Optimizing the Conductivity of a New Nano-particle Silver Ink for Aerosol Jet Printing and Demonstrating its use as a Strain Gauge

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Abstract

Aerosol Jet Printing (AJP) shows promise for printable electronics and additive manufacturing as it is capable of printing conformally on nearly any substrate due to its direct write patterning, non-contact printing process, and compatibility with a wide range of printing materials. However, nearly all printed inks require some form of post-processing sintering to achieve acceptable properties, such as electrical conductivity. In this study, a design of experiment (DOE) using Van der Pauw printed pads is presented which can be applied to characterizing any conductive ink. We focus on a new silver nano-particle ink from NovaCentrix (JS-A426) that was developed specifically for aerosol jet printing and study its electrical conductivity under a variety of sintering time and temperature conditions. From these results, a linear regression model is developed that accurately predicts the experimentally measured electrical conductivity of the printed ink. This DOE characterization process and resulting predictive model are especially useful for applications requiring limited thermal budgets, such as flexible electronics. SEM images are also used to analyze how the silver particles coalesce and densify due to thermal diffusion. Finally, the above results are used to design and fabricate an in-situ miniature strain gauge sensor using the NovaCentrix JS-A426 silver nano-particle ink on a thin flexible substrate. After printing and sintering, the miniature custom strain gauge had a nominal resistance of 355 Ω and a gauge factor of 1.74. These values are similar to commercial metal foil strain gauges and demonstrate that the aerosol jet printing is a viable manufacturing process for the production of custom miniature in-situ strain gauges. Advantages of this methodology include quick prototyping, custom digital design, conformal printing on essentially any surface, elimination of any adhesive layer, and manufacturing in less than a minute.

Biography of Presenter

Dilan Ratnayake, PhD, joined the KY Multiscale Manufacturing and Nanointegration Node (MMNIN) in April 2019 and is currently working as a Research Scientist. He has over 12 years of hands-on experience in semiconductor microfabrication and MEMS/Microelectronics devices in a class 100 cleanroom. Prior to joining KY MMNIN, he worked as a Process Engineer at the GW Nanofabrication and Imaging Center. He holds a PhD in Electrical Engineering and an MS in Physics from the University of Louisville.