In the last decade, additive manufacturing, commonly known as 3D-printing, has enabled numerous new technologies outside the conventional design and manufacturing paradigms including artificial tissues and organs, multi-functional soft robots and wearable devices, and flexible-hybrid electronics. One of the key manufacturing requirements to unlock such technologies is the capability to synergistically integrate different materials in a single product. Among the available AM methods, extrusion-based methods, particularly direct-ink-writing (DIW) emerged as the primary approach to address this need due to its broad material capabilities, ease of use and low cost. In DIW, the material "inks" are continuously extruded out of micro-scale nozzles and deposited along digitally defined paths. Despite its exciting potential, DIW lacks the resolution and precise control over material properties that are required for the broader implementation of the aforementioned technologies. This talk will present the ongoing research in the Manufacturing Processes and Machinery Lab at Washington State University towards addressing the shortcomings of DIW by miniaturizing the process. This research aims to understand the complex rheological and thermofluidic behavior of inks derived from various material systems at micro-scales and develop methods to control this behavior towards achieving high resolution structures with “as-designed” properties.

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