PROJECT SUMMARY (See instructions):

The development of optogenetics provides exciting opportunities to understand neuronal networks through selectively controlling a specific group of neurons by light. However, outstanding challenges remain on the implementation of optogenetics mainly because of the lack of devices that seamlessly interface with brain tissues. The objective of this project is to experimentally realize a novel device platform that best optimizes the interface for optogenetic experiments by affording chronical stability in vivo and integrating multiplex channels for simultaneous optical stimulation and electrical recording. The device is expected to have the following features: First, it has a effective bending stiffness approaching that of neural tissues, a few of orders magnitude smaller than conventional penetrating devices, so that it moves freely with tissues in the events of animal movement, heart beat and respiration without inducing scar response. Second, it has a minimized volume to reduce the disruption of glial network, which is thought to occur when devices are larger than an average cell. Thirdly, it integrates a large number of channels for both stimulation and recording in a 3D manner, in order to best address all the enclosed neurons. The device is expected to be fabricated by combining cutting-edge lithographic techniques on bio-compatible polymer substrates. The test of the device performance is expected to carry out on rodent model including histology to confirm the long-term bio-compatibility, and simultaneous electrical recording and optical stimulation in the medial prefrontal cortex (mPFC) during a behavioral task known to activate neurons in this area.

The proposed research is expected to fundamentally advance the combined fields of optogenetics and ensemble recording of neuronal activity by providing integrated, multiplex access and addressability to regions of brain beyond the superficial cortical layers with unsurpassed chronic stability. The successful development of these probes will provide valuable tools required for the basic research of neuron function and help define new circuits required for normal and adaptive function. Equally important, the results are expected to have positive translational impact because similar devices can be used to activate, suppress or to bypass specific neuronal circuits in the treatment of neurological diseases. With the support of the UT BRAIN seed fund we expect to produce adequate preliminary data related to the determination of function, mapping neural circuits and potential for treating neurological disorders to gain competitive advantage when applying external funding under National Insstitue of Biomedical Imaging and Bioengineering (NIBIB) and and National Institute of Metal Health Division (NIMH).

RELEVANCE (See instructions):

The proposed research directly targets the grand goal of the national BRAIN initiative by developing novel opto-electrical devices that enable addressability to the currently-prohibitive regime of the neuronal networks in the following two aspects. First, it is expected to resolve the challenge of mechanical mismatch between the device and the tissue, which enables chronic studies under optical stimulation in deep brain or deep layers of cortex. Secondly, the unique capability 3D multiplex simultaneous optical stimulating and electrical recording is a crucial step towards understanding the functionality of neuron, and is expected to provide unprecedentedly rich information.

Strong collaborative effort is an essential component to ensure the success of this project, due to its highly interdisciplinary nature. World-class researchers in their own fields are grouped together to secure the best expertise pushing every aspect of the project forward. Dr. Luan will oversee the entire project with focused effort on integration of optics and electronics at the device level. Dr. Xie will optimize the device design for best bio-integration. Dr. Li will design and optimize the coupling between optical device and external optics. Dr. Chitwood will oversee the histological processing and imaging of tissue to determine implant viability and assess biocompatibility. Dr. Siegel will oversee chronic implantation surgeries and in-vivo electrophysiology.