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E Paper Technology

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Abstract:
E-paper is one of the next generation paper technology. It is a portable reusable storage that in physical appearance looks like an ordinary paper but we can erase and write on it more than a thousand million times. Thus it makes it reusable. The e-papers have a battery power applications. It is reflective and even in bright sunlight it make reading easy and also in dim or dark environment. It appearance looks like paper and can also be seen virtually in any angle just like a paper. It is light in weight. It is ideal for highly portable application. This paper discusses the history, features, and technology of the electronic paper revolution. It also highlights various applications, advantages and disadvantages of electronic paper.

Keywords: E-paper, Gyricon, Electrophoretic, Electrowetting, Electrofluidic.

I. Introduction

E-paper (sometimes called radio paper or just electronic paper) is a portable, reusable storage and display medium that looks like paper but can be repeatedly written on (refreshed) - by electronic means - thousands or millions of times. Unlike conventional backlit flat panel displays that emit light, electronic paper displays reflect light like paper. This may make them more comfortable to read, and provide a wider viewing angle than most light-emitting displays. The contrast ratio in electronic displays available as of 2008 approaches newspaper, and newly (2008) developed displays are slightly better. An ideal e-paper display can be read in direct sunlight without the image appearing to fade. Computer monitors are uncomfortable to human's eye unlike ink on papers.

E-paper displays contain millions of miniscule capsules filled with a clear fluid containing microscopic particles of different colors and electrical charges. Electrodes located above and below the capsules move up and down when a positive or negative electric field is applied, which makes the surface of the electronic paper display reflect a certain color. E-paper is bistable – no power is needed to retain an image, and reflective ambient light reflects from the surface of the display.
For building an e-paper or smart paper several technologies such as plastic substrate, electronics and flexible electronics are being used. Smart paper has to be potential to be more comfortable to read than conventional display because of the stable image that does not need to be refreshed constantly. A smart paper display is also readable in direct sunlight without appearing faded image. The black and white ink on this paper look similar to that most widely read material on the planet newspaper.

II. History

In the 1970's Xerox PARC which was a power house of innovation in which the modem computer, ethernet, mouse, GUI(Graphic user interface) , laser printer ,Computer generated color graphic as well as the number of computer languages were invented around that time has lost this(e-paper) important breakthroughs which was later invented by Nicholas Sheridon an employee at xerox PARC in 1974 . Xerox's concept in the early 70s was the "paperless" office.

The first e-paper was called Gyricon a Greek term meaning „rotating image" .The first e-paper consisted of polyethylene spheres of about 75-106 micrometers across which are also called JENUS PARTICLE.

They consist of negatively charged black plastic on a side and positively charged white plastic on the other. In a transparent silicon sheet these are embedded with each sphere suspended in a bubble of oil for their free rotation. When the voltage is applied to the each pair of electrodes then it is used to find whether the black or white side is face-up, thus giving the pixel a black or white appearance. Later in the 1990's Joseph Jacobson has invented another type of e-papers which are called microcapsules, filled with different electronically loaded white particles that were dissolved in a dark coloured oil. In the 1997 Jacobson has also found

electronic ink and established a company on it which has become a partner with Philips. In 2005 Philips sold its first e-paper and its rights to Prime View International. Then this company has reintroduced the e-paper technology with the well-known Electrophoretic display technology though the usage of microcapsules allowed display to be used on flexible plastic sheets rather than glass sheets. In 2007, Amazon began producing and selling the Kindle, an e-book reader with e-paper display. In 2008, the Dutch daily NRC HANDELSBLAD distributed for the iREXiLiad reader. In 2009 Jason Heikenfeld has tried to create products based on electrofluidic display technology and a process called pigment dispersion. In 2010 it was further being researched using pixels. Now still the research is going on further and future development.

III. Literature Survey

There are many devices that uses or made by E-link display or E-Paper Technologies.

