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Roll-type Micro-contact printing process with PDMS stamp for patterning conductive Metal Line with Ag ink

Jun-Hak Kim[1], Mi-Young Lee[2], Yun-Jong Park[1] and Chung-Kun Song[1]

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

1. Introduction

Recent, by using an micro-contact printing, the conductiveity metal electrode is formed or the research about the OTFTs manufacture through the printing process is utterly proceeded. Among them, after the ink resist is printed on the metal layer in which it is evaporated by using the PDMS stamp, there is the method forming a pattern through an etching. And there is the method forming the Ag electrode pattern by the roll type mode in the film substrate. But, it is not all printing process and the etching process is added or the UV surface treatment, the SAM treatment and etc. are required for the ink transfer characteristic improvement[1,2]. Also, in the micro-contact printing of the plate, when it printed with the difficulty of the uniform pressure, large area, long contact time, there were disadvantages that the bubble between the PDMS stamp and a substrate are generated[3,4].

In this paper, we studied on the patterning of conductive metal line by roll type micro-contact printing(uCP) with PDMS stamp. The ink transfer characteristic during printing was improved by optimizing a coating condition, inking speed, printing speed, printing pressure and Ag content. Under the optimum condition, conductive metal line with a line width of 30um, a thickness of ~300nm, a roughness less than 40nm, and a specific resistance of $2.08\times10^{-5}\Omega\cdot$cm was obtained in area of 4×4cm^2

2. Experiment

As an experiment, we used the roll printer equipment (Narae nanotech) and Ag ink (Nano silver ink, ANP). Fig. 1. Shows the processing procedure of the roll type uCP. The roll type uCP is comprised of the coating process, the inking processing, and the printing process. In the case of PDMS stamp, the soft PDMS stamp was used. The PDMS stamp was made of Sylgard 184A and 184B(mixing ratio 10:1) of Dow Corning, and Si wafer was used for a master with 15 um pattern depth.

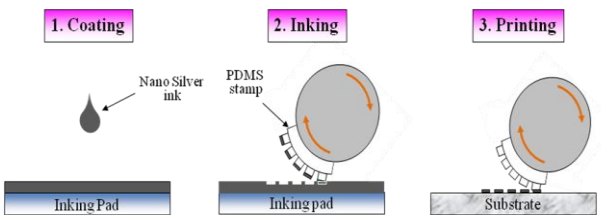


Fig..1. The schematics of roll-type micro-contact printing process; coating Ag ink over pad, inking Ag ink on PDMS stamp from pad, printing Ag ink on substrate from stamp.

The quality of patterned lines is determined by how to control attaching speed, detaching speed, and contact time of stamp to pad and of stamp to substrate. In roll uCP those parameters are controlled by rolling speed of the roll alone. Thus, the transfer ratio of ink was measured by varying the roll speed from 25 mm /sec to 200 mm/sec to find out an optimum roll speed for the largest transfer ratio. The Ag film thickness on pad also affected the transfer ratio so that the transfer ratio was tested according to spin coating speed.

Lastly, the printing characteristic according to the solid content was compared. Ag content of the ink was divided 10%,20%,30% into and it compared. Parameters then fixed with the condition that it is optimized.

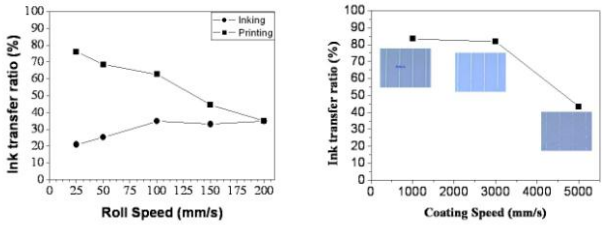
3. result and discussion

In Fig. 2(a) the ink transfer ratio from pad to stamp and from stamp to substrate was depicted according to roll speed. In inking process as roll speed increased the transfer ratio increased meanwhile the transfer ratio decreased in printing process. This is due to the different adhesion of Ag ink on stamp from glass pad and substrate. The adhesion of Ag ink on stamp is higher than that on glass pad and substrate so that the transfer from low adhesion to high adhesion material required the high roll speed. However, for transferring from high to low material the roll speed needed to be reduced in order to compensate the low adhesion by providing a sufficient contact time to substrate.

It is important to get a sufficient amount of ink on stamp for the high transfer ratio from stamp to substrate. The amount was examined according to the different spin coating speed which induced the different thickness of Ag film on pad. As show in Fig. 2b) at spin speed 1000 mm/sec the transfer ratio of 80 % was achieved. In this regime the breakage of Ag ink film was not occurred at the surface of pad but in the middle of Ag film.

The transfer ratio of Ag film from pad to substrate was varied depending on Ag content of ink. As shown in Fig.3 for the small line feature the transfer ratio was above 80 % regardless of Ag content. However, for the large feature the transfer ratio was rapidly reduced for the case of 10 % of Ag content. However, for 30 % of Ag content the transfer

ratio was about 100 % regardless of feature size.



(a) (b)

Fig. 2. Transfer ratio of Ag film with respect to a) roll speed in inking and printing process, b) spin coating speed in inking process thickness of ink layer.

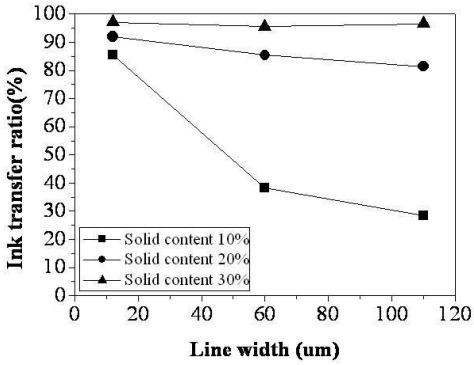


Fig. 3. Transfer ratio of Ag film from stamp to substrate with respect to Ag content of ink and feature size.

Finally, the optimum conditions of roll-type uCp for Ag ink were figured out and they were 1000 mm/sec of spin coating speed, 200 mm/sec of roll speed for inking process, 25 mm/sec of roll speed for printing process, and 30 wt% of Ag content. With the optimum condition we could achieve 30 um line width as shown in Fig. 4.

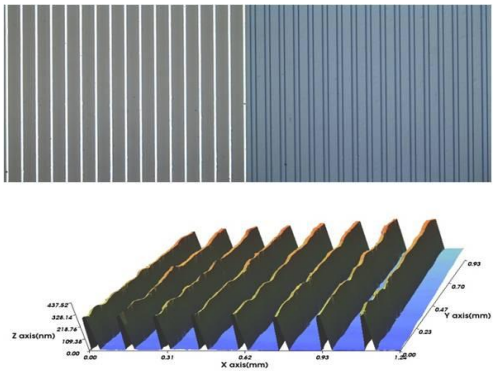


Fig. 4. The optical microscope picture of the final printed lines, and 3D profile images of the printed lines.

4. Conclusions

We optimized the printing parameters of roll-type uCP process such roll speed, spin coating speed, and Ag content of ink. They were1000 mm/sec of spin coating speed, 200 mm/sec of roll speed for inking process, 25 mm/sec of roll speed for printing process, and 30 wt% of Ag content. The feature size of 30 um was easily obtained.

Acknowledgements

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