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### 3D Parylene Sheath Neural Probe for Chronic Recordings

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We present a novel micromachined polymer-based probe with a 3D sheath for long term *in vivo* neuronal recording. The sheath design provides a conduit for the ingrowth of neural processes into the lumen of the microstructure and closer to interior recording sites, improving tissue integration and recording quality. This is further facilitated by biofunctional surface coatings such as Matrigel, NGF, NT-3, BDNF, and dexamethasone. The use of microfabrication and a flexible, biocompatible polymer, Parylene C, as the substrate material allowed batch manufacturing of identical probes with tightly controlled features. Parylene is more compliant than silicon or metallic substrates, which may alleviate the mechanical mismatch between probe and tissue and reduce tissue aggravation during brain micromotion, both of which contribute to scar formation and attenuation of signal over time. Parylene may also minimize glial encapsulation and its effects on diminishing reliable, long term neural recordings to enable practical, clinically-translatable neural prostheses.

The Parylene neural probe includes 8 platinum microelectrodes (45  $\mu\text{m}$  diameter) distributed along the interior and exterior of the sheath. A flattened Parylene microchannel was initially established using sacrificial photoresist. The final 3D shape was attained through a post-processed thermoforming step using a microwire, which was removed following forming. Three different sheath designs were evaluated. An integrated flexible Parylene ribbon cable culminated in 0.5 mm pitch contact pads facilitating direct electrical connections via a zero-insertion-force (ZIF) connector without requiring wirebonds or conductive epoxy. Rapid, reusable connections to all 8 pads were established simultaneously. A flexible PCB interface with 2 ZIF connectors allowed connection of 2 probes to create a dual-probe array for implantation.

We also developed a custom microwire-based inserter tool to be used with the flexible probe for implantation. The tool consists of an acrylic support shuttle with two tungsten microwires spaced 1 mm apart to match and target the rat barrel cortex anatomy. The dual-probe array was attached to the inserter tool using polyethylene glycol at two different points: (1) cable region for strain relief and support and (2) probe-microwire tip for stiffness during insertion. We demonstrated the successful implantation of the dual-probe array within *in vitro* 0.5% agarose brain models.

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