Biomaterials and nanostructured surfaces

Projects available for MTNANO and BIOPHYSICS students

Contacts: Prof. Pawel Sikorski, Department of Physics, NTNU, pawel.sikorski@ntnu.no
More information: http://www.ntnu.edu/physics/bionano

PROJECT 1: Nanotechnology based cell transfection. From development of the fabrication process to device applications.

In recent years we have been working on development of a novel system for the deliveryof bioeffector molecules (transfection) to cells. The system is based on CuO nanowires integrated in a polymer device and rely on a robust fabrication method to produce large area, defect free and highly reproducible arrays of CuO nanowires on copper foils. Controlled perturbation of living cells *in vitro* is a large endeavour in modern cell biology, with a main aim to understand cell function at a molecular level. This is important both from the perspective of fundamental, curiosity driven research, as well as key to understand diseases and to develop new treatments. This controled perturbation can be achieved by delivery of bioeffector molecules. This project is a continuation of the project running in 2012/2013, and is closely integrated with research activities in our group. Exact details will therefore depend on the outcome of the currently ongoing research and which aspects of the project is most interesting for the student. It could include the combination of bottom-up (CuO nanowire growth) and top-down (basic UV lithography) fabrication, device characterization by SEM/STEM, cell experiments, optical, fluorescence and electron microscopy of cells. In addition to device development

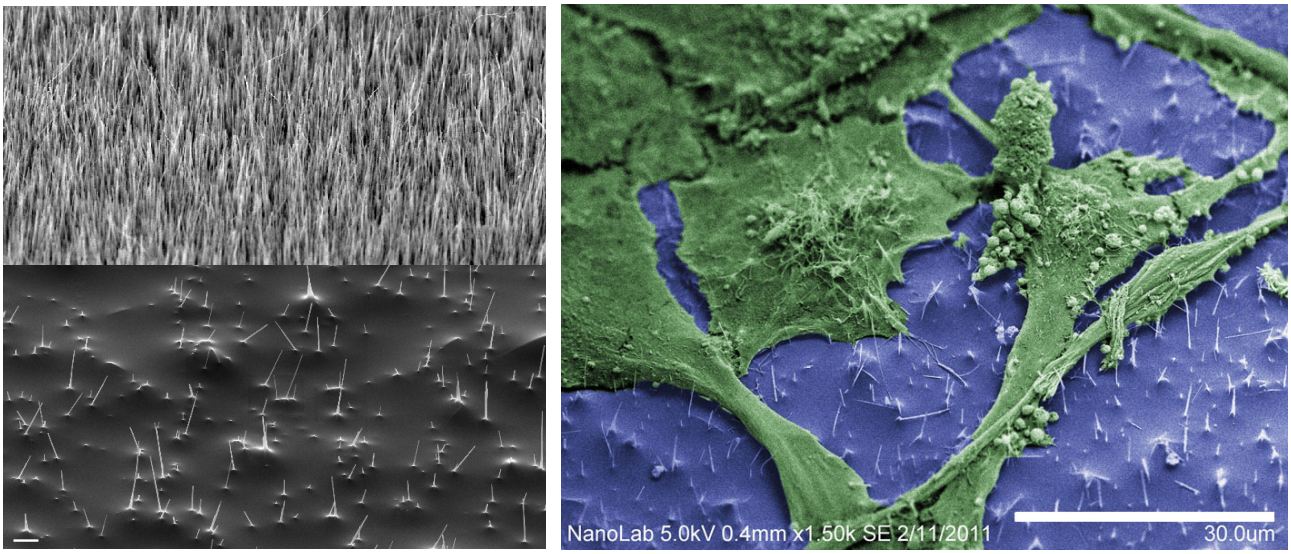

Figure 1: Array of vertically aligned CuO nanowires and sketch of the chemical composition of the substrate. Cells growing on nanowire decorated surface (photo: F. Mumm and K.Beckwith, NTNU)

and cell experiments, we would like to focus on a more detailed description of oxide nanowire growth (using growth at controlled conditions and characterization with SEM and X-ray diffraction).

