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Flexible Display & Sensor Technology

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ABSTRACT

LTPS technology has been applied especially to mobile use displays such as LCDs or OLED displays due to its superior TFT characteristics fabricated on glass substrate. Further, with improvements of flexible plastic substrate technology, the LTPS TFTs can be formed even on the plastic substrates. This has led to developments of flexible LCDs or flexible OLED displays. On the other hand, wearable type biometric sensors have been expected as a promising application field of TFT technology. We have developed a flexible organic photodetector using LTPS TFT technology on plastic substrate having 252x256 sensors with 508 ppi resolution. Both wave pulses and fingerprints/veins were captured successfully.

1. INTRODUCTION

LTPS technology has been applied especially to mobile use displays such as LCDs or OLED displays due to its superior TFT characteristics fabricated on glass substrate. That has contributed to improve thickness and weight of portable devices such as smartphones and tablet PCs.

Further, with improvements of flexible plastic substrate technology, the LTPS TFTs can be formed even on the plastic substrates. This has led to developments of flexible LCDs or flexible OLED displays [1].

On the other hand, as a promising application field of TFT technology, wearable type biometric sensors have been expected considering coming aging society. Then, the biometric authentication and the vital sign measurements are an urgent issue.

Considering these expectations, we developed a flexible organic photodetector using LTPS TFT technology on plastic substrate having 252x256 sensors with 508 ppi resolution [2].

In this paper, the core technology for mobile use LCD, flexible LCD and OLED display technologies, and flexible imager using LTPS TFT technology will be reviewed.

2. CORE DISPLAY TECHNOLOGY

The evolution of mobile use displays, such as displays in smartphones and automotives, has been ongoing. In the share of backplane technologies in mobile display, that of LTPS is increasing and is predicted to approach 50% in 2017. LTPS has relatively high mobility in comparison with other backplane technologies, and it excels in high resolution and narrow border; these are the main reasons for the expansion of the share of LTPS. We have been progressing LTPS over 20 years.

Furthermore, we have developed advanced LTPS TFT technology, which combined LTPS TFT and oxide TFT on the same substrate [3]. Good TFT characteristics were observed in LTPS and oxide TFTs in G6 glass substrate. Optimization of process condition reduced shift of oxide TFT characteristics under PBTS and NBTIS conditions. Prototype LCD at 5 Hz frame-rate driving, reduction value of power consumption of 62% was achieved for white raster image.

(a)

(b)

Fig. 1 (a) Flexible LCD and (b) Flexible OLED.

3. FLEXIBLE DISPLAY TECHNOLOGY

3-1. Flexible LCD is an LCD that uses plastic films instead of glass substrates. In recent years, film material has evolved. Properties such as heat-resistance, transmittance, and retardation have greatly improved. The backplane process temperature has also been decreasing. Although plastic film LCDs have been developed for a long time, with respect to performance, they are different to glass-substrate LCDs. With the abovementioned latest technologies, JDI was able to develop plastic film LCD with high resolution and high contrast ratio equivalent to glass-substrate LCD [1]. Figure 1a shows the 5.5 inches Full-HD (401ppi) prototype LCD with IPS and it is curved like a plastic film OLED display. JDI is developing elementary technologies and devices for mass production.

3-2. Flexible OLED display. The design flexibility of plastic film OLED display is still higher than the abovementioned plastic film LCD. OLED display is flexible as well as a plastic film LCD. A backlight unit is unnecessary; therefore, there is no flexibility constraint by a backlight unit. Moreover, the structure without backlight unit contributes to the slimming down of the design. Plastic film OLED is already marketed as the display for smartphones and watches. On the other hand, in OLED displays compared to LCD, there are issues regarding image sticking, productivity, and resolution. In addition, plastic film OLED display needs to evolve further in order to bend repeatedly, JDI is developing production technology using vapor deposition equipment and the vapor deposition mask of the new method. Improvement is expected in terms of the resolution and productivity issue [1]. Figure 1b shows the prototype OLED display. 5.5 inches Full-HD 401 ppi is realized without using subpixel rendering. Furthermore, saving power using low-frequency drive is possible by advanced-LTPS as a backplane. JDI aims at marketing this new high definition and power-saving plastic film OLED display at an early stage.

3-3. We verified neutral plane splitting experimentally and verified that one neutral plane splits into two ones. The neutral-plane position of the configuration with lower elastic adhesive is close to perfect splitting. We developed the foldable OLED display prototypes based on the concept of neutral-plane splitting [4].

4. FLEXIBLE SENSOR TECHNOLOGY

Flexible display technologies including LCD and OLED lead to promising thin image sensors as shown in Fig.2.

Figure 3 shows a developed thin image sensor that allowed for both high-speed readout and high-resolution imaging through joint R&D with the Someya Group of the Department of Electric and Electronic Engineering, School of Engineering, University of Tokyo. Integrating low-temperature polysilicon thin-film transistors with high mobility and high-sensitivity organic photodetectors has enabled to create a single sensor that measures not only pulse wave distribution, which requires high-speed readout, but also biometric information, such as fingerprints and veins, which require high-resolution imaging.

