SLAC NATIONAL ACCELERATOR LABORATORY

Interferometry of Microfluidic Sheet Jets

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Introduction

Interferometry can be used to determine the relative thickness of a sheet jet. This can be referenced with reflectometry measurements to get an absolute thickness measure over an entire sheet.
Sheet Jets are produced when the flow exiting the nozzle converges in one dimension, this causes the flow to fan out 90 degrees offset from the plane of convergence in a teardrop shaped sheet where most of the volume is contained on the edges of the jet creating a thin film in the center (fig 1.)

Interferometry is only really useful to find relative changes in thickness, but we are able to use reflectometry to find a absolute reference. DJ Hoffman created a chart of these absolute thicknesses (fig 2.)

I worked with Christina Hampton and Dan DePonte to characterize a few sheet jet nozzles using interferometry. The major characteristics we looked at were sheet thickness, irregularities in the sheet and flow rate independence.

Flow rate independence is a characteristic in ideal sheet jets where the thickness of the sheet as a function of distance from the nozzle is constant when flow rate is varied. The sheet just changes in length. In the real world this is not always the case. If the edge of the chip isn't a sharp 90°, flow can curl around the edge and cause irregularities in the jet as well as cancel the flow rate independence property.

After learning how to set up interferometry and characterize nozzles, I set out to make improvements to the cost and effectiveness of our interferometry setup using additive manufacture.

