Development of 2 inch LTPS-TFT AMOLED on Flexible Metal Foil

Dong Jin Park, Jae Hyun Moon, Yong Hae Kim, Choong Heui Chung, Myung Hee Lee, Jin Ho Lee and Yoon- Ho Song

IT Convergence & Components Laboratory
Electronics and Telecommunications Research Institute
161, Gajeong-dong, Yuseong-gu, Daejeon, 305-350, Korea
Phone : +82-42-860-5647, E-mail : jins1130@etri.re.kr

Abstract

We have developed a 2 inch LTPS-TFT AMOLED display with a top emission structure on a 50-μm-thick metal foil. The Active matrix back planes were fabricated with the p-channel LTPS TFT with a conventional pixel circuit consisting of 2 transistors and 1 capacitance. The p-channel TFTs on the metal foil exhibited the field-effect mobility of 22cm^2/Vs. Finally, a images from prototype monochrome AMOLED displays are successfully presented, with 64×88 pixels and 56-ppi resolution.

1. Introduction

Low-temperature polycrystalline silicon(LTPS) on glass have attracted considerable interest for large-area electronics including active-matrix liquid crystal display (AMLCDs) [1], active-matrix organic light emitting diodes (AMOLEDs) [2], and system-on-glass(SOG)[3] due to its high field effect mobility, compared to amorphous silicon(a-Si). Recent work has focused on the Si thin film transistor on such flexible substrates as stainless steel(SS) foil and plastic, because flat panel displays(FPD) on flexible substrate have the advantages in making robust and light-weight displays.[4,5]

The three obvious possibilities are:

<i> standard poly-Si TFT fabrication on glass substrates followed by transfer of the array to a flexible substrate, <ii> direct fabrication on the flexible substrate itself, and <iii> fabrication after laminated glass or Si wafer .

When is used metal foil as flexible substrate, i>,ii> is attractive because it is possible to exploit the high temperature process to crystallize the amorphous silicon precursor and deposited gate dielectric. And iii> is easy to handling flexible substrate, while process temperature is low for delamination between flexible substrate and glass or Si wafer about 250℃.

In this work, we have fabricated low temperature polycrystalline silicon(LTPS) on SS foil by iii> for application of plastic substrate process temperature(>250℃). And we have developed the LTPS-TFT array on a metal foil and applied it to make AMOLED.

2. Design

Figure 1 shows the schematic diagram of a 2 inch LTPS-TFT AMOLED with a top emission on the flexible metal foil. It was cured at 250℃ after BCB was coated on metal foil substrate. The metal foil substrates were laminated on 5" glass before buffer layer SiO_2 deposition. The metal foil substrates are 50 ㎛-thick. Poly-Si on SiO_2/metal foil was patterned for active island. A 70nm Al_2O_3 layer was deposited by plasma enhanced atomic layer deposition(PEALD) on a 80nm-thick poly-Si for a gate insulator. Then, a 200nm-thick Al was deposited and patterned for gate line. Boron ion doping was performed into source and drain regions using an ion implanter system. Organic material layer as an inter-layer was deposited by spin-coater at normal temperature and patterned for source and drain contact holes. A 200nm-thick Al was deposited and patterned source and drain. The passivation layer, then, was deposited, which was followed by etching to make via holes using SF_6/O_2 plasma. Finally, a reflector of Cr/Al/Cr was deposited and then patterned for pixel electrode and then parylene as a bank was formed by spin-coating.

Figure 2 shows the pixel layout of designed AMOLED backplane on the metal foil. For

preventing off-current of the switching TFT, a double gate was designed. And the driving TFT was designed to have a single gate. The capacitance was composed of 50nm-thick-AlON deposited by PEALD and its value is about 3pF. The OLED layers have the conventional structure with HIL, HTL, EML, ETL, EIL, and transparent cathode. The phosphorescent materials as an emitting material were used. Finally, the AMOLED display was encapsulated by a thin film process. The display has a 2 inch diagonal size with 56-ppi resolution and its pixel pitch is 450μm.

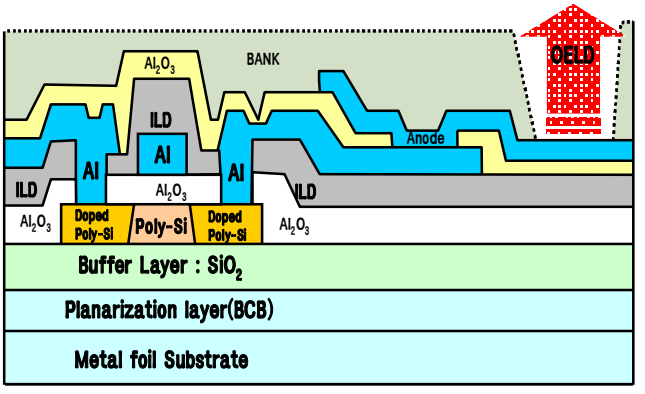

Figure 1. Schematic diagram of a 2 inch LTPS-TFT AMOLED with a top emission on flexible metal foil.

