Designing and Laser Cutting Microfluidic Chips for Affordable Lipid Nanoparticle Synthesis

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Grand Challenges Initiative

Introduction

Grand Challenge

Microfluidic chips typically range from $200-$600. By designing and laser cutting microfluidic chips, it allows for a more affordable and accessible resource for scientists within the field. Project success is estimated to decrease costs of microfluidic chips by 99%.

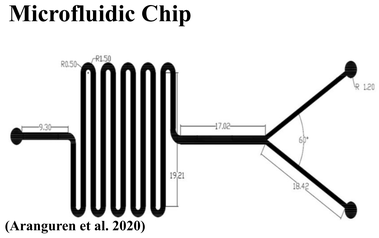
Nanoparticles (1-500 nm)

Ability to bypass a variety of biological membranes

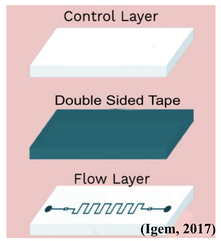
Lipid nanoparticles (LNPs) are versatile in applications:

- Not toxic, biocompatible and biodegradable (Duan et al. 2020)
- Easy, large scale production and characterization
- Progress in the area of DNA/RNA and drug delivery via LNPs

Microfluidic Chip



(Aranguren et al. 2020)



(Igem, 2017)

Figure 1- Microfluidic Chip Template and Structure

Left figure depicts the template used to laser cut the microfluidic chip. The Right figure illustrates the three layers that form the structure of a complete microfluidic chip.

Knowledge Gaps:

- Lack of microfluidic chip templates
- Effects of laser speed and power on microfluidic chip production
- Effects of laser cutting pattern on nanoparticle clumping and synthesis

Methods: Laser Cutting

1. Image traced figure of a microfluidic chip design[1]
2. Experimented with and optimized different laser intensities (power, speed) to get desired channel depth; verified through Scanning Electron Microscope (SEM) images
3. Cut two inlets on microfluidic chip for the lipid/ethanol and saline solution
4. Fit the double-sided tape layer to seal channels (Figure 4)

Materials

- Double Sided Tape
- Cast Acrylic (0.125")
- Laser Cutting Machine

Abstract

Nanoparticles are important tools in medical research because of their capabilities to deliver drugs and genetic material. Microfluidic chips are used in nanoparticle synthesis to ensure uniformity. However, there is a knowledge gap regarding cost-effective ways to create them. Through laser-cutting, we created customizable and cost-effective microfluidics chips. The template created can be used for accessible lipid nanoparticle synthesis.

Microfluidic Chip Imaging

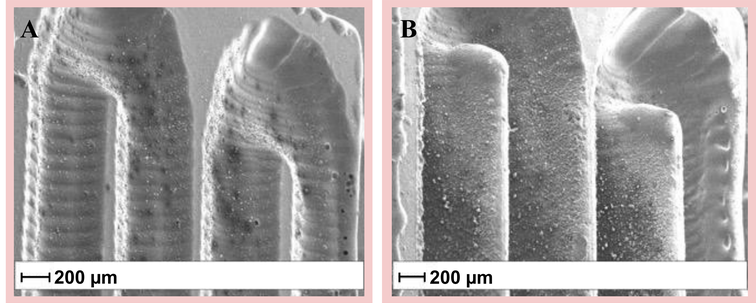


Figure 2- Microfluidic chip imaging under SEM- Altering Power Settings

For samples 1 (A) and 3 (B), the speed setting was kept constant at 20%, while power was altered. In sample 1, power was at 40% and channel depth was 406.1 µm. In sample 3, power was at 80% and channel depth was 627.3 µm.

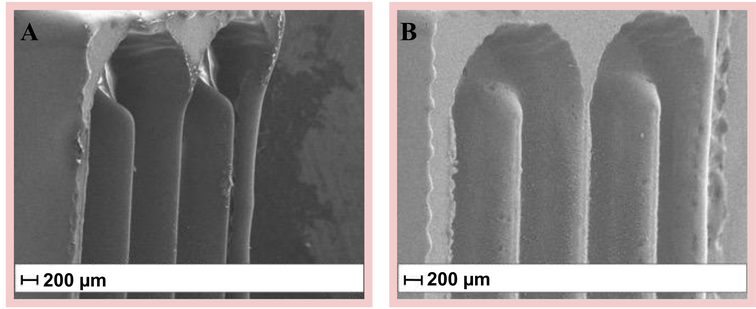


Figure 3- Microfluidic chip structure under SEM- Altering Speed Settings

For samples 4 (A) and 6 (B), the power setting was kept constant at 50%, while speed was altered. In sample 4, speed was 30% and channel depth was 1002 µm. In sample 6, speed was 70% and channel depth was 616.2 µm.

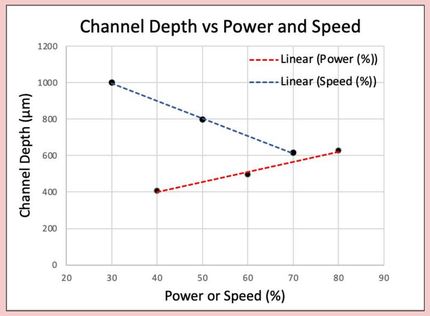
Future Impacts

- Template to be uploaded to website forums to help with the accessibility of creating microfluidics chips
- Can be applied in nanotechnology research to create more cost-effective and efficient ways for drug delivery
- Using custom microfluidic chips can yield better control over nanoparticle size, shape, and clumping

Conclusions and Findings

1. Microfluidic chips for nanoparticle synthesis can be created at a low cost of $2 per chip through laser-cutting and double-sided tape binding.
2. Varying the power and duration of laser exposure on acrylic, a 99% reduced-cost microfluidic chip can be made.
3. Laser power is directly proportional to channel depth
4. Laser speed is inversely proportional to channel depth
5. Too high of power or too low of speed resulted in burning and disfiguring of laser cut microfluidic chips.

Sample #	Power (%)	Speed (%)	Channel Depth (µm)
1	40	20	406.1
2	60	20	495.7
3	80	20	627.3
4	50	30	1002
5	50	50	796.7
6	50	70	616.2



Power: y = 5.53x + 177.9 | R^2 = 0.9881

Speed: y = -9.645x + 1287.2 | R^2 = 0.9986

Figure 4 - Adjustments of laser setting and effect on channel depth.

Samples 1-3 illustrate the effects of laser power on channel depth. The effect of laser cutting speed is shown in samples 4-6.

Acknowledgements

We thank Dr. Molla Islam for his continued support of our group and for providing his expertise and lab space. Additionally, Professor Miyuki helped us use the laser cutters located in the Design/Create/Innovate Lab. We also thank our advisors, Dr. Kelsey Gray and Dean Andrew Lyon for their guidance.

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