« All-in-one fabrication process of a rigidified flexible neural probe »

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Abstract : Intrantracortical microelectrodes, also known as neural probes, are gaining scientific attention as tool to improve our understanding of the brain. Mechanical mismatch between conventional rigid probes and soft brain tissue causes chronic neuro-inflammation which prevents longterm, stable recordings. To circumvent this problem, softer and more flexible materials are investigated in combination with mechanical supports to insert the neural probe into the desired location in the brain. The support is necessary to provide additional stiffness needed for insertion, while not counteracting the effort to minimize inflammation on longterm basis. Bioresorbable polymers are perfect candidates to provide such stiffness for insertion and have the additional advantage of being degraded and resorbed once the probe is in longer contact with cerebrospinal fluid. Promising polymer candidates are poly-vinyl pyrrolidone, polyvinyl alcohol and poly(lactic-co-glycolic acid).
The challenge is to integrate such bioresorbable polymers on neural probes with an efficient and high-resolutionfabrication process.

Here, we show an all-in-one fabrication process of a parylene-based neural probe[1] with a bioresorbable polymer support patterned using orthogonal photolithography. We focus on the strategy to integrate a custom-made bioresorbable polymer layer as shuttle for these probes and discuss the biocompatibility and electrophysiology recordings of the flexible neural probe in an animal model. Briefly, parylene with embedded electronics is first manufactured on a substrate wafer using standard photolithography and lift-off. A layer of bioresorbable polymer is then spin-coated or screen-printed at a desired thickness on top of the wafer. The shape of the neural probe is patterned on top of the sample using a photoresist from Orthogonal Inc., and transferred to the bioresorbable layer using dry- and wet-etching. Finally, the remaining photoresist is removed using a hydrofluoroether (HFE) solution, known as a water-immiscible fluorinated solvent.[2] We find that the bioresorbable polymer coating is not affected by the HFE solvent and that the thickness of the polymer is easily adapted.

To conclude, we have developed a very promising fabrication process for innovative neural probes by combining traditional photolithography with orthogonal patterning of bioresorbable polymers. Most importantly, the procedure is done in an efficient all-inone fabrication process and any of the above mentioned bioresorbable polymers can be used to rigidify the flexible probe. Altogether, this is a step towards achieving the ultimate aim of fabricating intracortical microelectrodes for long-term recording.

1. Williamson, A., et al., Localized Neuron Stimulation with Organic Electrochemical Transistors on
Delaminating Depth Probes. Adv Mater 27 (30), 4405-4410 (2015).
2. 2. Zakhidov, A.A., et al., Hydrofluoroethers as Orthogonal Solvents for the Chemical Processing of Organic Electronic Materials. Adv Mater 20 (18), 3481-3484 (2008).