Next Generation Nanoptrodes

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Simultaneous recording and stimulation of neural activity in different brain locations is crucial for understanding brain function. A scalable process for fabrication of high-density nano-optical-electrical probes (nanoptrodes) and a high-bandwidth head-mounted recording system are described. Our process is based on deep UV lithography of 250 nm features to fabricate a variety of 64 channel hybrid silicon-polymer probes (Fig. 1a) with cross-sectional dimensions as small as 30 × 23 um. To minimize tethering forces on the brain we incorporated 20 mm long flexible cables monolithically integrated with the silicon probe. The cable is made of parylene C, a highly compliant polymer, minimizing micromotion of implanted probes and consequent damage to brain tissue. To maximize spike amplitudes, arrays of small recording sites similar to conventional single unit electrodes were designed. The effective area of each recording site was precisely defined by angled-etching of the insulating layer over the recording site then growing various thicknesses of PEDOT conductive polymers. The impedance of the sites was reduced by two orders of magnitude to ~100kOhm at 1kHz, further improving the signal-to-noise ratio (SNR). In this paper, we also discuss a novel technique for on-shank high-index-contrast optical waveguide arrays using parylene polymers. We demonstrate acute in-vivo recordings and high-resolution excitation of channelrhodopsin-expressing neurons in transgenic mice. The post-fabrication packaging is carefully designed for mass production. The realization of minimally invasive high-density probes in large quantities makes distributed recordings in multiple brain areas possible with complete sampling of local cortical lamina.

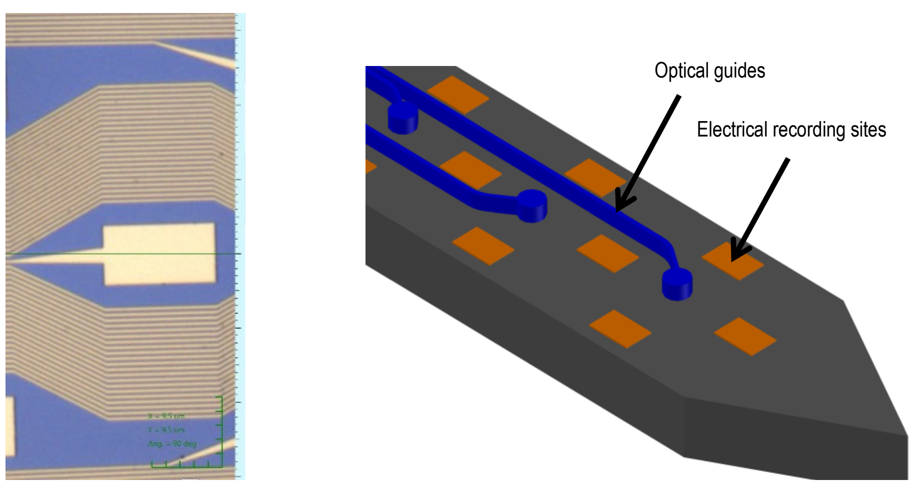

Fig. 1 a) Optical micrograph of a portion of a high-density 64-channel probe consisting of 350 nm wide electrical tracks and 8x15 μm recording sites. The metal layer is ~120 nm gold. b) Three-dimensional schematic of a hybrid nanoptrode consisting of electrical tracks and optical waveguides.