High-Throughput Microchannel Arrays for Peripheral Nerve Interfacing

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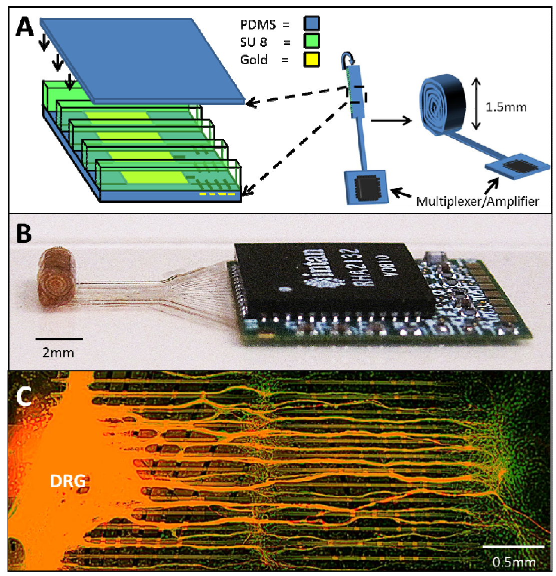
Loss of normal function due to amputation profoundly impacts the quality of life of the 1.7 million amputees in the US. This is an unmet clinical need because current prosthetics do not replace the full functionality of the natural limb. Next generation ‘neural prosthetics’ aim to interface with the original limb’s remaining nervous system and utilize ‘neural interfaces’ to provide the communication pathway. The *objective* of this project is to engineer a thin-film polydimethylsiloxane (PDMS) based regenerative microchannel construct with incorporated microelectrodes for the purpose of reliable, high-throughput peripheral nerve interfacing. Our *central hypothesis* is that forcing axons from an amputated nerve to regenerate through microchannels (Figure A) will provide intimate and isolated contact with integrated electrodes and facilitate more selective recording and stimulation.[1] This abstract describes the microfabrication process we have developed for the microchannel interfaces and validation of cytocompatibility through dorsal root ganglia (DRG) cultures.



The microchannel interface was fabricated by first patterning 32 gold electrodes on a 40 μm base PDMS layer using photolithography and lift-off techniques. This was insulated with a 10 μm PDMS layer by defining protective photoresist posts on the electrodes and bonding pads, adding the PDMS insulation, and then stripping the posts. Next, SU-8 microchannel walls 20 μm in width, 100 μm in height, and 3.3 mm in length were adhered using standard photolithography techniques.[2] Finally, a 10 μm PDMS capping layer was bonded. At this point a signal amplification and multiplexing chip was attached using conductive epoxy and the microchannel layer rolled forming a conduit. This is shown in Figure B where the integrated electrodes have an average impedance of 63 ± 19 k . To validate cytocompatibility, DRG’s from P0 rat pups were harvested and cultured on unrolled devices for two weeks. Samples were stained for axons (red) and Schwann cells (green). An overlaid image of both cell types is shown in Figure C. The DRG was placed to the left of the microchannels resulting in robust growth of axons and Schwann cells through the microchannels. Orange regions correspond to areas of high axon and Schwann cell density. In this experiment, the top PDMS layer was excluded to prevent growth over the microchannels.

In conclusion, by integrating microelectrodes into microchannel scaffolding that link to a multiplexing/amplification chip for recording, high-throughput microchannel arrays have been successfully fabricated. Cytocompatibility of the microchannel substrate has also been confirmed by supporting and spatially directing multicellular growth of axons and Schwann cells. Future work involves implanting these high-throughput microchannel interfaces in the rat sciatic nerve animal model to assess chronic peripheral nerve recording efficacy looking towards neural prosthetic control.

References

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[2] A. Srinivasan, L. Guo, and R. V. Bellamkonda, "Regenerative microchannel electrode array for peripheral nerve interfacing," Neural Engineering (NER), 2011 5th International IEEE/EMBS Conference on, pp. 253-256, 2011

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