МЕТОДЫ И АППАРАТУРА ДЛЯ НАУЧНЫХ ИССЛЕДОВАНИЙ

MULTICHANNEL SYSTEM FOR RECORDING OF NEURONAL ELECTRICAL ACTIVITY *IN VITRO*

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The method of recording and stimulation of electrical activity in neural tissue is widely used for study of various aspects of the nervous system functioning. The basic properties of neuronal excitability and synaptic plasticity can be investigated by means of conventional single microelectrodes. However, the basis of the brain structure is a neural network and therefore more sophisticated techniques of multichannel interaction with multiple neurons are required in order to uncover principles of brain data processing.

The common method of multichannel interfacing with neurons is based on utilizing of multichannel microelectrode arrays embedded into planar substrate. Slices of neural tissue or cultured dissociated neurons are placed on the substrate and the activity of neurons is recorded and evoked by planar microelectrodes. While providing comprehensive access to neural network, this approach requires a sophisticated system of multichannel amplification of neuronal activity, commutation of stimulating current pulses and high-performance processing of multichannel data.

Currently, there are a number of proposals from commercial manufacturers of systems for registration of neuronal activity *in vitro*, but they are characterized by fixed functionality and high cost. At the same time, similar system can be manufactured with a substantially lower cost on the basis of modern electronic components. The development of these solutions can contribute to new advanced studies of biological neural networks functioning.

The main objective of this work is to develop a system for interfacing with biological neural networks *in vitro* on the basis of the technique of multichannel recording and stimulation of electrical activity of cultured neurons.

For interfacing with cultured neurons, the 64-channel microelectrode sensor of electrical activity has been designed. The sensor consists of planar glass base with transparent indium-tin-oxide conducting tracks serving as electrodes. The electrodes are insulated by layer of silicon oxide. The openings in insulation forms contact pads at the sensor's sides and working area in the center. The chamber for neuronal culture solution is placed on the top of the sensor.

The system for placement of 64-channel sensor of electrical activity of neurons with connectors to registration/stimulation systems has been manufactured and tested. The system has a mechanism for sensor clamping to the base board by adapter board with spring-loaded pins. Spring-loaded pins provide signal transmission from the sensor pads and accurate mechanical fixing of glass substrate.

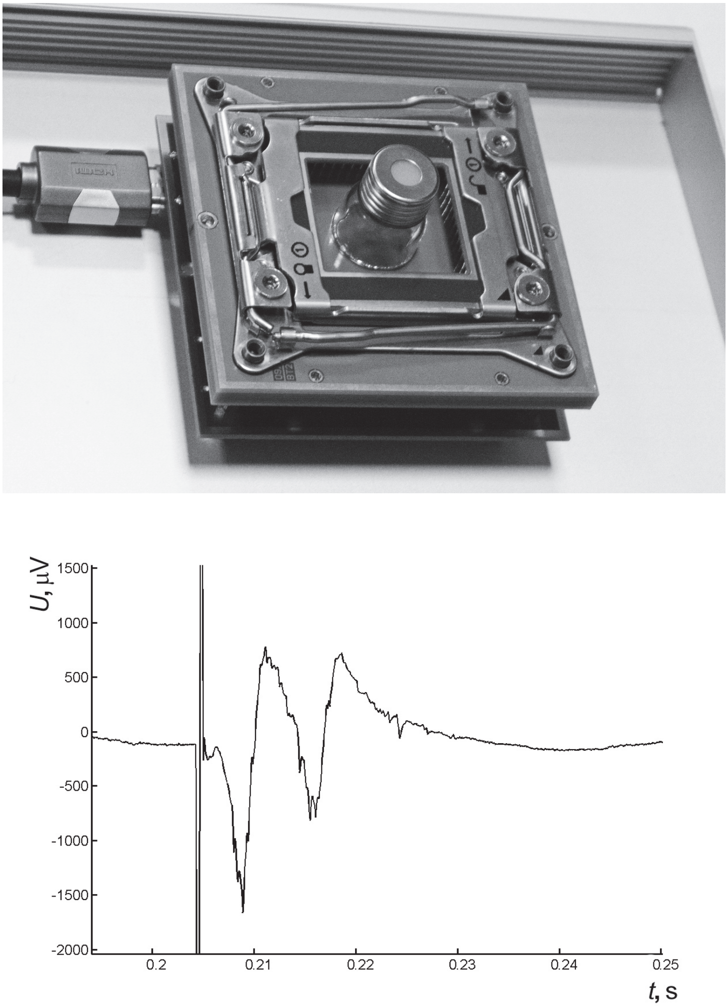
For recording of electrical activity of neurons, a specialized 64-channel amplifier has been developed. The base of the amplifier is a 32-channel integrated circuit RHD2132 (Intan Technologies, USA) with built-in analog to digital converter and digital serial interface. For recording system testing purposes, an autonomous 64-channel generator of test electrical pulses has been developed. Each channel has equivalent RC neuron model and parameters of the pulses correspond to the typical values of extracellular electrical activity of neurons.

The digital interface of RHD2132 chips is connected to the computer via an input-output system based on field-programmable gate array chip. Basic recording and visualization operations are controlled by the open-source software.

We have also developed and tested a four-channel computer-controlled optically isolated generator of stimulating current pulses. The complete system will be capable of independent 64-channel recording and stimulation of electrical activity of the cultured neural network.

The recording system with installed planar sensor and glass chamber for neuronal culture is shown at Fig. 1*a*. Recording system has been tested in experiments with rat brain slices. The response of rat hippocampal neurons to electric stimulus is shown at Fig. 1*b*. Noise level is low comparing to amplitude of the recorded population spike.

We can conclude that the system developed is capable of multichannel neural activity registration. The system has modular design – hardware and software components can easily be upgraded and scaled up, for example, neural spike detection software module can be added. Multichannel interfacing with neural ensembles opens possibilities for sophisticated experiments aiming investigation of learning processes in neural networks *in vitro*.



a

b

Fig. 1. (*a*) The recording system with planar sensor and culture chamber installed. (*b*) Neuronal response recorded from rat hippocampal slice

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