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Silicon Carbide Biotechnology for Robust Implantable Neural Interfaces

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Intracortical neural interfaces (INI) have made impressive progress in recent years but still display questionable long-term reliability. Here, we report on the development and characterization of highly resilient monolithic silicon carbide (SiC) neural devices. SiC is a physically robust, biocompatible, and chemically inert semiconductor. The device support was micromachined from p-type SiC with conductors created from n-type SiC, simultaneously providing electrical isolation through the resulting p–n junction. Electrodes possessed geometric surface area (GSA) varying from 496 to 500 K μm^2. Electrical characterization showed high-performance p–n diode behavior, with typical turn-on voltages of ~2.3 V and reverse bias leakage below 1 nArms. Current leakage between adjacent electrodes was ~7.5 nArms over a voltage range of −50 V to 50 V. The devices interacted electrochemically with a purely capacitive relationship at frequencies less than 10 kHz. Electrode impedance ranged from 675 ± 130 kΩ (GSA = 496 μm2) to 46.5 ± 4.80 kΩ (GSA = 500 K μm2). Since the all -SiC devices rely on the integration of only robust and highly compatible SiC material, they offer a promising solution to probe delamination and biological rejection associated with the use of multiple materials used in many current INI devices.

Recent Publications

1. Evans K. Bernardin, Christopher L. Frewin, Richard Everly, Jawad Ul Hassan and Stephen E. Saddow, "Demonstration of a Robust All-Silicon-Carbide Intracortical Neural Interface," Micromachines in press (2019).

2. S. E. Saddow, Editor Silicon Carbide Biotechnology: A Biocompatible Semiconductor for Advanced Biomedical Devices and Applications, © 2011 Elsevier LTD, UK ISBN 0-12385-906-9.

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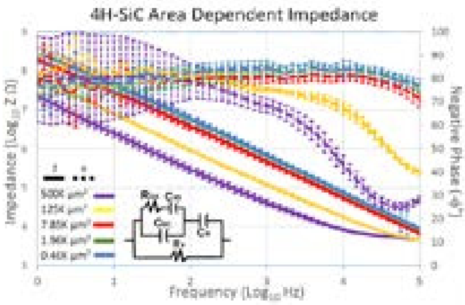

Figure: 1. Electrochemical impedance spectroscopy (EIS) performed on all-SiC electrodes of varying geometrical surface areas. Error bars represent standard deviation. Inset shows basic circuit model which produced an impedance profile similar to those obtained experimentally.

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Biography

Stephen E. Saddow has completed his PhD from The University of Maryland in College Park in 1993. He is Professor of Electrical Engineering and a member of the Biomedical Engineering faculty at the Univesity of South Florida, Tampa, FL. Dr. Saddow's research interests are to develop wide-bandgap semiconductor materials for biomedical and MEMS/NEMS applications. His prior expertise was in the growth of SiC epitaxial films on Si substrates. Presently he is pioneered the use of SiC for biomedical applications, having demonstrated that 3C-SiC is both bio- and hemo-compatible. His group has demonstrated several advanced biomedical devices, such as microelectrode arrays (MEAs), neural probes, in-vivo and non-invasive glucose sensors, and impedance-based biosensors.

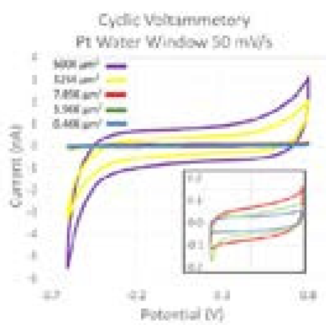

Figure: 2. CV plot showing single cyclic voltammetry sweep a select all-SiC electrode. Sweep bounded by potentials typically used for plati- num or iridium electrodes of −0.6 V and 0.8 V. Inset shows detail for the three smallest electrodes. All tests performed in naturally aerated PBS (i.e., no of gas bubbling) of 7.4 pH.

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