1SDA-02 培養神経細胞・神経回路操作のための表面マイクロ加工技術
Manipulating neurons and neuronal networks with micropatterned surfaces

Primary neurons cultured on a conventional coverslip grow neurites in random orientation and form a uniform network that covers the whole surface (~ cm). Using micropatterned surface as a growth scaffold, direction of neurite outgrowth in single neurons or the region of network formation can be extrinsically controlled. Such micropatterned neurons and networks allow us, e.g., to study development of neurons and to investigate how structure of the network determines its function. Here we present our recent work on the application of surface nano/micro-modification techniques in manipulating neurons and their networks. (Yamamoto et al., Appl. Phys. Lett. 99 (2011) 163701; Yamamoto et al., J. Neurochem. 123 (2012) 904-910.)

1SDA-03 Noninvasive real-time measurement of dopamine, action potentials, and postsynaptic potentials using carbon nanotube electrodes chip
Ikuro Suzuki (Department of Electronics, Tohoku Institute of Technology)

Multi-electrode arrays (MEAs) can be used for noninvasive, real-time, and long-term recording of electrophysiological activity, but it is still difficult to measure presynaptic activity, such as neurotransmitter release. In this study, we describe the development of planar carbon nanotube (CNT)-MEA chips that can measure both the release of the neurotransmitter dopamine as well as electrophysiological responses. Chronoamperometric measurements using these CNT-MEA chips detected dopamine at nanomolar concentrations and synaptic dopamine release from spontaneous firings. Our CNT-MEA chips made it possible to measure presynaptic activities, postsynaptic potentials, and action potentials, which have a central role in information processing in the neuronal network.

1SDA-04 神経ダイナミクス解明のためのレーザー挾動技術の開発
Laser-induced perturbation into living neuronal networks: Toward understanding neurodynamics
Chie Hosokawa (Health Res. Inst., AIST)

Living neuronal networks have been widely studied to elucidate information processing in brain systems. In order to realize artificial control of spatio-temporal dynamics in neuronal activity, we propose and demonstrate laser-induced perturbation into living neurons. Optical tweezers were applied to manipulate synaptic vesicles and neural cell adhesion molecules labeled with quantum dots in neurons. The fluorescence analysis revealed that these were trapped and assembled at the focal spot, because the small assemblies were effectively trapped. Moreover, laser processing and stimulation of neurons was succeeded with a focused femtosecond laser. Our methods have potential in realizing regulation of neuronal networks without application of any drugs and genes.

1SDA-05 Revealing Neuronal Dynamics through Advanced Electrophysiology and Chemical Sensing using CMOS Technology
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Measuring neuronal activity accurately and simultaneously is key for advancing our understanding of how the brain processes information. Microelectrode arrays (MEAs) are used for highly parallel, non-invasive, and long-term measurements from large assemblies of neurons in cell cultures, brain slices and retinal preparations. The use of CMOS technology for MEAs allows increasing the sensor count and spatial resolution drastically.

We present our recent progress in advancing MEA technology and in integrating carbon nanotubes to sense the chemical microenvironment in the extracellular fluid. We discuss our research on Purkinje cell functional dynamics in acute cerebellar slices and our investigations on subcellular extracellular dynamics of neurons in vitro cultures.

1SDA-06 培養神経回路網における情報表現
Information presentation in cultured neuronal networks
Suguru N. Kudoh (Department of Human System Interaction, School of Science and Technology, Kwansei Gakuin University)

A small-scale network of dissociated neurons cultured on a multielectrode-arrays-dish is one of useful models of fundamental units for brain information processing. Spatiotemporal patterns of electrical spikes evoked by external inputs were not only various but also reproducible, specific for stimulation electrodes. X-means clustering applied to the feature vectors of electrical spike activity revealed that there were numerous patterns of activity, however, highly reproducible spike patterns were not much, approximately 15 clusters in a 10-min-recording of spontaneous activity. These patterns were also modified according to the temporal pattern of input stimuli, suggesting that the cultured neuronal network possesses a short-term memory.

1SDA-07 聴覚皮質における聴覚神経応答の解析及び神経ダイナミクス制御のためのマイクロデバイス開発
Analysis of auditory neural responses in the auditory cortex in vivo and development of microdevices to control neurodynamics
Jun Nishikawa, Takeaki Haga, Yuishi Tachibana, Yasutaka Yanagawa, Takashi Tateno (Grad. Sch. of Inf. Sci. & Tech., Hokkaido Univ.)

Understanding sensory neural representation is important to realize bidirectional brain-machine interfaces (BMIs) to restore sensory function. In this study, we firstly analyzed neural response properties to auditory stimuli in rodent auditory cortex using spatiotemporal receptive fields (STRFs). The result showed different response properties in each cortical layer and subfield in the auditory cortex. Next, we developed a CMOS-based LSI system that is capable of both stimulation and recording of neurons at 64-ch electrode sites. We showed that various spatiotemporal patterns of stimulation can be applied and we can record neural signals from each stimulating electrode around 5 ms after stimulation. This microdevice could be a promising platform for bidirectional BMIs.