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Inkjet printed nano-particle Cu process for fabrication of re-distribution layers on silicon wafer

Ayat Soltani[1], Tero Kumpulainen[2], and Matti Mäntysalo[1]
Tampere University of Technology,

Abstract

Lately usage of copper nano-particle inks instead of silver or gold nano-particle inks in the field of printed electronics has gained popularity, the main reason being its good conductivity with respect to its bulk material price. One of the most crucial challenges is the reactive nature of copper nano-particles, which easily forms a non-conductive oxide layer. Laser sintering provides digital high energy-density sintering method, which is fast enough so that the copper oxide layer does not have enough time to form.

Material and samples

-Copper ink CI-002, particle size of ~50 nm and solid content of 25 wt.%
-Silicon wafer with 6 inch diameter, 380 µm thickness and 1 µm oxide layer.
-A DOD iTi XY MDS2.0 printer, Dimatix Spectra SE-128 printhead
-An 808-nm continuous wave semiconductor laser HLU35C10x2-808-CD by Lissotchenko Mikro-optik (Limo) laser output up to 35W, spectral beam width of 2.5 nm and the peak wavelength of 808.6 nm(Figure 1)

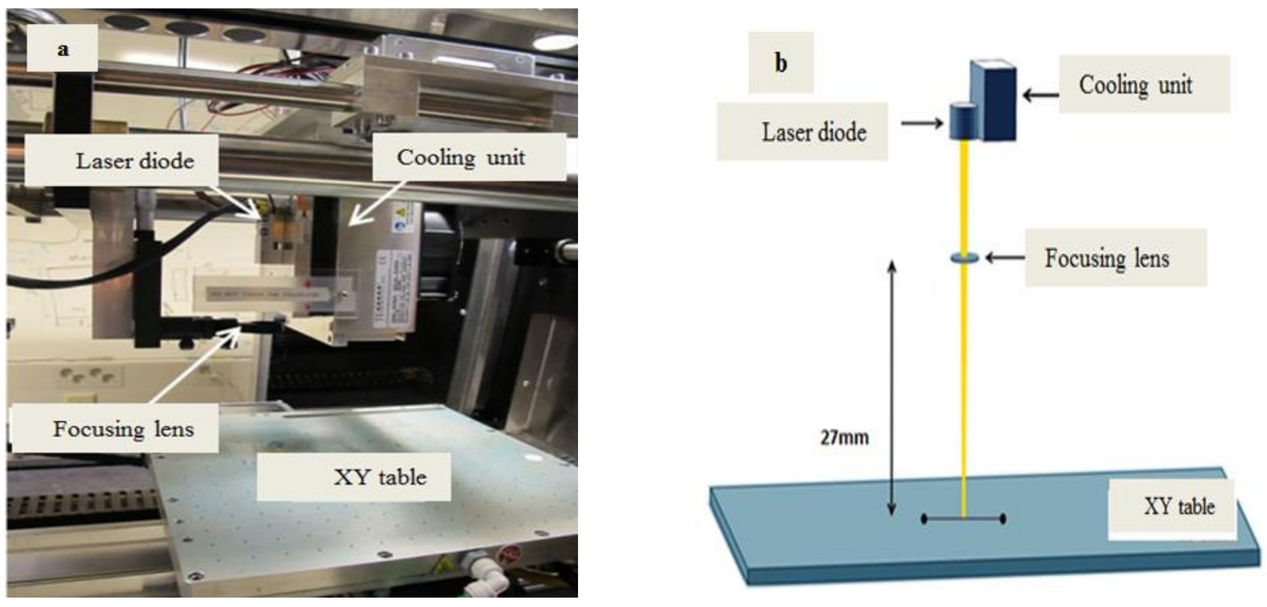

Figure 1. The laser setup

Structural analysis and electrical measurements

No conductivity was achieved with scanning speed from 1mm/s to 4 mm/s and the annealed patterns showed signs of burning (Figure 2). Based on this the velocity was increased from 5 mm/s to 300 mm/s in 20 increments and after each run the resistivity was measured. Figure 3 presents the sheet resistance versus scanning velocity. The sheet resistance shows a distribution between 250 mΩ/□ and 470 mΩ/□ with an increasing trend.

