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Dual-Metal-Layer Parylene-Based Flexible Electrode Arrays for Intraocular Retinal Prostheses

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Abstract

Purpose: To design, fabricate, and perform electrical and biostability tests of a parylene-based dual-metal-layer epiretinal 1024 electrode array with a biomimetic layout that closely matches the density of macular ganglion cells.

Methods: A layer of parylene C was deposited on sacrificial photoresist on silicon, followed by the deposition and patterning of a layer of titanium/platinum traces with 16 µm pitch. A thin insulating layer of parylene was deposited and vias patterned using O_2 plasma to enable electrical contact to a subsequently deposited second layer of electrodes and traces. A third layer of parylene was deposited to achieve topside insulation, the electrodes were exposed, the 5 mm by 6 mm array and cable geometry etched, and the implants were released in acetone. 60 of 1024 biomimetically arranged 75 µm-diameter electrodes were connected to two contacts each to test electrical conductivity over the traces and vias. The implants were annealed to optimize parylene-parylene adhesion and curved using a custom mold to approximate the curvature of the canine retina, sterilized, and implanted in the OD of two canines through a pars plana incision and were tacked to the retina. Follow up studies after three and two months respectively including fluorescein angiography (FA) and optical coherence tomography (OCT) are underway to assess the chronic biostability of the implant and the retina.

Results: Electrical testing of the two traces connected to each electrode demonstrated a typical impedance of ~5 kΩ, which includes two 8 µm-wide traces of 20 mm-length as well as two via step junctions. Each via has an impedance of less than 12.5 Ω. The arrays retained the desired retinal curvature after sterilization. Implantation was successful, with one animal later developing a lens opacity due to nicking during implantation. OCT showed that the array was within 50 µm of the retina in the center and slightly lifted at the edges. FA shows minimal to no leakage around the perimeter of each array and underneath the array retinal vessels filled normally. Some hyperpigmentation was noted at the tack site.

Conclusions: High density electrode arrays with a biomimetic design have been fabricated according to a novel dual-metal-layer process, with electrical conductivity between the two layers being verified. Prototype implants have been chronically implanted epiretinally and have shown nominal biomechanical behavior during follow up.

Key Words: retina • age-related macular degeneration • vitreoretinal surgery