Extended Abstracts of the 2009 International Conference on Solid State Devices and Materials, Sendai, 2009, pp631-632

Geometrical and electrical characteristics of gate electrodes for OTFT fabricated by screen printing and wet etching

Mi-Young Lee[1] and Chung-Kun Song[1,2]

[1]Univ. of Dong-A, Media device lab, 840, Hadan-dong, Saha-gu, Busan 604-714, Korea
[2]Univ. of Dong-A, Dept. of Electronics Engineering, 840, Hadan-2 dong, Saha-gu, Busan 604-714, Korea
Phone: +82-51-200-7711 E-mail: cksong@dau.ac.kr

1. Introduction

Organic thin film transistors(OTFTs) are attracting much attentions because of the low-cost, large-area and flexible electronic applications. For the implementation of low cost and large area applications the solution processes such as screen printing, ink-jet printing and micro-contact printing should be developed [1,2,3]. Especially, screen printing has many advantages such as simple and environment-friendly process, high material-efficiency and large-area applications [4].

In this paper, the solution processes for gate electrodes of OTFTs were developed by using screen printing and wet etching processes with nano silver ink. The effects of mixing ratios of components such as Ag particles and solvent and surface treatment and curing temperature on geometrical and electrical characteristics of gate electrodes were systematically investigated. And also the screen printing and wet etching processes were optimized to achieve the performance of thermally-evaporated OTFTs.

2. Experiment

In order to evaluate the adhesion of the nano silver ink film (Silver nano paste DGP, ANP) to substrate, the silver coating layers were deposited onto bare PC plastic, PVP-coated PC plastic and O_2 plasma-treated PVP-coated PC plastic substrates by screen printing using ink with silver content of 20wt%. The screen mask was made of a stainless steel fabric with 640 mesh. And cross-cutting test was conducted after curing at 150 ℃ for 30 min.

Also to study the curing temperature effects, the stability of the geometrical and electrical characteristics of electrodes was investigated by varying the temperature from 150 ℃, 170 ℃ to 200 ℃, in which Ag film was coated on PVP-coated PC plastic substrate. Finally, photolithography process was carried out on the Ag layer, and then followed by wet etching process to pattern the layer.

The various Ag layers with the different Ag contents from 15, 20, 30, to 40wt% were tested to examine the Ag contents effects by making OTFTs on the PVP coated-PC plastic substrate. The cross-linked PVP layer was used for gate dielectric and Au for S/D electrodes, and pentacene for semiconductor.

The geometrical characteristics were examined by optical microscopy(MX61L, Olympus), three dimensional profiler(NV-E1000, NanoSystem). The electrical characteristics were tested by four point probe(CMT-series, AIT) and Keithley 4200 semiconductor analyzer.

3. Results and discussion

From the cross-cutting test, it was found that the adhesion of silver coating layer to bare PC plastic was poor due to weak interaction between silver coating layer and bare PC plastic substrate. However, the adhesion to PVP-coated PC plastic and O_2 plasma-treated PVP-coated PC plastic substrate was much better than PC.

The Ag layer cured at 150 ℃ was partly stripped off during developing resist with alkali developer. It seems due to existence of pore and residual surfactant in the Ag layer cured at the low temperature. As the curing temperature increase, the thickness was reduced and conductivity increased as shown in Fig. 1. However, the surface roughness and leakage current through PVP dielectric layer in MIM device was not changed.

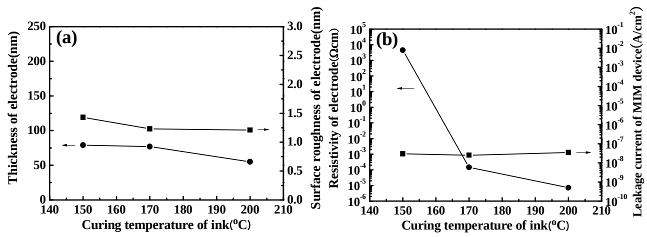


Fig. 1. (a) Geometrical characteristic and (b) electrical characteristic of screen printed-etched gate electrodes by curing temperature of nano silver ink

As Ag contents increased, the thickness was increased and the surface became rougher as shown in Fig.2a). As the results, the leakage current of MIM devices became larger due to the poor step coverage of the thick and rough electrodes as shown in Fig.2b). It was found that Ag film with the thickness less than 100 nm achieved by Ag content less than 30wt% produced the good electrical characteristics such as low leakage current less than 10^{-7} A/cm^2.

