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2024 FALL SEMINAR SERIES

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THURSDAY October 10, 2024
11am-12pm
PWEB 150

ABSTRACT:

Hierarchical Surface Restructuring: The Technology of the Future for Sustainable, High Performing and Multifunctional Neural Interfacing Electrodes and Microelectrode Arrays

Recent advancements in implantable neural interfacing devices have led to significant breakthroughs in neurostimulation and cardiac rhythm management, enabling precise neural stimulation and signal recording for the treatment of various neurological and cardiac disorders. To enhance the specificity, functionality, and overall performance of these devices, electrodes and microelectrode arrays—the core components of most emerging devices—must be further miniaturized and demonstrate exceptional electrochemical performance with neural tissue. Since the selective and targeted stimulation of small populations of neurons near implantable electrodes is crucial for their success, the trajectory for further refinement of neural interfacing devices largely depends on increasing electrode miniaturization, which enables higher spatial resolution, precision, and reliability. However, challenges remain in optimizing electrode performance, commercial viability, manufacturability, and sustainability. In this presentation, several key areas of innovation will be explored. First, the miniaturization and electrochemical enhancement of femtosecond-laser hierarchically restructured electrodes, which demonstrate unprecedented improvements in performance, will be discussed. Second, the development of multifunctional, high-performing antibacterial electrodes designed to combat post-implantation infections while maintaining superior electrochemical properties will be highlighted. Advancements in ultra-thin, flexible electrodes for invasive nervous system applications will also be presented, with a focus on their enhanced electrochemical properties and mechanical stability. Finally, a sustainable alternative to platinum group metal electrodes will be presented, showcasing how titanium-based electrodes, restructured using a novel reactive hierarchical surface restructuring platform, achieve superior electrochemical performance and provide a low-cost, sustainable solution for long-term neurostimulation and cardiac rhythm management devices.

BIOGRAPHY:

Dr. Shahram Amini is currently the Vice President of R&D at Pulse Technologies Inc., an Integer Holdings company. With over two decades of experience in research management and technology innovation, Dr. Amini has successfully driven the development and commercialization of cutting-edge materials and products across diverse industries, including automotive, aerospace, and medical devices. Additionally, Dr. Amini serves as a visiting professor and sits on the advisory board of the Biomedical Engineering Department at the University of Connecticut. His research focuses on the design of hierarchical surfaces, coatings, thin films, and hybrid surface solutions for medical devices as well as advanced materials, measurements and manufacturing technologies for extreme and harsh environments. As the founder of several R&D centers, he has led multidisciplinary teams and gained international recognition through numerous patents and scholarly publications. Dr. Amini earned his Ph.D. in Materials Science and Engineering from Drexel University in 2008, following his M.Sc. and B.Sc. degrees in Metallurgy and Materials Science from Sharif University of Technology and Shiraz University, respectively. He also completed a postdoctoral fellowship at the National Hypersonic Science Center at the University of California, Santa Barbara, and served as a visiting researcher at the Materials Department of Queen Mary, University of London, England, and a visiting professor in the Department of Physics and Astronomy at Rowan University.

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