MANUFACTURING OF GOLD MICRO- AND NANOSTRUCTURES WITH NANOINK LASER WRITING

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The present work is introducing a novel method for the manufacturing of electric microresistors and interconnections for semiconductors and other devices. The method combines three technologies: controlled (on demand) printing, low temperature laser curing, and the employment of gold nanoparticles.

Nanoparticles are employed because of their markedly reduced melting point compared to the bulk counterpart. The ultra fine particles in the suspension have a diameter size range of 2 – 5 nm. Due to curvature and surface effects of such small particles, the melting point is markedly lower (~ 400 °C) than that of bulk gold (1063 °C). Suspended in a carrier liquid the nanoparticles are printed with appropriately modified ink jet technology to form electrically conducting line patterns. Microdroplets of 60-100 micrometer diameter are generated and deposited on a moving substrate such that the droplets form continuous lines. Simultaneously to the printing, a laser with a wavelength tailored to the absorption properties of the nanoparticles is focused on the centre of the nanoparticle suspension line in order to evaporate the solvent, melt the metal nanoparticles in the suspension, and sinter the suspended particles to form a continuous, electrically conducting gold microline on the substrate. The produced conducting gold lines have a width of 10 to several hundred micrometers and a thickness between 20 to 200 nm. The dimensions are controlled by parameters of the process.

This method is straightforward, fast and conserving in the use of expensive material by only depositing material at desired places on the substrate whereas the conventional method, lithograpy, applies a metal coating over the entire substrate and removes the undesired layer by chemical etching producing highly toxic waste. The temperature is elevated only locally and in a controlled manner, limiting the built up of thermal stresses.

Atomic force microscopy, scanning electron microscopy, scanning near field optical microscopy and energy-dispersive x-ray analysis has been employed to investigate the topology of the cured line.

In-situ visualization of the curing process has been conducted helping to explain the physics behind the process.

The effect of the laser irradiation power and the curing velocity on the topology and resistivity of the cured lines are investigated.

The phenomena of bump formation in the centre of the manufactured gold conductors, occurring at specific laser power in combination with certain curing velocities, is explained and validated by calculations of temperature profiles inside a substrate induced by a scanning Gaussian laser beam.