Figure 3 shows the developed flexible thin image sensor which is light weight and bendable with a mere 15 micrometers thick.

Figure 4 shows a fingerprint/veins/pulse waves measurement module and Fig. 5 shows (a) pulse Waves, (b) fingerprint, (c) veins examples by using this measurement module.

As for biometric authentication, it is expected that the sensor will be applied to high security authentication systems to prevent imitations and impersonations by obtaining both biometric information (fingerprints and veins) and biometric signals (pulse waves).

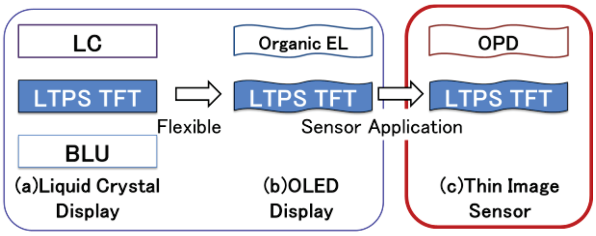

Fig. 2 Flexible Display Technology and Flexible Sensor Technology.

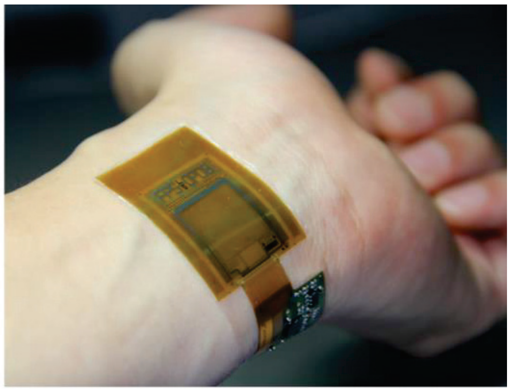

Fig. 3 Flexible thin image sensor.

Fig. 4 Fingerprint/Veins/Pulse Waves Measurement Module.

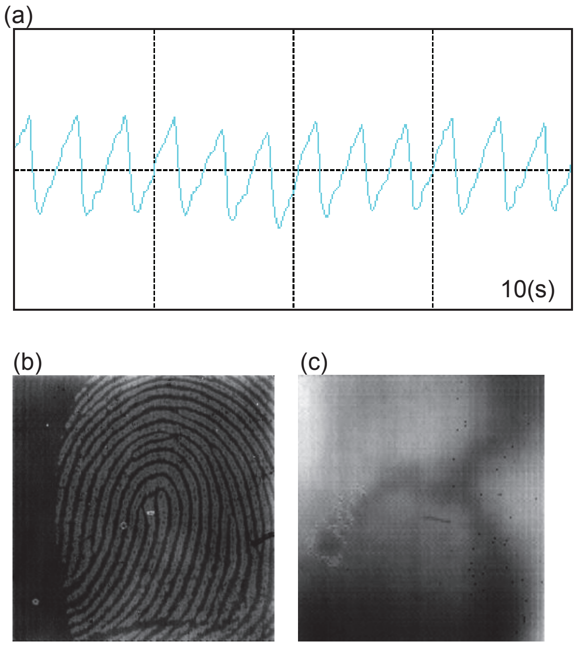

Fig. 5 Biometric data taken by the image sensor.
(a) Long-term measurements of pulse waves,
(b) Imaging of a fingerprint,
(c) Imaging of a finger Vein.

5. SUMMARY

Flexible high-speed readout and high-resolution thin image sensor was developed. Both wave pulses and fingerprints/veins were successfully captured by single sensor. By obtaining both biometric information (fingerprints/veins) and biometric signals (pulse waves), high security authentication system can be realized. This flexible thin image sensor can easily be implemented on wearable devices.

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REFERENCES

[1] A. Takimoto, “Next Generation Technologies for Mobile Use Display”, Proc. IDW’17, pp.1-4 (2017).
[2] T. Yokota, T. Nakamura, H. Kato, M. Mochizuki, M. Tada, M. Uchida, S. Lee, M. Koizumi, W. Yukita, A. Takimoto, T. Someya, “A conformable imager for biometric authentication and vital sign measurement”, Nat. Electron. **3**, 113-121 (2020). doi:10.1038/s41928-019-0354-7
[3] H. Watakabe, T. Jinai, I. Suzumura A. Hanada, R. Onodera, M. Tada, K. Mochizuki, H. Tanaka, T. Ito, “Development of Advanced LTPS TFT Technology for Low Power Consumption and Narrow Border LCDs”, SID’19 Symp. DIGEST, pp.541-544 (2019).
[4] M. Nishimura, K. Takebayashi, M. Hishinuma, H. Yamaguchi, A. Murayama, “5.5-inch Full HD Foldable AMOLED Displays Based on Neutral-Plane Splitting Concept", SID’19 Symp. DIGEST, pp.636-639 (2019).