

Parylene-C based mesh electrodes for recording neural signals in sciatic nerve

ByungWook Park, Hyunmin Moon and Sohee Kim

Abstract— In this work, we fabricated an ultra-flexible mesh-structured electrodes array using parylene-C, and conducted *in vivo* experiments to record neuronal signals from peripheral nerves using the developed electrodes. The developed mesh electrodes successfully recorded evoked afferent action potentials.

I. INTRODUCTION

Several intraneural interfaces for peripheral nerve applications have been developed previously. However, these electrodes induced strong immune responses [1], which caused the loss of electromyography (ENG) recording ability at the neural interface. Recently, a SU-8-based thin mesh structure with minimal bending stiffness has been introduced to reduce such immune responses. In this study, we developed a parylene-C-based ultra-flexible mesh electrodes array, because parylene-C is approved as a UPS class IV material and has a superior waterproof ability, better than SU-8 [2]. To verify the feasibility of the developed mesh electrodes for the use in peripheral nerves, *in vivo* recordings were performed.

II. METHODS

Fig. 1 shows the fabricated parylene-C based mesh electrodes, with a thickness of 6 μm . The widths of the parylene-C mesh and the metal line were 20 μm and 10 μm , respectively. The diameter of electrodes' active sites, made of Cr (30 nm) / Au (100 nm), was 30 μm . New Zealand white rabbits weighing more than 5 kg were used *in vivo* experiments.

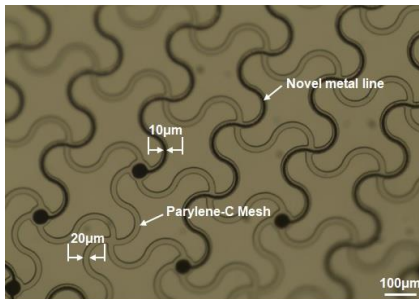


Figure 1. Fabricated Parylene-C based mesh electrodes.

After exposing the sciatic nerve, the surgical site was filled with soybean oil, which acted as a lubricant. The nerve was incised with a custom knife made of 80 μm thick stainless steel. After inserting the electrodes together with a carrier made of PDMS (180 μm) / parylene-C (5 μm) into the nerve, the mesh electrodes were lifted slightly from the carrier using tweezers. Then, soybean oil flowed into the gap between the

* Research supported by the Basic Science Research Program (No. NRF-2020R1A2C2008833) of the National Research Foundation (NRF) of Korea and the DGIST R&D Program (20-RT-01) funded by the Ministry of Science and ICT (MSIT) of Korea.

Byung Wook Park, Hyunmin Moon, and Sohee Kim are with the Department of Robotics Engineering, Daegu Gyeongbuk Institute of Science and Technology (DGIST) Daegu, Republic of Korea (e-mail: soheekim@dgist.ac.kr).

PDMS and mesh electrodes, and detached them from each other. The ground electrode was placed between the skin and muscle while the reference electrode was placed next to the developed electrodes, in the distal direction of the nerve. ENG was recorded using the developed electrodes, which were connected to a data acquisition system (CerePlex direct, BlackRock Microsystems).

III. RESULTS

As shown in Fig. 2(a), the electrodes were placed in the tibial fascicle of the sciatic nerve. Fig. 2(b) shows the positions of channels 2 and 3 where ENG was detected upon stimulation at the animal's skin. ENG signals were processed through a bandpass filter with a bandwidth of 250-5000 Hz, as shown in Fig. 2(c). Compound action potentials were detected by channel 2, and action potentials from a single axon were detected by channel 3, as shown in Fig. 2(d). The average peak to peak amplitude was about 700 μV and the duration was 2 m.

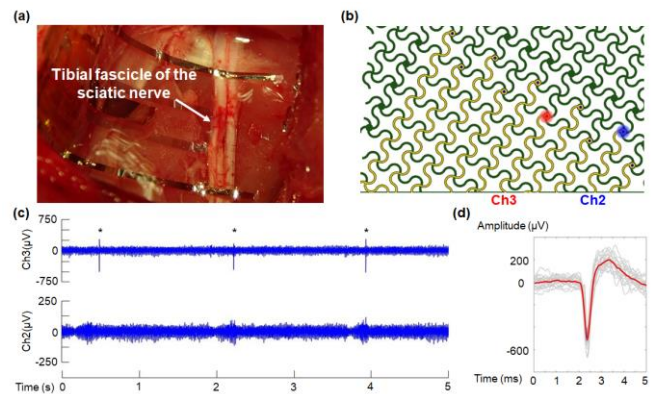


Figure 2. (a) Electrodes implanted in the tibial fascicle of the sciatic nerve. (b) Schematic of the mesh electrodes. The blue and red points represent channels 2 and 3, respectively. (c) Recorded sensory nerve signals according to stimuli, indicated by *. (d) Superimposed action potentials recorded from channel 3.

IV. CONCLUSION

The recording ability of the fabricated parylene-C based mesh electrodes was evaluated through *in vivo* experiments. Although neural signals were not detected in all channels, we verified the ability to detect ENG by the developed mesh electrodes implanted in the peripheral nerve. For further studies, we plan to perform chronic *in vivo* experiments.

REFERENCES

- [1] S. Wurth et al., "Long-term usability and bio-integration of polyimide-based intraneural stimulating electrodes.", *Biomaterials*, vol 122, pp. 114-129, 2017
- [2] J. H. Lee et al., "Soft implantable microelectrodes for future medicine: prosthetics, neural signal recording and neuromodulation.", *Lab on a Chip*. Vol 16, pp. 959-976 (2016)