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Fabrication of Hetero-Structured Three-Dimensional Nanorod Arrays by Dynamic Shadowing Growth[1]

YIPING ZHAO, University of Georgia

Multilayered heterogeneous one-dimensional (1D) nanostructures are important building blocks for nanodevice applications. A practical nanofabrication technique to produce heterogeneous nanostructures with arbitrary materials must meet the following criteria: (1) The ability to fabricate heterogeneous nanostructures with arbitrarily selected materials; (2) The ability to control the dimensions and uniformity of the heterogeneous nanostructures; (3) The ability to control the alignment of the heterogeneous nanostructures; (4) The ability to control the interfacial properties of the heterogeneous nanostructures. Here, we demonstrate a simple but versatile method to fabricate three-dimensional heterogeneous nanorod structures by multilayer dynamic shadowing growth (DSG). DSG is based on geometric shadowing effect and substrate rotation in a physical vapor deposition system. By programming the azimuthal rotation of the substrate, different shapes of aligned nanorod arrays, such as zig-zag, c-shape, spirals, etc, can be fabricated. With the change of the source materials during the deposition, we demonstrate that complicated heterostructured nanorod arrays, such as Si/Ni multilayer nanosprings, can be easily produced, and they exhibit particular magnetic anisotropic behavior. We also use DSG technique to design catalytic nanomotors with different geometries that are capable of performing different and desired motions in a fuel solution. Using the shadowing effect, a thin catalyst layer can be coated asymmetrically on the side of a nanorod backbone. Catalytic nanomotors such as rotary Si/Pt nanorods, rotary L-shaped Si/Pt and Si/Ag nanorods, and rolling Si/Ag nanosprings, have been fabricated, and their autonomous motions have been demonstrated in a diluted hydrogen peroxide solution. We observed that the catalytic decomposition of hydrogen peroxide on the surface of catalyst generated a propelling force to push the nanorod from the catalyst side. This fabrication method reveals an optimistic step towards designing integrated nanomachines.

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