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Cultured neural networks : optimization of patterned network adhesiveness and characterization of their neural activity

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Abstract-A 'cultured probe' is a hybrid type of neural information transducer or prosthesis, for stimulation and/or recording of neural activity in the brain or the spinal cord (ventral motor region or dorsal sensory region). It consists of a micro electrode array (MEA) on a planar substrate, each electrode being covered and surrounded by a local circularly confined network ('island') of cultured neurons, obtained by chemical patterning of the substrate. The purpose of the local networks of cultured cells is that they act as intermediates for collateral sprouts from the in vivo system , thus allowing for an effective and selective neuron electrode interface. As the local neural network of cortical neurons can also become spontaneously active and therefore has the principal capability of information processing, one may even envisage future applications of these intermediary networks as 'front-end' signal processors.

A general problem in the development of (local) cultured neural networks is that eventually the flat networks tend to aggregate into (3D) clusters or that islands tend to become connected by fasciculated neural interconnections. Optimization of the network-substrate adhesive properties is therefore one of the main research goals.

Two aspects of the development of this kind of cultured probe device are described. First, progress is shown on how substrates can be chemically modified to confine developing networks, cultured from dissociated rat cortex cells, to 'islands' surrounding an electrode site. Additional coating of neurophobic, polyimid coated substrate by tri-block-copolymer coating enhances neurophilic-neurophobic adhesion contrast enormously. Secondly, the paper presents results on neuronal activity in patterned, unconnected and connected, circular 'island' networks. The larger the island diameter (50, 100 or 150 μm), the more spontaneous activity is seen, for connected islands. For unconnected islands, activity may start at 22 DIV, which is two weeks later than in unpatterned networks. For connected islands, activity may show a very high degree of synchronization between two islands.

Keywords - Neural networks, network patterning, network activity, MEA, neurophilic/neurophobic substrate coating, synchronization