Carbon Nanotube Based Electrodes for Neuroprosthetic Applications

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Foster-Miller, Inc., in conjunction with InnerSea Technology, NanoTechLabs and Dr. Lois Robblee, has demonstrated a simple, low cost process for the fabrication of high capacitance, low impedance, and high surface area carbon nanotube (CNT) electrodes for use as implantable microelectrodes. Implantable microelectrodes for electrical stimulation of neurons and recording neuronal responses are essential tools for neurophysiologists studying the behavior of neurons in the brain, spinal cord and peripheral nerve. Critical properties of an electrode interface should include: low noise, low impedance, biocompatibility, electrical stability during chronic use, and high charge capacity. Iridium oxide has all of these properties and thus has been utilized for significant developments in the neural prostheses area. However, these electrodes have several shortcomings, including: high material cost, labor-intensive processing, and deterioration of long term stability. The results of electrochemical testing of the CNT electrodes show high capacitance and low impedance. Preliminary testing indicates that the CNT felt electrodes have advantages over state of the art iridium oxide electrodes in that their highest charge capacity is distributed within the cathodic portion of the water window, exactly where iridium oxide charge capacity is lowest. When the integration of the cathodic part of a CV is done in the potential window from 0.3 V (open circuit) to -0.7 V, at which the electrode will be used, we obtain a value of 38 mC-cm-2. Similar integration for an iridium oxide electrode gives a value of 15 mC cm-2. The high charge capacity of the CNT felt electrode over the cathodic potential range below 0.0 V is advantageous for electrical stimulation with cathodal current pulses. This is a feature lacking in Iridium oxide electrodes for which most of the charge capacity is accessed over anodic potentials above 0.0 V. In order for Iridium oxide electrodes to utilize their charge capacity during cathodal pulses, it is necessary to apply an anodic bias to the stimulation electrode between stimulus pulses. This leads to increased complexity of stimulation circuitry and the possibility of the intermittent occurrence of low dc current, both of which will be avoided with the CNT felt electrodes.

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