College of Science and Engineering

Department of Biomedical Sciences

Seminar

Upconversion-based All-optical Optogenetics

Dr. Peng Shi

Department of Mechanical and Biomedical Engineering, City University of Hong Kong

Label-free functional imaging of the brain in action

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Date: 29 June 2018 (Friday)

Time: 12:00 nn – 1:30 pm (Reception with light sandwiches at 11:45am, talks start at 12nn. To facilitate the order of sandwiches, please register through email chchung33@cityu.edu.hk.)

Venue: G4302, Yeung Kin Man Academic Building, City University of Hong Kong

Two Presentations of 30 min each, followed by a 30 min discussion on collaboration activities

Interdisciplinary Neurotechnology

1. Upconversion-based All-optical Optogenetics

Many nanomaterials can be used as sensors or transducers in biomedical research and they form the essential components of transformative novel biotechnologies. In this study, we present an all-optical method for tetherless remote control of neural activity using fully implantable micro-devices based on upconversion technology. Upconversion nanoparticles (UCNPs) were used as transducers to convert near-infrared (NIR) energy to visible light in order to stimulate neurons expressing different opsin proteins. In our setup, UCNPs were packaged in a glass micro-optrode to form an implantable device with superb long-term biocompatibility. We showed that remotely applied NIR illumination is able to reliably trigger spiking activity in rat brains. In combination with a robotic laser projection system, the upconversion-based tetherless neural stimulation technique was implemented to modulate brain activity in various regions, including the striatum, ventral tegmental area, and visual cortex. Using this system, we were able to achieve behavioral conditioning in freely moving animals. Notably, our microscale device was at least one order of magnitude smaller in size (~100 μm in diameter) and two orders of magnitude lighter in weight (less than 1 mg) than existing wireless optogenetic devices based on light-emitting diodes. This feature allows simultaneous implantation of multiple UCNP-optrodes to achieve modulation of brain function to control complex animal behavior. We believe that this technology not only represents a novel practical application of upconversion nanomaterials, but also opens up new possibilities for remote control of neural activity in the brains of behaving animals.

Biography

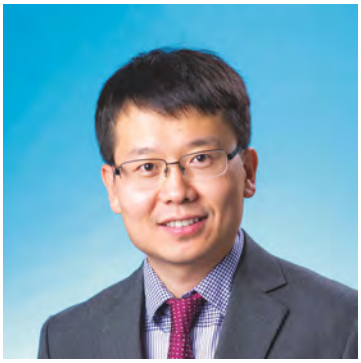
Peng Shi is an Associate Professor in the Department of Mechanical and Biomedical Engineering at City University of Hong Kong. He obtained his BS in Electrical Engineering from Wuhan University (China) and PhD in Biomedical Engineering from Columbia University. He completed his postdoctoral work at MIT in Electrical Engineering and Biological Engineering, where he was a Simons postdoctoral fellow. He has been working at the convergence between neuroscience and nano/micro-technologies, which is particularly emphasized as a promising approach toward substantial discoveries in brain research and as a technology foundation for future development of therapeutics.

Seminar

2. Label-free functional imaging of the brain in action

The brain accounts for more than 20% of total oxygen consumption even at the resting state. Oxygen metabolism is not only closely associated with neuron activities, but also plays a key role in many life-threatening brain disorders, such as ischemic stroke, Alzheimer's disease, seizure, neurodegeneration, and brain tumors. In vivo imaging of cerebral oxygen delivery in a small-animal disease model is of crucial importance for understanding pathogenic mechanisms and exploring new therapeutic strategies in translational medicine. This talk will introduce functional photoacoustic tomography that can quantitatively image oxygen transport in living tissue from trunk vessel to single red blood cells. Functional photoacoustic tomography can simultaneously quantify multiple functional parameters, including total hemoglobin concentration, blood oxygen saturation, and blood flow speed, metabolic rate of oxygen at scalable resolutions and depths, potentially opening up many new applications in the brain, such as ischemic stroke, Alzheimer's disease, or glioblastoma.

Biography



Lidai Wang received the Bachelor and Master degrees from the Tsinghua University, Beijing, and received the Ph.D. degree from the University of Toronto, Canada. After working as a postdoctoral research fellow in the Prof Lihong Wang's group, he joined the City University of Hong Kong in 2015. His research focuses on biophotonics, biomedical imaging, wavefront engineering, instrumentation and their biomedical applications. He has invented single-cell flowoxigraphy (FOG), ultrasonically encoded photoacoustic flowgraphy (UE-PAF) and nonlinear photoacoustic guided wavefront shaping (PAWS). He has published more 30 articles in peer-reviewed journals and has received four best paper awards from international conferences.

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