Semiconductor nanowires (NWs) have attracted much attention for use in future nanometer-scale electronic and optical devices, because NWs have a small diameter and large surface area that enables high density integration of active devices on various platforms and fabrication of various kinds of functional devices by using hetero-structures. The surface area for the growth of the radial hetero-structures enables the formation of core-shell (CS) NWs. Moreover, a top surface with a small diameter achieves a formation of axial heterostructures regardless of lattice mismatches. The use of core-shell or axial NWs gives some functionality to NW-based applications.

The purpose of this study is to develop low cost and low power consumption CSNW light emitting diode (LED), which is very promising for the next generation of LED. For solar cell development, we fabricate a tandem nanowire solar cell with three (or four) different bandgap and lattice constant semiconductors in a stacked structure with high energy conversion efficiency.

This growth technique enabled the position-controlled growth of vertically-aligned III-V NWs on lithography patterned substrates. Also, the growth temperature altered the axial NW growth direction and radial growth directions, resulting in formation of CSNWs. For light emitting diode (LED) applications, we fabricated AlGaAs/GaAs CSNW (infrared emission), and InGaP CSNW (visible light) on silicon substrates. For solar cell applications, we used InP lateral pn junction CSNWs. We also fabricate an InGaP/GaAs/InGaAs tandem solar cell with high energy conversion efficiency.

It is very important to develop low cost and low power consumption LEDs. The CSNW LED is very promising for the next generation of LEDs. For solar cell development, we fabricate tandem nanowire solar cell with three (or four) different bandgap and lattice constant semiconductors in a stacked structure, achieving energy conversion efficiency more than 50%. That means the NW solar cell has great potential for high efficiency solar cells.


Fig.1 Scanning electron microscope image of semiconductor nanowires

We used selective-area metal-organic vapor phase epitaxy (SA-MOVPE) for III-V nanowire growth and hetero-epitaxial technique of forming NWs on a Si substrate for optical applications. The crystal growth of SA-MOVPE is based on faceting growth without catalyst.