

Multichannel Implantable Optoelectronics for Wireless, Multisite Optogenetics across the Brain

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Abstract

Integration of advanced functional devices with multi-channel, high-throughput systems may yield new concepts of flexible optoelectronic devices with versatile capabilities. In optogenetics, an ability to conduct optoelectrical stimulations, electrophysiological recording and chemical sensing simultaneously at multiple sites across the brain may help us gain profound understandings of biophysiological processes such as the distribution of neurotransmitters, the conduction mechanisms of neural circuits and the metabolism process of nutrients.

Here, we demonstrate a new structure of multi-channel implantable optoelectronics with several flexible needle-like probes scattering from a central controller unit. These probes, which can be implanted into different brain areas, can be used to conduct controllable, distributed stimulations and measurements. The total thickness of each probe is around 60 μm , resulting in excellent flexibility and less damage to soft brain tissue. Each ultra-thin probe integrates functional components containing a μLED , four microelectrodes and three ion-selective sensors. Simultaneous recording of electrical activities within four different brain areas, as well as chemical activities under in situ optical stimulation, is presented. The proposed optoelectronics could accelerate more comprehensive understandings of neural circuits and reveal underlying mechanisms of biological processes.

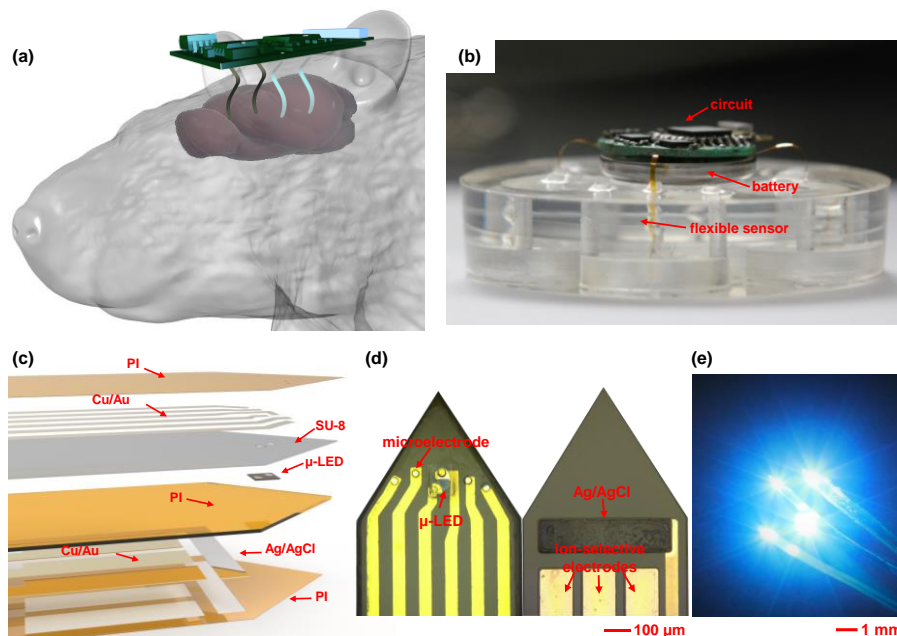


Figure 1: Schematic (a) and photograph (b) of the multichannel implantable optogenetic system. The multilayer structure (c) and optical micrographs (d) of the ultrathin, implantable probe. (e) An image of integrated probes with 4 μLEDs on.

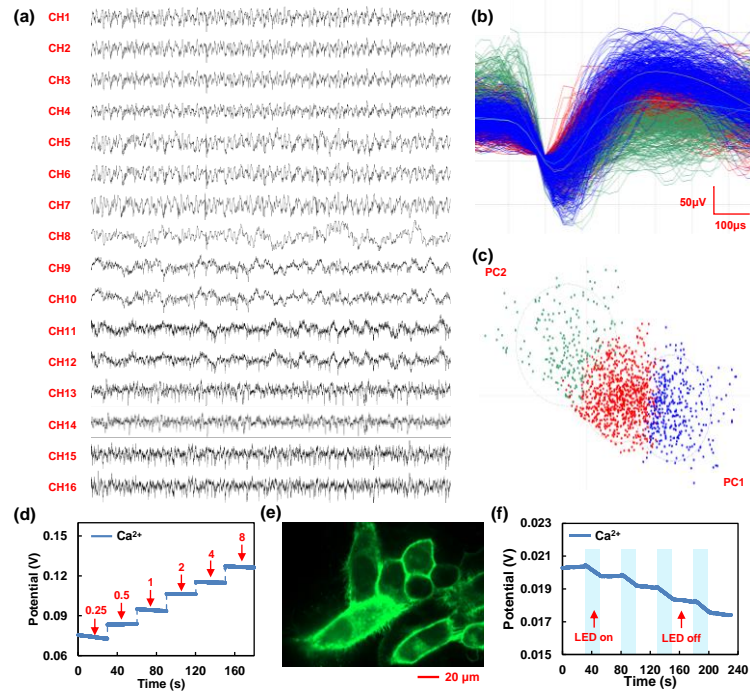


Figure 2: (a) 16-channel LFPs data recorded from four brain areas by the multichannel headstage. (b-c) Filtered and sorted results using principal components analysis to identify single units. (d) The open circuit potential response of the calcium sensors with Ca²⁺ concentrations ranging from 0.25-8 mM. (e) A fluorescent image of 293T cells transfected by plasmid pcDNA3.1-ChR2-GFP. (f) The open circuit potential response of the calcium sensor immersed in cell culture solution during intermittent optical stimulation.

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