Guiding, Rectifying and Sorting of Regenerating Axons by Free Standing Nanowire Patterns: A highway for nerve fibers.

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Axon guidance is of crucial importance when building neuronal networks or neural interfaces. Controlling the connections between neurons by guiding their axons on a chip surface offers the possibility to address axons from different types of neurons e.g. motor neurons and sensory neurons in different locations on a chip. We have shown that neurons can grow on free standing nanowires substrates [1] and that parallel rows of nanowires provide an excellent way of controlling cell growth and guidance of regenerating axons [2]. The rows of wires act as fences, confining the axons between two rows of nanowires. The small radius of the wires prevents the axon from climbing the nanowires as the growth cone always encounters the wires at a 90° angle, in contrast to micro structured walls, where fibers can reach the top of the wall by climbing at an intermediate angle. We have also shown that focal adhesions of the nerve fibers form specifically at the nanowires. Compared to walls, grooves and channels, the nanowire fences offer a higher degree of guidance. They also have a very open architecture, allowing a free flow of nutrients and oxygen, avoiding deficiencies that might occur in solid channels. Here, we present an EBL-defined nanowire pattern that allows us to differentiate between axons growing from different locations. Patterns of short rows of nanowires are used to rectify axonal outgrowth and we demonstrate that axons from two different populations can be fully separated, thus creating the possibility to independently address two populations of axons on a chip surface. These results, together with our earlier findings provide a basis for advanced control of neuronal growth on a chip, where a large range of functionalities can be implemented, including chemical sensors and electrodes to investigate neuronal function at high temporal and spatial resolution.

[1] W. Hällström, T. Mårtensson, C. Prinz, P. Gustavsson, L. Montelius, L. Samuelson, M. Kanje : *Gallium phosphide nanowires as a substrate for cultured neurons*. Nano Letters 7 (10) : 2960-2965 Oct 2007.

[2] C. Prinz, W. Hällström, T. Mårtensson, L. Samuelson, L. Montelius, M. Kanje: *Axonal guidance on patterned free standing nanowire surfaces,* Nanotechnology, 19 (34), 345101, Aug 2008.