NANOIMPRINT LITHOGRAPHY : TECHNOLOGY. PROSPECTS AND SOME APPLICATIONS

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Recent years have seen a large interest in development of new lithographic techniques. One of these that have quickly reached a level of maturity that makes it useful for practical applications is nanoimprint lithography (NIL) (ref 1). This cost-efficient, high throughput method opens new avenues for nanoscale research in general and for nanobio in particular where often a need for many samples exists in order to probe the variability that characterizes biological systems (ref 2).

In this talk, I will address its use for the study of protein interactions by discussing three specific projects. In all projects we explore nanostructured surfaces interacting with biomolecules demanding a retained biological function of the assembled biomolecules, e.g. proteins. The first projects deals with the fabrication of neural devices enabling mind-controlled prosthesis to be made. In the second project we address the possibility to make a nano-traffic system and explore its potential for high-throughput drug screening systems, in the third project single molecular interactions are studied using nanomechanical transduction and finally in the fourth project we explore the use of interdigitated electrodes for probing cellular activity. Below, due to space limitations, I describe in some detail only three of these projects.

Project 1: The potential impact of neuro-electronic junctions are enormous since they can be used to compensate for both sensory and motor deficits in the nervous systems e.g they could be used to restore vision, hearing and motor impairments but also autonomic functions. Crucial issues for such junctions are spatial resolution, selective guidance of different types of nerve fibers to hot spots i.e. recording or stimulating sites on the interface surface. With NIL we fabricated sets of positive and negative patterns, and each set consisting of seventeen different patterns with variable distances between ridges and grooves in the resist material (fig 1). We then used sympathetic ganglia to study axonal outgrowth on the chip surfaces. By immunostaining the axons were found to align along the protruding faces of the patterns (fig 2).

Project 2: The muscle proteins myosin and actin are important for the muscle contraction in living systems. When actin molecules tagged with flourophores are added to a myosin coated surface in presence of ATP, the interaction between myosin and actin molecules can be followed employing fluorescence microscopy. In our project we are using nanostructured surfaces in order to fabricate test tracks for guiding the movements and to achieve a rectified movement along the tracks [3].

Project 3: A cantilever can be used as a universal platform for sensing applications, especially as a mass detector. By decreasing the dimensions of the cantilever the sensitivity can be increased to the point where it is possible to perform single molecule detection. By using NIL and metal lift-off cantilevers can be made in large numbers, in arbitrary dimensions and of a wide variety of materials.

Each application presents new and unique challenges for NIL. It is our

experience that these usually relate to the ability to making good stamps [4]. Today we use a wide range of different materials, structuring techniques and etching methods.

REFERENCES

1. Heidari B., Maximov I., and Montelius L. 2000, Nanoimprint lithography at the 6 in. wafer scale, J. Vac. Sci. Technol. B 18: 3557

2. F. Persson, M. Beck1, P.Carlberg, T.G.I Ling and L. Montelius, Redox cycling in nanometer sized interdigitated sensor structures: A case for nanoimprint lithography, Applied Nanotechnology, 1st issue 2003.

3. R. Bunk, J. Klinth, J. Rosengren, I.A. Nicholls, S. Tagerud, P. Omling, A. Mansson, L. Montelius, Towards a "nano-traffic" system powered by molecular motors, Microelectronic Engineering (2003, Article in press)

4. Beck M, Graczyk M, Maximov I, Sarwe E-L., Ling T.G. I., Montelius L, Keil M. 2002. Improving stamps for 10 nm level wafer scale nanoimprint lithography, Microelectronic Engineering, 61-62: 441-8.

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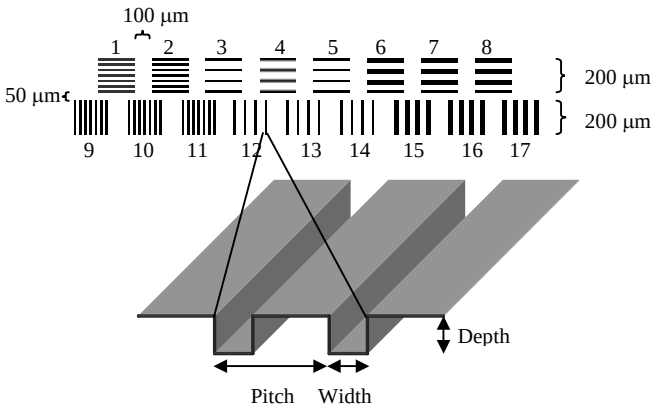

Figure. 1. *The features of the imprinted wafers on which the tests are performed. The wafers are ordinary 25 mm silicon wafer covered with PMMA 950. The pattern consists of 17 squares with grooves oriented horizontal and vertical and with different width and pitch.*

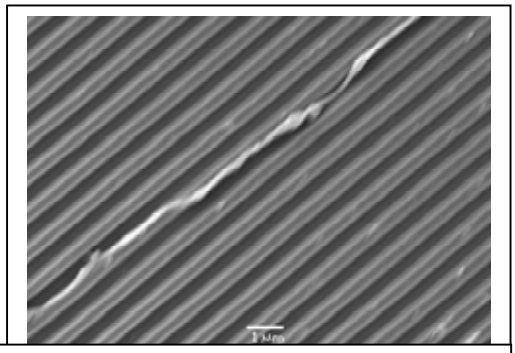

Figure 1. SEM pictures showing that the axons are growing on the ridge edges, and not in the grooves.

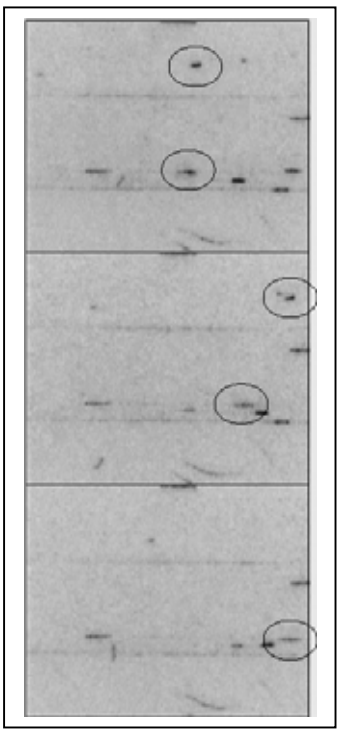

Figure 3. Left: Greyscale inverted image of optical micrograph showing fluorescently labeled actin moving approximately 30μm in polymer trenches.