High-quality GaSb buffer template on Si with multiple AlSb defect filter layers for high-performance SWIR laser diode

Eungbeom Yeon[1,2], Seungwan Woo[1,3], In-Hwan Lee[2], Daehwan jung[1], Won Jun Choi[1]

[1] Center for Opto-electronic Materials and Devices, Korea Institute of Science and Technology, Seoul, 02792, South Korea, [2] Department of Materials Science and Engineering, Laboratory for Optoelectronics Materials, Korea University, Seoul 02841, South Korea, [3] Department of Materials Science and Engineering, Research Institute of Advanced Materials, Seoul National University, Seoul 08826, South Korea

Growth of Sb-based materials on Si substrate has attracted much attention in the fields of short-wavelength infrared lasers and detectors because Si substrates can provide the several advantages including cost-effective and high thermal conductivity compared to GaSb substrate. However, the large lattice mismatch (12%) leads to threading dislocations (TDs) and micro-twins (MTs) [1,2]. In this work, we study the effect of defect filter layers (DFL) on the GaSb epilayers on Si and demonstrate record-low TDD GaSb buffer via molecular beam epitaxy. We first grew GaSb/Si and GaSb/GaAsSb step-graded buffer (SGB)/Si in order to investigate generation of MTs. Since the MTs are generated due to growth direction tilt originated from the initial large lattice mismatch between GaSb and Si, the GaAsSb SGB was introduced to bridge lattice mismatch. As a result, almost no MTs were confirmed in GaSb/GaAsSb/Si sample (Fig. 1) while a high density of MTs were observed. Also, we inserted a series of AlSb/GaSb DFLs (0~4×) to GaSb/GaAsSb/Si sample to lower threading dislocation density (TDD). The sample with four AlSb/GaSb DFLs shows RMS roughness of 0.88 nm and TDD of 2.1× 107cm-2 (Fig. 2). This result is the lowest TDD compared to ~3.5 μm thick GaSb/Si reported by other groups [1,3-9] (Fig. 3). We demonstrate the MT-free and the lowest TDD GaSb/Si template by using GaAsSb SGB template and multiple AlSb DFLs. We believe that this high-quality GaSb buffer template on Si can be served as a platform for high-performance Sb-based optoelectronic devices on Si.