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Nano-Micro Tubes & Fibers for Biomedical Applications

By advancing the technology man is now capable of producing ultra-fine fibers & tubes from different materials like Carbon, ceramic, plastic, metal and semiconductors. This advancement has revolutionized human life and moved the technology to a new dimension. A wide range of industrial and biomedical applications are based on these tiny tubes and fibers. The key secret that makes these fibers and tubes suitable candidates for a broad range of applications lies on their high aspect ratios (surface/volume) and the possibility to make large networks.

For a long time it was believed that the properties of materials depend only on their atoms and molecules and the interconnections between them. However today we know that these properties can change remarkably when the size of a material shrinks to nanoscale dimension. This size dependency in nano dimension is due to changes that happen to the electronic properties (like magnetic properties and electrical conductivity) of the material when the size of the material is on the nanoscale. This phenomenon is known as the quantum size effect and can be described by quantum mechanics. As a consequence of this effect, physical properties of the materials in nano dimension will be different from what is measured in bulk state. Weak interactions like van der Waals or hydrogen bonds can have a quite large effect in quantum realm (where at least one dimensional size is less than 100 nanometers and quantum size effects become important). For example, DNA with a cross section of 2nm is consisting of two helixes, and a large number of hydrogen bonds keep them together Ref. [1, 2]. Quantum effect may affect the interaction between the nanofibers (diameter <100 nm) and the biological entities like axons (nerve fibers) or cells. The effect can also appear in metallic nanostructures where the surface plasmon effect becomes important. Surface Plasmon effect occurs when light hits metal nanostructures and causes electron density waves (plasmons).

These effects are important in some special applications (e.g. plasmonic biosensors) and can appear in nanofibers and in metallic thin shell of metal nanotubes that were produced during this master work.

Networks of polymer based Nano-Micron size fibers and tubes with a large surface-to-volume ratio are the bases for a wide range of industrial and medical applications and various research branches. They can provide a true 3D environment with the capability of mimicking Extra Cellular Matrix (ECM) for supporting cellular life and Cell-division cycle with a good cell-fiber adhesion property and the possibility of high density cell culturing. They are capable of cellular differentiation, guiding axons, migrating cells and other cell extensions, guiding light, carrying electricity and liquid, drug release, exchanging heat, become magnetic and vibrate in dynamic electromagnetic and sound fields. Some of these capabilities have already been investigated in this master work and the novelty of some of the ideas and implants that I worked on during this master work, has been confirmed by the Lund University Innovation System (LUIS). These networks of tiny tubes & fibers have the potential to be used in a variety of biomedical applications especially in *nerve regenerative implants* and *neural electrodes*. Combing light with these networks can bring new concepts to these fields and may open a new window in neuroscience for diagnosis and treatment of neurological disorders and diseases.

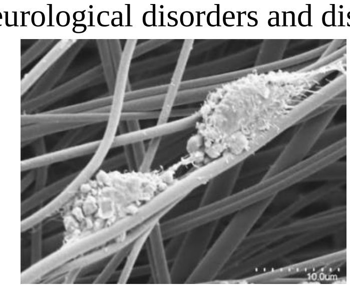

Fig.1. Fibroblast-PLLA (Poly-L-Lactide Acid) aligned micro fibers
The fibers support ***cellular life and Cell-division cycle***

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References:

1- Fundamental "Nano effects" Luisa Filipponi and Sutherland. Interdisciplinary Nanoscience Center (iNANO) Aarhus University, Denmark January 2010

2- Quantum size effects in nanostructures Lecture notes to the course Organic and Inorganic Nanostructures Kjeld Pedersen Department of Physics and Nanotechnology Aalborg University