Neuroelectronic MEMS

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INTRODUCTION

The study of the interconnections between neurons provides an insight into the working of the brain. Classic techniques include the use of the patch clamp, a glass micropipette with a narrow opening. Intracellular fluid comes into contact with a AgCl solution which in turn is connected to a Ag wire forming the contents of the micropipette. The technique is invasive and requires penetration of the cell membrane forming contact with the intracellular fluid.[1] Patch Clamp is limited in the study of living neural networks.

Studies have shown that when a neuron is placed on the gate of a FET (Field Effect Transistor) bathed in the extracellular fluid. The action potential generated by the neuron modulates the source-drain current of the FET. A noninvasive recording of the action potential is achieved. The device is known as the neuron transistor.[1] An array of neuron transistors can be fabricated. Neurons on the gates of these transistors grow processes called dendrites. Dendrites of different neurons make connections. The network of neurons so formed is a living neural network. Neurons can also be capactively stimulated and resulting changes in potential can be recorded from the neurons on the network. [2]

FABRICATION AND EXPERIMENTAL SETUP

The fabrication of neurotransistors is achived by standard MEMS techniques. <100> n-type Silicon wafer with resistivity of 5-8 ohm-cm are cleaned using the standard RCA technique. Silicon-di-oxide 10000 A thick which serves as a diffusion mask is grown using wet oxidation at 900 C. Photolithography techniques are used to open the source drain regions in the oxide with dimensions 5x100,10x100, 16x30 and 20x100 microns. A layer of phosphorosilicate glass is spun on which serves as a dopant (p-type) source. The dopant is driven in at 1050 C for 10 hours in a 1:1 Oxygen/Nitrogen environment. The spun on glass is removed using 2% Hydrofluoric Acid solution. A 10000 A oxide is grown using wet oxidation at 900 C. Gate region is opened using photolithography and a 200 A thin oxide is grown using dry oxygen in a TCE atmosphere. Contact regions are opened using photolithography and etching with Buffered Hydrofluoric Acid BOE. Alumnium is deposited by photolithographic patterning(lift off) technique. Deposited Aluminium is sintered at 475 C for 15 minutes in a Nitrogen atmosphere.

A glass petri dish with a hollow bottom spanning the gates of the transistors without exposing the contacts will be used to hold the neurons in culture. The setup is shown in figure 1. N1E-115 murine neuroblastomal cells are obtained from ATCC[3]. The cells were cultured in complete media mix consisting of 50 mL media mix, 5 mL fetal bovine serum, 0.5 mL antibiotics at 37 C in an incubator. The media was changed every three days. Upon reaching confluence the cells are seperated. Cells are detached from the flask with the addition of 0.05% Trypsin. Cells are pelleted and washed in serum free media to eliminate Trypsin residue. Cells are resuspended in 1mL serum free media. Cells are placed in a six well plate with glass cover slips at the bottom of each well. Cells attach to the coverslips which are used to place the cells in the Axopatch 200B from Axon Systems. Cells are starved and incubated and the coverslips that hold the cells are broken into small sections and studied using patch clamp recording technique. Cell membrane is ruptured by either an electrical impulse or suction allowing electrical access to the cell. Action potentials in the range of 30 mV were found after four days in serum free medium. The N1E115 cell line is found suitable for the study.

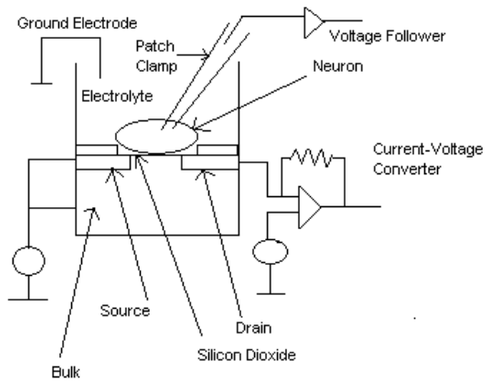

Figure 1

Detailed observations and results will be presented.

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