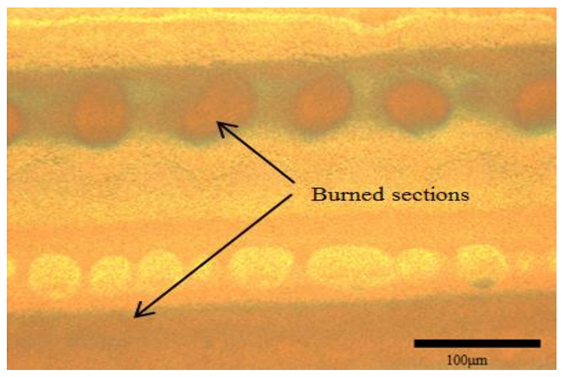

Figure 2. Optical picture demonstrating burn signs

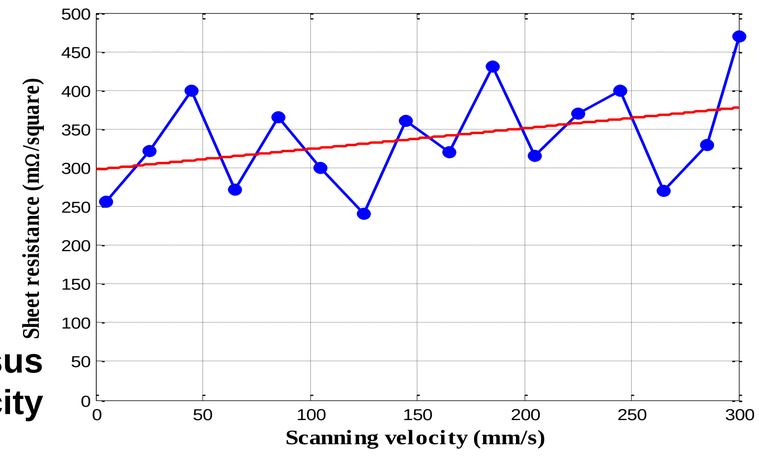

Figure 3. Sheet resistance versus velocity

Results

Optical and SEM pictures before and after sintering are presented in Figure 4 and 5. When compared, it can be seen that the particles are fused together forming the coherent structure while numerous pores available in the non-sintered structure disappear. There are some visible empty spaces, as seen in Figure 5 (c), that have separated sintered particles from each other. This is probably due to the remaining liquids such as dispersants that were stuck in the lower layers of the printed patterns.

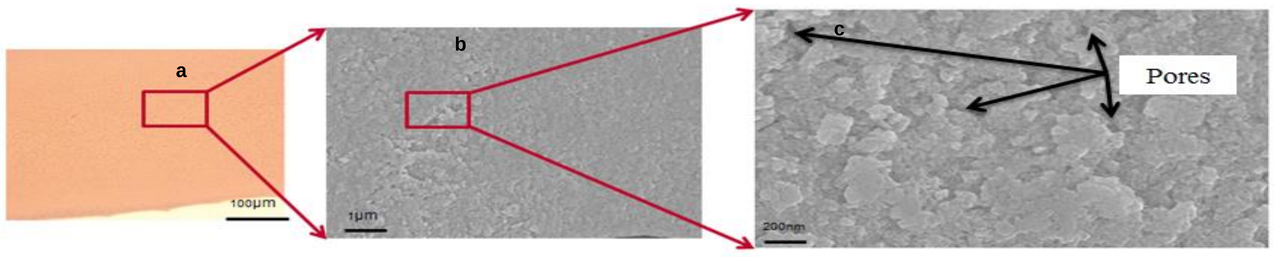

Figure 4. a) Optical picture of the non-sintered specimen, b) and c) Higher magnification SEM picture of the sintered specimen

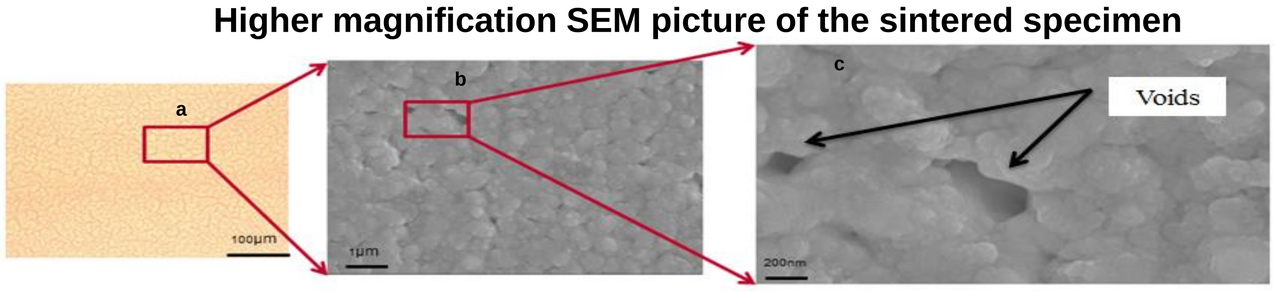

Figure 5. a) Optical picture of the sintered specimen, b) and c) Higher magnification SEM picture of the sintered specimen

[1]*Department of Electronics and Communications Engineering,*
[2] *Mechanical Engineering and Industrial Systems*
Korkeakoulunkatu 3, P.O. BOX 692, FI-33101 Tampere, Finland
ayat.soltani@tut.fi

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