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# BIOMIMETIC IONIC MICROSTIMULATION FOR NEURON CULTURE

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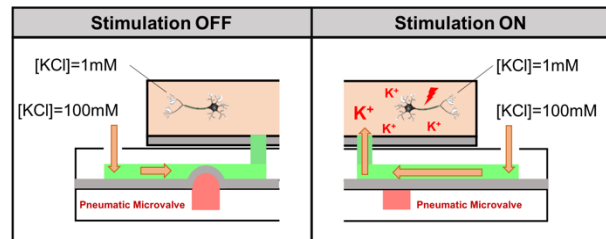
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## INTRODUCTION

Neurodegenerative diseases are incurable and debilitating conditions that influence cognitive and/or motor functions in millions of people worldwide. Neuroprosthesis are used today to support the quality of life but have yet to improve in their power consumption and biocompatibility issues. For the future realization of neuroprosthesis, understanding the neurophysiological behaviors and the investigations on the interaction of neuronal cell assemblies is therefore essential. Here, we propose a novel microfluidic system to investigate the response of the neurons directly stimulated by the potassium ions *in vitro*. Unlike the conventional way of stimulating neurons by pipetting or sending electrical stimulus, this biomimetic stimulation system enables precise and rapid control of ion concentration by utilizing microfluidic pneumatic valves, which mimics physiological stimulation in a body. By using the system, we demonstrated stimulations of the neuron cells with potassium ions and monitored neural activities with a calcium-specific fluorescence indicator.

## CONCEPT OF THE DEVICE

The device was inspired by nervous system which is a network of neurons. Each neuron is connected through synapses, to a large number of other neurons, through dendrites and axons. The axon transmits electrochemical pulses (including KCl, NaCl) to communicate between neighboring neurons by transmitting electrical signals based on ionic flow between intracellular and extracellular environments. To simulate this physiological behavior, a device made with Polydimethylsiloxane (PDMS) has two chambers intra- and extracellular chambers connected by channels with high and low concentrations of potassium chloride actuated by pneumatic microvalves. An ion selective permeable membrane (Sigma-Aldrich, Nafion® perfluorinated resin solution 5wt.%) is used for and the concentration of potassium ions can be changed.



Stimulation OFF and ON controlled by pneumatic microvalve

## RESULTS

The device with integrated cell dish for placing living neurons has a thinness of less than 5mm allowing the observation through microscope during calcium imaging. Our device can generate a biomimetic stimulation accordingly to the sequenced air pressure. The opening of the pneumatic microvalve was sequentially repeated after three pulses of 0.1s, 0.25s and 0.5s with each separated with 0.2s of closure. The matured neurons were stained with calcium specific fluorescence to observe the neural activity. Fluorescence response was successfully observed only during the opening of pneumatic microvalve.

## CONCLUSIONS

We successfully demonstrated stimulations of the neuron cells with potassium ions using microfluidic pneumatic microvalves operated by air pressure controller. The neural activities were visible according to the programmed air pressure applied, capable of generating a biomimetic behavior. We believe that our novel system can be utilized for the fundamental investigation of the response of the neurons stimulated by well-modulated ion stimulus to understand the neurophysiological behaviors.

## REFERENCES

- [1] Levi T., Fujii T. "Microfluidic Neurons, a New Way in Neuromorphic Engineering?". *Micromachines* 7:146. S.2016
- [2] Bonifazi P. et al, "In vitro large-scale experimental and theoretical studies for the realization of bi-directional brain-prostheses." *Frontiers in Neural Circuits*, 7:40, 2013.

**KEYWORDS:** Ionic stimulation, Biomimetic activity, Microfluidic neuron.