In Situ Functional Monitoring of Aerosol Jet-Printed Electronics

Interactive Poster Presenter: Roozbeh (Ross) Salary[1], Jack P. Lombardi[1], Darshana L. Weerawarne[2], Prahalad K. Rao[3], and Mark D. Poliks[1, 2, *] - [1]Department of Systems Science and Industrial Engineering,; [2]Center for Advanced Microelectronics Manufacturing, Binghamton University, Binghamton, NY 13902; [3]Department of Mechanical and Materials Engineering, University of Nebraska-Lincoln, Lincoln, NE 68588

E-Mail: rsalary1@binghamton.edu

Abstract

Aerosol jet printing (AJP), a direct-write (DW) additive manufacturing (AM) technique, has emerged as the process of choice for the fabrication of electronics, particularly in critical applications. AJP has paved the way for high-resolution device fabrication (feature size ≤10 μm) with high placement accuracy, edge definition, and adhesion. In addition, AJP accommodates a broad range of ink viscosity (0.7–2500 cP), and allows for printing on non-planer surfaces. Despite the unique advantages and host of strategic applications, AJP is a highly unstable and complex process, prone to gradual drifts in machine behavior and deposited material. Hence, real-time monitoring and control of AJP process seem to be inevitable. The goal of this research work is *in situ* monitoring of the functional properties of aerosol jet-printed electronic devices. In pursuit of this goal, the objectives are: (i) *in situ* image acquisition from the traces of a device right after deposition; (ii) *in situ* image processing and quantification of trace morphology; and (iii) estimation of the device functional properties in a near real-time fashion. In order to address the first objective, our AJP experimental setup was sensor-instrumented, including a high-resolution charge-coupled device (CCD) camera and a variable-magnification lens to support the stranded imaging system already mounted on the AJ printer. Subsequently, following the second objective, a broad range of digital image processing algorithms was devised to quantify 2D and 3D characteristics of trace morphology, such as width, edge quality, overspray, thickness, cross-sectional area, etc. Next, to realize the third objective, a novel multiple-input, single-output (MISO) learning model was forwarded, based on sparse representation for classification (SRC). The aim is to estimate and thus monitor line resistance (a functional property) as a function of process parameters as well as trace morphology features. Finally, a computational fluid dynamics (CFD) model was developed to explain the underlying aerodynamic phenomena behind aerosol transport and deposition in AJP process, as observed experimentally. The outcomes of this research pave the way for physics-based monitoring and control of AJP process, allowing for conformal deposition of electronics with uniform functional properties.