Technology Enhancement in Flexible Displays and Substrate

Anshu R. Jaiswal¹, Vibhuti A. Dakhare² and Prof. Priyanka M. Lokhande³

¹Final Year, Computer Science Department, J.D.I.E.T, Yavatmal, India, anshujaiswal29@gmail.com
²Final Year, Computer Science Department, J.D.I.E.T, Yavatmal, India, vibhuti.dakhare12@gmail.com
³Final Year, Computer Science Department, J.D.I.E.T, Yavatmal, India, priyanka.20it@gmail.com

ABSTRACT

This paper reports ITRI’s latest technological advances in flexible displays, particularly flexible substrates, thin-film transistor (TFT) backplanes, and active matrix organic light-emitting diode displays (AMOLED). Cholesteric liquid crystal technology of ITRI used to develop a rewritable, eco-friendly thermal printable e-paper. The e-paper, invented to reduce traditional paper consumption, results into a high quality of resolution of 300 dpi with a memory task. It also includes multisensing touch panels on 100-µm thick flexible glass substrates provided by Corning. In present situation it is unimaginable. This paper presents recent progress in three projects: rewritable electronic paper, flexible universal planes, and a total R2R process with 100-µm-thick flexible glass substrates.

Keywords- Cholesteric liquid crystal (ChLC), flexible substrate, roll-to-roll procedure, ultrathin flexible glass, Active matrix Organic light-emitting diode display (AMOLED).

1. INTRODUCTION

Due to the major trends of the market requirements for personal smart phone devices, the Industrial Technology Research Institute has carried a research on its Research and Development assets for innovating the future electronic displays, which are flatter, which is having a less weight and easiest way to carry and store our device. These upcoming have capability to bent, even we will be able to fold also we can roll it, which is even unimaginable to think today with displays in market present today as we are using largely rigid glass part of display with flat panel which we are going to exchange with plastic or even more thinner glass. ITRI developed cross-divisional, various disciplinary team to put under assurance of engineers and scientist equipped broad professional backgrounds and experience. Peoples from the display developing manufacturer are gradually more focusing on roll-to-roll (R2R) processing for its capability which will reduce the efforts of slower batch for giving out and capitalizing rigorous vacuum-based manufacturing. At ITRI, sheet-to-sheet vacuum procedure (i.e., Flex UP technology) or an Roll to roll method (display and touch panel module) is used to manufactured flexible displays. This paper represents recent trends in three latest missions: flexible universal planes, rewritable e-paper, and a full Roll to Roll procedure having 100-µm-thick flexible glass substrates.

2. TECHNOLOGICAL DEVELOPMENT IN GLOBAL TRENDS IN MARKET

Research on flat panel displays (FPD), which started in the 1960s, has finally reached the commercialization stage in the form of large plasma display panels (PDPs) and liquid crystal displays (LCDs). This research will hopefully lead to FPDs with larger displays, higher picture quality, lower power consumption, and lower prices. A spin-off of this trend is the growing demand for enhanced picture quality broadcasting in...
media such as Hi-Vision (HDTV) and in data services. In the future, broadcasting, communications, personal computers will have fused together to form a common media by which interactive broadcasting and mobile reception via digital terrestrial broadcasting will be available in most areas. The demand for ubiquitous and easy-to-use displays as human interfaces will also increase. One of these interfaces will be a lightweight, flexible display that can be rolled up or folded. In future it might be possible for everyone to carry a large home display device simply by rolling it up. [4]

While the dream of a flexible display has a long history, roll-up and paper-like displays are now estimated to be commercially will be feasible soon. It has also become apparent that the advent of flexible display systems will have a significant impact on the market, not only because of the ubiquitous and convenient systems that could be supported, but also because of the potential to provide unconventional visual effects that are not possible with conventional systems. The big advantage of the manufacturing technology for these displays will likely be low-cost and environmental friendly.

