Western Nanofabrication Facility

Western Science

Optimized Intra-Cortical Electrode Architecture for Maximum Stimulation Channel Packing

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Functional electrical stimulation (FES) of the central nervous system (CNS) has the potential to provide irreplaceable therapeutics and procedures for diagnosis and treatment. Moreover, cortical recording is critical for developing augmented control of neuro-prosthetics and brain-machine interfaces (BMI) for patients with impaired motor and sensory functions. Neuro-interfacing electrodes possess eminent role in the progress of neuro-engineering and electrotherapeutics. This motivated the development of intra-cortical electrodes during the past three decades starting with simple glass micropipettes, followed by metallic needle bundles, wire electrodes and finally, thin-film microelectrodes utilizing technologies developed for the microfabrication industry.

Advancements in electrode design will meliorate the delivered therapy and intra-cortical electrodes are progressing through many innovations. Researchers in the CIRFE Lab are developing new generation of electrodes introducing enhanced functionalities and biocompatibility. One of the designs was developed to create multi-shaft neuro-interfacing electrode for stimulation and recording through a two dimensional constellation of channels. The electrode was designed to maximize the pad packing without expanding the given electrode dimensions. This was achieved through a novel multi-layer architecture which relocated the pads and tracks into two separate metallization layers. The metallization layers were separated by dielectric thin film and the associated pads and tracks were connected by buried vias. The electrode layout was modeled and optimized using finite element analysis to minimize its footprint while maintaining the required mechanical strength, as well as minimize its DC resistance. The final quad-shaft electrode provided 24 channels each having a 100x100µm pad capable of neuron stimulation and local field potential recording through a low resistance channel. The electrode fabrication process was optimized

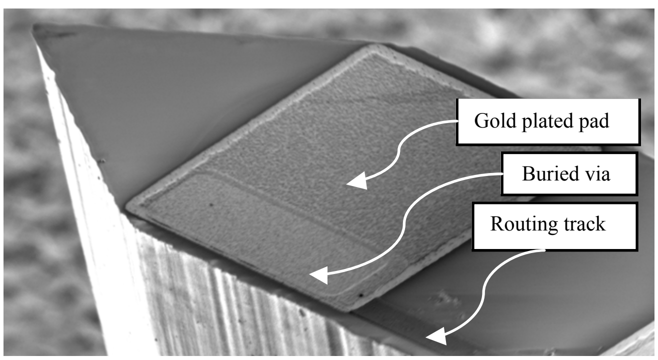

Fig-1. SEM picture of the electrode tip showing the pad, buried via and routing track. The pad and track are located in different metallization layers and connected by the buried via.

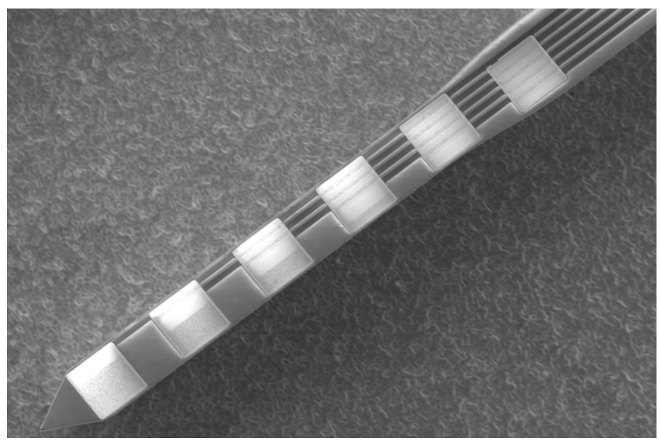

Fig-2. SEM picture of the electrode shaft with six pads

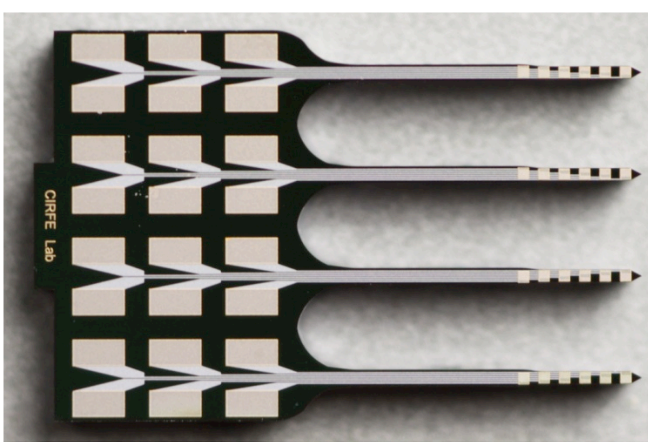

Fig-3. Quad-shaft intra-cortical neuro-interfacing electrode

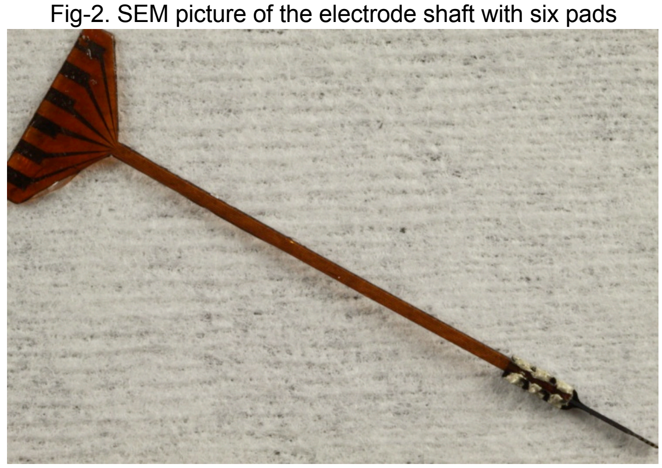

Fig-4. Single-shaft electrode and flexible cable assembly

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