A

Seminar report

On

E-Paper Technology

Submitted in partial fulfillment of the requirement for the award of degree of Bachelor of Technology in Computer Science

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Acknowledgement

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Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

Preface

I have made this report file on the topic **E-Paper Technology**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Content

Introduction

Electronic paper, also called **e-paper**, is a display technology designed to mimic the appearance of ordinary ink on paper. Unlike a conventional flat panel display, which uses a backlight to illuminate its pixels, electronic paper reflects light like ordinary paper and is capable of holding text and images indefinitely without drawing electricity, while allowing the image to be changed later.

To build e-paper, several different technologies exist, some using plastic substrate and electronics so that the display is flexible. E-paper is considered more comfortable to read than conventional displays. This is due to the stable image, which does not need to be refreshed constantly, the wider viewing angle, and the fact that it uses reflected ambient light. While it is lightweight and durable, it still lacks good color reproduction. The contrast ratio in common devices as of 2008 might be described as similar to dirty newspaper, though newly-developed implementations are slightly better.

Applications include e-book readers capable of displaying digital versions of books and e-paper magazines, electronic pricing labels in retail shops, time tables at bus stations electronic billboards, and the mobile phone Motorola FONE F3.

Electronic paper should not be confused with digital paper, which is a pad to create handwritten digital documents with a digital pen.

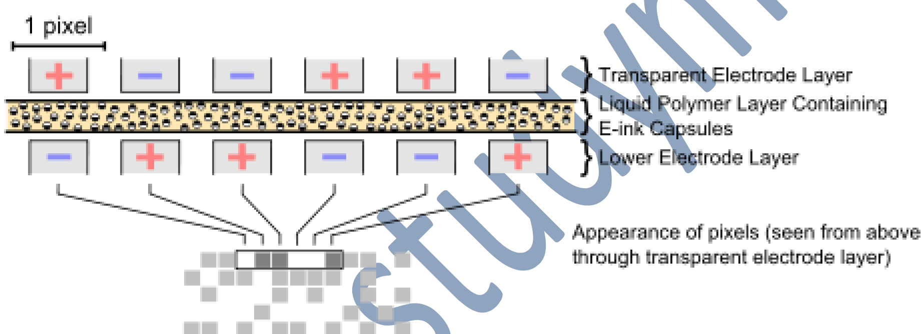
Technologies

Gyricon

Electronic paper was first developed in the 1970s by Nick Sheridon at Xerox's Palo Alto Research Center. The first electronic paper, called Gyricon, consisted of polyethylene spheres between 75 and 106 micrometers across. Each sphere is a janus particle composed of negatively charged black plastic on one side and positively charged white plastic on the other (each bead is thus a dipole).

The spheres are embedded in a transparent silicone sheet, with each sphere suspended in a bubble of oil so that they can rotate freely. The polarity of the voltage applied to each pair of electrodes then determines whether the white or black side is face-up, thus giving the pixel a white or black appearance. At the FPD 2008 exhibition, Japanese company Soken demonstrated a wall with electronic wall-paper using this technology. From 2007 Estonian company Visitret Displays is developing this kind of displays using PVDF as material for spheres dramatically improving the video speed and decreasing the control voltage.

Electrophoretic



Appearance of pixels

In the simplest implementation of an electrophoretic display, titanium dioxide (titania) particles approximately one micrometer in diameter are dispersed in a hydrocarbon oil. A dark-colored dye is also added to the oil, along with surfactants and charging agents that cause the particles to take on an electric charge. This mixture is placed between two parallel, conductive plates separated by a gap of 10 to 100 micrometres. When a voltage is applied across the two plates, the particles migrate electrophoretically to the plate that bears the opposite charge from that on the particles. When the particles are located at the front (viewing) side of the display, it appears white, because light is scattered back to the viewer by the high-index titania particles. When the particles are located at the rear side of the display, it appears dark, because the incident light is absorbed by the colored dye. If the rear electrode is divided into a number of small picture elements (pixels), then an image can be formed by applying the appropriate voltage to each region of the display to create a pattern of reflecting and absorbing regions.

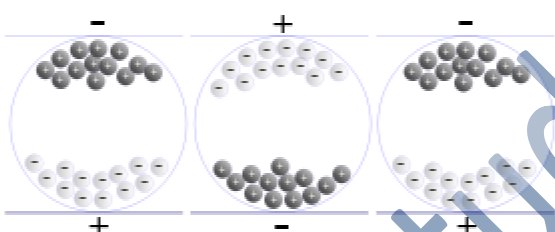
Electrophoretic displays are considered prime examples of the electronic paper category, because of their paper-like appearance and low power consumption.

