# Engineering Customized Electrical-Cellular Interfaces for Microphysiological Systems

Jennifer Gipson, jengip03@gmail.com
Laboratory for Living Systems Engineering
Alexander Hamilton Senior High School, Class of 2021
USC Viterbi Department of Biomedical Engineering, SHINE 2019

## Introduction

Each year in the United States, 1 in 4 deaths are due to cardiovascular disease- the leading cause of death in both men and women (Center for Disease Control and Prevention). In order to reduce these numbers, there is an increased need for more effective drugs and drug testing. Different technologies have been developed for aiding this process, such as the "heart-on-a-chip" system. This platform allows for the development of cardiac tissues *in vitro* for further pharmacological study in targeted drug testing. The chip mimics the function and structural makeup of the heart through stimulation by external electrodes. Although the electrodes are effective, other methods of stimulation, like indium tin oxide (ITO), have the potential to make analysis and testing easier and more customizable.

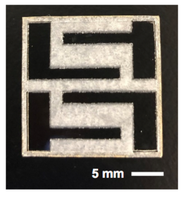
## STEM Coursework and Next Steps

- Having the opportunity to spend 7 weeks in a biomedical engineering research lab has allowed me to connect my schoolwork to real-world applications.
- Being able to see how topics I study in class are applied to new technologies has made complex topics easier to understand, such as the function of live tissue and how to maintain it.
- After my time in lab, I plan on continuing to explore topics related to biomedical engineering like the application of stem cells in drug discovery and disease modeling.

## Methods

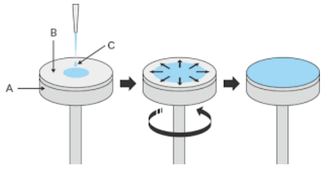
Laser Engraving

- Tape was placed on top of coverslips where the laser engraver would then cut out specific patterns.
- Once the tape was removed, areas of glass where the electrodes were wanted were left uncovered.
- ITO was then deposited onto the coverslip.
- When the tape was peeled, a pattern of the ITO remained.



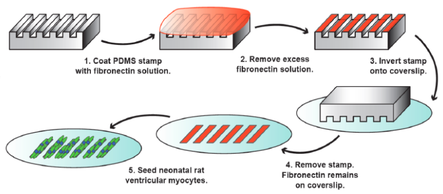

Spin-Coating

- With the spin-coating machine, poly *N*-isopropylacrylamide (PIPAAm) and polydimethylsiloxane (PDMS) were layered on the ITO coated coverslip.
- Muscular thin films (MTFs) were then cut out of the PIPAAm and PDMS using the laser engraver for analysis of the cardiac tissues.



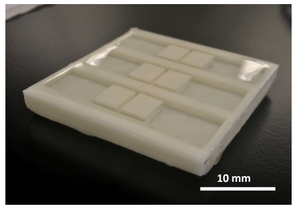

Microcontact Printing

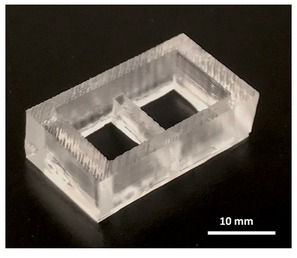
- Extracellular matrix proteins, which cells easily adhere to, were coated onto elastic stamps patterned with rows.
- After drying, these stamps were inverted onto samples, which aided in tissue alignment.




3D-Printing

- With the 3D-printer, a plastic mold was created for the PDMS well used in the chip.
- The mold was then filled with PDMS, put into the vacuum desiccator to remove air bubbles, and baked in an oven to harden/set.

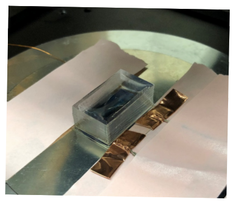


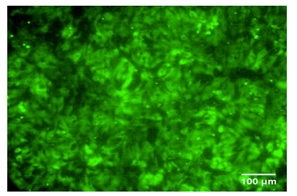



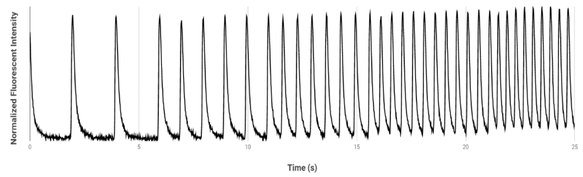

## Results

Calcium Imaging:

- Allows for imaging of the cells and their ability to beat when stimulated at different frequencies.

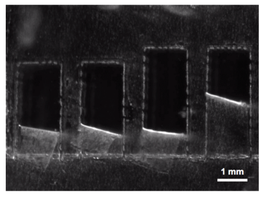


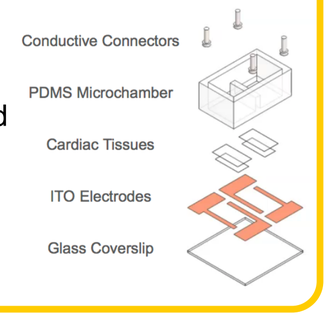



Muscular Thin Films (MTFs):

- Incorporates the "full set up" for the chip
  - ITO pattered coverslip
  - spin-coated PIPAAm
  - spin-coated PDMS
  - printed proteins
  - seeded cardiac tissue
- Successfully demonstrated that the use of ITO stimulated the cells which can be seen in the MTFs (rectangles).




## Acknowledgements

This summer experience would not have been possible without Joycelyn Yip, Dr. Megan McCain, Dr. Katie Mills, Dr. Megan Herrold, the SHINE team, everyone in the Laboratory for Living Systems Engineering, and the SHINE 2019 cohort.