A Novel Microchannel-Scaffold Electrode Array for Peripheral Nerve Interfacing

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Statement of Purpose:

Nerve injuries and amputation can result in severe loss of function, pain, and a reduction in quality of life of an individual. Neural interfacing technologies attempt to remedy this by electrically interfacing with the damaged nerve to achieve some functional outcome whether it is stimulation, recording, or conduction blocking to name a few. Current technologies fall short in terms of efficacy and reliability of the electrode implant as a result of tissue damage induced at the tissue-implant interface.

The *objective* of this project is to engineer a polydimethylsiloxane (PDMS) based regenerative microchannel scaffold with integrated microelectrodes for reliable, high-throughput peripheral nerve interfacing. This microchannel-scaffold electrode array will be functionally evaluated through the stimulation of and single unit recordings from regenerated axons in a rat sciatic nerve model. Our *central hypothesis* is that by forcing regenerating axons to grow through microchannels with integrated microelectrodes (Figure 1A and 1B), the intimate and isolated contact will facilitate a more selective recording and stimulation. The scope of this abstract hinges on our first-stage development efforts of the PDMS-based regenerative microchannel scaffold, while in the second stage, microelectrodes will be integrated into the scaffold. *In vitro* studies were performed to validate dorsal root ganglia (DRG) neurite extension through the microchannels.

Methods:

To fabricate the microchannel-scaffold, a PDMS base layer was first formed, in which a microelectrode array would be fabricated[3] if electrodes were to be incorporated into the scaffold (Figure 1A and 1B); SU-8 microchannel walls were then patterned on the PDMS surface; lastly, a PDMS cover layer was bonded onto top of the SU-8 walls to form closed microchannels (Figure 1A). Microchannel wall width and height were 20um and 100µm respectively; microchannel widths ranged from 50 to 150 µm; and channel lengths ranged from 1 to 5 mm. In the final configuration, the scaffold was rolled on itself forming the final implant with a total radius of 1.5mm (Figure 1C).

In *in vitro* studies, open versions of the PDMS-SU-8 scaffolds (lacking the top layer) were coated with Poly-D-Lysine and then Laminin. DRG's were explanted from P1 rat pups and cultured on coated open scaffolds.

Results:

Figure 1D shows a fabricated PDMS-based scaffold with SU-8 microchannel walls prior to rolling up: an entrance view. In this prototype, the top and bottom PDMS layers were both 70 µm thick and the microchannel width was 50 µm.

DRG's were cultured for 1 week on open scaffolds. The sample was stained for axons (red) and cell nuclei (blue) (Figure 2A and 2B). Robust growth and proliferation of axons and Schwann cells extending through the microchannels was observed.

Figure 1: Microchannel Schematic and Image

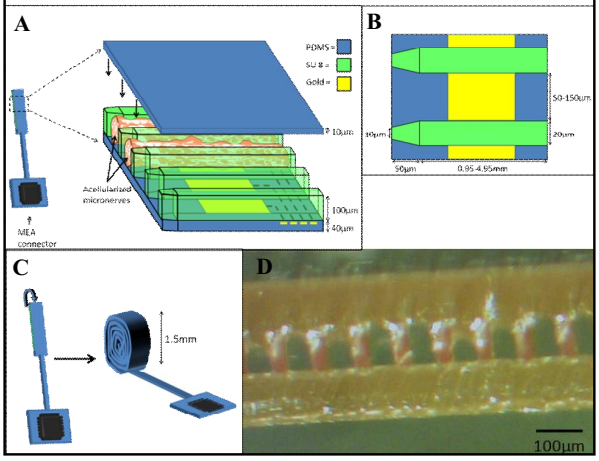
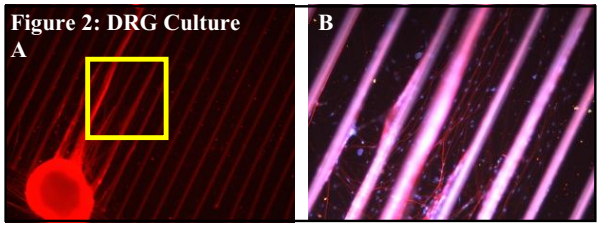


Figure 2: DRG Culture



Conclusions:

In conclusion, we have fabricated a PDMS-based microchannel scaffold and verified its capability of guiding DRG neurite outgrowth along the microchannels. This microchannel scaffold design provides an efficient way to guide regenerating axons and can be used as a novel platform to incorporate electronics for recording and stimulation specifically from small groups of axons. By integrating a microelectrode in each microchannel to form a high-throughput electrode array, such a microchannel-scaffold electrode array has potential to significantly enhance the efficacy and reliability of peripheral nerve interfacing.

References:

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3. Guo, L et al., *IEEE Biomedical Circuits and Systems Conference*, 2010.

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