Kaddour Lekhal et al., J Laser Opt Photonics 2017, 4:4 (Suppl)
DOI: 10.4172/2469-410X-C1-017

Fabrication of nanowires-based devices grown with controlled orientation

Kaddour Lekhal, Si-Young Bae, Ho-Jun Lee, Ousmane I Barry, Yagiang Liao, Shigeyoshi Usami, Yoshio Honda and **Hiroshi Amano**
Nagoya University, Japan

One-dimensional (1D) nanostructures-nanowires have shown promising potential to improve the device performance, such as high-efficiency LEDs. The growth of semiconductor nanowires was discovered for the first-time by Wagner and Ellis in 1964 through the vapor-liquid-solid (VLS) mechanism. Since then, this method has become widely used for synthesizing semiconductor nanowires. However, the growth of III-nitride nanowires with controlled orientation is challenged limited by the nature of the catalyst or the substrate used for the growth. The control of following parameters is important for large-scale integration of nanowires into practical devices: the vector (x, y) on a plane, orientation (ψ), length (L) and diameter (d). First, the growth mechanism based on nucleation theory and key issues related to the growth of III-nitride semiconductors nanowires will be presented. After that, some solution will be proposed to grow GaN nanowires with controlled orientation by using VLS approach or selective-area-growth (SAG) approach. We show that GaN nanowires grown on sapphire substrate with VLS approach can be controlled by tuning the atomic percent ratio of Au to Ni in HVPE environment. Pure Ni catalyst resulted in the growth of single-crystalline horizontal GaN nanowires, whereas mixture Au/Ni catalyst resulted in the growth of inclined nanowires with exceptional length and defect-free structure. Subsequently, we focus on the growth of GaN nanowires by SAG-MOCVD on silicon substrates; in particular we are interested to control the direction by inserting an orientation-induced buffer layer deposited by a directional sputtering before the nanowires growth. Highly ordered nanowires along the surface normal direction to parallely inclined GaN nanowires were obtained. HR-TEM and photoluminescence measurements indicated that the nanowires not only are free from structural defects (stacking faults or dislocations) but also have a good optical quality regardless of the orientation. Field effect transistors (FETs) based on horizontal nanowires have been fabricated by using conventional photolithography. The FETs exhibit reasonable electrical properties similar to other vertical nanowires, confirming the good structural quality of our nanowires. This example highlights the potential of the controlled oriented nanowires for the large-scale integration into practical devices.

Biography

Kaddour Lekhal received his PhD in Physics - Material Science from the University Blaise Pascal (France) in 2013 followed by Post-doctoral training at National Center for Scientific Research (CNRS). He is currently working as a Researcher at Amano lab., Nagoya University. His work focuses on the synthesis and characterization of nano-structures, particularly the growth of long III-V semiconductor nanowires by HVPE and MOVPE. He is deeply interested in developing new devices using long nanowires for LEDs, LDs and solar cells. He has published more than 30 papers in reputed journals.

lekhal.kaddour@yahoo.fr

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