Characterization of Electrophysiological Properties of Neurites using a Microfluidic-Microelectronic Platform

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The understanding how the electric transmission of neuronal activity occurs and is propagated plays an important role in neurobiology. Various properties of the cell type, e.g. type and number of membrane channels play an important role on the electrical propagation along the neurites. In order to provide a versatile platform to investigate the propagation along neurites of different cell types we developed a device that separates neurites from the whole culture and provides microelectrodes for electrical recording near them. Our platform consists of a microfluidic device aligned on top of a multielectrode array. This setup enables the simultaneous recording of neuronal activity of neurites through microchannels and optical investigation of the whole growing cell population at the same time (Figure 1).

Using two microelectrodes for each neurite the differences between the shape and the propagation speed depending on the characteristics of the cell can be determined. The proof-of-concept was demonstrated with the growth of sympathetic neurons from the superior cervical ganglion of P5 WT mice and the determination of the propagation speed and spike shapes (Figure 2). The cells were also chemically stimulated by different potassium concentrations showing the effect of different extracellular potassium concentrations on the electrical excitability of the cells.

Our results show that the microelectrode-microfluidic platform was sensitive enough to determine the propagation velocity as well as different extracellular medium compositions. Due to the microchannels which act as isolation tubes for the neurites the device will be capable to investigate electrophysiological properties of different cell types of nerve cells.

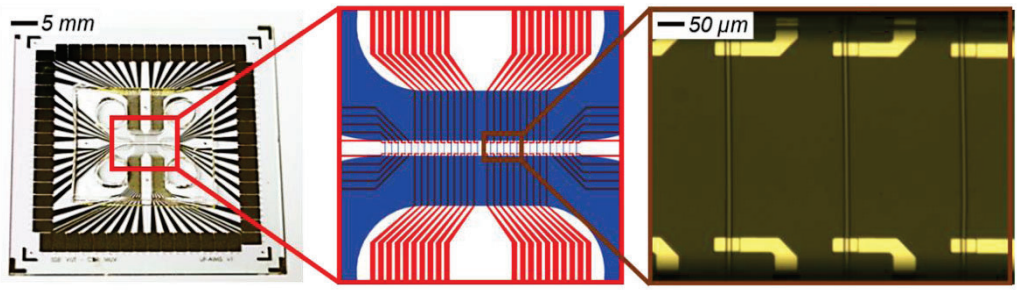

Figure 1: Microfluidic-Microelectrode platform. Left: Image of the NI-MEA composed of a microelectrode array and a mounted neurite isolation microfluidic device. Middle: Design of the center area: 30 microchannels (blue) with 2 microelectrodes (red) in each microchannel. Right: Microscopic image of the precisely aligned gold microelectrodes in the microchannel.

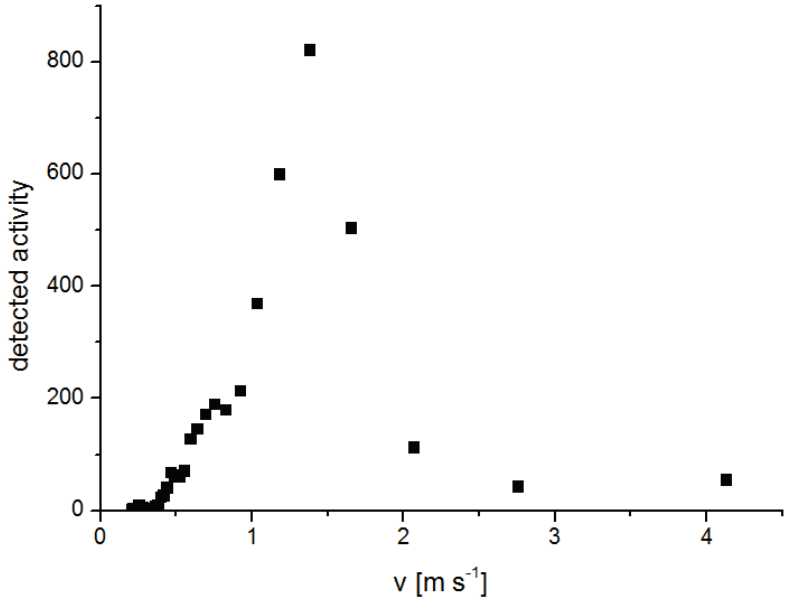

Figure 2: Propagation speed of neurites from the Superior Cervical Ganglion. The figure shows the propagation speed along a neurite with respect to the detected neuronal activity.