

BIOENGINEERING

PRESENTS

Bioelectronics for tissue and organ interfaces: from tissue-like electronics to genetically-targeted biosynthetic electrodes



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ABSTRACT:

Rapid progress in materials science and electronics has blurred the distinction between man-made electronic devices and biological systems. Seamless integration of electronic devices with living systems could contribute substantially to basic biology as well as to clinical diagnostics and therapeutics through tissue-electronics interfaces. In this presentation, I will first introduce a syringe-injectable tissue-like mesh electronics for merging nanoelectronic arrays and circuits with the brain in three-dimension (3D). The injectable mesh electronics has micrometer feature size and effective bending stiffness values similar to neural tissues. These unprecedented features lead to the gliosis-free and 3D interpenetrated electronics-neuron network, enabling the chronically stable neuron activity recording at single-neuron resolution in behaving animals. Second, I will describe a fully stretchable electronic sensor array through the development of multiple chemically-orthogonal and intrinsically stretchable polymeric electronic materials. The fully stretchable sensor array has modulus similar to biological tissues, allowing an intimate mechanical coupling with heart for a stable and anatomically precise electrophysiological recording. Its application for high-throughput and high-density mapping of 3D cardiac arrhythmogenic activities on the porcine model with a chronic atrial fibrillation will be discussed. Third, I will present a fundamentally new approach for a direct formation of electrical connections with genetically-targeted cells. This approach is accomplished through the convergence of genome engineering, in situ enzymatic reaction and polymer chemistry. These genetically-targeted electrodes are inherently assembled to the subcellular-specific region of neurons throughout the intact functional neural tissue and in stem cell-derived human brain organoids. Importantly, this system also enables the cellular-resolution tuning of local neuronal activity and bridging of brain regions to external devices for the targeted recording. Finally, I will briefly discuss the prospects for future advances in bioelectronics to overcome challenges in neuroscience and cardiology through the development of “cyborg animals” with single-cell resolution and cell-type specificity.

BIOGRAPHY:

Dr. Jia Liu obtained his B.S. in Chemistry from Fudan University in Shanghai, China, in 2009, where his research focused on superparamagnetic materials for bio-imaging. He then obtained his Ph.D., along with a short postdoctoral stay, with Prof. Charles M. Lieber at Harvard University, where his research focused on the development of nano-bioelectronics, which mimic the structures and properties of tissue scaffolds. Using these tissue-like nanoelectronics, he developed nanoelectronics-innervated synthetic tissues and syringe-injectable mesh electronics as a gliosis-free and chronically stable

brain probe. Dr. Liu is currently supported by Stanford Bio-X Interdisciplinary Seed Grants Program to perform his postdoctoral studies with Prof. Zhenan Bao at Stanford University since 2015, where he worked on the genetically-targeted whole brain-electronic interface (collaborative project with Prof. Karl Deisseroth) and the patient-specific cardiac disease diagnosis (collaborative project with Prof. Anson Lee). His research was recognized as 2015 Top 10 World Changing Ideas by Scientific American and Most Notable Chemistry Research Advances in 2015 by Chemical and Engineering News.