Effect of Kinetically Processing Conditions on Ink Transfer Ratio for Transfer Printing

Sung-Ryool Park[1], Se-min Kim[1], Gi-Seong Ryu[2], Chang-bin Lee[2] 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

Keywords: OTFT, Ag-ink, Microcontact printing

Abstract

This paper examines attaching speed, detaching speed and contact time which affected in the ink transfer ratio and presents the best conditions for fabrication process of electrodes with Ag-ink using microcontact printing method.

In conclusion, it shows the best printing characteristic by two conditions. One of condition is the attaching speed have to within less than 1mm/s and the detaching speed is high velocity as 1000mm/s and the contact time is taken about the minimum time when inking process. Another condition is the attaching speed have to within more than 100mm/s and the detaching speed have to within less than 1mm/s and the contact time is longer than 30second when the printing process. As using these condition and the stamp sized 5cm×5cm, it was possible for printing equally until 30㎛ of width. The printed thickness of a electrode was about 300 to 500 ㎚, the surface roughness was about dozens ㎚ under 50 ㎚.

.

1. Introduction

Recently, a printing process for the fabrication of organic thin film transistor (OTFT) is attracting much attention because it has advantages to use a substrate material which has a big CTE such as plastic substrate as keeping the processing at the room temperature and reduced processes, fabrication cost. These printing methods include screen printing, ink-jet printing, micro-contact printing, gravure printing and flexography printing. Especially, micro-contact printing has advantages to the ability of the nano-sized channel length fabrication because it's possible to direct printing as the stamp used PDMS (polydimethylsiloxane) and simple, low-cost fabrication of PDMS stamp.

Recently, micro-contact printing has been used for electrodes with Ag-ink of OTFTs by using heat treatment when inking and printing process. And the printed surface of a film treated plasma because it improves surface roughness [2-6].

The purpose of this paper is find out the effect of kinetically processing conditions on the ink transfer ratio for the simple process of a fabrication of electrodes with Ag-ink of OTFTs using micro-contact printing.

2. Experimental

The micro-contact printing process for the fabrication of electrodes is depicted in Fig. 1. First, the coating process was used by the spin coating which was the ink coating on the stamp pad for the inking process, and then it was the inking process which transfers the ink from the inking pad to PDMS stamp. Finally, the printing process which transfers the ink from PDMS stamp to substrate. We used the equipment to control the position and the speed when the inking and the printing process.

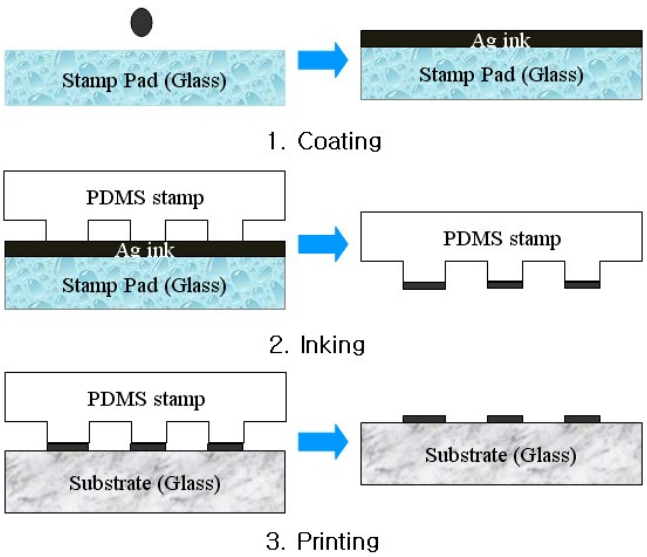

Fig. 1 The micro-contact printing process

In this printing process, it is important that the ink film is a good transfer in the process of each step. At this point, the adhesion between each surface is sensitive to the rate at which the transfer ink film. To transfer well, it should be that the adhesion between the attaching substrate and the ink film is lager than the adhesion between the detaching substrate and the ink film. Basically, in the situation without affected another force, we measured the contact angle which is adhesion with Ag ink, and it is depicted in Fig. 2. We can know that the adhesion between the substrate which is used a glass or a plastic and Ag-ink is lager that the adhesion between PDMS and Ag-ink. Thereby, it is easy to transfer ink from PDMS stamp to the substrate, but in the opposite situation, the transfer ink from the substrate to PDMS stamp is that the inking isn't successful well. Therefore, in the mostly transfer method using PDMS stamp treated the surface such as plasma at the stamp and made increasing the substrate adhesion between the PDMS stamp and Ag-ink, and used the method coating PDMS stamp.

