Bio-packaging development of a ultra-thin profile silicon probe array for chronic implantation

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***Abstract*—Neural recording and stimulation has become increasingly important in understanding the neuroscience, exploring the central nervous system and aiming to help in restoring sensory function such as vision and hearing[1]. The implantable neural device will be inserted into the motor cortex to perform required task, e.g. the movement of hand of a paralytic human.**

This paper presents a bio package method of ultra-thin silicon probe array for chronic implantation purpose. Ultra thin silicon probe is fabricated and assembled to form 3D probe array [2]. An orthogonal connection formed by solder jetting is used. The profile of probe array is controlled within 500 µm and the potential tissue damage is minimized after implantation. Medical grade silicone is used to encapsulate the neural device. The impedance of the assembled probe electrode in artificial cerebrospinal fluid (aCSF) is measured to be about 1.4 MΩ at 1kHz.

I. Design and Fabrication

The neural probes used in the study were fabricated as in [3]. The Si platform fabrication begins with the deposition of a 1 um oxide for electric isolation purpose. Next, 500Å Ti and 4000Å Au was sputter on the substrate as metal trace for future package purpose. 2 um photoresist (PR) and Iodine based chemical were used to define the metal trace. Another 1um oxide layer is deposit to passivate patterned metal trace. 2 um PR is used to define the bonding pads. 10 um PR is used as etch mask for final deep reactive-ion-etching (DRIE) of 300 um. The DRIE process is used to define slot for probes. Then, oxygen plasma is used to strip the remaining PR. Silicon substrate is thin down to 250 um as final platform thickness. Medical grade silicone were coated and cured after probe assembly and wire soldering.

II. Experiment Results

The electrode impedance of the 3D probe array has been measured to evaluate its electrical characteristics. The three-electrode setup depicted in figure 2(a) is used to measure the impedance of the probe. The assembled probe array is immersed in the artificial cerebrospinal fluid (ACSF, consisting of 124 mM NaCl, 4.4 mM KCl; 1.2 mM MgSO4, 1 mM NaH2PO4, 2.5 mM CaCl2, 26 mM NaHCO3, 10 mM glucose) during measurement. The magnitude and phase components of the electrode impedance are measured by the Electrochemical Workstation (CH Instruments Inc.). An Ag/AgCl wire is used as a reference electrode and a Pt electrode is used as a counter electrode. A sinusoidal AC voltage with peak-to-peak amplitude of 10 mV was applied with varying the frequency from 100 Hz to 100 kHz to measure the impedance of the electrode on the assembled microprobe array. The measurement results are shown in figure 2(b). The impedance is mainly capacitive and the magnitude of the impedance measured at 1 kHz is about 1.4 MΩ.

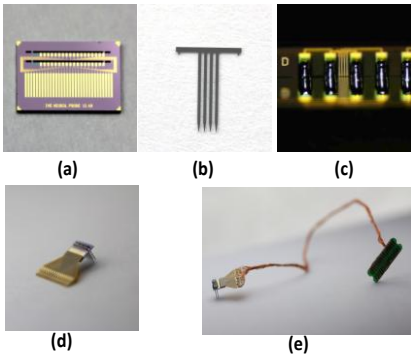

Figure 1: (a) Si platform, (b) Si probe, (c) Solder joint between platform and probe, (d) Si platform assembled on FPCB, (e) The assembled fabricated device.

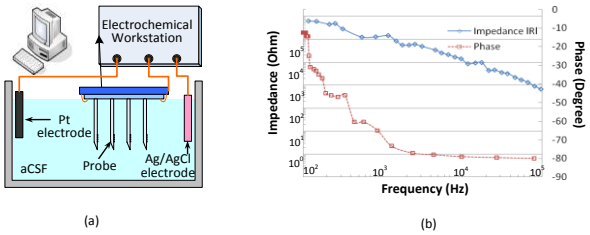

Figure 2: (a) Schematic of the impedance measurement set-up, (b) Impedance measurement

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