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Optimizing Etching Parameters to Produce Ordered Nanochemical Patterns

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INTRODUCTION: Nanopatterns for bioapplications 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. 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 controlled drying from aqueous suspensions on silicon wafers (sputter-)coated with 46 nm SiO_2 (intermediate layer) and 11 nm TiO_2 (top layer). The latex particle patterns were then etched by reactive ion etching (RIE) to homogeneously reduce the size of the latex. The etched latex particle patterns served as a mask to create a metal oxide contrast into the underlying substrate by RIE. This technique produces TiO_2 pillars in a SiO_2 background. Size and morphology of the latex features created after RIE as well as the etch rates of SiO_2 and TiO_2 strongly depend on the parameters, such as gas composition, forward power and chamber pressure used during the RIE. Optimizing the etching parameters was the topic of this work.

RESULTS: We successfully performed above mentioned two-step RIE process to produce a well defined metal oxide contrast with nano-sized TiO_2 features in a SiO_2 background.

Etching of the latex spheres was performed with 50 sccm N_2 and 50 sccm O_2 (100 W, 100 mtorr, 12 min) leading to shrinkage of the spheres from 1.9 µm to 750 nm as shown in Figure 1.

After the latex particle mask was etched to the wanted size, the metal oxide substrates were etched through this mask. Best selectivity for the metal oxides was achieved with 95 sccm SF_6 and 5 sccm O_2 (80 W, 100 mtorr, 2 min). With these settings we successfully achieved metal oxide contrast dot structures. The diameters of the TiO_2 pillars in the SiO_2 background were in the range of 200 nm, separated by the distance of the initial particle diameters (1.9 µm).

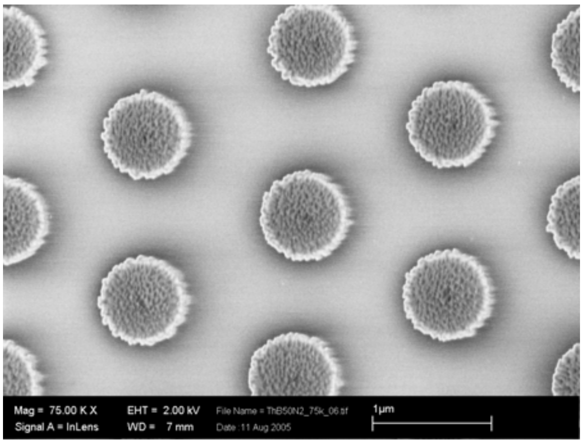

Fig. 1: Scanning electron microscopy image of latex spheres after RIE (50 sccm N_2 and 50 sccm O_2, 100 W, 100 mtorr, 12 min)

DISCUSSION & CONCLUSIONS: We were able to define RIE parameters which allow for the creation of TiO_2 nanopillars in a SiO_2 background with latex particles as etching mask.

The selective molecular-assembly patterning (SMAP)[1] technique can transfer the metal oxide contrast into a biochemical contrast, by two simple dip-and-rinse steps. In short; first alkane phosphates self-assembled monolayers (SAMs) are created on the TiO_2 pillars. In a second step the SiO_2 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 nanofeatures while the background is protein resistant.

REFERENCES: [1]R. Michel et al. (2002) *Langmuir* **18**:3281-3287.

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