

Study on Electro-polymerization Wiring System Imitating Axonal Growth of Artificial Neurons towards Machine Learning.

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For years, brain emulation becomes academically interesting and important work. ¹Since brain emulation is the logical endpoint of computational neuroscience attempts to accurately model neurons and brain systems. Machine learning using the artificial neuron network research is supposed to be the best way to understand how the human brain trains itself to process information. Derivation from the necessity of increasing in computation ability and in reduction of power consumption, accelerator circuits using on neural network training for machine learning become critical. Contrary to inorganic semiconductor based circuits, alternative circuits association with conducting polymer micro/nanowires must show advance features. Due to the unique characteristics, such as, conductive, flexible, predictable in wiring path, and selectable in polymerization direction, conducting polymer wires are the promising candidate for the project of optimization accelerator circuits.

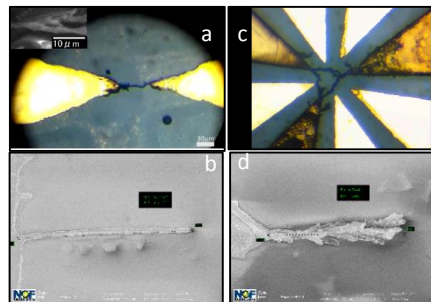


Figure 1: Wires morphology: a. PPy wire grew between bipolar electrodes; b. PEDOT wire 100μm in length and 2μm in diameter; c. PPy wires grew between selective electrodes; d. piece of PPy wire in cauliflower.

In this work, PPy and PEDOT nanowires were potentiostatically grown crosslinking the designated electrodes, which were prefabricated by lithography, when a square wave DC voltage was applied. Under the condition of $\pm 3.2\text{V}$ (DC), 300Hz, 25μL aqueous solution of 0.5M Py and 0.125M counter ions, PPy wire has grown with cauliflower structure 2-5μm in width (Fig.1), several ten to hundred micrometers in length. Whereas in higher applied voltage ($\pm 5.0\text{V}$ (DC)), 300Hz, 25μL aqueous solution of 0.135M EDOT and 20mM counter ions, PEDOT wire possesses dendritic morphology with less branches, 1-3μm in width, and up to several hundred micrometers in length. It takes less than 30 seconds for a typical PEDOT and 5-7 minutes for PPy wire to grown in an equal channel length of 100μm between a pair of electrode. After drying and removing residual solution surrounding electrodes, average conductance of PPy wires ranges from 10^4 - $10^8\Omega$, and that of PEDOT ranges from 10^7 - $10^9\Omega$. However wire resistance strongly depends on the concentration ratio between counter ions and monomer, as well as the wire length. In this study, wire growth process imitates axonal growth of artificial neuron, and the changes in wire resistance during growing process will then be necessary as the changes of synaptic weigh in machine learning algorithm.

References

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