FLEXIBLE CONDUCTIVE PATTERNS FABRICATED WITH SILVER NANOPARTICLES BY INKJET PRINTING METHOD

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Microflow visualization (μ-FV) has been performed to study the silver nanoparticle droplet ejected from a drop-on-demand piezoelectric inkjet printhead and the equilibrium line characteristic of the nano-silver droplet deposition on PI substrates. The unipolar waveform with a frequency of 1000 Hz and an amplitude of 60 V has been adopted for ejecting the silver nanoparticle droplet with a solid content of 30%, surface tension of 30 mN/m and viscosity of 15 cps. The back pressure is modulated to prevent the formation of satellite droplets experimentally. The PI substrate was placed onto a computer-controlled three-axis moving stage capable of a movement accuracy of 30 μm. Therefore multiple prints of the nano-silver conductive lines have also been carried out based on the moving accuracy. The deposited silver nanoparticle conductive lines with the inter-dot spacings from 25 μm to 45 μm with single print to prints quadruple prints have also been investigated. Besides, the O_2 plasma treatment has been applied on the PI substrates with two durations. After the thermal treatment (sinter temperature of 200°C and sinter duration of 1 hour), the optical microscopic images of the deposited silver nanoparticle conductive lines before and after O_2 plasma treatment have been obtained. For the first time, the quadruple prints of the silver nanoparticle conductive lines on the PI films have been investigated to observe the line widths and electrical resistances.

The result of only single print with various inter-dot spacings of the nanosilver droplets was shown at Molecular Crystals and Liquid Crystals 2006 [1]. Besides, the effects of impact inertia and surface characteristics on deposited polymer droplets in microcavities was reported at IEEE J. MEMS 2008 [2] and the characteristics of polymer droplet deposition in fabricated rectangular microcavities was reported at J. Micromech. Microeng. 2009 [3]. An unusual strategy was designed to fabricate conductive patterns with high reproducibility for flexible electronics by drop or fit-to-flow method was reported at Nanoscale Research Letters 2013 [4].

A schematic of nanosilver droplets ejection and deposition on a PI substrate is shown in Figure 1. Figure 2 and figure 3 show the optical microscopic images of the deposited silver nanoparticle conductive lines with the inter-dot spacings from 25 μm to 45 μm for single to quadruple prints respectively. Figure 3 depicts the optical microscopic images of the deposited and sintered silver nanoparticle conductive lines with the inter-dot spacings from 25 μm to 45 μm before and after 2 min O_2 plasma treatment. The resistances of the deposited silver nanoparticle conductive lines with various inter-dot spacings after O2 plasma treatment are shown in Figure 4.

μ-FV has been successfully carried out to study the silver nanoparticle droplets ejected from a piezoelectric ink-jet printhead and the equilibrium film characteristic on PI substratse. The nano-silver conductive lines with quadruple prints on the PI substrate have a line width of 800 μm and a resistance of 1.4 Ω/cm which is also measured on the PI substrate with 2 min O_2 plasma treatment and single print (line width = 680 μm).

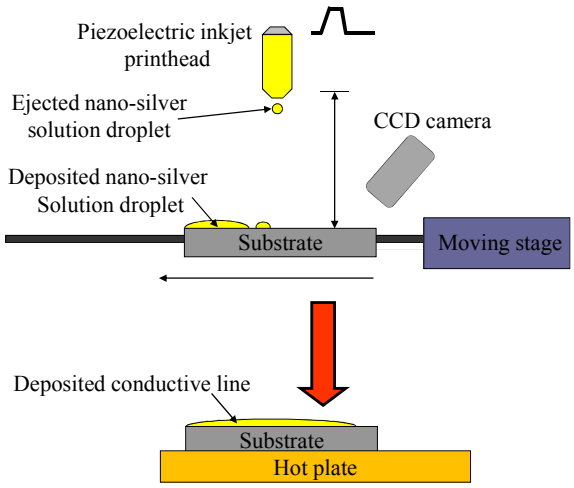

Fig.1 Schematic diagram of droplet ejection and deposition on PI substrates.

Spacing (μm)	Single print	Double prints
25		
30		
35		
40		
45		

Fig. 2 Optical microscopic images of the deposited silver nanoparticle conductive lines with the inter-dot spacings from 25 μm to 45 μm for single and double prints.

Spacing (μm)	Triple prints	Quadruple prints
25		
30		
35		
40		
45		

Fig. 3 Optical microscopic images of the deposited silver nanoparticle conductive lines with the inter-dot spacings from 25 μm to 45 μm for triple and quadruple prints.

Interval (μm)	Single print	
	Before O_2 plasma treatment	After 2 min O_2 plasma treatment
25		
30		
35		
40		
45		

Fig. 4 Optical microscopic images of the deposited and sintered silver nanoparticle conductive lines with the inter-dot spacings from 25 μm to 45 μm before and after 2 min O_2 plasma treatment.

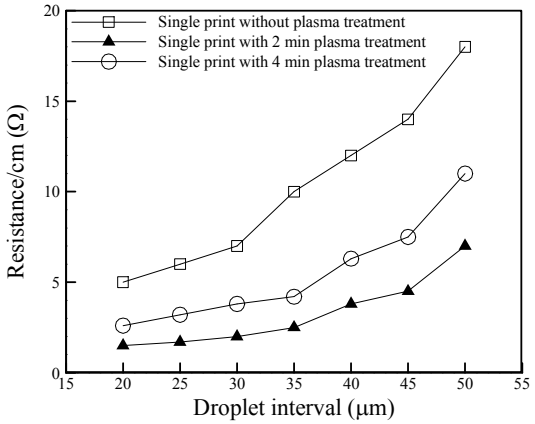

Fig. 5 Resistances of the deposited silver nanoparticle conductive lines with various inter-dot spacings for single to quadruple prints.

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