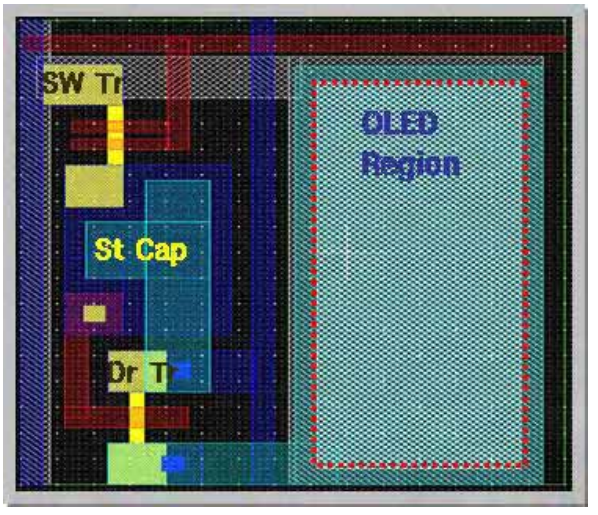

Figure 2. Pixel layout of designed AMOLED backplane.

3. Results

Figure 3 shows SEM images of the SS metal foil before and after a planarization process. We have tried to planarize it using various materials such as SOG(spin-on glass), J1(organic materials), and BCB. Among then, the BCB had the best result showing a RMS roughness of 100Å.

Figure 4 shows the device characteristics of a LTPS-TFT on the metal foil with a 1-μm-thick BCB planarization layer. We fabricated the poly-Si TFTs on the flexible metal foil using SLS(sequential lateral solidification) process for crystallization. below 200℃. The p-channel TFTs with W/L=10/20 on metal foil exhibited the field-effect mobility of 54cm^2/Vs, the on/off current ratio of 10^6, the threshold voltage of -3V, and the subthreshold slope of 0.8V/dec.

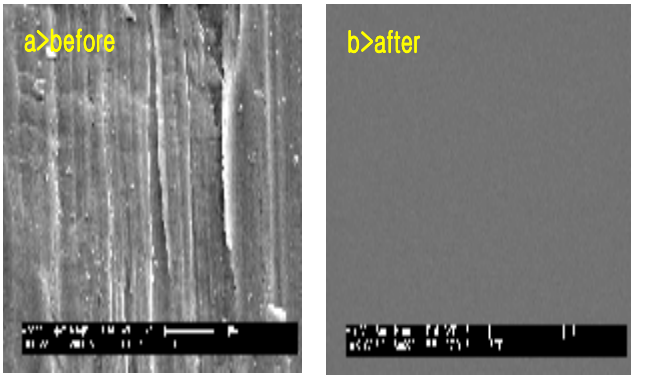

Figure 3. SEM images of a>before and b> after coated BCB planarization layer on the metal foil

Table 1 shows the specification of 2 inch AMOLED on flexible metal foil. Pixel pitch has 450um and aperture ration has 35%.

Figure 5 shows display images from the fabricated AMOLED on the metal foil. The operation voltage were Vdd=15V and $V_{cathode}$= 0V. Base on the measured transfer characteristics of the pixel driving transistor, the input negative and positive voltages, which are applied onto the scan line, were determined to 15V and 0V, respectively and the data signal voltage was varied from 15V to 0V. The AMOLED has the gray level of 64, full white luminance of 3000cd/m^2 and contrast ratio of 1000:1.

