

FABRICATION AND PHYSICAL PROPERTIES OF SEMICONDUCTING  
NANOWIRES GROWN BY MOLECULAR BEAM EPITAXY

Abstract

By

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Semiconducting nanowires have received significant interest from the scientific community due to their potential for electronic applications. This thesis is devoted to understanding the growth mechanisms and physical properties of a variety of nanowire structures grown by molecular beam epitaxy. This study described in this thesis can be subdivided into four main topics: the formation of self-assembled eutectic nanoparticles, the formation of single crystal semiconducting nanowires, the formation of heterostructured semiconducting nanowires, and the magnetic properties of GaAs/Fe core/shell nanowires.

As a part of this study, I explore the growth mechanisms behind the formation of eutectic nanoparticles which are used as a catalyst to fabricate nanowires by molecular beam epitaxy. The morphology of nanowires grown by molecular beam epitaxy is very closely related to the morphology of the eutectic nanoparticle catalysts, and therefore is of considerable interest for the study of the formation of nanowires. From this study, I find that the size and spatial distributions of self-assembled eutectic nanoparticles are strongly influenced by the growth conditions, and therefore can be controlled.

The study of the formation of single crystal semiconducting nanowires examines the growth mechanisms, morphology, and crystal structure of GaAs, ZnTe, ZnSe, and Ge nanowires grown on a variety of substrates by molecular beam epitaxy. This study employs electron microscopy to study growth mechanisms responsible for the nanowire aspect ratio, crystal structure, and shape. As a part of this study we find that the migration of surface adatoms contributes significantly to the nanowire morphology.

Layered semiconducting structures can have interesting properties that are useful for producing a variety of electronic, magnetic, and optoelectronic devices. The study of the formation of heterostructured semiconducting nanowires explores several core/shell structures as well as several axial heterostructures. As a part of this study, we observe several growth mechanisms which impede the formation of high quality layered structures, as well as several that promote high quality layered structures.

Finally, we examine the magnetic properties of GaAs/Fe core/shell nanowires. To overcome the various challenges associated with studying nanoscale magnetic crystals, many advanced experimental techniques were employed in this thesis. These experimental techniques include, superconducting quantum interference device magnetometry, ferromagnetic resonance spectroscopy, magnetic force microscopy, electron holography, and small angle neutron scattering. Using these techniques, we characterize the magnetic behavior of single GaAs/Fe core/shell nanowires both with and without the presence of an externally applied magnetic field.