, download stories and graphics into memory, and display them on eight dual-sided, durable, flexible pages printed with electronic ink.

Figure 5.3: IBM's e-Newspaper

5.4 Mobile Display Solutions

Since e-ink displays offer a range of benefits for mobile applications, including 180 degree viewing angle, ability to be easily read in dynamic lighting conditions and image stability - drawing current only when the image is changed, it is extremely useful as an electronic display screen for PDAs, cell phones, pagers, watches, and handheld computers. It can also be used on current mobile devices as a secondary display on the outer case which will exhibit key information to the user such as reminders or shopping lists. Communications giant Motorola has invested in E Ink for this purpose.

Figure 5.4: An Electronic Display Screen for a PDA Device Using E-Ink

5.5 Signage

There are over 350 million signs used around the world in stores alone. Replacing these or a proportion of them with electronic signs will give supermarkets and shops unprecedented control over their pricing and promotional systems. It will enable rapid trial and roll-out of special offers and the like. Additionally the displays might be used to provide interactive information to customers - such as the location of products within the store. They could even be used as an after-hours guide to aid shelf refilling.

Point-of-sale signs using electronic ink can be changed in stores across the country from a single computer at headquarters. J.C. Penney Corp. is testing the signs, which it has installed in Penney's Marlboro (Mass.) and Chicago stores. By sending a text message over pagers hooked up to the back of each sign, Penney's marketers alter messages to suit particular promotions. The Marlboro store saw sales rise by about 30% when it ran a series of promotions on the E Ink sign.

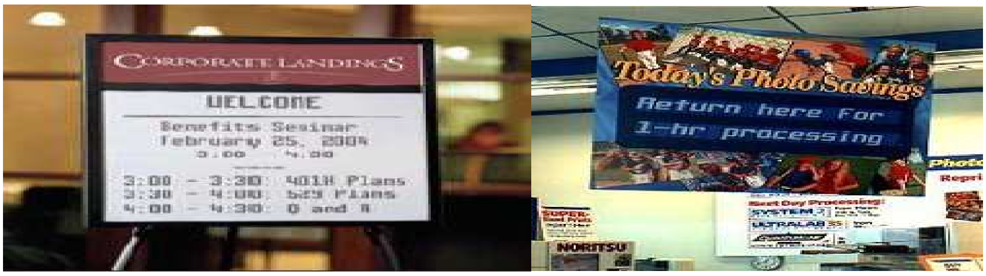


Figure 5.6: Sign Boards Using Electronic Ink Displays

CONCLUSIONS

The technology to make the e-ink realizable is already available in its initial form. Whether e-ink will become a commercial reality in the timeframes proposed by the different companies will depend on the developers' ability to scale down the technology to the sizes needed to make useful e-ink. The rapid rate at which the technology is developing suggests that this is feasible. However, the fact that markets for books and newspapers made using e-ink will be large scale by 2010 is less certain. While discussing about complete domination by e-ink it has to be remembered that attempts to replace paper have failed. This is partly because there's nothing much wrong with traditional paper. It is totally intuitive to use, its design has evolved over thousands of years, it's cheap, and it can be written on using a number of materials. Not only that, but many people also enjoy the sensory experiences associated with paper – its feel, its smell, and the look of bookcases full of paperbacks and hardbacks.

People are creatures of habit and for many, there would have to be some very compelling reasons to switch to e-ink. Products combining the familiarity and usability of paper with the functionality of the digital medium may well provide those reasons, and have the potential to appeal to diverse markets. It is this issue, of whether e-ink meets the futuristic expectations implied by its name that will determine its ultimate popularity and success.

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