Microelectrode Fiber Sensors: Advancing Chemical Sensing for Implantable and Wearable Applications.

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Abstract
Globally, millions suffer from brain disorders, highlighting the urgent need for advanced therapeutic interventions. Achieving this requires a comprehensive understanding of neural circuits across molecular, cellular, systemic, and behavioral dimensions. Our research addresses this by leveraging innovative engineering solutions to bridge critical knowledge gaps. Traditional neural technologies have focused primarily on electrical activities, overlooking the potential of intrinsic chemical signals within neural circuits. Our research involves the development of polymer-based microelectronic fibers developed through thermal drawing techniques, which integrate electrical, chemical, optical, and mechanical functionalities with in a single thin strand of fiber with its footprint at microscales. These multifunctional fibers serve as advanced bio-interfaces, facilitating both detailed mechanistic studies and therapeutic applications.

One particular focus of our work is the integration of novel bioreceptors, such as aptamers and ionophores, into these fibers to enable high-sensitivity in vivo neurochemical sensing[1]. Additionally, we are pioneering the development of shape-programmable smart fibers that act as multimodal catheters. These fibers dynamically adjust their orientation based on chemical sensing data, enhancing their functionality[2] (PCT/JP2022/17664). By incorporating microfluidics, we enable precise manipulation of biofluids, pioneering lab-in-fiber (LoF) bioanalytical applications.[3] Extending their utility further, we have also developed fiber-based smart textiles for continuous health monitoring[4], capable of measuring diverse physiological parameters including sweat compounds, brain waves, body temperature, and respiration rate.

This innovative approach not only propels forward fundamental neuroscience research but also revolutionizes the study of brain-body interactions. Our ongoing research into these microelectronic fiber-based multimodal bio-interfaces is poised to pioneer new frontiers in in vitro Lab-in-Fiber (LoF) analyses, in vivo neuroscience studies, and the wearable technology domain for health surveillance.

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Short Bio
Dr. Yuanyuan Guo serves as an Associate Professor at the Frontier Research Institute for Interdisciplinary Sciences (FRIS) at Tohoku University, Japan. Her research group specializes in the development of thermally-drawn, multimodal sensing fibers designed to interface with complex biological systems. She earned her Ph.D. in Biomedical Engineering from Tohoku University on March 24, 2017. During her doctoral studies, Dr. Guo was a Japan Society for the Promotion of Science (JSPS) Research Fellow and gained invaluable experience working with Professor Polina Anikeeva at MIT (2014-2015) and Professor Xiaoting Jia at Virginia Tech (2015-2016). Her collaborations in these groups fueled her enthusiasm for developing multifunctional and multimaterial fibers for neural interface applications. Prior to her current position, Dr. Guo served as an Assistant Professor at the Graduate School of Life Sciences at Tohoku University, where she applied fiber technologies to explore glial functions within the brain. In 2018, she joined FRIS as a Principal Investigator to extend her research into developing fiber-based multi-sensing biosystems. Dr. Guo's is the recipient of the MEXT Young Scientist Award (2024), the Innovators Under 35 Japan Award (2022), the Murasaki Sendai Hagi Award (2022), the Tokin Science and Technology Award (2021) and other honors.