We are looking for motivated and dedicated students interested in nanofabrication and bionanotechnology to work in active and multidisciplinary research group. Around 50% of the project work will be done in the NTNU Nanolab.

Co-supervisors: PhD student Kai Beckwith, Dept. of Physics, NTNU (kai.beckwith@ntnu.no)

Colaboration: Astrid Lægreid, Torunn Bruland, Department of Cancer Research and Molecular Medicine, NTNU
NTNU Project student 2012: Åsmund Flobak (MTNANO), Jonathan Torstensen (MTNANO)
See also: Florian Mumm, Kai M. Beckwith, Sara Bonde, Karen L. Martinez, and Pawel Sikorski. A Transparent Nanowire-Based Cell Impalement Device Suitable for Detailed Cell-Nanowire Interaction Studies. Small 2013. 9, 2, 263–272.

PROJECT 2: Micropatterning of cells for controllable, high-throughput *in vitro* model systems.

The last 60 years, studies on cell lines grown on glass or plastic have given a wealth of information about cell biology and disease pathology. However, there is great potential for further developments to teach us more about complex diseases, drug testing, genome-environment interactions, etc. Further developments include increased control over the cells' microenvironment and signaling molecules, cell growth and more organ-like cell cultures, while maintaining simplicity and compatibility with typical microscopy and biochemical techniques. In addition, high throughput is desired to increase the number of variables that can be tested, requiring systems that are possible to automate. Our group has recently developed a simple yet robust platform that allows patterned cell growth (see Figure 2). This is done by combining a cell-repelling polymer (polyvinyl alcohol) with a cell-adhesive polymer (polydopamine), which is patterned using soft-lithography techniques.

We are looking for students interested in bionanotechnology to work in an active and multidisciplinary research group to further develop this project. Specific goals include increasing the cell patterning capabilities through e.g. nanoimprint lithography, making more versatile devices that can pattern multiple cell types and biochemical functionalities, integrating the devices with microfluidic systems, or testing of new material combinations that allow for further control of cultured cells. Depending on the specific project, fabrication techniques can include photolithography, nanoimprint lithography, soft lithography and microfluidics, together with polymer thin films and surface modification chemistry. Characterization of the devices is done mainly by optical microscopy and confocal fluorescence microscopy, but electron microscopy and atomic force microscopy can also be relevant. The project will give a good background in the use and modification of bio-active materials, as well as cell culturing work. Around 30% of the project work will be done in the NTNU Nanolab.

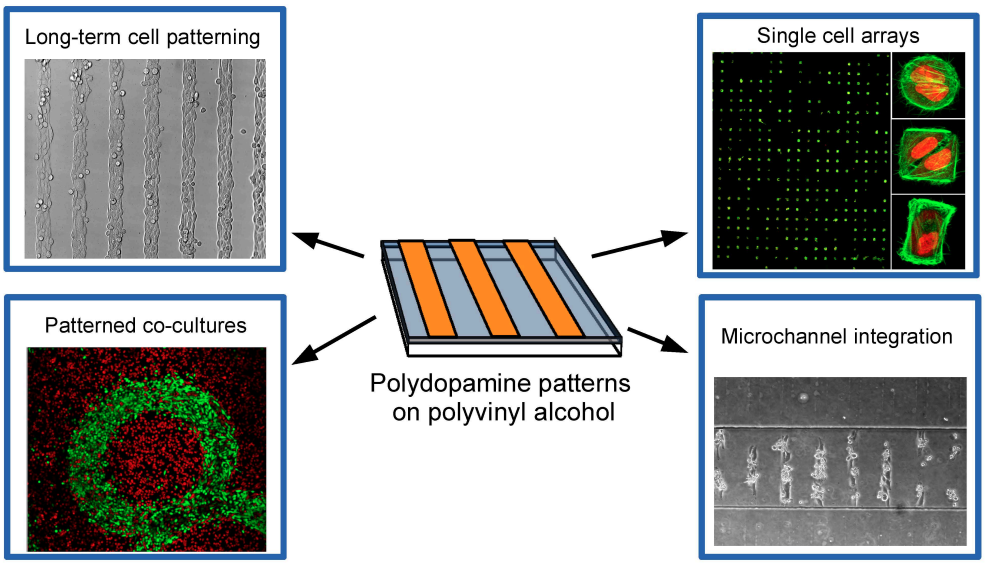

Figure 2: Different possibilities for control of cell cultures using the polyvinyl alcohol/polydopamine system (photo: K. Beckwith, NTNU).

