

Present Status and Future Trend for E-Paper

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Abstract

It is said that first year of e-Paper was 2004, when "sigma-Book" (LCD) by Panasonic and e-Book "Librie" (EPD) by Sony were introduced in the market. After that, many prototypes of e-Paper have followed in 2005. And also the related technologies have been evolved. I summarize the present status of e-Paper technologies and then propose the future trend.

1. Introduction

Recently, when we have to choose thick books or a USB memory stick for the proceeding papers in some institute or academic conferences. We are wondering which we should take, because the paper is very heavy and bulky, and on the other hand, USB memory stick needs a note PC which can not read easily and quickly. Therefore, we hope that the medium which has both the advantages of paper and the ones of display like a note PC will appear.

E-Paper is considered to be a concept medium that both "Paper" and "Display" are compatible between both advantages, as shown in Fig.1 [1].



Figure 1. Concept Approach for "e-Paper"

It is said that e-Paper started in 2004, as the first year of e-Paper, when "Σ-book (LCD)" by Panasonic and e-Book "Librie" (Electrophoretic display or EPD) by Sony were introduced in the market. After that, many prototypes of e-Paper have followed in 2005 to 2006, as follows.

- 2005 Watch (EPD) by Seiko Epson
- Facility watch (EPD) by Citizen
- Billboard (EPD) by Toppan Printing
- Electronic File Reader (EPD) by Polymervision
- Photo-addressing e-Paper (LCD) by Fuji-Xerox
- Nanochromic Display (EC) by Ntera
- Color e-Paper (LCD) by Fujitsu
- Color e-Paper (EPD) by E-ink
- 2006 AD Board (LPD) by Hitachi
- e-Reader (EPD) by iRex

The present status and the future trend of e-Paper are discussed in this paper from both market and technological side.

2. What is e-Paper ?

E-Paper like concept has been introduced in the movie film of "Minority Report" in 2002. They are Live Newspaper, Interactive Display and moving signage and so on. Concept approach for e-Paper is described in Fig.1. E-Paper should be a medium that combines both advantages of the paper and the display, in the future.

On the other hand, e-Paper has two forms, which consist of "Rewritable paper" (Hardcopy type) and "Paper like display" (Softcopy type), as shown in Fig.2. The former is near paper and rewritable by printers over and over again. The latter is near display but displays and holds information kindly to eyes without electronic power, and is rewritable without printers.

I am discussing "Paper like display" mainly in this paper.

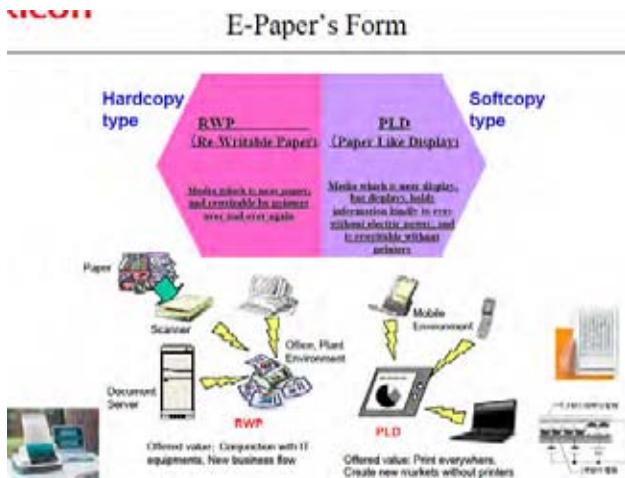


Figure 2. E-Paper's Form

3. Markets and Applications for e-Paper

The market and applications for e-Paper or "Paper like display" have been studied and then classified in the following figure.

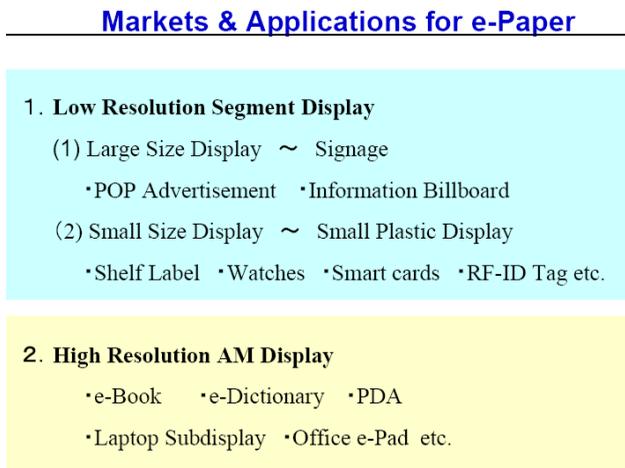


Figure 3. Markets & Applications for e-Paper

The market sizes for e-Paper are estimated in several papers, as follows.

