Implantable High density Neurophotonic Interfaces

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Functional mapping of brain activity enables better understanding of the mechanisms underlying processing, memory, and control in the brain, which could in turn inspire design of next generation neuromorphic computers. Optical stimulation and recording is poised to become a powerful technique for high throughput, minimally-invasive, and selective stimulation or inhibition of specific cell-types (using optogenetics) as well as imaging and recording of neuronal firings (which can utilize genetically encoded optical indicators). The tantalizing notion of performing closed-loop experiments to isolate neural circuits and study causal effects using such optical techniques still remains elusive; this is largely due to lack of an effective method for delivering light deep into the brain tissue to provide high spatial and temporal resolution. Here, we discuss how active and passive photonic devices can be integrated to realize compact implantable neural optical probes for generating arbitrary patterns of light in the brain. In particular, we will present our recent demonstration of a neural probe consisting of an array of micro-LEDs (with apertures ranging from 10 to 20 μm) realized on a flexible polymer substrate. The compliance of the substrate facilitates its safe implantation into the brain while minimizing damage to tissue during recording and stimulation. The probes are expected to remain floating in the brain and freely move with brain micromotions. Since individual array elements are independently addressable, any desired pattern of light corresponding to particular patterns of activity can be generated; these can be reconfigured by simultaneous activation of different groups of LEDs.