Mechanical Engineering Doctoral Defense

3D Printed Gas Dynamic Virtual Nozzles for X-Ray Laser Sample Delivery and Optical Characterization of Microjets and Microdroplets.

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Abstract

Gas Dynamic Virtual Nozzles (GDVN) produce microscopic flow-focused liquid jets and are widely used for sample delivery in serial femtosecond crystallography (SFX) and time-resolved solution scattering. Recently, 2-photon polymerization (2PP) made it possible to produce 3D-printed GDVNs with submicron printing resolution. Comparing with hand-fabricated nozzles, reproducibility and less developing effort and similarity of the performance of different 3D printed nozzles are among the advantages of using 3D printing techniques to develop GDVNs. Submicron printing resolution also makes it possible to easily improve GDVN performance by optimizing the design of nozzles. In this study, 3D printed nozzles were developed to achieve low liquid and gas flow rates, and high liquid jet velocities. A double-pulsed nanosecond laser imaging system was used to perform Particle Tracking Velocimetry (PTV) in order to determine jet velocities and assess jet stability/reproducibility. The testing results of pure water jets focused with Helium sheath gas showed that some designs can easily achieve stable liquid jets with velocities of more than 80 m/s, with pure water flowing at 3 microliters/min, and helium sheath gas flowing at less than 5 mg/min respectively. We also introduced a numerical simulation pipeline to characterize the performance of different 3D printed GDVNs. Our findings highlight the potential of making reproducible GDVN's with minimum fabrication effort, that can meet requirements of present and future SFX and time-resolved solution scattering research.

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Zoom Link: https://asu.zoom.us/j/84037734361