学術変革Bスケール横断分析セミナー
第72回 工学とバイオセミナー
Engineering in Medicine and Biology Seminar

Multidimensionally Shape-morphing Bioelectronics for Cardiac and Neuronal Interfaces

April 17, 16:00-17:00, 2025 Room: Dw601

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Bioelectronic devices show great promise in integrating biological systems with electronics and creating advanced medical devices to diagnose, monitor, and treat a broad spectrum of health conditions effectively. They precisely interact with excitable tissues such as neurons and cardiac cells, enabling electrical stimulation, biosensing, electrophysiology monitoring, and neural interfaces for neuroprosthetics. Despite their huge potential, there are still technological challenges in optimizing electrode sensitivity due to low signal-to-noise ratio (SNR), primarily due to high electrode impedance and noises derived from the electrode-tissue interface. We have addressed high impedance and sought solutions to improve SNR in bioelectronics by developing shape-morphing and flexible electrodes that facilitate the transition from 2D to 3D electrodes and improve contact with cells and tissues. These electrodes consist of conductive materials with low impedance, including gold, platinum, graphene, or conductive polymers. By using the shape-morphing electrodes, we demonstrated that an in vivo nerve interface could fold itself to a cuff around a small nerve, triggered by the body moisture during insertion, as well as stimulation and recording capabilities. This leads to precise and non-pharmacological means to provoke the leg's fast extensor tibiae neuron to extend its tibiofemoral joint and modulate and control cardiac functions. We also applied this self-folding electrode for real-time and electrophysiological monitoring of 3D neural and cardiac cultures to reveal cellular communications in their tissue-like 3D environment. Firing dynamics among reconstructed modular networks consisting of multiple 3D aggregates will offer valuable insights into disease mechanisms and therapeutic interventions. In this seminar, I will introduce our recent works on shape-morphing 3D MEA technologies and flexible bioelectronic implants, enhancing the precision of both stimulation and recording. This seminar will cover the design, fabrication, and application of neural and cardiac interfaces and the highlighted future potential of bioelectronics in personalized medicine and high-throughput disease modeling.

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