Studies on display systems and materials have just begun, so that it is risky to give definitive statements about such a display system for television. [4]

3. TECHNOLOGICAL ADVANCES OF INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE

In the 1960s, Research on flat panel displays (FPD) takes place and finally reached the commercialization phase in the form of large plasma display panels (PDPs) and liquid crystal displays (LCDs). This leads to FPDs having larger displays than previous, great display superiority, less power consumption, and economical in comparisons. The offshoot of this technology is the results in growing demand for better picture quality used for broadcasting in media like Hi-Vision (HDTV) also in a data services. In upcoming years, broadcasting, communications media, computers will have combined together to form a common media through which interactive transmission and mobile reception via digital global broadcasting will be offered in various areas. This will result in easy to displays as human interfaces. In near future it might be possible for everyone to carry a large home display devices.[3]

However the displays are the most significant in mobile devices which has many important components because it provides facility which allows intercommunication between man and machine. latest technology have to be focused on the form factor that lead to development of screen technology, energy management, and environment affability. Flexible displays have huge possibilities to offer remedies that are light in weight, flat and easily foldable. In the interim, electronic-paper-based on the new bistable displays have the ability for providing displays that save energy and live long time without recharging also Roll to Roll technique in future will lead future market for eco-friendly, economical on paper electronics.

For achieving the goal the development contains mostly the use of more latest thin-film transistor liquid crystal display technology applications, also the manufacturer of Samsung display co. Ltd based in south Korea have started focusing on developing active matrix organic light-emitting diode displays which contains glass substrates.
This technology already implemented in smart phones and tablets, and display production team has started development of AMOLED production technology using plastic substrates. Along with Samsung Electronics Co, LG Electronics also announced production of flexible AMOLED products and launching it to market. Industrial Technology Research Institute (ITRI) research institution has produced flexible AMOLED core technology.

The demand in the most initial stage is that the displays should be weightless and indestructible. The inspiration of these displays is provide by mobile devices, Because of the long battery life and weightless quality the demand of this device can be increased effectively.

The second stage includes personalization and invention of a structure for foldable products. (Fig: 1). According to ITRI report, the result of flexible AMOLED panels will achieve US$37 up to 2020.

![Fig 1: graph of plastic substrate-based AMOLED display applications.](image)

Expert have recently become much confident about future energy-conserving display techniques involving electronic-paper and bistable displays which includes Taiwan's E Ink Holdings Inc, and Japan's Bridgestone’s electromorphic technique, Liquavista of the Netherland’s electro wetting technology and Japan’s Fujitsu who is among leader of Cholesteric LCD techniques.

![Fig: 2 Developmental trends of handheld devices.](image)

4. FLEXIBLE UNIVERSAL PLANE

According to the requirements of advanced displays, like thin and a weightless and robust architecture, developer are willing to produce a flexible AMOLED. In near future the smart phones and tablet PCs can be converged. (Fig. 2).

4.1 ITRI technologies

For providing the active matrix displays flexible, the ITRI’s Flexible Universal Plane (Flex UP) technique has developed a procedure in which thin layer of release material is inserted in between a layer of polyimide and a glass transmitter. TFT array are used to compose the flexible display on a high-temperature. AMLCDs applied this Flex UP technique which results into two major issues which are:

1) It’s hard to handle the cell gap at the time we bent panel, this may result in inferior image eminence; and
2) AMLCDs requires flexible backlight for developing the construction intricate.

The first Flex UP technology was Colour flexible AMOLED display which is about 6in which has bending radius of around 1 cm. Ultrathin screen gives display of image of brightness up to 150 nits also its screen can be bent to 100 000 times without getting display function affected. IN spite of this quality it has drawback of high-temperature constancy of the flexible substrates to avoid this ITRI is working on it.
Fig. 3 Drawbacks to cover for flexible AMOLEDs.

4.2 Active matrix organic light-emitting diode display (AMOLED)

Fig: 4 improving into new flexible OLED device structure.

