Aerosol-jet Printing, an enabling Technology for printing Electrodes, Interconnects, Sensors or Antennas on 2-or 3-D Parts

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Aerosol-jet printing technology uses an additive manufacturing process that prints with high resolution different materials including conductive nanoparticles, dielectric pastes, semiconductor and other functional materials on 2D and 3D substrates. This flexible and cost effective printing technique is ideal to develop and prototype devices for the consumer electronics, sensors, MEMS, medtech and life science industries.

CSEM acquired recently the aerosol-jet printer AJ300 from OPTOMEC. The system consists of an ultrasonic atomizer for materials with a viscosity from 1 to 5 cP and a pneumatic atomizer for materials with a viscosity from 1 to 1000 cP that first create a dense mist of material droplets. The generated aerosol mist is then delivered to the printing head where a sheath gas accelerates, focuses and deposits it on the surface. During travel from the nozzle to the substrate (up to 10 mm) the particle stream remains focused. Therefore linewidth down to 10 microns can be written depending on the nozzle aperture and nature of the printed material. The AJ300 aerosol jet printer has a displacement capacity over 300 × 300 mm with an accuracy ±6 µm and a repeatability of ±1 µm which is compatible with microsystem fabrication.

Several conductive materials like inks based on gold or silver nanoparticles have been be printed on different substrates. After thermal curing the resulting tracks showed good conductivity typically 2 to 3 times the value of bulk materials. Curing temperature is usually ranging from 150°C to 200°C depending on the nature of both the ink and the substrate. On nanoporous paper specifically designed for flexible electronics application, a curing temperature down to 80°C was demonstrated. Thus different features have been printed like connections for flexible photovoltaic cells (Figure 1), electrodes and antennas on plastic rods (Figure 2), or electronic circuits on nanoporous paper (Figure 3).

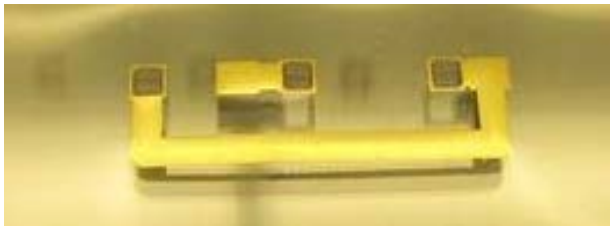

Figure 1: Printed interconnection for flexible PV cell.

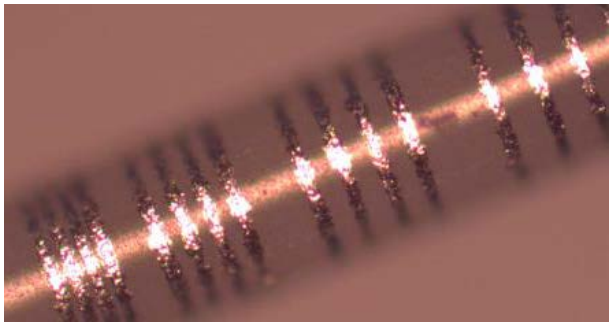

Figure 2: Printed electrodes or antennas on plastic rods.

Thanks to the large working distance (more than 5 mm) it is also possible to write on complex shapes substrates, as an example Figure 4 shows electrodes printed in the cavities of a complex 3D plastic part.

Figure 3: Printed electronic features on nanoporous paper.

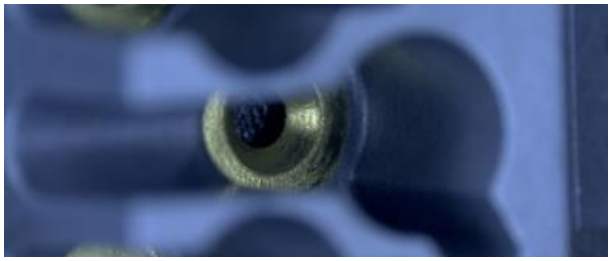

Figure 4: Printed conductive tracks on complex 3D shape plastic part.

In addition to conductive inks, UV curable polymers with a viscosity from 7 to 500 cP could also be printed. Such features allow us to isolate conductive tracks, to deposit tiny amount of glue for high precision assembly and also to fabricate directly in place gasket preventing gas or liquid leakage in microsystem assemblies.

Finally, the displacement table with high accuracy and repeatability combined with the alignment camera could be used to perfectly align printed patterns. Optical apertures can be printed and aligned directly on packaged light source or photodetectors to avoid tedious optical alignment.

Aerosol-jet printing is a versatile system able to print functional materials with different viscosities on structured substrates (plastic, ceramic, or metallic). Interconnections, electrodes, antennas and optical structures were printed to build several industrial prototypes and accelerate the development of microsystems. We should also notice here that this printing technology is scalable to support high-volume production requirements.

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