A. E-Reader

One of the things that makes ebook readers so popular is the easy-to-read, high-contrast screens that simulate the look of the printed page. Because it incorporates E Ink panels, the e-paper doesn't require battery power while the text is on the screen. Energy is used when flipping pages as an electric charge rearranges the e ink capsules to either white or black to display the text. This results in a long battery life that lasts for approximately 6000-8000 page-turns, depending on the reader. Electronic paper refreshes the screen as you turn each page, causing it to blink for a split second. Like print, the text is very crisp and clear, and can be viewed comfortably in bright light, unlike backlit computers and phones. E Ink displays are formed by printing ink onto thin sheets of plastic film that are laminated to a layer of circuitry. The circuitry can be controlled by a display driver to form patterns of pixels on the film. Pearl active matrix electronic paper display (EPD) is one example, and the most popular among e-readers.

Figure 1: E-paper Reader

B. E-Paper Smartwatch

Smart Watch is one of wearable devices which used e-paper. The cutting-edge smartwatches on the market include bells and whistles such as waterproofing, cellular connectivity, and bright color displays. However, not all users need these features. The most obvious advantage to having a smartwatch with an e-paper display is that you get much longer battery life. This technology requires less power than other display types, so you don't need to charge your watch anywhere near as frequently. Looking at the top smartwatches from a battery life perspective, you'll see that e-paper options such as those from Pebble rank high. Depending on your lifestyle and whether you tend they are easier to forget to plug in your tech every night before bed, the ability to go several days on a charge could mean you ultimately get more use out of your smartwatch.

Figure 2: Sony E-Paper Smartwatch

Beyond long battery life, e-paper smartwatches offer great viewing angles, so you don't have trouble making out the notifications on your screen even if you're outside under direct sunlight. If you're a frequent outdoor runner or spend a lot of time outside, this feature could make a difference. It's unlikely you'll be reading e-books from your wrist on a smartwatch, so it's not as essential to have an e-paper display on this sort of wearable as it is on an e-reader, but it can still come in handy.

C. Electronic shelf labels

ESL modules use electronic paper (E-paper) or liquid-crystal display (LCD) to show the current product price to the customer. E-paper is widely used on ESLs as it provides crisp display and supports full graphic imaging. A communication network allows the price display to be automatically updated whenever a product price is changed. This

communication network is the true differentiation and what really makes ESL a viable solution. The wireless communication must support reasonable range, speed, battery life, and reliability. The means of wireless communication can be based on radio, infrared or even visible light communication. Currently, the ESL market leans heavily towards radio frequency based ESL solutions with additional integrations. E-Shelf label take the best qualities out of e-paper technology and paper-like look. On top of that, there is a possibility to indicate the product's rating from one star up to the top five.

Figure 3: Electronic Shelf Labels

Product information stickers display for example product name and code, EAN or QR-code. Pricing information is dynamic and easily updated. For promoting purposes and campaigns a percentage can be shown with wording like Offer or Sale.

D. E-Notebook

This market leading electronic lab notebook is used by researchers in the pharmaceutical, biotech, institutions.

Figure 4: Electronic-paper Notebook

E-Notebook provides an electronic laboratory environment that increases researchers' productivity, improves the quality of data captured and fosters collaboration and innovation by creating a secure and searchable repository of corporate and institutional intellectual capital. Electronic lab notebooks offer many benefits to the user as well as organizations; they are easier to search upon, simplify data copying and backups.

E. Outdoor Signage

Reading text from a display for extended periods of time has always been problematic for a large number of electronic readers. Since the advent of the e-paper display, most of the inconveniences of traditional displays have been reduced. In fact, e-paper displays have become the de-facto standard for eBook readers. The key advantages to using e-paper displays in eBook readers are also beneficial to other applications. They're easy to read, immune to the effects of bright sun glare, and are extremely power efficient. Hence, e-paper displays are suited for signage applications that change frequently, such as those that display schedules or other live information.

