Droplet Microfluidics for Advanced Additive Manufacturing

Semester Project

(Section: Material Science – Microengineering – 3D/4D Printing)

Droplet microfluidics is a cutting-edge technology that encapsulates fluids and materials into micron-scale droplets, which can serve as fundamental units for constructing 3D objects[1]. This enables the assembly of 3D objects voxel by voxel during the printing process. Recent achievements have been made on developing voxelated printheads to produce parts with multi-material compositions[2,3]. However, material combinations with dissimilar properties remain limited in current techniques.

The objective of this project is to develop a novel microfluidic-based additive manufacturing (AM) technique that can deposit polymerizable microdroplets. By utilizing droplet microfluidic chips as printheads, we aim to generate droplets of active and passive resins in controllable sizes. This project will investigate the generation and polymerization of droplets within a compressed gas flow (such as air or Argon) to eliminate the need for a secondary liquid medium. These droplets will be solidified within microfluidic channels using UV light or heat before being ejected. Additionally, we will explore the strategies for ejecting these polymerized beads and accurately depositing them onto a printing bed.

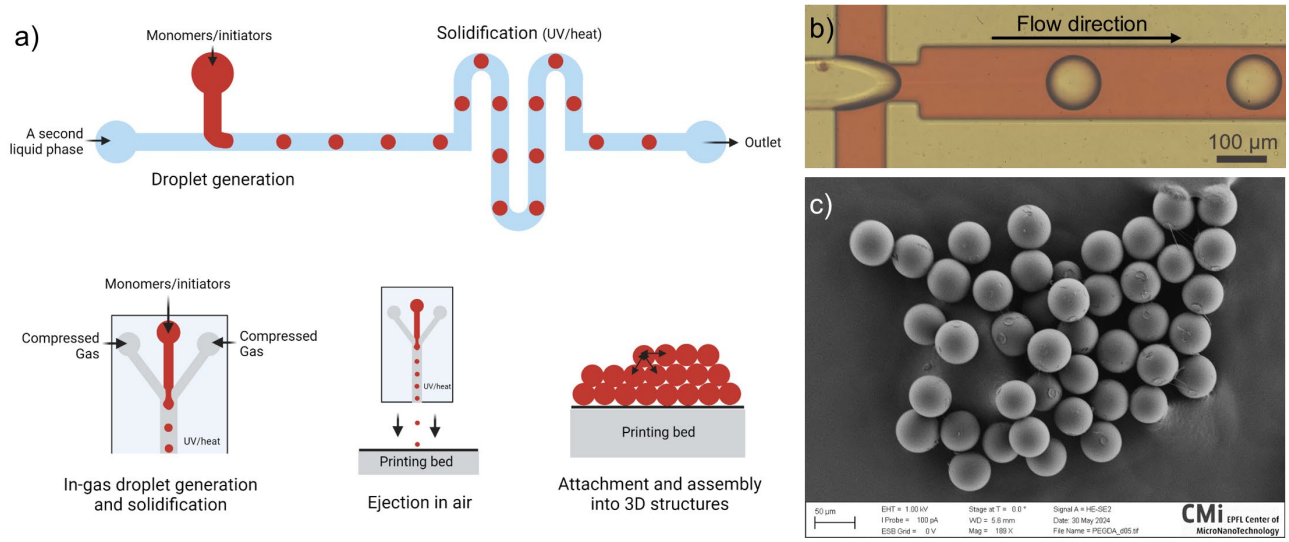

Figure 1: (a) schematic drawing of key steps in this project; (b) an optical image of PEGDA250 (clear) droplet formation in an aqueous phase (red) on a flow-focusing microfluidic chip; (c) an SEM image of PEGDA250 beads which were in-flow polymerized under UV light.

Possible tasks:

a) Characterization of the influence of compressed gas flow rate on droplet size, generation frequency and polymerization.

b) Generation of droplets of viscous resins (viscosity >1 Pa.s) or resins containing nanoparticles via a phase inversion method.

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[1] Zhang, Pengfei, et al. "Printhead on a chip: empowering droplet-based bioprinting with microfluidics." Trends in Biotechnology (2023).
[2] Skylar-Scott, Mark A., et al. "Voxelated soft matter via multimaterial multinozzle 3D printing." Nature 575.7782 (2019): 330-335.
[3] Buchner, Thomas JK, et al. "Vision-controlled jetting for composite systems and robots." Nature 623.7987 (2023): 522-530.

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