Electrophysiological MEMS Device with Micro Channel Array and Its Application to Analysis of 3D Cell Culture Construct

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This thesis describes electrophysiological devices with MCA (Micro channel array) and its application to analysis of 3D cell culture construct. It is important cell-cell interactions of in vitro cell tissues formed by controlling the environment on the level of single-cell are analyzed to understand a mechanism of biomedical tissues with complicated cellular networks. Cell analysis devices using MEMS (Micro electro mechanical systems) and μTAS (Micro total analysis systems) technologies are required to realize above analysis. This thesis reports on the following issues aiming at in-vitro multiscale bio-interfaces from single-cell to 3D cell culture structure: (1) Multipoint recordings of cellular networks cultured on a MCA integrated with suction holes and electrodes, (2) Magnetic cell induction using a MCA integrated with ferromagnetic paths, and (3) Multipoint recordings of a 3D cell tissue constructed on a MCA with spatially arranged microelectrodes. This thesis is comprised of 7 chapters. Chapter 1 describes the background, objective and overview. In chapter 2, a MCA structure integrated with suction holes and electrodes is described. A recording technique of electrophysiological signal and cell clamping on the single channel were demonstrated. Chapter 3 presents electrophysiological MCA devices. Signals of a slice tissue could be recorded using MCAs of batch- and multi-recording types, and a transparent type. Chapter 4 describes an improved MCA for cellular network analysis. Spontaneous and evoked activities of cultured neurons on the MCA could be successfully recorded at multiple points. In chapter 5, a MCA with magnetic paths for cell manipulation are described. Magnetically labeled cells scattered on the MCA could be successfully induced to the magnetic paths. Chapter 6 describes a MCA with spatially arranged microelectrodes toward in vitro cell tissue analysis. It was indicated electrophysiological activities depending on the growth of 3D neuronal structure could be recorded. The final chapter summarizes this thesis.