Figure 5: Outdoor Signage made by e-paper

Indoor/outdoor signage is a good example of an application where the benefit of clear readability and glare resistance shines. Further, e-paper requires little power to operate. Battery powered units could be remotely deployed and last for years with one battery. Combine the battery with solar or even energy harvesting technologies and the system could run indefinitely. Note that building e-paper displays into watertight and/or reinforced packages may be necessary to protect against the elements or vandalism. Often the display choice for public transportation information is an LED matrix. If more information is required, TFT-LCDs can be used. Both systems have their respective pros and cons. LEDs are bright enough to be read clearly in bright sunlight. However, they consume a lot of power. Alternatively, TFT LCDs consume considerably less power but are hard to see in bright conditions. With e-paper you get both—an ultra-low power solution that's visible in bright conditions and easy to read.

IV. Construction of E-paper

Basically, an epaper can be comprised into two different parts namely; a front panel and back panel. the front panel consists of electronic ink and some other parts like the Gyricon whereas the back panel consists of the electronic circuits .

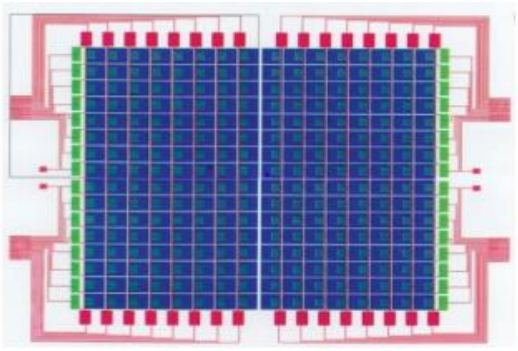

Figure : 6 Back Panel Layout

For forming the electronic ink display the electronic ink is printed onto a plastic film which is laminated over a layer of circuitry.

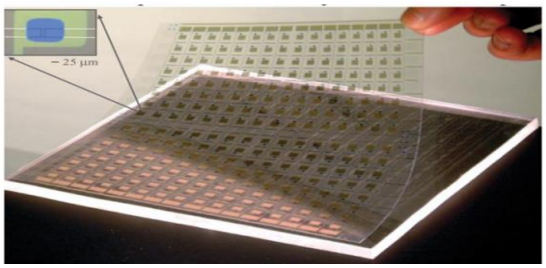

Figure 6: Plastic Film Sheet Of Electronic Ink

V. Working of E-paper

As read in the history after many years Gyricon eink has been created by Nicholes after a wide range of study of tiny rotating particles. Based on a thin sheet of flexible plastic containing a thin layer of tiny plastic beads which can free rotation within the plastic sheet. Each and every hemisphere has a different charge and colour, when electric field applied as backbone beads rotate. This occurs in the front plane. Later as the electrophoretic technology was developed which consists of microcapsules has given a new form. some more new forms are described .

VI. Technique

A. Gyricon

The first Gyricon was developed by Nicholas Sheridon. It consists of polyethylene spheres of diameter between 75-106 micrometers. Each sphere is also called Janus particle composed of negatively charged black on one side and positively charged white plastic on the other side. In this each and every hemisphere has its own different colour and charge. When an electric field is an applied as backbone then the beads in it rotate creating a di-coloured pattern. When the electric polarity is applied to each pair of electrodes determines the white or black side is face-up, thus giving up black or white appearance. This method has two limitations; one - lack of color, two - low brightness and resolution.

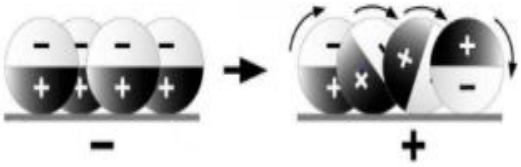

Figure 7: Gyricon e-paper Technology

B. Electrophoretic:

The electronic ink display from E Ink is based on encapsulated electrophoretic. Electrophoretic are microcapsules containing many tiny white pigment chips, or particles, that are suspended in a blue-black liquid dye.

Applying an electric field moves the particle about; the microcapsules can be switched into the reflecting or absorbing state by applying a positive or negative voltage across the indium-tin oxide (ITO) electrodes. If some voltage is supplied across the two plates , the particles will move to the plate which is bearing the opposite charge from that of the particles. When a negative electric field is applied the particles move to bottom and thus there is hidden view. When a positive electric field is applied the particles move to top and thus there is a image or text generated by the white particles.

