2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

In-vitro evaluation of 3D subretinal microelectrodes with hexagonal arrangement

Hee Won Seo[1], Seongkwang Cha[2], Yurim Jeong[2], Yong Sook Goo[2], and Sohee Kim[1]

***Abstract*— A retinal prosthetic device is one of the biomedical devices that help patients with visual impairment. Various electrodes have been developed and some of them have even been applied in clinical tests to partially restore the patient's vision. In this study, we investigated the feasibility of the previously developed 3D subretinal microelectrodes in evoking retinal responses in an *in-vitro* environment.**

I. Introduction

Retinal prosthetic devices are used to help patients with visual impairment such as retinal degenerative diseases. To support patients with such diseases, various retinal prosthetic devices, which can replace the role of the lost photoreceptors, have been developed. Especially, to achieve high visual acuity including spatial resolution, a large number of electrodes must be arranged within a limited size of the device. Previously, we developed a 3D microelectrode array with hexagonal arrangement based on a transparent base [1]. In this study, we investigated the feasibility of the developed hexagonally arranged microelectrodes in evoking retinal responses of retinal ganglion cells (RGCs) *in-vitro*.

II. Methods

Based on previous studies [1, 2], we fabricated the 3D microelectrodes with hexagonal arrangement (Fig. 1). The electrodes were coated with iridium oxide. The fabricated 3D microelectrodes were connected with a custom-designed polyimide cable (PI) and a flexible printed circuit board (FPCB) for *in-vitro* evaluation, as shown in Fig. 1.

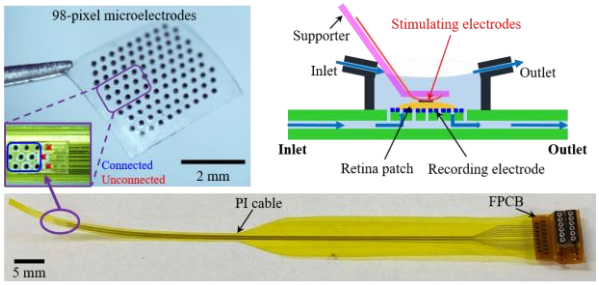

Figure 1. (Top) Fabricated 3D microelectrodes and *in-vitro* experimental set-up. (Bottom) Microelectrodes integrated with the PI cable and FPCB.

* Research supported by the Bio & Medical Technology Development Program of the National Research Foundation funded by the Korean government (No. NRF-2017M3A9E2056463, NRF-2017M3A9E2056460).

[1]Hee Won Seo, 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). [2]Seongkwang Cha, Yurim Jeong, and Yong Sook Goo are with the Department of Physiology, Chungbuk National University School of Medicine, Cheongju, Republic of Korea (e-mail: ysgoo@chungbuk.ac.kr).

Fig. 1(top-right) shows the schematic illustration of the *in-vitro* experimental setup including a multi-electrode array (MEA) for recording of RGC responses and the fabricated microelectrodes for subretinal stimulation. Eyes of a wild-type (C57BL/6J strain) mouse at postnatal 10 weeks were used, and 9 electrodes were put on the retinal patch. For stimulation, cathodic phase-first biphasic symmetric pulses with 1 Hz were used, and current amplitudes were applied from 10 to 50 μA. The return electrode was positioned far from the retinal patch.

III. Results

Fig. 2 shows peri-event raster diagrams and RGC responses as increasing the current amplitude with a fixed pulse duration of 1 ms. RGC responses were elicited through one of the 9 electrodes. As the current amplitude increased, more RGC spikes were evoked in a larger area of the retina patch. Using the fabricated 3D electrodes, we demonstrated that it was possible to subretinally stimulate RGCs.

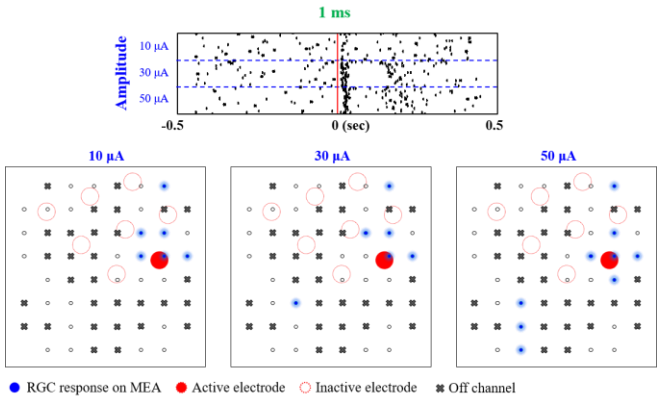

Figure 2. Representative elicited RGC responses by current stimulus from an electrode.

IV. Conclusion

The feasibility of the developed 3D electrodes in RGC stimulation was demonstrated through the *in-vitro* test. For further studies, we plan to perform experiments to selectively stimulate RGCs using close return electrodes.

References

[1] H. W. Seo, N. Kim, and S. Kim, "Fabrication of subretinal 3D microelectrodes with hexagonal arrangement," *Micromachines*, vol. 11, no. 5, pp. 19–24, 2020.

[2] H. W. Seo et al., "A 3D flexible microelectrode array for subretinal stimulation," *J. Neural Eng.*, vol. 16, no. 5, p. 056016, 2019.