FIELD-ASSISTED AERSOL JET PRINTING FOR ELECTRONICS APPLICATIONS

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Key Words: acoustophoresis, aerosol jet printing, printed electronics, flexible electronics, ink

The additive manufacture of production-grade electronics is of intense academic, industrial, and government interest on account of the ability to rapidly design, prototype, and fabricate electronics without reliance upon traditional electronics fabrication pathways (i.e. cleanroom processing). Of additional interest is the ability to directly integrate electronics on arbitrary, non-planar surfaces, expanding the potential form-factors and application spaces, such as forensic sensors directly integrated on gloves. The suitability of most broadly-explored additive manufacturing technologies (fused deposition modeling, ink-jet printing, screen-printing, stereolithography) is limited by the materials system, print resolution, throughput, or substrate requirements. Aerosol Jet Printing (AJP) offers a maturing additive manufacturing platform for the high-resolution fabrication of printed high-quality electronic circuits, antennas, and sensors on arbitrary substrates, such as complex, non-planar surfaces (e.g., contact lenses). Indeed, AJP enables the rapid fabrication of advanced electronic circuitry, such as mm-wave circuits with high Q factors or solenoid inductors, not possible through other additive manufacturing technologies.

AJP relies upon the controlled deposition of an aerosolized, liquid ink which requires the utilization of specialized material formulations, typically conductive inks of appropriate viscosity and particle fill volume, to adhere to the deposition surface and maintain the prescribed print resolution. Current work centers on obtaining (A) narrower line-width printed circuits, (B) expanded libraries of printable inks, (C) improved control over the rate and volume of deposited material, and (D) improved material properties from printed components in order to expand the utilization and capabilities of AJP. Here, we describe a new type of AJP print-nozzle that integrates recent scientific developments in particle control via acoustic field ('acoustophoretic') focusing for printing high-fidelity, high-resolution print lines. The acoustophoretic focusing relies upon differences in material properties between the ink and surrounding medium (air), rather than the material itself, enabling a "material agnostic" approach that is extensible to a broad array of established and nascent AJP ink chemistries. Acoustic forces offer the possibility to control the width of the printed material by focusing the aerosol jet to a narrower region than would be possible with a physical orifice (Figure 1). As the acoustic focusing effect is dependent on the ink droplet size, the utilization of acoustic focusing provides a means to "refine" the jet (especially if not material rich) such that the deposited material has a smaller line width and exhibits a reduction in the typically observed particle overspray.

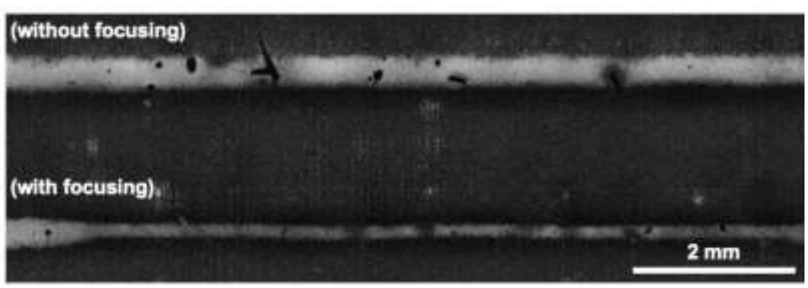

Figure 1: Image of AJP printing without focusing (top line) and with focusing (bottom line). Acoustic field applied and removed during printing to indicate the real-time control over print line. The transition distance is approximately the print-width without focusing.