

## Smart Paper Technology a Review Based On Concepts of E-Paper Technology

Adithya. Potu<sup>1</sup>, R.Jayalakshmi<sup>2</sup>, Dr.K.Umpathy<sup>3</sup>  
( MTech(Edt)<sup>1</sup> Associate Professor MTech<sup>2</sup> Associate Professor MTech<sup>3</sup>,  
Department Of Electronics and Communication Engineering SCSVMV University)

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**Abstract:** Smart paper is one of the next generation paper technologies . It is a portable reusable storage display medium that in physical appearance looks like an ordinary paper but we can erase and write on it more than a thousand million times. These smart papers have a battery power applications such as pager, watches, hand held computer, cell phones etc.,

Smart paper is the technology used for applications such as ebooks, electronic newspaper, portable signs & and foldable, rollable displays. It is reflective and can be easily read in bright sunlight and also dim or dark environment. It can also be seen virtually in any angle just like a paper. It is light in weight from factor allowing it to be ideal for highly portable application. It is also be low in cost.

In case of building a smart paper many new and different technologies exist in it for making it a flexible device. It is not a digital paper which is written with a pad and digital pen.

**Keywords :** Smart paper, Epaper , Electronic ink, Construction ,Front plane, backplane, working, Gyricon , Electrophoretic, Electrowetting, electrofluiding, comparison of e-paper and LCD.

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### I. Introduction

Smart paper is another name for the e-paper or electronic paper which is the electronic ink display technology which is designed to get the similar appearance of an ordinary ink on paper. It is also called Radio paper or electronic ink display. The smart paper reflect light alike a conventional flat panel display. The main aim of it is that this paper should be light weighted, lower cost, simple and with flexible 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.

Applications of this include time table at bus stations, labels for showing the price in retail shops , e-readers, e-paper magazines, general signage and Motorola Fone F3.

### 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 Sheridan an employee at xerox PARC in 1974 .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.

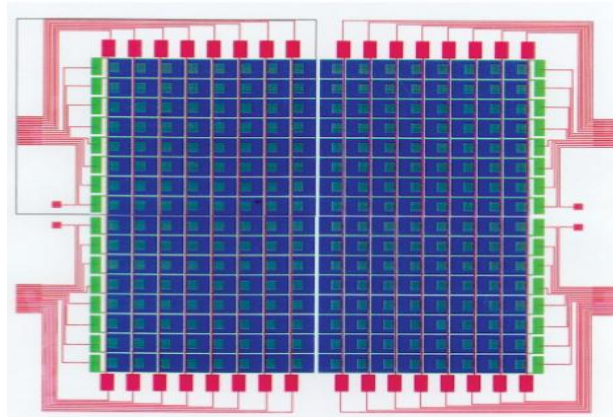
Later in the 1990's Joseph Jacobson has invented another type of e-papers which are called microcapsules, filled with different electronically loaded white particles that were dissolved in a dark coloured oil.

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 epaper 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.

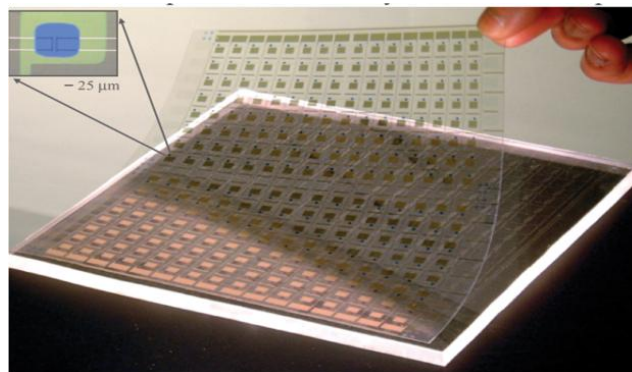
### 1. Construction of E-Paper

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 .



**Fig1.1: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.



**Fig1.2:Plastic Film Sheet Of Electronic Ink.**

## II. Working Of The Epaper

As read in the history after many years Gyricon ink 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 .

### 2.1 Gyricon

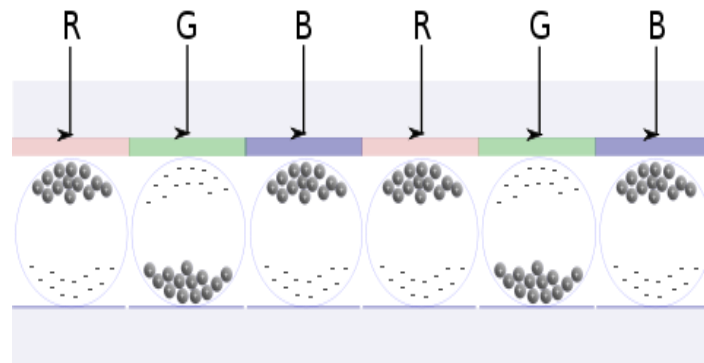
The first Gyricon was developed by Nicholas Sheridan. It consists of polyethylene spheres of diameter between 75-106 micrometers. Each sphere is also called Janus particle composed of negatively charged black on one side and positively charged white plastic on the other side. In this each and every hemisphere 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.