Emitting device structure of a glass-based OLED is same as flexible OLED. However, without the glass protections too much challenging. The ITRI constructions consist of an inert waterproof layer and a buffer layer, as shown in Fig 4. soft BL level counterbalance the stress produced by the bending process. The soft buffer layer and adhesion enhancement layer (AIL), improves the flexibility of OLED for bending it. [2]

A flexible AMOLED display was constructed by using a 2T1C circuit backplane, and by successively depositing OLED structure on the TFT backplane. Fig 5 develops monochrome AMOLED of 6-in. It also provide waterproofing. The display of flexible AMOLED display is approximately 65 µm, bent up to curvature radius of 5 cm.

Fig: 5 Flexible AMOLED display developments at ITRI.

5. REWRITABLE ELECTRONIC PAPER-i2R e-PAPER

For numerous environmental considerations Green technology has been discussed and developed. E-paper technology can be used for saving trees and to eliminate the energy association.

The rewritable and again usable paper which is present is i2R e-Paper. It has a difference ratio of more than 10:1, various colours such as red, blue, green, and purple. i2R e-Paper consist the processes such as first is laser patterning, second is slot-die coating then sputtering then screen printing and lastly cutting as shown in Fig: 6.

Fig: 6 The measurement of 3 meter long Roll to Roll process flow of i2R.
6. R2R PROCESS TECHNOLOGY AND TOUCH PANEL MODULES WITH ULTRA-THIN FLEXIBLE GLASS

Industrial Technology Research Institute has newly established the technology with processing of roll to roll is carried on the ultra-thin glass and is advanced in nature.

| Glass thickness 100µm | Winding shift <500 ppm without auto correlation | Tension 2kgf | Screen printing line width:100µm | Lamination accuracy quality: <200ppm fully | TP | Laminating Metal alignment and pattern line width 15µm 180°wrap angle Pass 6” and 9” rollers with a 1064nm laser wavelength ≤<10µm | Power ≤<2kohm | Metal resistivity: e<4kohm | Screen printing speed 3m/min | Line width:3µm | Printing accuracy ≤<50µm | Winding speed 1m/min | ITO line width ≤<4kohm |
|----------------------|-----------------------------------------------|-------------|----------------------------------|---------------------------------------------|-----|------------------------------------------------|-----------------|-----------------------------------|---------------------|----------------|-----------------------------|------------------|-----------------------------|------------------|
| Lamination quality bubble, glass crack free | Laser pattern accuracy: 15µm | | | | | | |

Table-1: Table showing important results of R2R techniques

As shown in Table.7 the capability of touch panel is like five-finger inputs. This great result requires a performance with high signal reliability this usual processes gains due to high temperature and processing of high vacuum to reduce the line resistance and overlap capacitance. on the other side, the Roll to Roll technique contain process terms involves only normal temperature and an atmospheric environment to complete good performance with good signal reliability. Subsequently, we are using a commercially obtainable driver IC for the touch panels the driven IC set fulfilment limits of line resistance.

7. CONCLUSION

The Flex UP , novel technology, to manufacture flexible devices, as well as displays and sensors are also included, inflexible substrates which is of glass and silicon wafers can be reported in this paper. With the use of release layer, displays as well as electronic devices are made-up flexible substrates very easily, and de-bounded also easily. The flexible substrate developed flexibility barrier and encapsulation technologies for defending Active Matrix Organic Light Emitting Diode from performance-threatening oxygen and moisture infusion. Roll to Roll technologies are also attained two important techniques: the plastic is used to support for rewritable electronic-papers, and a complete Roll to Roll procedure with an ultrathin glass substrate having touch sensors with flexibility. In this paper technological advances detailed more illustrate the importance and advantage of working with industrial research laboratory such as Industrial Technology Research Institute. By the view of future, it is totally expect to these technological advances will too much fast with its industrial partners to apply these newly invented technologies in product-manufacturing environment.

REFERENCES