Multifluid Sheets

D.P. DePonte[1*] J.D. Koralek[1] , Rita Graceffa[2]

[1]SLAC National Accelerator Laboratory, USA

[2]European XFEL GmbH, Germany

INTRODUCTION

Devices that can generate thin liquid sheets have been previously demonstrated as either converging channels, colliding jets, or gas accelerated liquids. In this work, we have combined fluids in the device immediately prior to ejection from the device for the purpose of reducing flow rate and/or mixing.

EXPERIMENTAL

Two prototype devices were produced by Micronit Microfluidics BV. The first consists of three channels converging at the edge of a glass chip. By flowing liquid in the outer two channels, a sheet can be formed by the well-known colliding jet method. The central channel allows for an additional fluid to be added to the sheet. The second device has an additional hydrodynamic focusing stage just upstream. Either device can use gas in the outermost channels to form a liquid sheet by gas-dynamic forces acting on the fluid leaving the central channel.

The sheets generated by gas dynamic forces were tested using fluorescent dye in the central channel, water in the hydrodynamic focusing channels and helium in the outermost, gas-dynamic, focusing channels. The sheets generated from three liquid colliding jets was observed by back illumination in an optical microscope. A spectral reflectometer from Filmetrics was used for thickness measurements.

RESULTS

Two colliding ethanol jets produced a sheet 1800micrometers long by 850 micrometers wide and 1.5 micrometerss thick at its center. Adding flow through the central channel made a noticeable change to the center of the sheet. The thickness was not measured but the change was clearly visible as a flow rate dependent, cone-shaped structure, in the sheet center shown in the figure.

Two gas accelerated devices were tested, one that was mirror symmetric about the centerline and the other was made with the liquid channel intentionally slightly off center. In both cases, a sheet "chain", a series of orthogonal sheets of alternating orientation, was generated with water at 200 microliters per minute. The fluorescent dye in the center channel went through the dripping-jetting transition at 3 microliter per minute. Do to the very small thickness of the sheet, dye could not be observed in the flat region of the sheet but only in the thick rims at the sheet edges. In the off-center nozzle, the dye was visible in only one of the two outer rims of each sheet in the chain whereas in the symmetric nozzle, dye was visible in both rims implying distribution throughout the sheet.

This material is based upon work supported by the U.S. Department of Energy,
Office of Science, under Contract No. DE-AC02-76SF00515.

CONCLUSION

Using three rather than the usual two colliding jets to produce a sheet resulted in a sheet with varying central thickness. Addition of a hydrodynamically focused liquid just upstream of a liquid sheet generated by gas dynamic forces distributed the focused fluid through the central part of the sheet. These two devices demonstrate that by hydrodynamic focusing, fluids can be added to sheet structures.

ACKNOWLEDGEMENTS

This research used the resources of SLAC National Accelerator Laboratory, supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Contract No. DE-AC02-76SF00515.

CONTACT

* Corresponding author: deponte@SLAC.Stanford.edu