

## **Abstract**

### **Hierarchical heterostructures based on 1-D nanostructures**

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Chemical vapor deposition (CVD) and solution synthesis was coupled to realize a unique surfactant-free approach for the direct nucleation of nanoparticles on 1-D nanostructures leading to novel hierarchical heterostructures based on 1-D nanostructures. Carbon nanotubes (CNTs)–nanoparticles or nanowire and CuO nanowire-Co<sub>3</sub>O<sub>4</sub> nanoparticles heterostructures were synthesized. Morphological evolution of nanoparticles as a function of various growth parameters was studied using TEM, SEM, and XRD. Surface, electronic, and optical properties were studied using XPS, FTIR, and UV-vis-NIR and Raman spectroscopy. New kinds of lattice relationships, interfaces, and morphologies were established. For example, CuO nanowire-Co<sub>3</sub>O<sub>4</sub> nanoparticles showed unique optical characteristics leading to enhanced absorbance in visible light. Growth mechanisms of heterostructures revealed the importance of various competing phenomena at nanoscale including thermodynamic stability and chemical potential. These heterostructures hold great promise as novel chemical and biological sensors, energy technologies, and visible light photocatalysis.