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論 文 の 内 容 の 要 旨

This dissertation mainly presents an experimental study on the controlled growth, doping and coating for various 1D semiconductor nanostructures including GaN, GaP and SiC, and the characterization of their electric, optical, and magnetic properties. The structure, growth mechanism and dependence of morphology on experimental conditions for the as-synthesized 1D nanostructures have been studied in details based on SEM and TEM analysis.

Fabrication of the 1D semiconductor nanostructures was mainly realized based on the well-known Vapor-Liquid-Solid (V-L-S) mechanism (GaN, SiC@SiO₂) in which the Au catalyst was involved for promoting the nanowire growth, or the Vapor-Solid (V-S) method (GaP, Mn-doped GaN) free of catalyst. The morphology controlling growth of GaN nanowires indicated that the needle-like GaN nanowires with sharp tips can be obtained in a rather lower deposition temperature of 900°C ~ 1000°C, whereas the bicrystalline GaN nanowires can be synthesized under larger gas flux rate of ~ 200 sccm and high deposition temperature of 1150°C. By using [001]-oriented sapphire as substrate, the [001]-oriented GaN nanowire arrays can be obtained. CL measurement indicated that the band-edge emission peak for aligned GaN nanowires showed an obvious blue-shift of ~ 17 nm compared with the one for randomly grown GaN nanowires with [210] growth direction. The pure and [001]-oriented GaN nanotubes synthesized via one-stage method have been obtained for the first time and this result confirmed the theoretical predication for the formation of tubular structure for non-layered GaN.

The first exploration of P-doping in pure GaN nanowires indicated that P atoms can be introduced into GaN nanowire host with a maximum content of 5at% and the P-doping has greatly enhanced the electron emission properties by decreasing the turn-on field from 7.5 V/μm for pure GaN nanowires to 5.1 V/μm. Exploration on the magnetic doping for GaN nanowires suggested that Mn is the optimal magnetic dopants in GaN nanowires and the GaN nanowires with 5 at % Mn-doping have a larger coercivity of ~ 5000 Oe at 5 K, whereas the nanowires with less than 3 at % Mn-doping have a lower coercivity of 200 Oe at 5K. In addition,

the AFM measurement also demonstrated that the Mn-doping can greatly improve the conductivity of GaN nanowires.

Lastly, partial work of this dissertation focuses on some novel semiconductor nanostructures such as GaP nanoflowers, GaP@Ga₂O₃ and SiC@SiO₂ core-shell heterostructures. The peculiar GaP nanoflowers have strong emissions at ~ 600 nm near the band-edge and ~ 750 nm around the defect-related level. Sheathing of Ga₂O₃ layers on GaP nanowires does not only protect the inner GaP nanowires from contamination and oxidation, but also acts as a template for the conversion of other GaP-based heterostructures such as GaP@GaN, GaP@GaAs etc.

審 査 の 結 果 の 要 旨

本研究は GaN や GaP の半導体の 1 次元ナノ構造物質の創製と評価に関して, Applied Physics Letter 等の国際ジャーナルに筆頭著者で 7 編の論文を発表するなどの優れた成果を挙げている。また, 研究資質も博士(工学)を取得するに十分であると判断した。

よって, 著者は博士(工学)の学位を受けるに十分な資格を有するものと認める。