The line width of 30 um and the resistivity of ~10^{-6} Ω·cm was achieved by using screen printing and wet etching at the curing temperature of 200 ℃ in which the silver content was 20wt% as shown in Fig. 2 and Fig. 3.

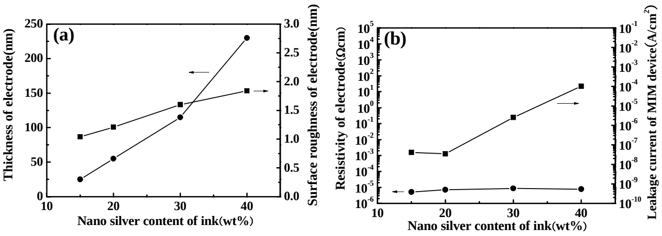
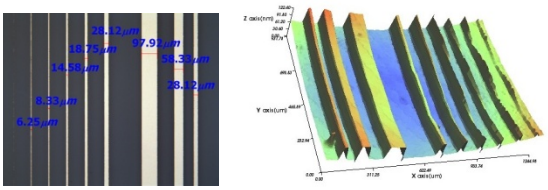


Fig. 2. (a) Geometrical characteristic and (b) electrical characteristic of screen printed-etched gate electrodes by nano silver contents of ink



(a) (b)

Fig. 3. (a) Microscopic image and (b) three-dimensional image of screen printed-etched gate electrode using ink with silver content of 20wt% at curing temperature of 200℃.

Fig. 4 shows the output and transfer characteristics of pentacene TFT with the screen printed-etched gate electrode on a PVP coated PC plastic substrate. The Ag content was 20wt% and cured at 200 ℃. Pentacene was used for semiconductor and PVP for gate dielectric and Au for S/D electrode. The mobility and $I_{on/off}$ were 0.13 cm^2/Vs and ~10^5, respectively.

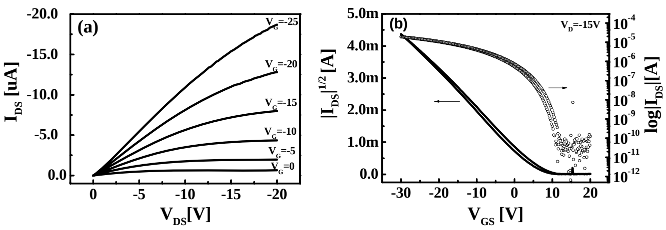


Fig. 4. (a) The output characteristic and (b) the transfer characteristic of OTFT(W/L=400/20 um) with screen printed-etched gate electrode using ink with silver content of 20wt% cured at 200℃.

4. Conclusions

We fabricated gate electrodes for OTFT by using screen printing and wet etching with nano silver ink (20wt%) combining with surface treatment of substrate. As a result, the gate electrode with a line width of 6 um, a thickness of ~50 nm and a resistivity of ~10^{-6} Ω·cm was manufactured on a PVP coated PC plastic at curing temperature of 200 ℃. The mobility and $I_{on/off}$ of pentacene TFT were 0.13 cm^2/Vs and ~10^5, respectively, and comparable to the performance of the thermally evaporated-OTFTs.

Acknowledgements

This research was supported by a grant(F0004020) from the Information Display R&D Center, one of the 21st Century Frontier R&D program funded by the Ministry of Knowledge Economy of Korean Government.

References

[1] D. Kim, S. Jeong, S. Lee, B. K. Park, and J. Moon, Thin Solid Films, **515** (2007) 7692

[2] Y. G. Seol, J. G. Lee, and N.-E. Lee, Org. Electron., **8** (2007) 513.

[3] T. Kawase, T. Shimoda, C. Newsome, H. Sirringhaus, and R. H. Friend, Thin Solid Films, **438-439** (2003) 279.

[4] Z. Bao, Y. Feng, A. Dodabalapur, V. R. Raju, and A. J. Lovinger, Chem. Mater., **9** (1997) 1229.