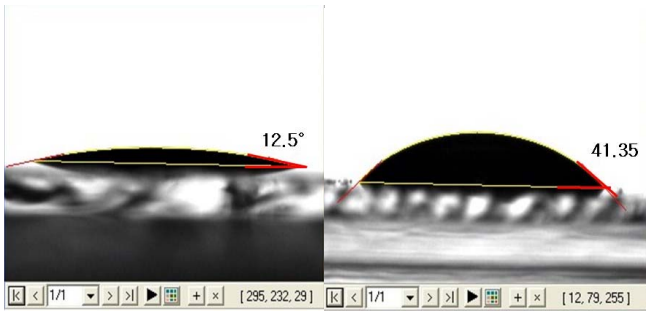

Fig. 2 The contact angle of Ag ink on glass and PDMS stamp

If these methods used, there is a disadvantage that decease the transfer from PDMS stamp to substrate as the rate at which increasing the surface adhesion between the PDMS stamp and Ag-ink. On the contrary, it happen the problem that coating is not uniform if the surface adhesion between the stamp pad and Ag-ink is decreased. To solve these problems, we think that transfer characteristic will improve by using the elastomer in the energy of adhesion is changed by the velocity.

3. Results and discussion

It was divided into three classes that the attaching speed, the contact time after attached, the detaching speed. From affecting primary factors at each of the step, we divided the process at each of the inking and the printing into three classes that the attachment, the stay after contact, and the detachment. We studied an influence weather divided factors have an effect about the transfer of ink.

First, the relation between each of the factors and the transfer in the processing inking shows at Fig. 3. It shows that the ratio of the ink transfer was increased while the attaching speed was slower and slower and the detaching speed was faster and faster, the contact time taken about minimum time. As a result of these, if the speed after contact become fast, we could know that the surface adhesion between the PDMS stamp and Ag-ink is larger than.

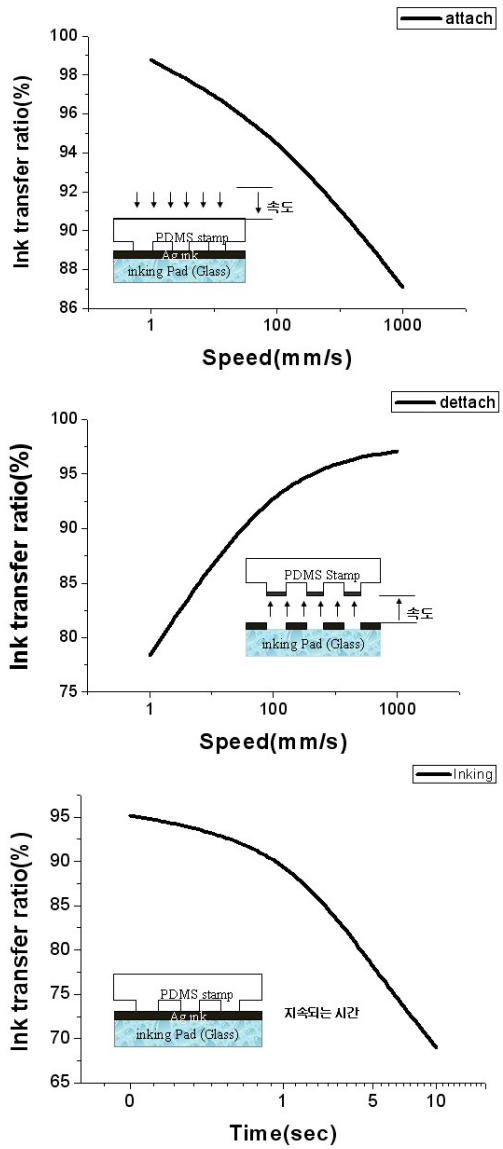

Fig. 3 The ratio of ink transfer for attaching and detaching speed and contact time at inking process

Likewise at the printing processing, it was made an experiment on factors into three classes. In contrast

as the inking process, the ratio of ink transfer was increased when the high attaching speed and the low detaching speed and the long contact time. It is reached a decision because basically the surface adhesion between the PDMS stamp and Ag-ink is larger than the surface adhesion between the substrate and Ag-ink.

