An Distributed Multi-channel Electrical Signal Readout with Light Stimulation for Optogenetics

Jingxian Yu, Ya Li, Xian Huang

Department of Biomedical Engineering, Tianjin University, 92 Weijin Roead, Tianjin 300072, China(huangxian@tju.edu.cn)

Abstract

With the development of optogenetics, people gain the ability to control neuronal activity in high spatial and temporal resolutions. A large amount of integrated, biocompatible, mechanically soft devices with light stimulations, electrophysiological recording and many other functions have been developed, offering powerful apporaches to reveal . These powerful research methods provide the possibility to reveal the relationship between specific neural circuits and biological functions of brain. Despite the apperance of high density of optical and electrical stimualtion and monitoring devices, majority of these devices can only work on limited brain areas, lacking the ability to conduct distributed stimulation and sensing.

Here, we developed a new form of multi-channel implantable optoelectronics that has four fleixble optical fibers coupling with four LEDs to conduct deep brain stimulation. The wavelenghts of the four LEDs can be switched to satisfy the demand of different light-sensitive proteins for optogenetics. In addtion, each fiber was transfer-printed with flexible microelectrodes, which can be used to conduct feedback monitoring to evaluate the effectivenss of optical stimulation. Moreover, defects were deliberately introduced on the fibers, allowing leakage of transmitted light not only on the tips of the fibers but also on selective locations. Other parameters such as pulse duration of each LED and frequencies can be controlled by a wireless circuit.

Experimental results have demonstrated that the light intensity that outputed from the optical fibers satisfy the requirement of optogenetics. All 32 electrodes on the distributed optical fibers have exhibited excellent performance in in-vivo experiemnts using mice. These multifunctional flexible fibers allow us to gain systematic information to reflect the connection among different brain zones, and provide excellent tools to correlate animal behaviors with biophysilogical signal.

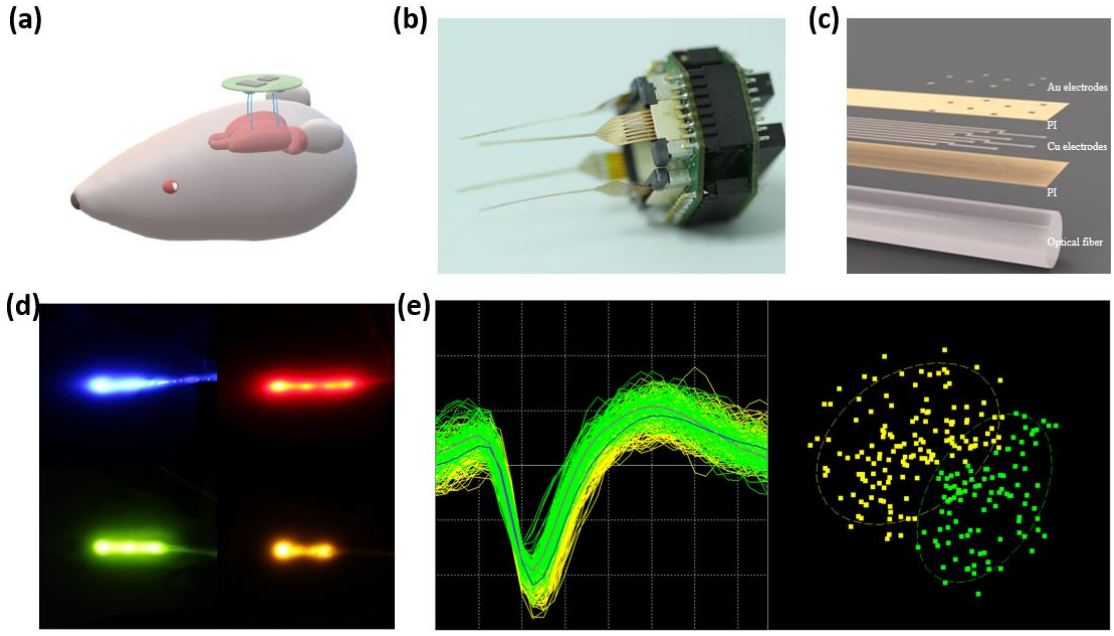

Figure 1: (a) Schematic of the device. (b) A image of the integrated devices with a wireless circuit, four optical fibers and transfer printed electrodes. (c) Explored view of a device's channel with an optical fiber and multiple eletrodes. (d) Distrubution of light at varied wavelengths in four optical fibers with delibrately introduced defects. (e) Measured spike signal on one electrode and PCA results to distinguish source neurons.

References

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