【Grant-in-Aid for Scientific Research(S)】
Integrated Science and Innovative Science (New multidisciplinary fields)

Title of Project : Compound Semiconductor Nanowires and Their Optical Device Application

Takashi Fukui
(Hokkaido University, Graduate School of Information Science and Technology, Professor)

Research Area : New multidisciplinary fields
Keyword : Compound Semiconductor, Nanowire, Optical Device, Solar cell

【Purpose and Background of the Research】

Semiconductor nanowires (NWs) have attracted much attention for use in future nanometer-scale electronic and optical device, 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 a 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.

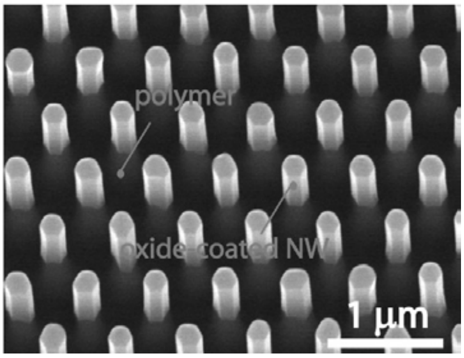

Fig.1 Scanning electron microscope image of semiconductor nanowires

【Research Methods】

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. 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.

【Expected Research Achievements and Scientific Significance】

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.

【Publications Relevant to the Project】

1. K. Tomioka, J. Motohisa, S. Hara, K. Hiruma and T. Fukui, "GaAs/AlGaAs core multishell nanowire-based light-emitting diodes on Si", NANO LETTERS, vol. **10**, pp.1639-1644,(2010)
2. H. Goto, K. Nosaki, K. Tomioka, S. Hara, K. Hiruma, J. Motohisa and T. Fukui, "Growth of Core-Shell InP Nanowires for Photovoltaic Application by Selective-Area Metal-Organic Vapor-Phase Epitaxy", APPLIED PHYSICS EXPRESS, vol. **2**, pp.035004, 1-3 (2009)

【Term of Project】 FY2011-2015

【Budget Allocation】 163, 200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.rciqe.hokudai.ac.jp/