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Intermittent Operation of a Gas Dynamic Virtual Nozzle (GDVN)

Background

Fabrication and analysis for materials often take place in high vacuum (HV) or ultra-high vacuum (UHV) conditions. These environments are necessary for reactive samples or cases where ambient atmosphere can detrimentally affect the deposition/probe beam (e.g., x-ray, electrons, ions). Liquid samples, including biological species immersed in aqueous solution, can be compatible with HV or even UHV conditions provided that the sample is a liquid droplet of sufficiently small size, usually microscopic. With the advent of the gas dynamic virtual nozzle (GDVN), a free liquid jet can be compressed in diameter through a co-flowing gas; because there is no liquid interfacing with a physical nozzle, clogging is a nonissue. However, a normally operating GDVN delivers often precious samples in a continuous steam, regardless of the frequency of performed measurements. Therefore, a GDVN system whose emissions can be synchronized with the repetition rate of probing pulses can achieve the same measurement quality but with far lower sample consumption.

Invention Description

Researchers at Arizona State University have developed an intermittent GDVN system for sample delivery into vacuum. The time between liquid stream emissions (i.e., "off time") have been demonstrated to range from a few tens of microseconds to over 10 milliseconds, while the "on-time" of the stream never exceeds a few tens of microseconds. These attributes are ideally suited for intermittent delivery of sample-containing liquid streams at the repetition rate of the SLAC Linac Coherent Light Source (LCLS), 120 Hz or 8.33 milliseconds between pulses. In this configuration, LCLS measurements would be indistinguishable from those of a continuous-flow GDVN, but would require a dramatically lower flow rate: 200 nanoliter/min compared to a typical 10-20 microliter/min.

This invention is able to operate in both vacuum and ambient air, and can also be immediately switched from intermittent to continuous flow at any time. Unlike drop-on-demand (DoD) injectors, intermittent and continuous-flow GDVNs do not require heating of the nozzle for reopening, making them advantageous for delicate biological testing.

This technology is covered by U.S. Pat. No. 9,839,922.

Potential Applications

- Beam testing of liquid biological samples
- Microfluidics

Benefits and Advantages

- Resource-Preserving – Reduces sample consumption by 2 orders of magnitude
- Adjustable – Stream on and off times can be modified through adjustments of nozzle geometry, nozzle gas pressure, and liquid sample pressure
- Adaptive – Operation is suited for SLAC LCLS system specifications
- Versatile – Can be switched to continuous-flow mode in either vacuum or ambient air conditions