A SIMULTANEOUS MULTICHANNEL RECORDING OBTAINED FROM RAT CORTEX USING A PLASMA ETCHED SILICON DEPTH PROBE

E. Hwang*, S. Kim*, T. Yoon*, D. Shin*, S. Oh**, S. Jung**, and H. Shin**
* School of Electrical Engineering, Seoul National University, Seoul, Korea, kim@helios.snu.ac.kr
** School of Medicine, Hallym University, Chunchon, Korea

Abstract—Combination of plasma and wet etching was done in developing a new silicon depth-probe type microelectrode array. The plasma etch uses low temperature oxide (LTO) mask instead of thick photoresist mask, and enables the thickness of the probe shank to be defined more freely and in wider range. The entire probe shaping process was performed only at low temperature, and is CMOS compatible. A probe with 30 μm shank thickness was successfully used in recording from rat's somatosensory cortex. A four-channel simultaneous neural recording shows signal-to-noise ratio performance comparable with that obtained using conventional microprobes.

Index terms—silicon microelectrode array, neural probes, plasma etch, multi-channel electrode

I. INTRODUCTION

Simultaneous recording from populations of neurons has been increasingly required for better understanding of functional relationships between cells in brain and other neuronal networks. The thin film microelectrode arrays have many advantages over wire bundles. Among a number of efforts to develop silicon-based microelectrode array, the majority has employed high temperature boron diffusion and selective wet etch to define the precise probe shape [1]. Recently, combination of plasma etch of the front side and wet etch of the back side was also introduced for the probe shaping [2]. Considering the wide availability of the CMOS foundry services such as MOSIS for custom integrated circuit, one may prefer the latter approach which involves neither high temperature nor impurity doping. The probe shaping can then be performed as a post process to the CMOS fabrication.

II. METHODS AND RESULTS

The depth probe described in this paper was also fabricated using methods similar to those described in [2]. Instead of the thick photoresist(PR) mask used in [2], however, we employed LTO etch mask for the plasma etch. This material is more readily available, has higher etch selectivity , and allows better uniformity and reproducibility. We were able to obtain 30 μm probe thickness which was difficult with boron diffusion. Fig. 1(a) shows the cross-sectional view of the completed probe. The probe was then mounted on a printed circuit board as shown in Fig. 1(b). The length of the shank was 3 mm. Each site was 40x40 μm^2 and was spaced at 150 μm center-to center.

Animal experiments were conducted using probes developed. The area of Sprague-Dawley rat's primary somatosensory cortex, which responds to electrical stimuli at digits, was recorded. Simultaneous neural activities from 4 consecutive electrode sites located perpendicularly through cortex were recorded as shown in Fig. 2. The signals were amplified with a gain of 10^4, and filtering was not used.

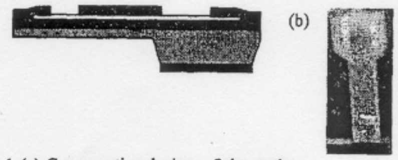

Fig. 1 (a) Cross-sectional view of the probe
(b) Probe packaged on a printed circuit board

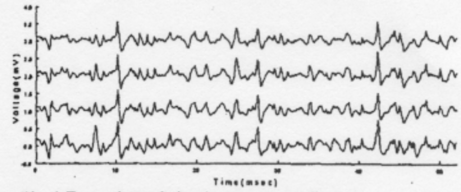

Fig. 2 Four -channel simultaneous recording

III. DISCUSSION AND CONCLUSION

Out of six probes inserted in the rat cortex, none broke or failed. For comparison of performance, we have also tried similar silicon depth probe fabricated by Univ. of Michigan and the tungsten metal electrode at the same experiments. All other setups were consistently applied, and neural activities were successfully recorded from all. While signal-to-noise ratio (SNR) of 6-14 dB was obtained from the activity recorded using our probe, the SNR was 6-10 dB and 3-6 dB from those using Michigan probe and tungsten probe, respectively. This proves the effectiveness of our probe, both structurally and electrically.

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