니켈 촉매를 이용하여 성장된 질화갈륨 나노선의 발광 특성

Photoluminescence characteristics of Ni-catalyzed GaN nanowires

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GaN nanowires have attracted much attention due to their potential applications of optoelectronic devices in the nanoscale.(1) GaN nanowires can be obtained by numerous semiconductor nanowire growth methods. Especially, metal catalyst assisted vapor-liquid-solid (VLS) method has widely been employed for growth of GaN nanowires due to its feasibility of size control and simple procedure.(2) However, metal catalysts used for nanowire growth may be incorporated into the semiconductor nanowires. Nevertheless, the incorporation of metal catalysts in nanowires during the VLS process has rarely been investigated because the nanowire length-scales of interest are smaller than the spatial resolution of volumetric mapping of conventional characterization methods such as secondary ion mass spectroscopy and transmission electron microscopy. The characterizations on unintentional incorporation of metal catalysts during semiconductor nanowire growth are very important because even a small amount of metal impurities in semiconductor nanowires can significantly affect physical properties of the host materials. Photoluminescence (PL) spectroscopy as non-destructive and sensitive tool for radiative defects can be useful for defect characterization of the semiconductor nanomaterials. We report on PL characteristics of GaN nanowires grown by Ni-catalyst assisted VLS method.

In this research, the effects of metal catalysts in GaN nanowires were investigated by time-integrated (TI) PL and time-resolved (TR) PL spectroscopy. For preparation of GaN nanowires, 2-nm-thick Ni film was deposited on Al_2O_3 substrate. After thermal annealing of Ni thin film to form Ni dots acting as catalysts, GaN nanowires were grown by low pressure metal-organic vapor phase epitaxy system. TIPL spectra of Ni-catalyzed GaN nanowires exhibit several PL peaks at 3.472, 3.437, and 3.266 eV, respectively. Each PL peak is tentatively assigned to excitonic emission. PL peaks at 3.472 and 3.266 eV are attributed to neutral donor bound excitons and donor-acceptor pair, respectively.(3) However, the origin of the PL peak at 3.437 eV can not be assigned from reported results on PL characteristics of GaN bulk and thin film materials. The PL peaks at 3.472, 3.437, and 3.266 eV were investigated by temperature-dependent PL and TRPL spectroscopy. From temperature-dependent PL spectra, the bound exciton localization energy for 3.437 eV was determined to be 17.1 meV. The TRPL data obtained at 3.437 eV were fit well with a double exponential decay curve. The decay time constants of the PL emission at 3.437 eV are estimated to be 252 and 816 ps. The bound exciton localization energy and the decay time

constants for 3.437 eV are similar to those of acceptor bound excitons in GaN bulk materials.[4] Among the possible acceptors in Ni-catalyzed GaN nanowires, Ni^{2+} is the most probable acceptor.

In summary, we performed TIPL and TRPL measurements of Ni-catalyzed GaN nanowires. From a series of PL measurements, the origin of the acceptors in the GaN nanowires can be considered to result from Ni catalyst metals. This result implies that PL measurements can be used to characterize the defects in semiconductor nanomaterials.

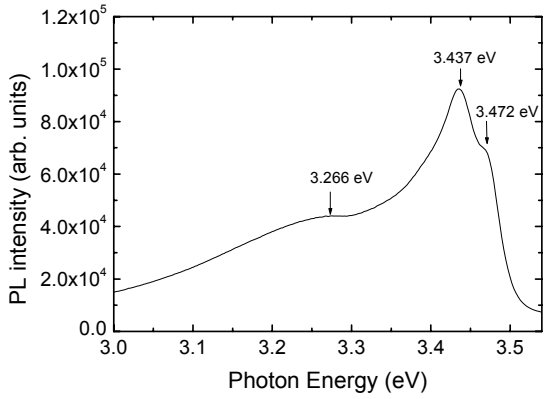

Figure 1. TIPL spectra of Ni-catalyzed GaN nanowires at 10 K.

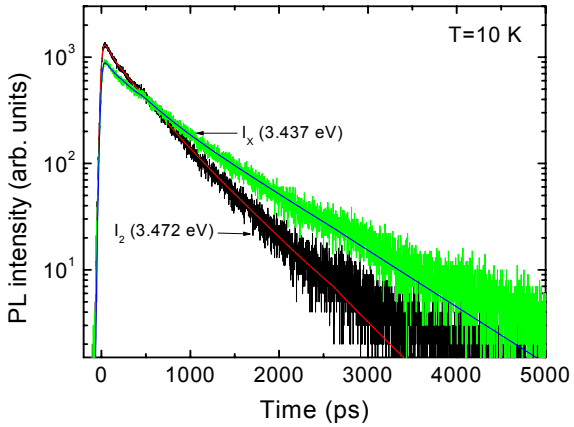

Figure 2. TRPL spectra of Ni-catalyzed GaN nanowires at 10 K

[References]

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