An integrated microfluidic, microelectrode array device used to temperature clamp sensory neurons in culture
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Abstract
A NEMS device was developed which allows the temperature to be rapidly changed and maintained at a precise, fixed magnitude, producing an effective, spatially-controlled temperature clamp in kymoargentum fibres. A high-performance channel system was created on the surface of a commercially available 60-electrode recording MEA (MEA-60). A unique design was constructed by combining the high density microfabricated channels with a novel, microfabricated chamber constructed of polydimethylsiloxane (PDMS). The latter was prepared using a method similar to that described by Nvidia's patent (US Patent # 6,221,194), which allow the flow rate of the solution to be controlled by the flow rate of the solution.

Methods

A commercially available microelectrode array (MEA; Scientific, USA) was used. It contains 60 recording sites, each 50 μm in diameter, and with the same pitch of 350 μm. A microfabricated chamber is constructed on top of the array using PDMS. The chamber, which is fabricated using a method similar to that described by Nvidia's patent (US Patent # 6,221,119), which allows the flow rate of the solution to be controlled by the flow rate of the solution.

Results

Cell Isolation and Classification

Action potentials recorded from DRG neurons. The neurons were isolated using time-voltage window discrimination techniques. After sorting spike waveforms, several cells were found to bebursting, firing in trains in response to the temperature change. (A) shows the resulting waveform shape following a stimulation. (B) shows the mean spike shape and the standard deviation.

Cellular Response to Changes in Temperature

Neural activity in response to rapid changes in temperature. (A) shows the raw data obtained recorded from a single electrode, the oscillations to different stimuli, and red markers where a spike is detected. (B) shows the data after a neuron was identified and sorted on the electrode. (C) is a raster display of the same data. It is interesting to note that the mean firing rate of the cell increased during each application of cold solution from the previous, compelling (4.7±0.4 Hz) and gradually increasing to 1.0 (75 Hz and finally to 1.5 Hz).

Conclusions

A NEMS-based microfluidic array integrated with a microfluidic channel network was developed to control the environment of a culture of neurons. Microfluidic samplers can be expanded or replaced using the system. For example, it is hypothesized that some temperature-sensitive neurons may adapt, whereas others may not. The time scale on which the changes occur is critical, and it enables researchers to ask questions that would have been impossible to answer before.

Acknowledgments

We gratefully thank all of the members of the MIT Lab: Alex Baker, Matt Hinkle, Javen Kim, Ryan Pope, and Paul Victorus. In addition, we would like to thank David Bower and Andy Pomerantz.

References

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