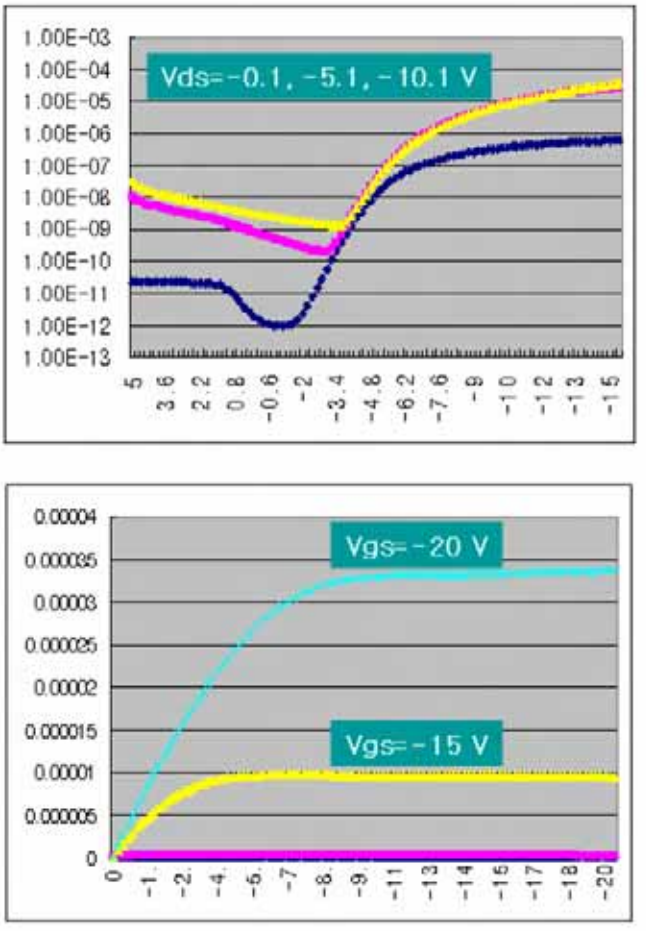

Figure 4. Transfer and output characteristics of a p-channel poly-Si TFT on metal foil.

ITEM		Unit	Design parameter
CLASS			AM(LTPS) OLED
Sample Division			2.0" QQIF (MONO)
Number of Pixel	Scan (row)	EA	64
	Data (column)	EA	88
Size of Active Area	Horizontal	mm	29.88
	Vertical	mm	41.08
Size of Pixel Area	Row	μm	467
	Column	μm	467
Aperture ratio		%	35%
Resolution		ppi	65

Table 1. The specification of a 2 inch AMOLED on flexible metal foil

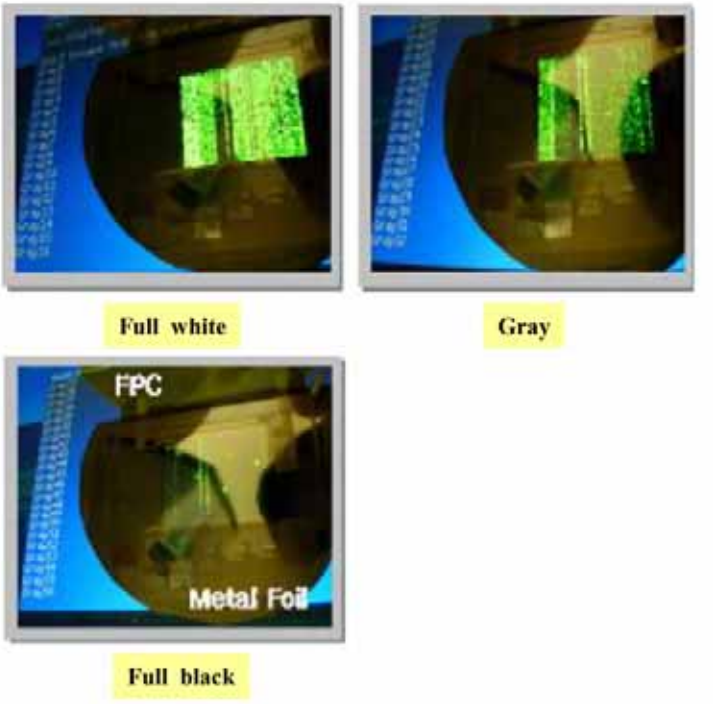

Figure 5. Display images from the fabricated AMOLED on the metal foil.

4. Conclusion

We have fabricated a 2 inch LTPS-TFT AMOLED on flexible metal foil. The p-channel poly-Si TFT on flexible metal foil exhibited the field-effect mobility of 54cm^2/Vs, the on/off current ratio of 10^6, the threshold voltage of -3V, and the subthreshold slope of 0.8V/dec.

The AMOLED has 54ppi resolution with 3000cd/m^2 brightness. It can be used for flexible display in various applications.

5. Acknowledgements

Authors would like to thank W. S. Park and J. S. Noh for their valuable help in sample preparation. This work is supported by the Korea Ministry of Information and Communication.

6. References

[1] Y. M. Ha 'P-type technology for large size low temperature poly-Si TFT-LCDs, " Digest of SID'00, 1116(2000).

[2] M. Stewart, R, S, Howell, L. Pires, and M, K, Hatalis, "Polysilicon TFT technology for active matrix OLED displays," IEEE Trans. Electron Device, 48, 845(2001).

[3] H. Sakamoto, N, Makita, M. Hijikigawa, M. Osame, Y. Tanada, and S. Yamazaki, "2.6 inch HDTV panel using CG silicon," SID Digest'00, 1190(2000).

[4] E. Y. Ma and S. Wagner, "Amorphous silicon transistors on ultrathin steel foil substrates, " Appl. Phys. Lett. 74, 2662(1991)

[5] C. C. Wu, S. D. Theiss, G. Gu, M. H. Lu, J. C. Sturm, S. Wagner, and S. R. Forres, " Integration of organic LED's and amorphous Si TFT's onto flexible and lightweight metal foil substrates, " IEEE Electron Device Lett. 18, 609(1997)