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Self-assembly of nanostructures on electron beam lithographically patterened templates for biomedical and nanoelectronic sensor applications

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A major goal of nanotechnology is to couple the self-assembly of molecular nanostructures with conventional micro as well as nanofabrication, for instance the so-called bottom-up and top-down fabrication methods that would enable us to register and recognize individual molecular nanostructures in order to integrate them electronically into functional devices for various sensor and diagnostic tools. However, the integration of top-down (lithographic pattern) with bottom-up (functionalizing with synthetic chemical) approaches remains a central challenge in nanofabrication. The lithographic templates can be used to create several hierarchical orders for the nanostructures to organize themselves with internal features of dimensions significantly smaller than those of the original template, which can serve as scaffolds for the assembly of still smaller components. We demonstrate some examples of such self-assembly.

First, we demonstrate that the selective self-assembly of DNA nanostructures can happen on electron beam lithographically patterned surfaces at lower energy. The fluorescent dye coupled amine modified DNA nanostructures were selectively attached to the patterned glass substrates. The optimized binding interaction between self-assembled DNA nanostructures occurred preferably at lower beam energy due to the attractive energy between the pattern and DNAs. Patterns containing self-assembled DNA molecules with dimensions as small as 2 nm in height and 68 nm in width have been successfully demonstrated. The periodicity in DNA self-assembly was observed. This technology of combination of “top-down” fabrication and “bottom-up” self-assembly may find use wherever there is a need to attach self-assembled DNA molecules in a nanometer scale patterned surface for various applications.

Similarly, we have demonstrated the attachment of ZnO nanorod arrays on to the electron beam lithographically patterned oxide surface at lower energy. At higher beam energy (~ 20 KeV), the accumulated negative charges that already built on the surface in due course of irradiation restrict the growth of nanorod arrays. This causes a negative shielding potential close to the surface at micron level, and completely unfavorable for the attachment of the negative ZnO carriers. However, at comparatively lower beam energy (~ 5 KeV or less), the secondary electrons are responsible for the pattern with the irradiation zone centered by the local positive field. This allows negatively charged ZnO nanorod arrays to grow at lower voltages, which initiate site selective attachments. This protocol of site selection is very useful for various sensor fabrications. We will show other evidence of the self-assembly, such as gold nanoparticles of different dimension on electron beam lithographically patterned substrates.

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