Effect of Light Emission on Recording Electrodes of Opto-Neural Probe with Upconversion Nanoparticles

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1. Introduction

Optical stimulation has been widely used in neuroscience, especially in optogenetics, to induce both inhibition and excitation effects on neurons. Recently, upconversion nanoparticles (UCNP) have attracted much attention as a suitable material for optical stimulation in optogenetics. Typical UCNP consists of ytterbium and erbium and can emit visible light when irradiated by near-infrared (NIR) light. In our previous work, we developed a wireless opto-neural probe with UCNP light emitter [1,2]. Then, we fabricated an opto-neural probe with a UCNP light emitter and neural recording microelectrodes to realize simultaneously optical stimulation and electrical recording, as shown in Figure 1 [3]. This study evaluated the effect of the light emission from UCNP on Au electrodes through the electrochemical analysis.

2. Fabrication of the opto-neural probe with UCNP

Figure 2 shows the process flow of the opto-neural probe with UCNP light emitter and recording microelectrodes. First, the 3-μm-thick SiO_2 layer was deposited on a 2-inch Si wafer as a sacrificial layer. Then, the light emitter was formed with green-light-emission UCNPs, which were dispersed into SU-8. The light emitter is a 1-mm length, 170-μm width, and 70-μm thick. Next, another SU-8 layer was formed over the light emitter, and the probe shape was formed. The shank length was 10 mm. Then, Ti/Au/Ti (50 nm/500 nm/50 nm) wirings were formed on the probes. SU-8 passivation was coated over the samples, and electrode holes were formed with lithography. Finally, the opto-neural probe was released from the Si wafer.

3. Electrochemical measurements and discussion

We measured the cyclic voltammetry (CV) characteristics of the Au electrodes formed on the opto-neural probe in the PBS solution. Figure 3 shows the measured CV characteristics with different scan rates of 10 mV/s, 50 mV/s, and 100 mV/s. The sweep voltage was from -0.1 V to 0.8 V. We observed an electric-double-layer-induced current increase with an increase of the scan rate. These CV results were consistent with the typical measurement values for Au electrode. Also, we observed little influence due to NIR irradiation on the CV characteristics because the reaction at the Au electrodes in PBS solution was capacitive. Here, the power and wavelength of NIR were 300 mW and 980 nm.

4. Conclusions

We conducted further evaluations about the recording microelectrodes on the opto-neural probe with UCNP light emitter. The CV characteristics indicated that light emission from UCNP does not affect the neural signal recording.

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References

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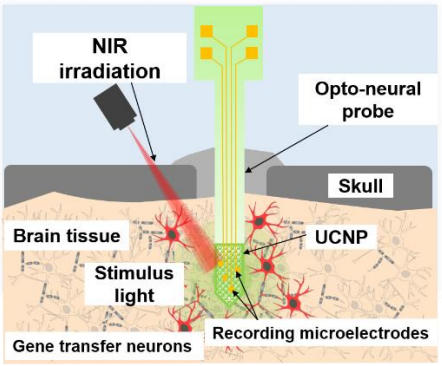

Fig. 1. Schematic drawing of the opto-neural probe with UCNP and recording electrodes.

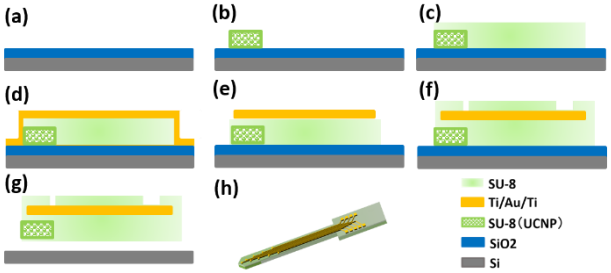

Fig. 2. Process flow of the opto-neural probe with UCNP and recording microelectrodes.

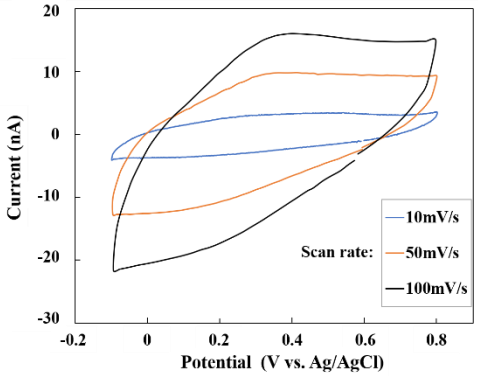

Fig. 3. Cyclic voltammetry characteristics of the recording microelectrode formed on the opto-neural probe with UCNP light emitter.