Examples of commercial electrophoretic displays include the high-resolution active matrix displays used in the Amazon Kindle, Barnes & Noble Nook, Sony Librie, Sony Reader, Kobo eReader and iRex iLiad e-readers. These displays are constructed from an electrophoretic imaging film manufactured by E Ink Corporation. A mobile phone that used the technology is the Motorola Fone.

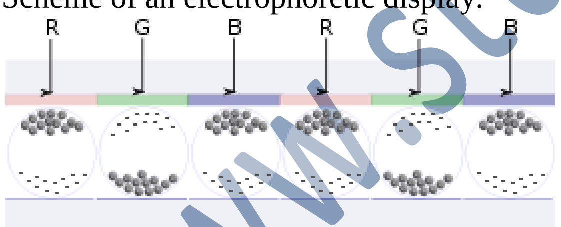
Electrophoretic Display technology has also been developed by Sipix and Bridgestone/Delta. SiPix is now part of E Ink. The Sipix design uses a flexible 0.15mm Microcup architecture, instead of E Ink's 0.04mm diameter microcapsules. Bridgestone Corp.'s Advanced Materials Division cooperated with Delta Optoelectronics Inc. in developing the Quick Response Liquid Powder Display (QR-LPD) technology.

Electrophoretic displays can be manufactured using the Electronics on Plastic by Laser Release (EPLaR) process developed by Philips Research to enable existing AM-LCD manufacturing plants to create flexible plastic displays.

Electrophoretic display



Scheme of an electrophoretic display.



Scheme of an electrophoretic display using color filters.

An **electrophoretic display** forms images by rearranging charged pigment particles with an applied electric field.

Macro photograph of Kindle 3 screen; microcapsules are evident at full size

In the 1990s another type of electronic paper was invented by Joseph Jacobson, who later co-founded the E Ink Corporation, which formed a partnership with Philips Components two years later to develop and market the technology. In 2005, Philips sold the electronic paper business as well as its related patents to Prime View International. This used tiny microcapsules filled with electrically charged white particles suspended in a colored oil. In early versions, the underlying circuitry controlled whether the white particles were at the top of the capsule (so it looked white to the viewer) or at the bottom of the capsule (so the viewer saw the color of the oil). This was essentially a reintroduction of the well-known electrophoretic display technology, but microcapsules meant the display could be made on flexible plastic sheets instead of glass. One early version of electronic paper consists of a sheet of very small transparent capsules, each about 40 micrometers across. Each capsule contains an oily solution containing black dye (the electronic ink), with numerous white titanium dioxide particles suspended within. The particles are slightly negatively charged, and each one is naturally white. The screen holds microcapsules in a layer of liquid polymer, sandwiched between two arrays of electrodes, the upper of which is transparent. The two arrays are aligned to divide the sheet into pixels, and each pixel corresponds to a pair of electrodes situated on either side of the sheet. The sheet is laminated with transparent plastic for protection, resulting in an overall thickness of 80 micrometers, or twice that of ordinary paper. The network of electrodes connects to display circuitry, which turns the electronic ink 'on' and 'off' at specific pixels by applying a voltage to specific electrode pairs. A negative charge to the surface electrode repels the particles to the bottom of local capsules, forcing the black dye to the surface and turning the pixel black. Reversing the voltage has the opposite effect. It forces the particles to the surface, turning the pixel white. A more recent implementation of this concept requires only one layer of electrodes beneath the microcapsules.

Electrowetting

Main article: Electrowetting

Electro-wetting display (EWD) is based on controlling the shape of a confined water/oil interface by an applied voltage. With no voltage applied, the (colored) oil forms a flat film between the water and a hydrophobic (water-repellent) insulating coating of an electrode, resulting in a colored pixel.

When a voltage is applied between the electrode and the water, the interfacial tension between the water and the coating changes. As a result the stacked state is no longer stable, causing the water to move the oil aside.

This makes a partly transparent pixel, or, if a reflective white surface is under the switchable element, a white pixel. Because of the small pixel size, the user only experiences the average reflection, which provides a high-brightness, high-contrast switchable element.

Displays based on electro-wetting provide several attractive features. The switching between white and colored reflection is fast enough to display video content.

It's a low-power and low-voltage technology, and displays based on the effect can be made flat and thin. The reflectivity and contrast are better than or equal to other reflective display types and approach the visual qualities of paper.

In addition, the technology offers a unique path toward high-brightness full-color displays, leading to displays that are four times brighter than reflective LCDs and twice as bright as other emerging technologies.

Instead of using red, green and blue (RGB) filters or alternating segments of the three primary colors, which effectively result in only one third of the display reflecting light in the desired color, electro-wetting allows for a system in which one sub-pixel can switch two different colors independently.

This results in the availability of two thirds of the display area to reflect light in any desired color. This is achieved by building up a pixel with a stack of two independently controllable colored oil films plus a color filter.

