IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Aerosol Jet Printing: From Fundamentals to Graded Multimaterial Patterning

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Abstract

Printed electronics offers a compelling fabrication platform for flexible and hybrid electronic devices with diverse functionality, spanning applications in advanced sensors, logic circuits, energy conversion and storage, and wireless communication. Among printing technologies, aerosol jet printing provides a digital, non-contact, high-resolution and versatile patterning method for functional materials based on aerodynamically focused deposition of micron-scale liquid droplets. The first component of this presentation will highlight efforts to advance aerosol jet printing technology using a multilevel approach. By combining basic principles of multiphase flow and mass transport with focused experiments, mechanistic insight into aerosol jet printing is established to guide printer design and streamline ink formulation. Building on this foundation, custom 3D-printed components enable experiments to study and enhance process reliability with both passive and active approaches. Finally, an open printing platform based on custom firmware and software provides a promising route to achieve more sophisticated process control going forward. The second component of this talk will explore unique multimaterial printing capabilities based on aerosol jet technology. By exploiting the aerosol nature of ink droplets, in-line mixing of disparate inks with digital control provides a platform for graded, reactive, and combinatorial patterning. Static mixer assemblies are modeled and designed into the printhead, while custom software allows material composition to be programmed into a print file and varied on the fly. This system is demonstrated for gradient thin film patterns of several nanocomposite systems, including optical, electronic, and magnetic materials. Going forward, this nascent technology unlocks a broad design space for functional applications spanning electronics, optics, and energy, among others.

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Biography

Ethan B. Secor is a Harry S. Truman Fellow at Sandia National Laboratories, working in the Advanced Materials Laboratory. He received his Ph.D. in Materials Science and Engineering in 2017 from Northwestern University, where he developed graphene inks for printed electronics with applications spanning flexible circuits, sensors, and energy storage devices. His current research explores the physics of aerosol jet printing to improve printer design, ink formulation, and process development, with a focus on developing digital multimaterial printing capabilities to enable graded, reactive, and combinatorial patterning.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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