E-paper Technology

A Seminar Report Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

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BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE (AUTONOMOUS)

(Approved by A.I.C.T.E, New Delhi & Permanently Affiliated to J. N.T.U.K, Kakinada)

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CERTIFICATE

This is to certify that the seminar work entitled "E-paper Technology" is being submitted for the partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering, at BVC Engineering College, Odalarevu, is a bonafide work done by R. Uday Shankar under the academic year 2020-21 and it has been found suitable for acceptance according to the requirement of university.

The results embodied in this thesis have not been submitted to any other University Institute for the award of any degree.

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E-paper is a revolutionary material that can be used to make next generation I, electronic displays. It is portable reusable storage and display medium that look like paper but can be repeatedly written one thousands of times.

These displays make the beginning of a new area for battery power information applications such as cell phones, pagers, watches and hand-held computers etc. Two companies are carrying our pioneering works in the field of development of electronic ink and both have developed ingenious methods to produce electronic ink. One is E-ink, a company based at Cambridge, in U.S.A.

The other company is Xerox doing research work at the Xerox's Palo Alto Research Centre. Both technologies being developed commercially for electronically configurable paper like displays rely on microscopic beads that change color in response to the charges on nearby electrodes. Like traditional paper, E-paper must be lightweight, flexible, glare free and low cost. Research found that in just few years this technology could replace paper in many situations and leading us ink a truly paperless world.

Electronic ink is a pioneering invention that combines all the desired features of a modern electronic display and the sheer convenience and physical versatility of sheet of paper. E-paper or electronic paper is sometimes called radio paper or smart paper. Paper would be perfect except for one obvious thing: printed words can't change. The effort is to create a dynamic high-resolution electronic display that's thin and flexible enough to become the next generation of paper.

The technology has been identified and developed is well under way. Within five years, it is envisioned electronic books that can display volumes of information as easily as flipping a page and permanent newspapers that update themselves daily via wireless broadcast. They deliver the readability of paper under b virtually any condition, without backlighting. And electronic ink displays are persistent without power, drawing current only when they change, which means batteries can be smaller and last longer.

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 has demonstrated a wall with electronic wall-paper using this technology

Electrophoretic

An electrophoretic display forms visible images by rearranging charged pigment particles using an applied electric field.

In the simplest implementation of an electrophoretic display, titanium dioxide 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 micrometers. When a voltage is applied across the two plates, the particles will migrate electrophoretically to the plate bearing 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 titanium 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. Electrophoretic displays can be manufactured using the Electronics on Plastic by Laser Release (EPLaR) process developed by Philips Research to enable existing AM-LCD (Active matrix liquid crystal display) manufacturing plants to create flexible plastic displays.

Electronics on Plastic by Laser Release (EPLaR)

Electronics on Plastic by Laser Release (EPLaR) is a method for manufacturing flexible electrophoretic display using conventional AM-LCD manufacturing equipment avoiding the need to build new factories. The technology can also be used to manufacture flexible

OLED (Organic LED) displays using standard OLED fabrication facilities. The technology was developed by Philips Research and uses standard display glass as used in TFT-LCD processing plants. It is coated with a layer of polyimide using a standard spin-coating procedure used in the production of AM-LCD displays. This polymide coating can now have a regular TFT matrix formed on top of it in a standard TFT processing plant to form the plastic display, which can then be removed using a laser to finish the display and the glass reused thus lowering the total cost of manufacture.

Development in Electrophoretic Display:

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 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 wellknown electrophoretic display technology, but the use of microcapsules allowed the display to be used 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 microcapsules are held in a layer of liquid polymer, sandwiched between two arrays of electrodes, the upper of which is made transparent. The two arrays are aligned so that the sheet is divided into pixels, which each pixel corresponding to a pair of electrodes situated 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 is connected to display circuitry, which turns the electronic ink 'on' and 'off' at specific pixels by applying a voltage to specific pairs of electrodes. Applying a negative charge to the surface electrode repels the particles to the bottom of local capsules, forcing the black dye to the surface and giving the pixel a black appearance. Reversing the voltage has the opposite effect - the particles are forced from the surface, giving the pixel a white appearance. A more recent incarnation of this concept requires only one layer of electrodes beneath the microcapsules.

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 (coloured) oil forms a flat film between the water and a hydrophobic (water-repellent), insulating coating of an electrode, resulting in a coloured 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 results in a partly transparent pixel, or, in case a reflective white surface is used under the switchable element, a white pixel. Because of the small size of the p ixel, the user only experiences the average reflection, which means that a high-brightness, high-contrast switchable element is obtained, which forms the basis of the reflective display. Displays based on electro-wetting have several attractive features.

The switching between white and coloured reflection is fast enough to display video content. It is 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 or equal to those of other reflective display types and are approaching those of paper. In addition, the technology offers a unique path toward high-brightness full-colour 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 colours, which effectively result in only one third of the display reflecting light in the desired colour, electro-wetting allows for a system in which one sub-pixel is able to switch two different colours independently. This results in the availability of two thirds of the display area to reflect light in any desired colour. This is achieved by building up a pixel with a stack of two independently controllable coloured oil films plus a colour filter.

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.

Conclusion

The Holy Grail of electronic ink technology is a digital book that can typeset itself and that readers could leaf through just as if it were made of regular paper. Such a book could be programmed to display the text from a literary work and once you've finished that tale, you could automatically replace it by wirelessly downloading the latest book from a computer database. Xerox had introduced plants to insert a memory device into the spine of the book, which would allow users to alternate between up to 10 books stored on the device. Just as electronic ink could radically change the way we read books, it could change the way you receive your daily newspaper. It could very 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 who simply press a button on their computer that would simultaneously update thousands of electronic newspapers each morning. Sure, it would look and feel like your old paper, but you wouldn't have to worry about the newsprint getting smudged on your fingers, and it would also eliminate the piles of old newspapers that need recycling. Prior to developing digital books and newspapers E-Ink will be developing a marketable electronic display screen for cell phones, PDA's, pagers and digital watches.

Electronic ink is not intended to diminish or do away with traditional displays. Instead electronic ink will initially co-exist with traditional paper and other display technologies. In the long run, electronic ink may have a multibillion-dollar impact on the publishing industry. Ultimately electronic ink will permit almost any surface to become a display, bringing information out of the confines of traditional devices and into the world around us.