Brain on Chip

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Microfabricated multi-site electrode arrays (MEAs) have attracted immense interest in the neurosciences because of their high spatial resolution, high-throughput capability of carrying out tests and ease of handling. More recently, Laboratory-on-a-Chip technology has been introduced in this field, too, enabling the development of novel brain models in a dish facilitated by MEMS technology. These miniaturised systems claim a significant reduction of animal models and propose a number of advantages in the study of neuronal processes.

We hypothesise that for brain disorders characterised by abnormal signalling, 3D cell co-culture models will simulate natural neuronal networks more effectively than 2D systems, and may therefore serve as a more relevant physiological model to study novel therapeutic procedures.

The creation of platform technology, which allows us to reliably co-culture both neurons and support cells within a 3D interconnected configuration, will require essential vascularisation. In this contribution, the combination of microfluidics, tissue engineering and neuroelectrophysiology on MEA-chips is presented as a tool to generate a better understanding of both healthy and diseased brain function. We will explain our systems' design in the context of the different length scales of biology and discuss our approach of utilising a miniaturised cell culture chamber to facilitated 3D tissue culture atop of MEAs[1] as well as introduce the directive nature of nanogrooved cell culture substrates[2], showing that these physical cues add in neuronal cell differentiation.

The main objective of this work is to design and develop microsystems, which allow to further our understanding of biological function with respect to the influence of nanocues in cell-cell communication within a neuronal network formed from cells' inside of scaffolds, which preserve the cell's three-dimensional morphology[3].

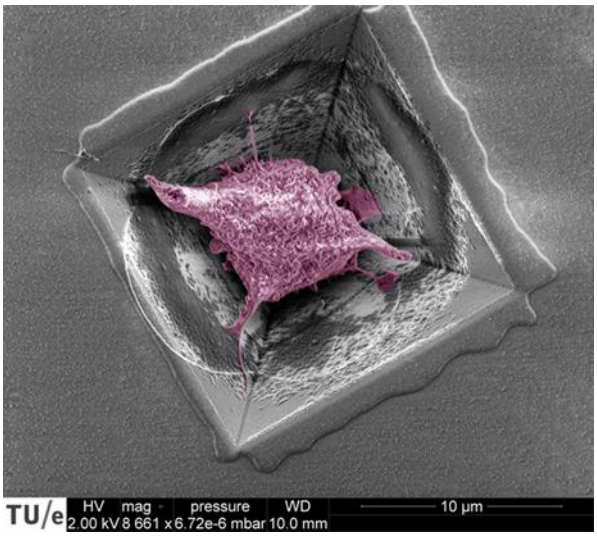

Figure 1: 3D pore of silicon microsieving structure capturing a neuron-like cell: Scanning electron micrograph of a SH-SY5Y cell cultured for 7 days in vitro inside of one of 900 pores in the microsieve, whereas 60 out of 900 pores are actually functionalised by a thin-film electrode matching the layout of commercial MEA readers.

References

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