The colors are cyan, magenta and yellow, which is a subtractive system, comparable to the principle used in inkjet printing for example. Compared to LCD another factor two in brightness is gained because no polarisers are required.

Examples of commercial electrowetting displays include Liquavista, ITRI, PVI and ADT.

Miortech’s 2nd generation electrowetting display technology solves a number of issues of 1st generation electrowetting display technology and large-area devices are easy to manufacture since the pixel walls act as spacers. Miortech develops rearview mirrors using its 2nd generation EWD technology.

Electrofluidic

Electrofluidic displays are a variation of an electrowetting display. Electrofluidic displays place an aqueous pigment dispersion inside a tiny reservoir. The reservoir comprises <5-10% of the viewable pixel area and therefore the pigment is substantially hidden from view. Voltage is used to electromechanically pull the pigment out of the reservoir and spread it as a film directly behind the viewing substrate. As a result, the display takes on color and brightness similar to that of conventional pigments printed on paper. When voltage is removed liquid surface tension causes the pigment dispersion to rapidly recoil into the reservoir. As reported in the May 2009 Issue of Nature Photonics the technology can potentially provide >85% white state reflectance for electronic paper.

The core technology was invented at the Novel Devices Laboratory at the University of Cincinnati. The technology is currently being commercialized by Gamma Dynamics.

Interferometric modulator (Mirasol)

Main article: Interferometric modulator display

Technology used in electronic visual displays that can create various colors via interference of reflected light. The color is selected with an electrically switched light modulator comprising a microscopic cavity that is switched on and off using driver integrated circuits similar to those used to address liquid crystal displays (LCD).

Other bistable displays

- Plastic Logic, manufacturer of flexible plastic electrophoretic displays
- Kent Displays, manufacturer of cholesteric liquid crystal display (ChLCD)
- Nemoptic, nematic materials]
- TRED
- Sharp Memory LCD, used in Pebble smartwatch.

Other technologies

Other research efforts into e-paper have involved using organic transistors embedded into flexible substrates, including attempts to build them into conventional paper. Simple color e-paper consists of a thin colored optical filter added to the monochrome technology described above. The array of pixels is divided into triads, typically consisting of the standard cyan, magenta and yellow, in the same way as CRT monitors (although using subtractive primary colors as opposed to additive primary colors). The display is then controlled like any other electronic color display.

Applications

Several companies are simultaneously developing electronic paper and ink. While the technologies used by each company provide many of the same features, each has its own distinct technological advantages. All electronic paper technologies face the following general challenges:

- A method for encapsulation
- An ink or active material to fill the encapsulation
- Electronics to activate the ink

Electronic ink can be applied to flexible or rigid materials. For flexible displays, the base requires a thin, flexible material tough enough to withstand considerable wear, such as extremely thin plastic. The method of how the inks are encapsulated and then applied to the substrate is what distinguishes each company from others. These processes are complex and are carefully guarded industry secrets. Nevertheless, making electronic paper is less complex and costly than LCDs.

There are many approaches to electronic paper, with many companies developing technology in this area. Other technologies being applied to electronic paper include modifications of liquid crystal displays, electrochromic displays, and the electronic equivalent of an Etch A Sketch at Kyushu University. Advantages of electronic paper includes low power usage (power is only drawn when the display is updated), flexibility and better readability than most displays. Electronic ink can be printed on any surface, including walls, billboards, product labels and T-shirts. The ink's flexibility would also make it possible to develop rollable displays for electronic devices.

The Motorola F3 uses an e-paper display instead of an LCD.

Wristwatches

In December 2005 Seiko released the first electronic ink based watch called the Spectrum SVRD001 wristwatch, which has a flexible electrophoretic display and in March 2010 Seiko released a second generation of this famous e-ink watch with an active matrix display. The Pebble smart watch (2013) uses a low-power memory LCD manufactured by Sharp for its e-paper display.

e-Books

iLiad e-book reader equipped with an e-paper display visible in the sunlight
Main article: List of e-book readers

In 2004 Sony released Librié EBR-1000EP in Japan, the first e-book reader with an electronic paper display. In September 2006 Sony released the PRS-500 Sony Reader e-book reader in the USA. On October 2, 2007, Sony announced the PRS-505, an updated version of the Reader. In

November 2008, Sony released the PRS-700BC, which incorporated a backlight and a touchscreen.

In late 2007, Amazon began producing and marketing the Amazon Kindle, an e-book reader with an e-paper display. In February 2009, Amazon released the Kindle 2 and in May 2009 the larger Kindle DX was announced. In July 2010 the third generation Kindle was announced, with notable design changes. The fourth generation of Kindles were announced in September 2011. This generation was unique as it marked the Kindle's first departure from keyboards in favor of touchscreens. In September 2012, Amazon announced the fifth generation of the Kindle, which incorporates a LED frontlight and a higher contrast display.

