Spray coating of highly reproducible, conductive and uniform silver nanowire layer over large areas: an industrial perspective

Yilei Shen[1], Marius Adler[1], Karen Forberich[1] and Christoph J. Brabec[1]

[1]Institute for Materials in Electronics and Energy Technology (i-MEET),
Friedrich-Alexander-University Erlangen-Nuremberg, D-91058 Erlangen, Germany

Highly conductive, transparent and flexible solution-processed silver nanowire (AgNW) networks recently have received extensive attentions for the applications in touch panels, E-paper, OPVs and OLEDs as a replacement of the expensive and inherently brittle ITO. However, AgNW layers applied by wet coating processes maintain predetermined orientation induced by the machine direction for most used coating methods, which can cause deviation in optoelectrical properties of AgNW films. To avoid this dependence on direction, spray coating is capable to deposit such networks from the liquid phase in random orientation, which is also easily scalable for industrial fabrication. In addition, spray coating has also the benefit to apply coatings over irregular surfaces, such as finely structured thin film electronic devices.

In this work, an experimental study was systematically carried out for spray coating AgNWs depending on ink formulation (solvents, additives), aspect ratio of nanowires, coating parameters (substrate temperature, spray flow pressure, air atomization pressure, air brush height, etc). Thereby, a master curve for spray-coated AgNWs was investigated in terms of their transparency and conductivity as a function of dry film thickness. Moreover, spray coating generated droplets and containing nanowires were examined regarding their deformation caused by the shear forces of the carrier gas flow and the impact of the receiver substrate.

As results, we can demonstrate a highly reproducible, controllable up-scaled spray coating process for silver nanowire with well-defined standard operating parameters. By optimizing the ink formulation and the coating parameters, a highly conductive, transparent, long term air-stable, large-area and uniform AgNW layer fabricated by a low-temperature process can be obtained.