3D multi-layer probe for application in neuroprosthetics

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In neuroprosthetics, prostheses with higher and denser electrodes are needed to obtain both more precise recordings and targeted stimulations. The main limit is the routing of the active sites to the electronic control unit. A solution is to place electrodes and connecting traces on different layers. A multi-layer approach allows the upscaling of electrodes number, thus increasing also their density. Nevertheless, a drawback of the multi-layer system is the passivation layer that increases the gap from the exposed electrode to the target tissue, especially when polymeric materials are used, such as PI or PDMS. For the layers placed more at the bottom, this gap may increase to undesired values. Indeed, the electrode-cell distance is one of the most important parameter affecting the spatial resolution and the efficiency in recording and stimulation. We introduced a new 3D design and microfabrication process, allowing all of the active sites to reach or even protrude the implant surface and traces to be placed in multi-layers. Our device may be fabricated on flexible and soft substrates, with arbitrary number of layers and arbitrary height of active sites. Bi-layer polyimide neural probes with Pt electrodes reaching 6 µm above the encapsulation layer were produced; the electrode size is 100 µm. Electrochemical characterizations show no significant differences between the multi-layer 3D shaped electrodes and planar monolayer electrodes. The average impedance at 1 kHz is 80 kOhm.