

Novel Micro- and Nanopatterning Techniques for Biological Applications Using Particle Self-Assembly as Template

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INTRODUCTION: Nanopatterns for bioapplications are increasingly popular because they provide novel tools to address biological problems. For example, protein nanoarrays not only enable molecular level statistics of binding events but also offer an increased sensitivity compared to microarrays. Additionally, nanopatterning plays a key role in cell studies, where cell-cell or cell-extracellular matrix interactions can be investigated. Particles arranged into 2D ordered structures can serve as a template for the fabrication of well-defined nanostructures. Certain novel applications, such as single molecule fluorescence studies, require nano-sized features in geometrically ordered patterns with a separation between the features in the low micrometer range in order to be able to detect individual nanostructures by optical microscopy.

METHODS: To achieve such patterns we have self-assembled micron sized latex particles by dip-coating and controlled drying in aqueous suspensions on silicon wafers and microscopy glass slides (sputter-)coated with 70 nm SiO₂ (intermediate layer) and 11 nm TiO₂ (overlayer). The latex particle patterns were then etched by reactive ion etching (RIE) to homogeneously reduce the size of the latex. Size and morphology of the latex features created after RIE strongly depend on the parameters, such as gas composition, forward power and chamber pressure, used during the RIE. The etched latex particle patterns can be used to create biologically active molecular assembly patterns by lift-off (MAPL) [1] or can serve as a mask to create an oxide contrast in the underlying substrate by RIE. The latter technique produces TiO₂ pillars in a SiO₂ background. With the selective molecular-assembly patterning (SMAP) [2] technique the oxide contrast is translated into a biochemical contrast, by two simple dip-and-rinse processes. In short; alkane phosphates SAMs are created on the TiO₂ pillars by selective assembly and in a second step the SiO₂ background is passivated towards unspecific protein adsorption with poly(L-lysine)-graft-poly(ethylene glycol) (PLL-g-PEG). SMAP patterns are then used for specific protein adsorption on the protein adhesive alkane phosphate SAM nanostructures while the background is protein resistant.

RESULTS: We will present results on SMAP nanopatterns as described above showing the crucial steps and parameters starting from the self-organized latex particle patterns to the RIE patterns (Fig. 1) all the way to the nano-sized protein patterns produced by the SMAP technique.

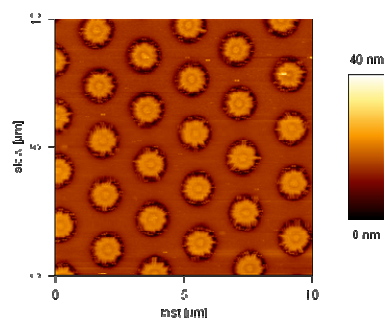


Fig. 1: AFM image of the etched oxide substrate after lift-off of the latex particles (1.9 μm). The height of the pillars is ~15 nm.

DISCUSSION & CONCLUSIONS: We were able to produce nano-sized features of TiO₂ separated in the micron-range in a SiO₂ background and could successfully apply these patterns to SMAP patterns.

Future applications of our nanopatterned substrates include the study of cell-surface, vesicle/bilayer as well as protein-surface interactions.

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