FABRICATION AND TESTING OF A POLYMER-BASED MICROELECTRODE ARRAY FOR HIPPOCAMPAL RECORDINGS

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Background: Penetrating neural probes can record electrophysiological activity with spatial and temporal resolution high enough to identify individual neurons in real-time. The cost of this resolution is inevitable tissue damage and fibrosis. Silicon and metal probes, in direct contact with soft neural tissue, physically damage surrounding cells during micromotion and trigger the foreign body response. Polymer-based neural probes, featuring significantly lower material hardness and Young's moduli, offer a path towards long-term, stable recordings by reducing the damage incurred during and after probe implantation. Here we present the fabrication and validation of a polymer-based neural probe array for recording unitary neural activity in multiple-regions of rat hippocampi.

Materials and Methods: The neural probe array consists of 8 polymer probes supporting a total of 64 Pt recording electrodes. The probes consist wholly of the biocompatible polymer Parylene C (poly(chloro-p-xylylene)) and thin-film Pt. Arrays were producing using batch-scale microlithographic methods adapted for Parylene substrates. Probes were approximately 20 μm thick and 150 μm wide with 30 μm diameter electrodes. Four arrays were implanted in the hippocampi of male Sprague-Dawley rats to an average depth of 4.10-4.15 mm, using a simple dissolvable brace to prevent buckling of the flexible polymer probes. Neural activity was recorded acutely from all four rats, and chronic recordings were acquired for three rats over a span of either 1 or 2 months. A sham array, featuring no electrodes, was implanted in a rat for 1 month to test the immune response to probe insertion and presence; brain slices were preserved and prepared with immunohistological staining, then examined under microscopy to compare neuron and astrocyte density at the implantation sites, and at corresponding control regions.

Results: Complex spikes, emblematic of the pyramidal neurons of the hippocampus, were recorded from both the CA1 and CA3 during all four implantations. Average spike amplitudes (139.3 ± 75.6 μV), baseline noise (37.8 ± 6.5 μV), and signal to noise ratio (3.6 ± 1.4) were calculated from these acute recording sessions and compared favorably with previous results from metal microwire probes. 33 individual neuronal units, across 3 subjects, were tracked during chronic recording experiments. The average SNR of these recorded spikes was 5.6, and remained stable across the duration of these experiments. Histological results revealed that astrocytic density increased near the insertion site, and neuronal density decreased, but both values returned to control levels within a 100 μm span of the implant site.

Conclusions: These results validate the efficacy of polymer-based, neural probe arrays for chronic subcortical recordings. In on-going work, data from this study is directing the fabrication and application of larger-scale polymer-based neural interfaces with hundreds of recording sites.

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