Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

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3D-Printed Low-Flow Gas Dynamic Virtual Nozzles

Invention Description

X-ray free electron lasers (XFEL) provide intense x-rays flashes which can be used by researchers to study many macromolecular structures and dynamics. XFELs are one of the most promising sources for performing advanced analyses in structural biology. Despite all of the new innovations in XFEL science, its destructive nature necessitates fast sample replenishment between pulses, usually accomplished with a liquid jet. Gas Dynamic Virtual Nozzles (GDVNs) are able to produce such a liquid jet and are widely used for injecting a stream of protein solution or nanocrystals into an XFEL. However, the production of GDVNs is often performed by hand or injection molding, making reproducibility difficult and custom or specialized designs nearly impossible.

Researchers at Arizona State University have developed novel GDVNs and fabrication methods using 3D printing technologies. These methods create highly reproducible GDVNs that can generate liquid microjets with greater stability and a broader range of liquid flow rates and jet speeds. Flow rates of 0.35 ul/min and jet diameters of submicron diameter have been reproducibly achieved. The GDVNs are straightforward and easy to manufacture and assemble, enabling a variety of complicated or custom geometries for different fluid requirements to be printed.

Easy and reproducible fabrication of custom or specialized GDVNs opens up even greater opportunities for investigations of molecular structures and dynamics.

Potential Applications

- Delivery of biological samples to an XFEL
  - Investigating molecular structures and dynamics
- Food industry
- Pharmaceutical industry
  - Drug delivery, biomedicine, etc.
- Mass spectroscopy (e.g. to replace electrospray)

Benefits and Advantages

- Highly reproducible dimensions – accuracy on the sub-micron scale
- Different and complicated geometries can be printed to adjust to changing requirements such as different liquid properties, chemical composition and so on
- Produces highly monodispersed droplets
  - The size distribution has a standard deviation of roughly 5% of the mean value
- Capable of producing liquid jets with very small liquid flow rates (<2ul/min)
- Improved stability and reduced jet jitter
- Faster scale production
  - Several nozzles can be printed in parallel for increased production
  - Printing takes as little as a few minutes for simple designs to a few hours for more complicated designs
- Allows nozzles to be printed in an array, connected to liquid and gas lines and mounted in the experimental chamber for fast switching if one gets clogged

Faculty Profile of Professor Richard Kirian

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