Towards Implantable Microsystems for Intracellular Neural Recording and Stimulation

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Microfabricated devices are promising as neuronal interfaces due to their small dimensions, suitability for multi-electrode recording and ease of integration with on-chip electronics; various device designs have been developed for successful extracellular neuronal recording. However, these devices cannot record action potential shapes, synaptic potentials, or other sub-threshold signals that are needed to answer many neurobiological questions, such as, for example, how are excitatory and inhibitory synaptic inputs used to modulate the activity of a neuron. Here, we present an implantable sub-micron silicon probe device with flexible interconnects that is capable of intracellular neuronal recording. We test the probe's ability to penetrate and record from neurons in an isolated brain of the marine mollusk *Tritonia diomedea*, and report on recent results that demonstrate, for the first time, that an implantable device can record intracellular action potentials.
Biocompatibility poses a formidable challenge to the application of chronic engineered implants. Protein adsorption, inflammation, and fibrous encapsulation are typical foreign-body responses with time constants from minutes to months that can disturb or completely disrupt the functionality of implants. The development of biomaterials aims at minimizing these adverse effects. We show the integration of biocompatible thin film coatings with micromanufacturing processes, leading to improved performance and durability of bioelectrodes. This work is an important step toward self-contained, implantable devices suited for neural recording.

Keywords:

*Microfabrication***:** technology used to manufacture components and systems at the micrometer-scale; this technology originates from the processing of silicon in the microelectronics industry but now extends to glass, plastics, and other materials.

*Intracellular***:** inside a biological cell

*Biocompatible***:** causing no or minimal adverse effects (such as inflammation or encapsulation) when interacting with biological tissue