Hybrid Silicon Neural Electrodes: Simultaneous recording of Neural Electro-potentials and Biomarkers

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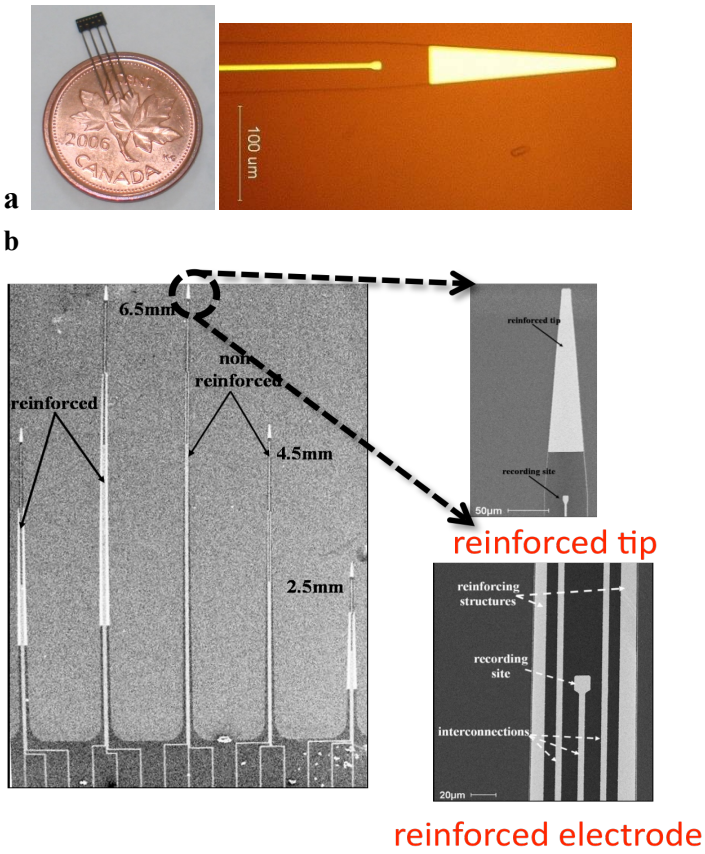
Background and Significance The recent success of clinical trials in paralyzed humans has generated exciting results that give credence to Brain Machine Interfaces (BMIs) as a viable therapeutic solution for paralysis. Many more obstacles must be overcome before these devices are able to restore more complex motor function. Even hundred of electrodes implanted in the brain have not yielded adequate information rates capable of restoring complicated function. Patients must also be able to autonomously control devices but decoding a 'GO' signal that instructs execution has proven elusive. BMI research is highly interdisciplinary requiring research across many branches of medicine and engineering. A BMI framework encompasses 1) an implantable device to record neural signals, 2) algorithms to interpret the neural signals and 3) the device to be controlled. In this project, *we are developing methods to develop novel implantable arrays made from silicon that can simultaneously record electrical action potentials, local oxygen concentration, and pH*. We hypothesize that the various signals recorded by the multimodal probes will increase the information yield when compared to a single probe. As a consequence, the number of probes that need to be implanted will also be minimized.

Methodology We employ the concepts of structural probe reinforcements to support regions of the electrodes that are more susceptible to breaking during the implantation and operation producers. We used gold as structural reinforcement material to develop functional probes that are 1cm long while having a thickness of 50µm and width of 100µm. We are now working to develop probes that are 2cm long and are still 50um thick using SiC, SiO_2 and Si_3N_4 as structural reinforcement structures on silicon substrates.



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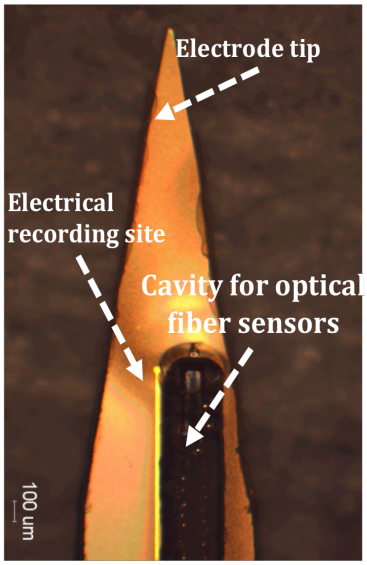

Project duration: April 2010 –March 2013

Figure 1: (a) Ultra-long silicon neural electrodes (10mm long with 50µm thickness) required to gather cognitive neural information. (b) Silicon neural electrodes fabricated in a commercial MEMS process. (c) Hybrid silicon neural electrodes to simultaneously record brain tissue oxygenation and neural electrode potentials.

Selected publications

1. M. Hajj-Hassan, V. P. Chodavarapu, S. Musallam, *"Reinforced Silicon Neural Microelectrode Array Fabricated using Commercial MEMS process"*, SPIE Journal of Micro/Nanolithography, MEMS, and MOEMS, vol. 8, 033011, 2009. **(Selected for Virtual Journal of Biological Physics Research, vol. 18, iss. 3, August 2009)**
2. M. Hajj-Hassan, V. Chodavarapu, S. Musallam, *"Microfabrication of Ultra-long Reinforced Silicon Neural Electrodes"*, Micro & Nano Letters, vol. 4, pp. 53-58, 2009. (**Featured Letter of the Issue**)

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