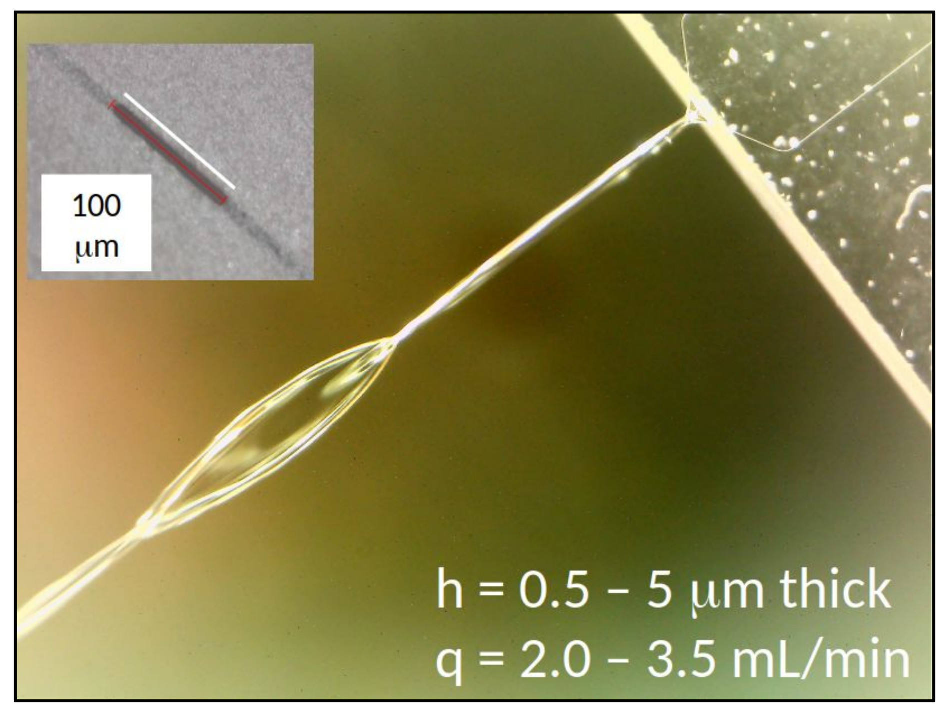

Figure 1 - Sheet Jet Nozzle

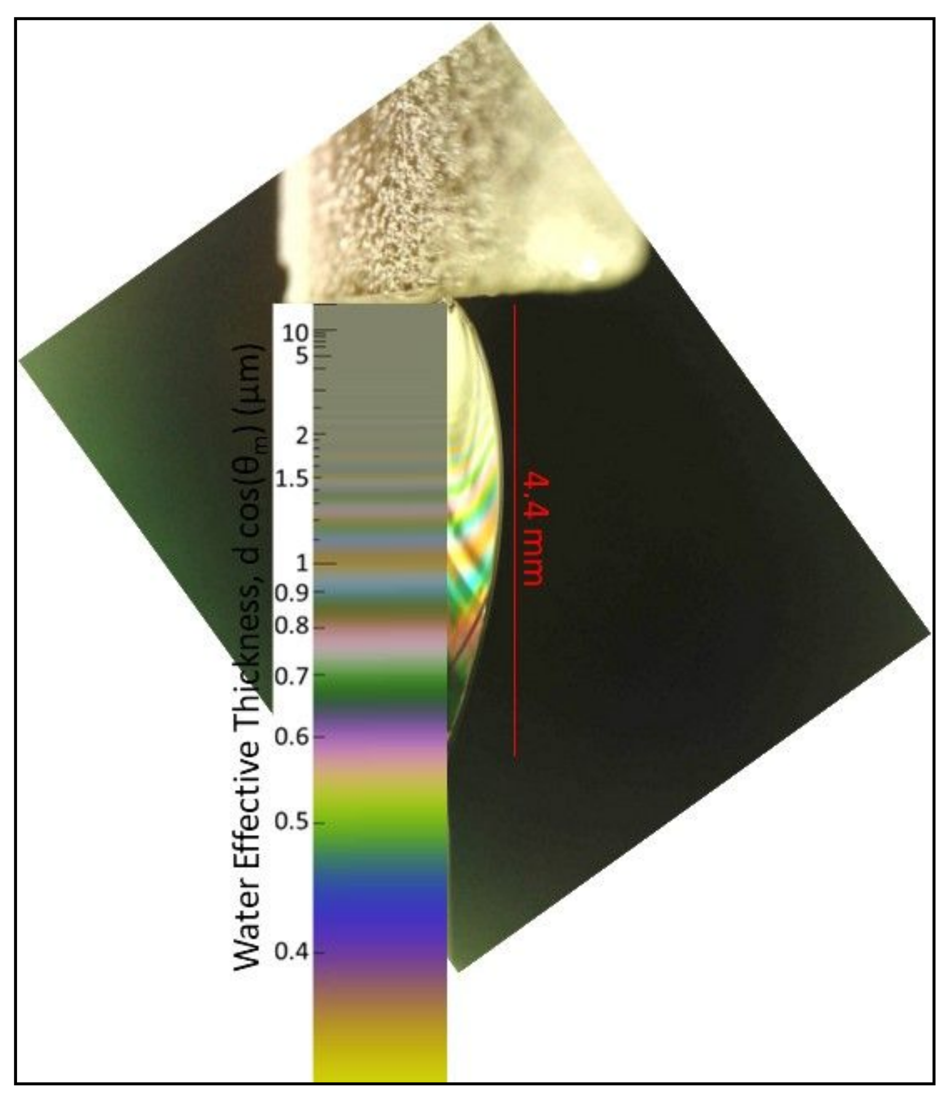

Figure 2 - Interferometry Absolute Thickness

My first project was a catcher for DJ Hoffman's Interferometry setup. The goal was to catch the flow coming out of the nozzle and place it in a beaker off to the side of the motion stage the nozzle was mounted on, with the stretch goal of compatibility with vinyl tube for recirculation.

Minimizing misting from the high velocity jet impacting my catcher mechanism was a major difficulty. We tested a variety of funnel angles before I decided to have the jet plunge into a capillary, dissipating its energy in the resulting pool (fig 3.)

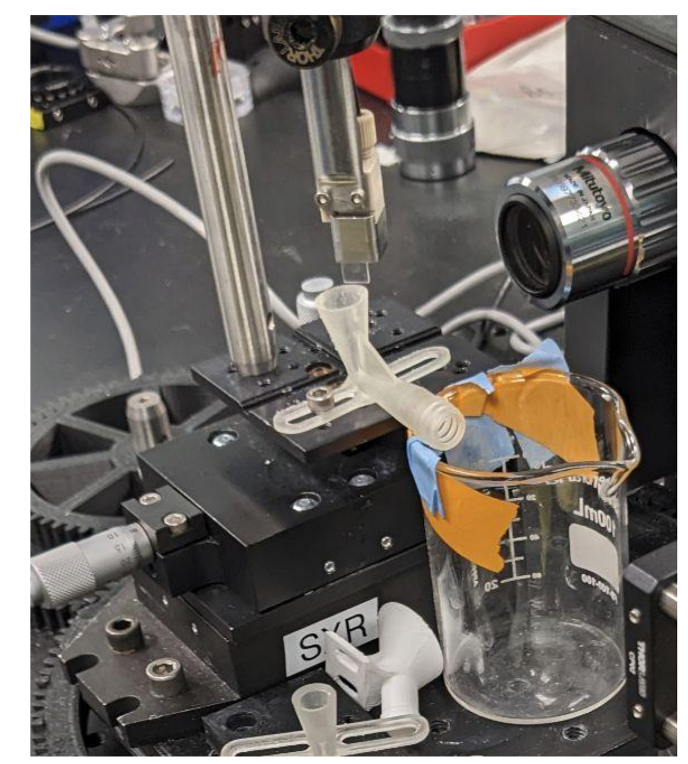

Figure 3 - Jet Catcher

Another project was to manufacture the chip interfaces on the resin 3D printer. The conventionally manufactured parts take over $120 of machine time, meaning they can only really be consumables during operations. The hope is by 3D printing them they can also function as consumable parts in testing.

The difficulty in this project came from cleaning resin out of the narrow capillaries in this part. The formlabs wash system performed poorly, but I found using a sonicator performed far better (I cannot confirm if this was due to cleaner solvent or better performance). After a few tweaks to the design to include threads and clean up the fluid path, I managed to make working interfaces that required minimal post processing.

I also made a few small improvements to DJ Hoffman's Interferometry setup, such as a cover for the optics to minimize the effect of ambient light.

My other projects included repairing the Chico state Cooler-Shaker. This included revising much of the motor control code, as well as rewiring the internals.

Following with my experience from the Cooler-Shaker, I aided another intern, Andrew Smith, in configuring a menu system on Arduino for his capillary grinder.

I also did a handful of small 3D design projects for various people around Sample Environment and Delivery, such as a vial holder for Sandra Mous's Tensiometer, and an Airtag mount for the ICL HPLC Pumps.

Conclusions

Over the course of my internship I used additive manufacture to reduce cost of development for the Sample Environment and Delivery team. I made small improvements to various test setups, and developed my programming skills.
I used my time at this internship to develop skills I already practiced at home, such as Additive Manufacture and Programming, as well as expand those skills into new areas, such as Resin printing and Object Oriented Programming.

Acknowledgments

Thank you to Christina Hampton for teaching me Interferometry, DJ Hoffman for your Interferometry instrument, Dan Deponte for the Sheet Jet chips, and Bob Sublett for mentoring and teaching Object Oriented Programming.