Colloidal Transfer Printing mediated fabrication of Novel Nanostructures

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Abstract:

Monodispersed colloids self-assemble into 2-D and 3-D crystalline arrays, which allows one to obtain interesting and useful functionalities not only from the constituent materials but also from the long-range, mesoscopic order that characterizes periodic structures. A crystalline colloidal array has numerous applications in areas such as photonic crystals, sensing materials, etch masks for large area micro and nanostructure fabrication, coatings and so on. Self-assembly is an equilibrium process where the assembled components are in equilibrium with the individual components. Self-assembly is driven by the minimization of Gibbs free energy. Self-assembled 2D colloidal crystals are monolayer arrays of colloidal microspheres or nanospheres, which have drawn much attention owing to their successful applications in surface patterning. Monodispersed colloidal spheres can be self-assembled into ordered 2D arrays on solid supports or in thin films by the following by different techniques. However, spin coating is the preferential technique because of its high-throughput, low-cost of fabrication and ease of control for fabrication of large-area ordered monolayer arrays (chapter 1). This thesis reports the detailed parameter optimization required for obtaining perfect HCP and non-HCP arrays of different type of colloids on flat and patterned substrates by spin coating (chapter 2). Since this is a very rigorous approach and requires elaborate experimentation, a UV-based colloidal transfer printing technique has been developed (chapter 3). The most important and novel feature of the colloidal transfer technique lies in the fact that any type of particle can be transferred onto any type of substrate, including rough and non-planar surfaces. Based on this transfer technique, monolayer HCP arrays were transferred on zinc oxide (ZnO) surfaces, and colloidal template assisted ZnO nanorods (NRs) were grown by hydrothermal method (chapter 4). Since colloidal arrays could be transferred onto any type of surface, ZnO NRs were grown on rough and curved surfaces as well. The fabricated ZnO NRs displayed superhydrophobicity and self-cleaning property. Apart from transferring colloidal particles, Janus particles were transferred into a liquid medium based on UV induced degradation of a sacrificial PMMA layer (chapter 5). These Gold-PS Janus particles were fabricated on a PMMA coated quartz substrate, and then were transferred directly into a liquid medium by UV exposure. An inherent advantage of the transfer technique is that it works for all type of particles, and particles can be transferred from any type of PMMA matrix. This feature has been taken into advantage for transferring non-close packed arrays of particles confined in a PMMA matrix (chapter 6). Scopes of possible future work have been discussed in the final chapter, along with a general conclusion of the work presented in the thesis (chapter 7).