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CONTROLLED SYNTHESIS OF 3D NANOSTRUCTURES USING PROXIMITY-FIELD NANOPATTERNING LITHOGRAPHY AND GRADED TEMPERATURE ALD

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The combination of Proximity-field nanoPatterning (PnP) and graded temperature ALD has enabled the synthesis of robust three dimensional nanostructures. The PnP process uses a simple elastomeric optical phase mask to generate a complex three dimensional interference pattern in photopolymer.[1] By controlling the geometry of the phase mask features, various three dimensional interference crystal patterns can be obtained inside the photopolymer. These include simple cubic, face centered cubic and quasi crystal geometries. By varying the spacing of the features on the phase mask, the lattice parameters of these crystal forms can be controlled. Once the photopolymer structure has been obtained, it is subsequently used as a template for graded temperature ALD. The graded temperature ALD chemistry is used to coat and lock-in the designed nanostructure without melting the template. This process generates a thermally robust nanostructure for further higher temperature ALD surface treatments. The ALD chemistry is performed at various (increasing) temperatures to secure the nanostructure and to reduce the macroscopic thermomechanical stress of the structure as higher temperature ALD depositions are utilized.

A necessary requirement of the graded temperature ALD is that the deposition temperature has to be below the softening point of the photopolymer. Graded temperature ALD of both Al_2O_3 and TiO_2 have been used to template the three dimensional nanostructures. Further, higher temperature ALD chemistries have been subsequently deposited on these structures for unique applications. These application include: photonic band gap materials, catalyst support materials, sulfur getter membranes, electrical materials and Li^+ battery electrodes to name a few. ALD chemistries performed on designed PnP nanostructures for these applications include: platinum metal, ZnO, ZrO_2, and MnO_2.

This talk will cover the fabrication process for generating PnP nanostructure templates and the correlations between the phase mask and the resulting PnP structure. Details of the graded temperature ALD chemical process for both Al_2O_3 and TiO_2 will be covered and structural characterizations will be presented. Experimental data on the unique applications of these structures will also be presented.

[1] D.J Shir, et al., J. Phys. Chem. B. **111** 12945 (2007).