Graduate Seminar (EEL 6936)
Department of Electrical Engineering
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Center for Urban Transportation Research (CUTR) Room 102

Improving the Reliability of Cortical Neural Implants

Abstract

Implantable microelectrodes have yet to show a robust long-term reliability, where failure mechanisms include both biotic and abiotic processes. The biotic mechanism is believed to originate from the chronic foreign body response following initial implantation. Abiotic mechanisms have been shown to involve material degradation, stress mismatch, and interactions between multiple materials. Our group is investigating two different approaches to these issues. The first approach is through a class of polymers known as shape memory polymers (SMP). Unlike many polymers, our SMP formulations do not significantly swell with water absorption (< 3% volume change), and small alterations in monomer ratios allow for the tuning of device stiffness and transition temperature. This tuning allows us to fabricate probes possessing the stiffness required for tissue insertion, but quickly soften to the modulus of brain, avoiding secondary micro-motion injuries. As the devices are mechanically compliant and do not swell over time, they do not further displace healthy tissue as well. Our second approach involves a physically resilient, chemically inert semiconductor material, silicon carbide (SiC). It has been shown that many materials deteriorate within the physical environment, leading to electrical and physical device failure. As a semiconductor, SiC has the advantage of alternating doping allowing creation of electrical current barriers, enabling the fabrication of a single material electrode. This material not only will not degrade or delaminate, but it also hampers a negative biotic response, as SiC has previously shown excellent long-term *in vivo* compatibility within multiple tissues and flowing blood. Although there are many questions which are still being examined for both the solutions, the presentation will show excellent arguments and evidence in each approach meriting serious consideration for improving the reliability of neural implants and other biomedical applications.

Biography

Dr. Frewin is currently a research associate at the University of Texas at Dallas. Dr. Frewin applies experience in the fields of materials research, micro-electromechanical machines (MEMS), electronic device fabrication and design, computer programming, and electrochemistry, and neuroscience. Dr. Frewin is a graduate of the University of South Florida, under the tutelage of his mentor, Dr. Stephen E. Saddow, where he investigated the use of novel semiconductors silicon carbide, diamond, and graphene for biomedical applications. During this research, he has worked as a visiting researcher at Max Planck Institut für Metallforschung in Stuttgart, Germany and L'Istituto per la Microelettronica e Microsistemi/ Consiglio Nazionale delle Ricerche (IMM/ CNR) in Catania Sicily. He has collaborated with Walter Schottky

Institut in München, Germany, combining organic and inorganic materials through self-assembled monolayer functionalization for biomedical applications. He received a prestigious National Institute of Health (NIH F32) sponsored post-doctoral position in the University of South Florida's medical school with the neuroscientist Dr. Edwin Weeber and specialized in the electrophysiology of learning and memory. He worked on a Defense Advanced Research Projects Agency (DARPA) project which focused on the examination of novel materials for suitability and reliability in neural implantation devices, and now works for the leader of that project, Dr. Joseph Pancrazio, at the University of Texas at Dallas (UTD). He is currently working alongside Dr. Stuart Cogan who has a translational DARPA project to improve the longevity and stimulation capability of the only device currently used in humans, the Blackrock array, using silicon carbide and iridium oxide. Another Department of Defense project involves SMP which is covered in this presentation.