PROJECT 3: Application of focused ion beam (FIB) and scanning electron microscopy (SEM) for characterization of tissue, cells and biocomposites for tissue engineering applications.

FIB is a promising method for nanometer scale characterization of biological composite materials. The aim of the project is to develop sample preparation methods and imaging techniques suitable for obtaining information regarding 3D organization of tissue and cell samples, as well as composite materials for applications in tissue engineering. Those materials developed mainly for tissue engineering applications are made as a part of larger research effort at NTNU. Cell and tissue samples will be related to research on tuberculosis, a global infectious disease that still claims close to 2 million lives every year. The FIB will be used to further examine the host-pathogen relationship and study granuloma (infectious foci wrapped in dead cell material) in 3D. This project is a continuation of the master projects by Ker Roger Ervik (2011) and Marianne Sandvold (2012).

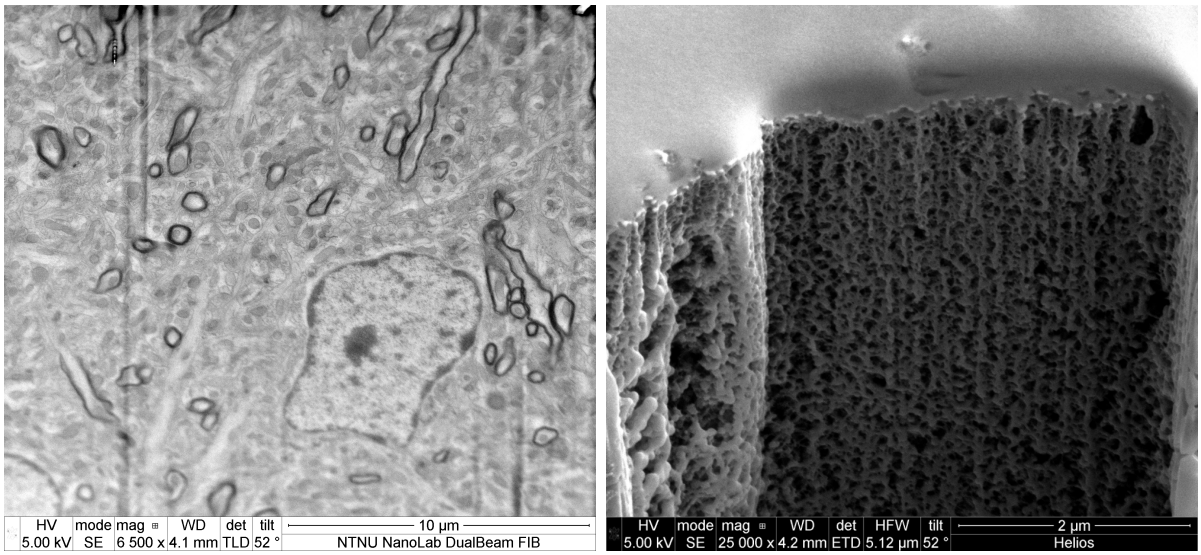

Figure 3: Electron microscopy image of brain tissue sample sliced with FIB (left, photo Marianne Sandvold, MTNANO Master Student) and FIB milled hydrogel material (right, photo: Ken Roger Ervik, MTNANO Master Student).

Project will give good background in microscopic characterization of biomaterials. We are looking for students interested in microscopy (especially electron microscopy) and bionanotechnology to work in active and multidisciplinary research group. Around 75% of the project work will be done in the NTNU Nanolab. **Summer job related to this project is possible**.

Collaboraton:

Prof. Øyvind Halaas, Department for Cancer Research and Molecular Medicine

Prof. Menno Witter, Kavli Institute for Systems Neuroscience, Centre for the Biology of Memory; http://www.ntnu.no/cbm/witter