Daugybinių GaAsBi kvantinių duobių artimosios infraraudonosios spinduliuotės šviestukas, skirtas integravimui ant silicio padėklo

GaAsBi Based MQW NIR LED for Integration on Silicon Platform

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Gallium arsenide (GaAs) is a classical, widespread material, used to manufacture devices such as light emitting diodes (LEDs), laser diodes (LDs) operating in the IR spectral range. A novel way to improve the properties of active light emitting devices is the incorporation of bismuth (Bi) [1], [2]. Bi offers reduction and bandgap stabilization at high temperatures, as well as suppression of Auger recombination.

An industry standard method to grow GaAs based structures is via molecular beam epitaxy (MBE) using GaAs substrates. This work focuses on the development of multiple quantum wells (MQW) GaAsBi/GaAs near infrared (NIR) LED on sacrificial aluminum arsenide (AlAs) layer for integration on Si platform. The latter layer is meant to be removed via wet etching and lift the entire LED structure from the GaAs substrate, which later can be bonded onto a silicon substrate.

In this work the GaAsBi/GaAs MQW LED was grown using MBE technology. The growth of high-temperature (HT) layers took place at 665 ℃, while the low-temperature (LT) layers were grown at 435 ℃. Firstly, 500 nm of AlAs sacrificial layer was grown. 500 nm was chosen as an optimal thickness, as it provides enough surface area for the wet etchant to react and efficiently remove the layer. Further increasing the thickness of AlAs layer is not optimal as it unnecessarily prolongs the growth duration with diminishing improvements to etching capabilities. The n-GaAs:Si layer (n-type region) was grown at 665 ℃, had Si concentration of $2 \cdot 10^{18}\ cm^{-3}$. The first GaAs spacer was grown at high temperature to ensure high quality base to the QW structure grown atop. For QW growth the temperature was dropped to 435 ℃ to allow for incorporation of Bi. Total of 5 standard rectangular QWs were grown with optimized thicknesses for a 1.1 μm emission spectral range. LT-GaAs spacer was grown on top. Low temperature was selected to avoid potential redistribution of Bi atoms into the barriers induced by the elevation of temperature. Lastly, the p-GaAs:Be (p-type region) was grown on top with Be concentration of $5 \cdot 10^{18}\ cm^{-3}$ at 550 ℃. Such temperature was chosen due to high diffusivity of Be atoms. Greater temperature may induce Be accumulation sites and thus general dopant inhomogeneity in the region.

The LED structure was characterized via x-ray diffraction (XRD), atomic force microscopy (AFM), and electroluminescence measurements (EL). To carry out the room temperature electroluminescence measurements, the structure was wet etched in order to expose its' n-type region and allow for application of indium (In) contacts. The complete structure after etching and contact application is seen in Figure 1.

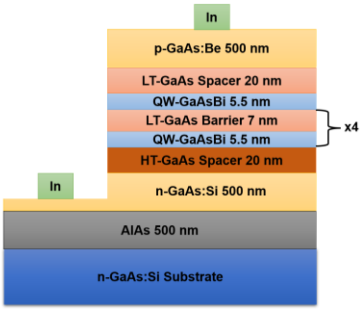

Figure 1. GaAsBi/GaAs MQWbased LED structure, processed for electroluminescence measurements.

The electroluminescence results, demonstrating the central spectral wavelength at 1.15 eV (corresponds to 1078 nm), are depicted in Figure 2.

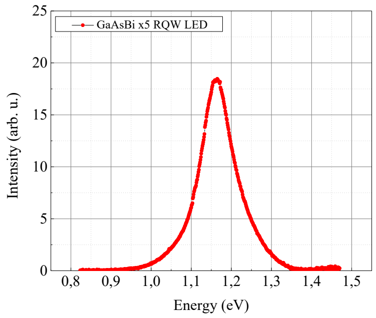

Figure 2. EL spectrum of GaAsBi/GaAs MQW LED measured at room temperature.

Keywords: LED, GaAsBi, MBE, sacrificial layer, Si, GaAs, electroluminescence.

Literature

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