Two-Substrate-Temperatures Growth Technique: An effective method for reduction of Bi segregation effect in GaAsBi/GaAs MQWs

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The semiconductor alloy GaAsBi has attracts increasing interest in the last few years owing to their potential application in optoelectronic devices operating in the near to long infrared wavelength regions with enhanced capability. GaAsBi/(Al)GaAs MQWs are considered to be a good candidate for infrared optoelectronic devices. The growth of MQWs requires an abrupt interface between the layers. Fabrication of GaAsBi/(Al)GaAs MQWs with abrupt composition profile of bismuth (Bi) is obstructed by strong surface-segregation tendency of Bi. Bi atoms are incorporated not only in GaAsBi layers but also into the successive (Al)GaAs barrier layers. Sometimes structural defects are formed dependent on growth condition. In order to improve the structural and optical quality of GaAsBi/GaAs MQWs, modifications in the growth is reported. In the growths, two-substrate-temperatures (TST) technique was used, where GaAsBi layers were grown at $T_{\mathrm{GaAsBi}} = 350$ °C and GaAs layers at $T_{\mathrm{GaAs}} = 550$ °C. The TST procedure proves as a very efficient method to reduce Bi segregation and thus increase the quality of the layers and interfaces. Fig. 1(a) shows the investigations of the microstructure using transmission electron microscopy (TEM) also reveal laterally homogeneous MQWs free of extended defects. Furthermore, Bi distribution profile across the MQWs region using TEM techniques shows in Fig. 1(b) and (c), the uniform Bi distribution with significantly reduction in Bi segregation effect for $GaAs_{0.96}Bi_{0.04}$/GaAs MQWs growth using TST. Bi segregation is significantly reduced (up to 18 % reduction) compared to previous reports on Bi segregation in GaAsBi/GaAs MQWs. Hence, the TST procedure proves as a very efficient method to reduce Bi segregation and thus increase the quality of the layers and interfaces. These improvements positively reflect in the optical properties. Room temperature photoluminescence (PL) and electroluminescence (EL) at 1.23 μm emission wavelength are successfully demonstrated using TST MQWs LED containing 4 % Bi content. These results not only demonstrate that TST technique provides optical-device-quality GaAsBi/GaAs MQWs but highlight the relevance of TST-based growth techniques on the fabrication of future heterostructure devices based on dilute bismide.

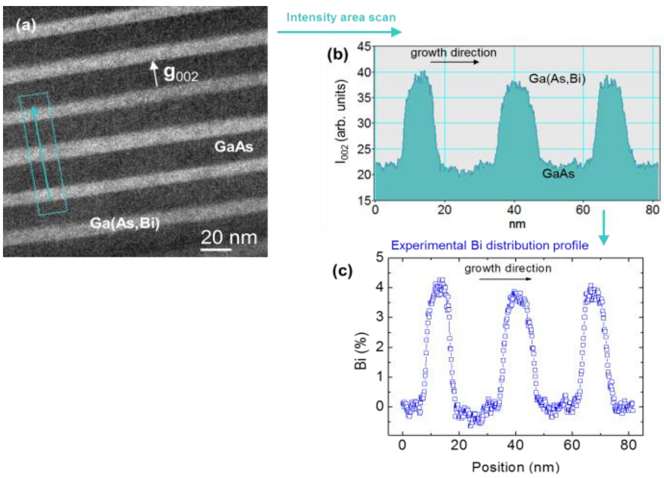

Figure 1. (a) Dark field g_{002} TEM image of $GaAs_{0.962}Bi_{0.38}$/GaAs MQWs using the two-substrate-temperature growth technique. (b) Intensity linescan from the area marked in (a) from where the experimental Bi composition profile shown in (c) is obtained.