In November 2009 Barnes and Noble launched the Barnes & Noble Nook, running an Android operating system. It differs from other big name readers in having a replaceable battery, and a separate touch-screen color LCD below the main electronic paper reading screen.

Newspapers

In February 2006, the Flemish daily *De Tijd* distributed an electronic version of the paper to select subscribers in a limited marketing study, using a pre-release version of the iRex iLiad. This was the first recorded application of electronic ink to newspaper publishing.

The French daily *Les Échos* announced the official launch of an electronic version of the paper on a subscription basis, in September 2007. Two offers were available, combining a one year subscription and a reading device. The offer included either a light (176g) reading device (adapted for Les Echos by Ganaxa) or the iRex iLiad. Two different processing platforms were used to deliver readable information of the daily, one based on the newly developed GPP electronic ink platform from *Ganaxa*, and the other one developed internally by Les Echos.

Displays embedded in smart cards

Flexible display cards enable financial payment cardholders to generate a one-time password to reduce online banking and transaction fraud. Electronic paper offers a flat and thin alternative to existing key fob tokens for data security. The world's first ISO compliant smart card with an embedded display was developed by Innovative Card Technologies and nCryptone in 2005. The cards were manufactured by Nagra ID.

Status displays

USB flash drive with E Ink-implemented capacity meter of available flash memory

Some devices, like USB flash drives, have used electronic paper to display status information, such as available storage space. Once the image on the electronic paper has been set, it requires no power to maintain, so the readout can be seen even when the flash drive is not plugged in.

Mobile phones

Motorola's low-cost mobile phone, the Motorola F3, uses an alphanumeric black-and-white electrophoretic display.

The Samsung Alias 2 mobile phone incorporates electronic ink from E Ink into the keypad, which allows the keypad to change character sets and orientation while in different display modes.

On December 12, 2012, Yota Devices announced the first "YotaPhone" prototype and was later released on December 2013, a unique double-display smartphone. It has an 4.3-inch, HD LCD display on the front and an e-ink display on the back with smart battery usage.

Electronic shelf labels

Main article: Electronic shelf label

E-Paper based electronic shelf labels (ESL) are used to digitally display the prices at retail stores. Electronic paper based labels are updated via two-way infrared or radio technology.

Other

Other proposed applications include clothes, digital photo frames, information boards and keyboards. Keyboards with dynamically changeable keys are useful for less represented languages, non-standard keyboard layouts such as Dvorak, or for special non-alphabetical applications such as video editing or games.

Advantages

Conventional displays have a number of disadvantages in this application. They may be too expensive, too power consuming, or too hard to see when affixed to a shelf. On the other hand, e-paper can produce small, battery-operated, flexible displays.

E-paper's potential flexibility can also be an advantage when affixing displays to shelves. Conversely, e-paper's current limitation-poor color capability-is not much of a disadvantage in this context. Color is not a requirement; monochrome displays would be quite capable of displaying most pricing or product information. When improved color is developed, it would then increase the advertising capabilities of such displays.

There is tremendous opportunity here as stores have ongoing problems with changing prices for promotions and other variables. Smart shelving would also add value by reducing incorrect pricing on the shelves; the bane of every customer.

From the e-paper industry point of view the volume of displays would be very large because of the number of items in any given store that need pricing information. Hundreds of displays are likely. However, such displays would be very small (2 to 3 inches).

Disadvantages

Like all technologies, E-paper has its flaws that make it inaccurate to use. Organizations face many disadvantages with e-paper and e-paper technologies. Publishing departments may have a bad time adapting to this new technology because it is still complex to use. Organizations still have manufacturing costs that were higher than expected, and some companies had trouble programming signs in their stores.

Hence, companies are still reluctant to use this technology because it is more complex than paper and it is more expensive to use. Also, e-paper is still less attractive to technologies such as LED or LCD, because it still unable to reproduce animations and it is difficult to read when there's no light.

Thus, unless the room is not bright enough, employees in an organization will have a very hard time reading the e-paper. The biggest challenge a company faces with e-paper and its sister technologies is piracy.

In this internet era, it is easy to send information from one side of the globe to another, thus, organizations have to be careful with their information. For example, your file can be easily emailed to someone living thousands of miles away. It can even be placed in a public server for anyone to download.

Hence, this could be troublesome for book publishing companies that may lose millions of dollars and for organizations that have classified information.

Conclusion

While we may know electronic paper today for its near-ubiquitous use in eBook readers, the flexibility of the technology creates possibilities far above and beyond that very basic use. Unlike flying cars and personal teleporters, the paperless office of the future may not be so far-fetched after all. And a clean desk is just the beginning.

Reference

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