Paper market would be \$300B on just books, newspaper and magazine, and then \$1 Trillion/year on total paper market in 2004, by Philips in IDW2004 [2]. Major paper contents in Japan would be \$110B and US is 3 times bigger market compared to Japan, by E ink in FPD2005 [3]. E-Paper market would be 530Bil. Yen in 2005 and 630Bil. Yen in 2010 worldwide, by Fuji Kimera Souken. [4]

4. Technical Trend for E-Paper

Recent technologies for e-Paper including both PLD and RWP are classified in Table 1.

| Recent Technology Trend | | | | |
|-----------------------------|--------------------------------|----------------------------|------------------|-------------------------|
| 1. Paper Like Display (PLD) | | | | |
| Phenomena | | Device | Operation Energy | Participant |
| Physical Particles | Particles Movement | Microcapsule type EPD | Voltage | E-ink(USA) |
| | | Microcup type EPD | Voltage | SuPa(USA) |
| | Particles Rotation | Twist Display | Voltage | Bridgestone (JPN) |
| | | Twist Ball | Voltage | Xerox/Gyrcon(USA) etc. |
| Physical Molecule | Optical Anisotropy | Cholesteric LCD | Voltage | KDI(USA), Fujitsu(J) |
| | | Nematic LCD | Voltage | Nemoptic(J) |
| Electro-chemical | Ion | Electrochromic | EVoltage | Nira(J) |
| | | Wetting | Electrowetting | Voltage |
| Mechanical | Gap Change | MEMS | Voltage | Quake(USA) |
| 2. Re-Writable Paper (RWP) | | | | |
| Phenomena | | Device | Operation Energy | Participant |
| Chemical Melt | Color dev. & res. Phase Change | Leuco Dye Color Developing | Heat | Ricoh, Mitsubishi Paper |
| Physical Particle | Light scattering Phase Change | Transparency Opacity | Heat | Ricoh, Mitsubishi Resin |

Table 1. Recent Technology Trend for E-Paper

PLD has a structure consisting of two planes, which are 1) front plane (display pannel) and 2) back plane (driving device). Not only the front plane but also the back plane is important for completing the e-Paper products.

The technologies for the back planes are classified in Table 2.

| Technologies for E-Paper's Back Plane | | | |
|---------------------------------------|-------------------|-------------|---------------------|
| Back plane Methods | | Front plane | Participants |
| Passive Matrix | | LPD | Bridgestone |
| | | LCD | Fujitsu |
| Active Matrix | a-Si/TFT | EPD | Philips/ Prime-view |
| | p-Si/TFT (SUFTLA) | EPD | Seiko Epson |
| | O-TFT | EPD | Plastic Logic |
| | | EPD | Polymervision |
| Others | FA Switch | EPD | PARC |
| | | EPD | Rolltronix |

Table 2. Technologies for E-Paper's Back Plane

The products of RWP were already introduced by using thermal print heads in the market in 1991, for examples, card application (loyalty card, ski pass

etc.), IC tag sheet and ID board. On the other hand, the products of PLD have been recently started to be done since 2004.

The above mentioned technologies will be discussed in more detail, including the review of e-Paper related technologies in SID2006, which was held in San Francisco, USA this June and where 28 papers were presented.

5. Summary

Finally, the present status and the future trend of e-Paper will be summarized.

5. References

- [1] [Revised]: R.Shioda, Electrophotography Society of Japan, Feb. 24, 1998.
- [2] M.T. Johnson et al., Proc. IDW'04 pp15-18 (2004).
- [3] R.Kuwada, FPD International (2005).
- [4] Fuji Kimera Souken (2005).
- [5] [Revised]: T. Kitamura, Proc. E-Paper Workshop '05 pp1-6 (2005).