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Hands-on Teaching Module: Fabrication of Cost-Effective Microfluidic Chips

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Hands-on Teaching Module: Fabrication of Cost-Effective Microfluidic Chips

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BACKGROUND

Microfluidics techniques have a multi- and interdisciplinary nature, which offers exciting potentials for enhanced education-al activities. It is an ideal tool to enthuse, educate, and train minorities and under-represented students about the inter-disciplinary aspects of modern engineering, chemistry, and biomedical sciences. Exposing students to microfluidics will help prepare the next generation of engineers who will use this technology to solve challenges in healthcare, biology, and the industry (Fig. 1).

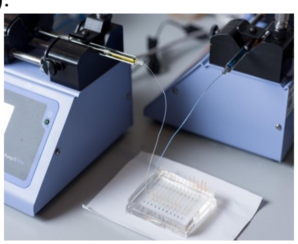

Figure 1. A typical microfluidic chip connected to two syringe pumps.

INTRODUCTION

Conventional microfluidic devices are made of polydimethylsiloxane (PDMS), which is a silicone elastomer can be used as a support frame which provides biocompatibility and optical transparency [1]. PDMS has similar flexibility to that of blood veins and it allows for smooth surface and cell attachment [1].

METHODS

This hands-on activity introduces students to a simple fabrication approach, and it deals with the selection of materials, geometries, assembly strategy, and science. An efficient method of creating PDMS molds is introduced by cutting acrylic sheets using laser ablation. Commercial Poly-methyl methacrylate (PMMA) sheets are used in the manufacturing process of the PDMS molds and the stand for mounting the tubing/connections. All PMMA sheets are cut using a laser laser-cutter using dxf files taken from SolidWork files of designed parts. The PMMA sheets are bounded together using high-strength cement while the PDMS chip encasements. Then, we use a 10:1 ratio of PDMS precursor and curing agent. The mixture is placed in a vacuum to remove any bubbles. The mixture is poured into the acrylic mold (Fig. 2) where they undergo the same vacuum process to remove air bubbles.

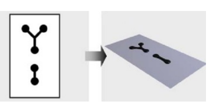

Figure 2. A simple Y-shape mold (left) and pouring the prepared PDMS precursors (right)

The PDMS is cured in an oven overnight (60-80°C) and then gently separated from the mold. The final step is to assemble the chip with a fluid pump and PVC tubing to direct flow. A more complex model is introduced to show blood flow to students here (Fig. 3).

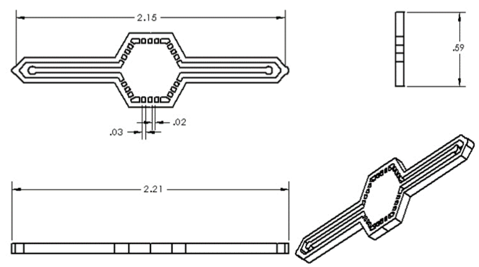

Figure 3. Drawing of the selected Hex structure (~ 0.75 mm inner channels).

RESULTS

The range of useful properties such as high strength and melting point and ease of manufacturing make acrylic sheets an ideal tool. The encasements are used to cure liquid PDMS at high temperatures into chips. The transparency of acrylic also allows for high-resolution images and videos during particle perfusion. An imaging component is suggested such as students' cell phones for demonstrating the dynamic flow and maybe blood flow (Fig. 4).

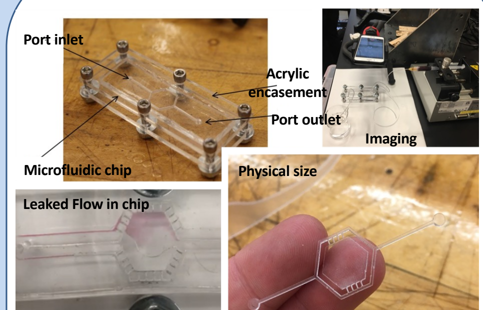

Figure 4. Microfluidic Device Layout, along with the experimental setup. Acrylic Hex structure (eight ~ 0.5 mm permeability channels) is also shown.

CONCLUSIONS

Our models aims to take steps towards the education of microfluidic-based modules that can be used to study blood flow and drug transportation. By manufacturing several designs, we are able to incorporate the complicated vasculature within the PDMS chip and gain an accurate model of fluid flow. Using blockage within the channels also mimicked the behavior or blood flow seen in cases of various diseases.

REFERENCES

[1] Friend, James, and Leslie Yeo. "Fabrication of microfluidic devices using polydimethylsiloxane." Biomicrofluidics vol. 4,2 026502. 15 Mar. 2010.

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