Electrochemical characterization of nanotube coatings on silicon-based microelectrodes

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INTRODUCTION
Through precise electrical stimulation, microelectrodes can treat injuries and disorders such as spinal cord injuries and Parkinson’s disease, and through neural recording, microelectrodes can be used as powerful tools to help us learn more about neurological functions. However, when inserted into the body for long periods of time, microelectrode failures can occur partially due to the foreign body response. As previously published, rosette nanotubes (RNTs) are synthetic molecules with a lysine side chain and a double ring mimicking DNA G^C bases. They are of interest for their biological properties, eliciting fewer negative responses from the body than other materials. This project seeks to apply a version of these nanotubes, Janus Base Nanotubes (JBNTs), to the surfaces of microelectrodes without negatively impacting the electrochemical properties of the microelectrode itself in neural recording and stimulation in vivo.

METHODS
Initial tests of JBNTs on microelectrodes have been conducted. The microelectrodes (Figure 2) have silicon shanks 2.5 mm long, gold/platinum/titanium traces, plasma-enhanced chemical vapor deposition (PECVD) silicon nitride and silicon dioxide insulation, and sputtered iridium oxide film (SIROF) electrode sites with areas 2000-4000 µm². The microelectrodes were subjected to coatings of JBNTs and the nanotube distribution along the electrode surfaces were examined using SEM and AFM. The electrochemical properties of the electrodes before and after nanotube coating were analyzed.

RESULTS
The JBNTs were shown to aggregate on the surfaces of the electrode sites, forming bundles near the edges (Figure 3). Cyclic Voltammetry (CV) (Figure 4), Electrochemical Impedance Spectroscopy (EIS) (Figure 5), and charge injection tests showed largely unchanged electrochemical characteristics after coating. Impedance at 1kHz on a sample electrode site before coating was 84.5 kΩ, and after coating was 74 kΩ. Charge Storage Capacity (CSC) on a sample electrode site before coating was 4.97 mC/cm² and after coating was 4.61 mC/cm².

CONCLUSION
The mostly unaltered electrochemical properties of the JBNT-coated microelectrodes combined with the promising biocompatibility aspects of the coating make for an exciting novel application of Janus Base Nanotubes.

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