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PATTERNING OF SURFACES WITH X-RAY INTERFERENCE LITHOGRAPHY AT MACROMOLECULAR LENGTH SCALES

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INTRODUCTION: Interaction of biological systems with artificially patterned surfaces attracts interest due to diverse potential applications. For example influencing growth of cells on patterned surfaces may have great impact in tissue engineering and implant applications, or controlling the molecular self assembly processes may lead to new ways of synthesis and analysis of biological materials. Until recently most experiments in the field have used surfaces patterned with micrometer sized or slightly smaller features. However when the feature sizes approach the length scales of the macromolecules involved in biological processes we can expect to have more and potentially stronger ways of influencing the interaction between the artificially patterned surface and the biological system the surface is in contact with. Here we introduce a new way of patterning surfaces that can be used for this purpose.

METHOD: X-ray Interference lithography (XIL) offers a way to achieve high resolution patterning that is beyond the capabilities of today's production techniques. In IL two or more coherent light beams are brought together to form an interference pattern which is then recorded in a photosensitive material. In general the patterns achieved with IL are periodic; e.g. one-dimensional line/space patterns or two dimensional dot arrays are readily obtained. Lasers are commonly used as light sources in IL due to their coherent properties. We have extended the technique to the x-ray region where the extremely small wavelength has allowed us to achieve patterns with periods as small as 40nm[1]. The theoretical limit for pattern period is equal to the half of the wavelength, which is about 6nm in our system. The technique is based on the coherent light available from modern synchrotron sources. We have recently completed the construction of a unique X-ray interference lithography facility at the Swiss Light Source in Switzerland. The main goals of the project are to produce patterns with sub 50nm periods, over areas as large as several square millimeters with high throughput. The technique has advantages over alternative techniques; e.g. it has higher throughput and higher resolution for dense patterns than electron beam lithography.

In this project we target applications that require high resolution periodic patterns which are not easily available from alternative methods. This includes production of patterned templates that can later be used for guided self-assembly of macromolecular systems such as block copolymers[2] or crystallization of proteins. Periodic patterns with nanometer scale resolution can be used to influence the growth of cells and tissues. Even though cells are often as big as tens or hundreds of micrometers, the processes and intracellular structures have much smaller length scales. There is growing evidence that through these processes high resolution surface patterns influence cell growth behavior[3].

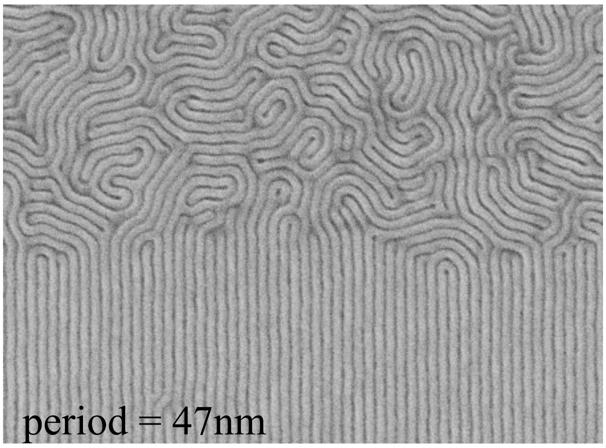

Fig. 1: Epitaxial self-assembly of a block copolymer film on a surface patterned with X-ray interference lithography. The upper part of the SEM image shows the random orientation of the block copolymer domains in the un-patterned area of the sample whereas the domains in the lower part have aligned themselves to the lithographically defined surface template.

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