IMPACT OF RAPID THERMAL ANNEALING ON STRUCTURAL AND OPTICAL PROPERTIES OF GaAsBi/(Al,Ga)As QUANTUM WELLS

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Replacing a small fraction of As atoms in the GaAs lattice by Bi strongly reduces the band gap energy (E_g) and significantly suppresses its temperature dependence [1,2]. These properties make GaAsBi quantum structures promising for active regions of near-infrared light-emitting devices. However, the very low growth temperatures required (< 440 ^{o}C [3]) increase defect density and reduce photoluminescence (PL) efficiency [4]. Post-growth annealing is commonly used to improve epitaxial layer quality, yet its effects on GaAsBi remain controversial [5,6] and requires further investigation.

In this work, optical properties of GaAsBi/(Al,Ga)As multiple quantum well (MQW) structures grown by molecular beam epitaxy (MBE) were investigated using PL spectroscopy. The Bi concentration ranged from 8 to 11 %. Post-growth annealing was performed in a rapid thermal annealing (RTA) furnace under nitrogen atmosphere at 550, 600, 650, 700, and 750 ^{o}C for 3 minutes. Structural and morphological properties were additionally examined using high-resolution X-ray diffraction (XRD) and atomic force microscopy (AFM).

Annealing GaAsBi MQW with GaAs barrier resulted in degradation of crystalline and optical properties at all investigated temperatures. This behavior is attributed to Bi segregation from the GaAsBi to the surface, disrupting the periodic GaAsBi/GaAs structure. In contrast, GaAsBi MQW with AlGaAs barriers exhibited enhanced optical performance upon annealing at 650 ^{o}C and 700 ^{o}C, with PL intensity increases of 83% and 24%, respectively, indicating improved crystalline quality and effective Bi confinement. Annealing above 700 ^{o}C degraded the optical properties of all samples. A blueshift of the PL emission was observed in all structures annealed above 600 ^{o}C, indicating a reduction of Bi content in the GaAsBi lattice. Although literature reports suggest Bi quantum dot (QD) formation during annealing [7], no QD-relate emission was detected from 4 K to 300 K, implying an insufficient concentration of optically active Bi nanocrystallites.

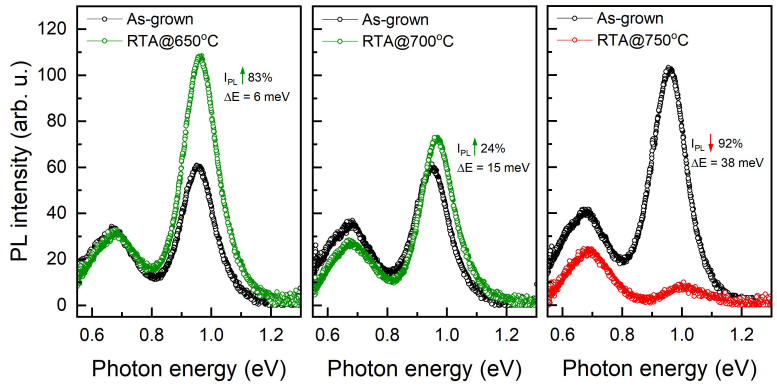

Fig. 1. Room-temperature PL spectra of GaAsBi/AlGaAs MQW before and after RTA at different temperatures.

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