Virus-Based Genetic Toolkit for the Directed Synthesis of Magnetic and Semiconducting Nanowires

Angela M. Belcher, Chuanbin Mao, Daniel J. Solis, Brian D. Reiss, Stephen T. Kottmann, Rozamond Y. Sweeney, George Georgiou, and Brent Iverson
Department of Materials Science and Engineering and Biological Engineering
Massachusetts Institute of Technology
Department of Chemistry and Biochemistry
University of Texas, Austin

The exploitation of the self-assembly motifs employed by the M13 bacteriophage to produce a biological scaffold provides a means of generating a complex, highly ordered, and economical template for the general synthesis of single crystal nanowires. By introducing programmable genetic control over the composition, phase and assembly of nanoparticles, a generic template for the universal synthesis of a variety of materials can be realized.

We report a virus-based scaffold for the synthesis of single crystal ZnS, CdS and free-standing $L1_0$ CoPt and FePt nanowires, with the means of modifying substrate specificity through standard biological methods. Peptides selected through an evolutionary screening process that exhibit control of composition, size, and phase during nanoparticle nucleation have been expressed on the highly ordered filamentous capsid of the M13 bacteriophage. The incorporation of specific, nucleating peptides into the generic scaffold of the M13 coat structure provides a viable template for the directed synthesis of semiconducting and magnetic materials. Removal of the viral template via annealing promoted oriented aggregation-based crystal growth, forming individual crystalline nanowires. The unique ability to interchange substrate specific peptides into the linear self-assembled filamentous construct of the M13 virus introduces a material tunability not seen in previous synthetic routes. Therefore this system provides a genetic tool kit for growing and organizing nanowires from semiconducting and magnetic materials.