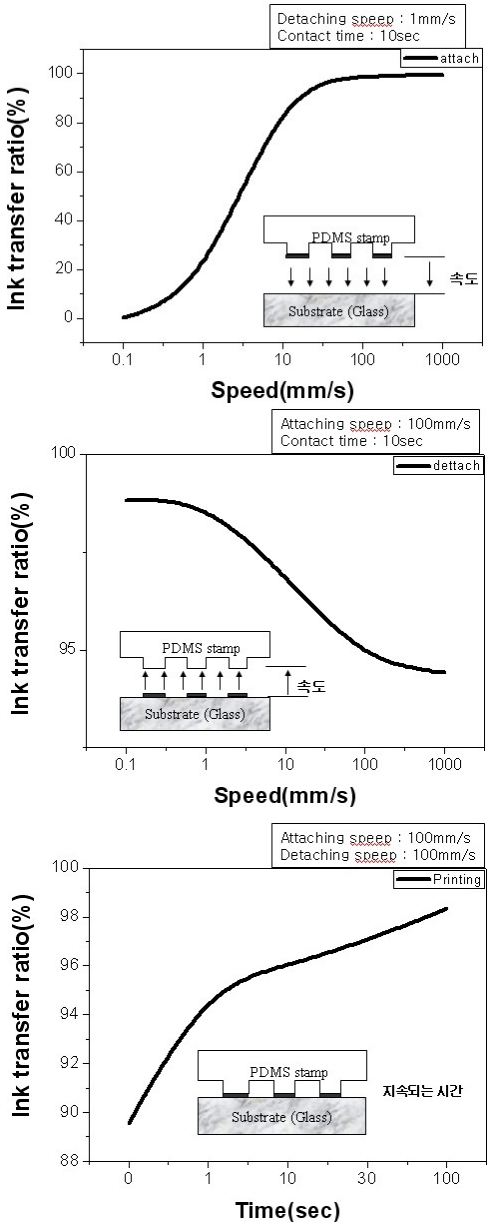

Fig. 4 The ratio of ink transfer for attaching and detaching speed and contact time at printing process

In conclusion, in inking process the attaching speed was preferable to be less than 1 mm/s, attaching time as short as possible and detaching speed larger than 1000 mm/s in order to obtain the transfer ratio of ink larger than 98%. Meanwhile in printing process the parameters were totally opposite to the results of inking process; attaching speed larger than 100 mm/s, attaching time larger than 30 sec, and detaching speed less than 1 mm/s for the best results. With the parameters we could obtain the micro-contact printed electrodes with the minimum line width of 30 ㎛, thickness of 300 ~500 nm, roughness less than 50 nm, and resistivity of about 15~16 μΩ ·㎝.

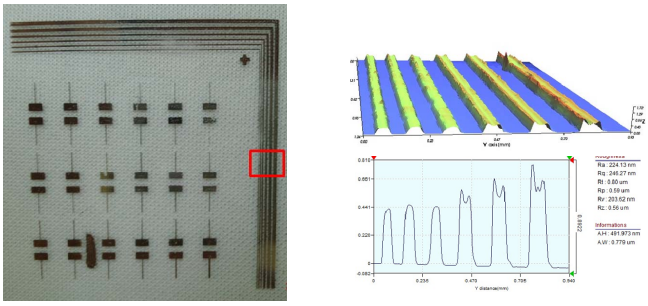

Fig. 5 Printed image and 3D profiler image

Because it is possible for the processing to print needed material where they want likewise the micro contact printing stamps with, it can be made minute patterns with the exceedingly simple processing. Also, because of both it doesn't have to cost expensive vacuum equipment and doesn't have to be through a photolithography processing that used to be a necessity for making at the evaporation of existing, it can make processing simple.

This paper studied to make the electrode of OTFT with Ag-ink using the micro contact printing method. The problems was an adhesion problem between PDMS stamp and Ag ink and which is the bad surface state of a film after printing when printing a electrode directly with the method of micro contact printing. To solve this problems, it has been used with the treatment process including heating treatment and plasma treatment, but it was possible for making the processing more simple because treatment process was removed as using the kinetically parameter of process. Also, it has an advantage to use a substrate material which has a big CTE such as plastic substrate as keeping the processing at the room temperature except curing of ink.

4. Summary

We develop a simple and soluble process by using transfer printing for electrodes of OTFTs report fabrication of electrodes with Ag ink using transfer printing. We removed evaporation, etching and lift-off process for fabrication of electrodes in OTFTs. Also, it has an advantage to use a substrate material which has a big CTE such as plastic substrate as keeping the

processing at room temperature except curing of ink.

Acknowledgement

This research was supported by a grant(F004061) from 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. Xue Feng, "Competing Fracture in Kinetically Controlled Transfer Printing," Langmuir, Vol. 23, no. 25, pp. 12555-12560, 2007
2. Jeongdai Jo, SSDM 2008, pp. 610-611. (2008)
3. Zhe Wang, Advanced Materials, Vol. 15, no. 12, pp. 1009-1012. (2003)
4. Dietmar Knipp, J.Vac. Sci. Technol. B 25, 1321. (2007)
5. Dietmar Knipp, Thin Solid Film. 515, 7679. (2007)
6. Fang-Chung Chen, Microelectronics Engineering. 83, 1333. (2006)