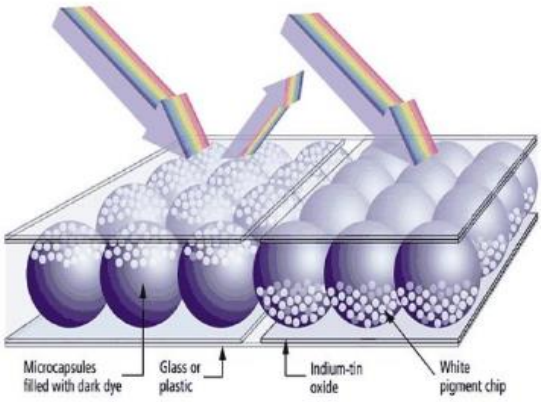

Figure 8: Electrophoretic e-paper Technology

C. Electrowetting:

Electrowetting 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. Applying voltage between the electrode and the water causes the

interfacial tension to change, which causes the water to move the oil aside. The result is a partly transparent pixel; if a reflective white surface is used under the switchable element, a white pixel results. This forms the basis of the reflective display.

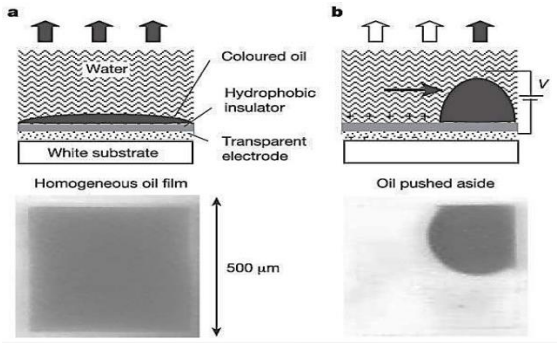

Figure 9: Electrowetting E-paper Technology

D. 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.

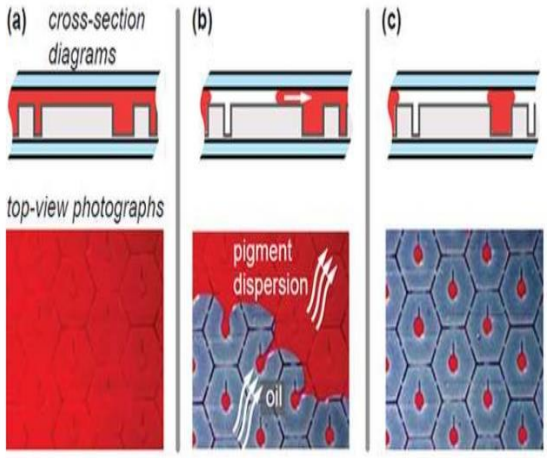

Figure 10: Electrofluidic E-paper Technology

VII. Advantages and disadvantages of Electronic paper

Electronic Paper offers several advantages over printed paper. For example you can use electronic bookmarks, choose you preferred level of magnification, you can also use search to find information quickly. You have the option to print on to real paper if required.

Advantages of electronic paper include

- Paper like appearance
- Low power usage (power is drawn when the display is updated), flexibility, and better readability.
- Flexible battery or solar power displays
- Really high definition.

Limitation of e-paper technology is that

- E-paper cannot support animation**.**
- An imprint of an image may be visible after refreshing parts of the screen. Those imprints are known as ghost images, and the effect is known as “ghosting”.
- It requires light source to read as there is no backlit like LCD.
- E-paper only has the option of displaying in black and white and a range of gray tones. It cannot display color e-ink. This lack of color is a huge disadvantage.

VIII. Conclusion

The present world is of rapidly changing technology. But, paper remains the most popular document medium because of its credibility, tangibility, ease of use, flexibility, portability, and compatibility which has made it difficult to replace. But researchers are thinking of making a paperless world by using the e-papers. Finally, there would be a more usage of E-paper technology rather than an LCD and an ordinary paper. The replacement of all paper documents with electronic documents is difficult to achieve, and hence prediction of a co-existence between paper and E-paper can be made.

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