## 2.2 Electrophoretic Display

As there are some limitations with Gyricon, they have to be solved thus it had a solution called Electrophoretic display. By using an applied electric field it forms visible images by rearranging charged pigment particles. This consists of titanium oxide particles as microcapsules with one micrometer in diameter dispersed in a hydrocarbon oil which contains a dark coloured dye along with the surfactants and charging agents.

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.

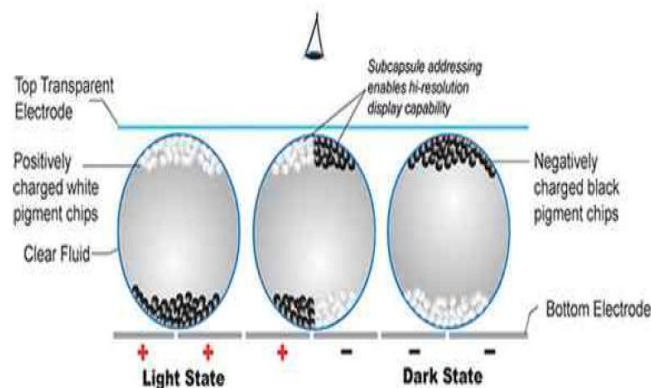


**Fig2.1: Pigmented Particles Of Electrophoretic Display**

Electrophoretic displays was generally developed by Philips research which was manufactured using electronics on plastic by Laser release (EPLar) process which has enabled the existing AM-LCD manufacturing plants for the creation of flexible displays.

## 2.3 Electronic Ink

Basically, an electronic ink is combination of tiny plastic well particles and flexible particles well which consists of both black and white particles suspended by with a clear fluid. The black and white have opposite charge which is appeared on giving an electrical supply embeds underneath or to top or both sides of the layer to create an E display .



**Fig2.2: Cross Section Electronic Ink Particles.**

The main disadvantage of this is the particles moving from upside down.

## 2.4 Electrowetting

Based on the controlling of the shape of a confined water or oil interface by an applied voltage electrowetting is obtained . The oil forms a film with no voltage between electrode and water, when voltage is applied the coating changes. As a result no stable state for stacked state. It results in the party transparent pixel, or, in case of reflective white surface that is being used under switchable element of white pixels. The switching between white and colour reflection is fast enough to display the content

## 2.5 Electro Fluidic Display

It is different from the above types of display. An aqueous pigment dispersion inside a tiny reservoir is placed by the electro fluidic display. 5-10% viewable pixel area is present in the reservoir. For pulling the pigment out of the reservoir voltage is applied. Liquid surface tension creates the pigment dispersion which helps to rapidly recoil into the reservoir when voltage is removed.

### III. Comparison of Smart paper with LCD display

<u>E- ink display</u>	<u>Liquid Crystal Displays</u>
It has a Wide viewing angle	It has the Best image from only one position.
Black on paper white .	Gray on Gray
It can be read in sunlight.	It cannot be seen in sunlight
It holds images without Drain	It requires power to hold the images.
It has plastic or glass sheets.	Glass sheets only.
It is light weighted.	It is heavy relatively.
Its thickness is nearly equal to 1mm.	Its thickness 7mm.

### IV. Applications

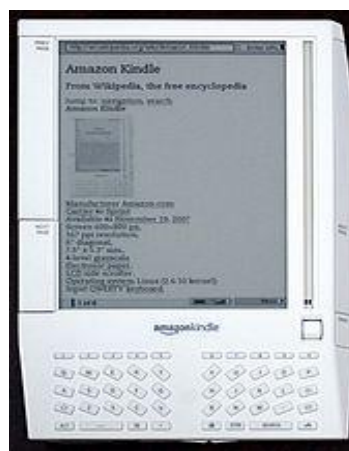
In Wrist watches : in 2005 Seiko company has used for their Spectrum, in 2010 the same Seiko released another advanced E- watch. Not only that there are also some types of Matrix watches in which E-ink Display is used.



Active Matrix EPD watch

**fig4.1:A MATRIX WRIST WATCH (from BASEWORLD)**

In E-books: In 2007 Amazon Kindle was released .In 2009 Amazon released Kindle2 , in the same year larger kindle dx was released and now until November 2015 amazon Kindle store contains four million kinds of eBooks.



**fig4.2: THE FIRST GENERATION KINDLE(from WIKIPEDIA).In cell phones such as Motorola fone3andSamsungAlias .**



**fig4.3: MOTOROLA F3 FONE (from WIKIPEDIA)**

In status displays such as USB flash drive to display status information such as storage.

In case of digital school book, in 2007 Jan, the Dutch specialist has used for edupaper.nl

It is also used for Digital Photo Frame in order to overcome the disadvantages of high quality, power supply and wide viewing angle.

## V. Conclusion

The technology keeps on changing. From the 1990's until today the smart paper technology is almost continuously used. Though it has the updates in between 1990 -2010 which we are still using in our daily life we are still trying for its advancement. It is used for decreasing the usage of LCD display also. Thus it would be the most evergreen thing being updated. Alike a human life is used make many things the electronic ink display or smart paper technology can be used make many wonders. The e-paper can also communicate satellite and other computer easily .And for the further more updates the researchers are thinking of making a paperless world by using the smart papers. Finally, there would be a more usage of E-paper technology rather than an LCD and an ordinary paper.

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