A dual-chamber microelectrode array to facilitate neuronal network communication

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This work is focused on building compartmentalized microelectrode arrays to control communications between two *in vitro* neuronal networks. The goal is to assess the impact of conditioned cell culture media exchange between two initially isolated neuronal networks. There are two types of brain cells – neurons and glia, and astrocytes, a type of glial cell, significantly contribute to the synchronization of neuronal network activity. Mutations in genes of proteins produced by astrocytes can adversely impact neuronal synchronization and synapse formation leading to neurodegenerative diseases like Alzheimer[1]. Studies have shown that neurons grown in culture in the absence of astrocytes do not form strongly connected neuronal circuits, while neurons grown in the presence of astrocyte-conditioned media develop healthy functional networks[2]. Specialized microelectrode arrays may facilitate the investigation of differences in neuronal firing activity in networks where fully functional astrocytes are present vs. networks with genetically modified astrocytes that will impair neural synchrony. Network activity will be compared before and after cell culture media exchange.

Dual-chamber microelectrode arrays are fabricated and consist of Ti/TiN electrodes that record the electrical activity in 58 locations and two reference electrodes. A quartz substrate was chosen because it provides transparency in both visible and ultraviolet illumination which will be required for monitoring cell growth and performing fluorescence measurements. A thick SiO_2 isolation layer is patterned on the surface, allowing 30 μm wide openings only at the neural recording and measurement sites. A temperature-resistant resin ring with a removable partition is 3D printed and glued on the substrate. This microelectrode array is designed to provide two separate chambers, each containing 29 recording sites and one reference electrode. Since both inorganic and organic materials are used for the fabrication, sterilization of the dual-chamber array is done via gamma radiation. Surface functionalization with poly-D-lysine and laminin provide biocompatibility for cell growth. This dual-chamber system allows two neuronal cell cultures to develop separately; media exchange will occur once the partition is removed. The developed microelectrode array enables the electrical monitoring of developmental changes in two *in vitro* neural networks and can be used for a variety of studies in neurophysiology.

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