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Arsine Flow Rate Effect on the Low Growth Rate Epitaxial InGaAs Layers

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Abstract—Effect of arsine (AsH_3) flow rate on epitaxially grown unintentionally doped and low-growth rate InGaAs layer by using metal organic vapor phase epitaxy at growth temperature 640°C are investigated. While all other sources and parameters are kept constant during growth, the AsH_3 flow rate in InGaAs layer is increased from 20 to 120 sccm. The epitaxial grown InGaAs layers have been characterized by optical microscopy, X-ray diffraction, photoluminescence, and Hall effect. It is found that the mobility of carriers increases from 3780 to 7043 cm^2/Vs, sheet carrier density decreases from 7.74×10^{11} to 4.01×10^{11} cm^{-2}, PL intensity of emission increases from 1.1 to 8.6 V by increasing the AsH_3 flow rate from 20 to 40 sccm. Moreover, the same trend of improvement is observed on the crystalline quality of InGaAs layers with changing of AsH_3 flow rate. The changing of AsH_3 flow rate between 20 and 120 sccm is found to have strong effect on properties of epitaxial InGaAs alloys.

Keywords: InGaAs, metal organic vapor phase epitaxy, arsine, V/III ratio, thin film

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1. INTRODUCTION

Indium gallium arsenide ($In_xGa_{1-x}As$) compound semiconductors on indium phosphide (InP) substrate have many applications because of the range of band gap (0.86–3.54 μm) available through the composition range and its superior properties. They have been extensively used for uncooled infrared detectors, light emitters, field-effect transistors, remote sensing, environmental monitoring applications, quantum cascade lasers, and fiber optic communication devices [1–13]. State-of-the-art growth technologies such as metalorganic vapor phase epitaxy (MOVPE) and molecular beam epitaxy (MBE) have been employed to produce such high-performance devices. The performance of these devices included InGaAs layers is sensitive to InGaAs quality. Therefore, several groups examined the effect of growth parameters (growth temperature, growth rate, reactor pressure, etc.) of InGaAs layer to improve the quality of epitaxial layer [14–16]. One of other important parameters for material growth that affects the quality of InGaAs epilayer is V/III ratio to reach the desired material quality. Jiang et al. investigated the effect of V/III ratio on heavily doped InGaAs (Si) [17]. They found that AsH_3 variation has a stronger effect on Si incorporation in InGaAs layer at a lower temperature than at higher temperatures. A. Jasik et al. studied the effect of growth rate as well as the effect of V/III ratio on the crystal quality of InGaAs epilayer grown by MBE and MOVPE systems [15].

In this current study, the influence of AsH_3 flow rate (V/III ratio) on InGaAs layers grown by MOVPE is studied. High-resolution X-ray diffraction (HRXRD), room temperature photoluminescence (RTPL), in situ optical reflectance measurements, and room temperature Hall effect measurements are used to characterize the effect of AsH_3 flow rate on the properties of InGaAs layers. The results obtained indicate that variation of AsH_3 (or V/III ratio) is one of the most effective growth parameter on the growth of InGaAs layers.

2. EXPERIMENTAL DETAILS

InGaAs epilayers were grown on 2-inch, (100)-oriented, semi-insulating, double-side polished (dsp) indium phosphide (SI-InP) substrates by using a horizontal flow reactor MOVPE system. The system was outfitted with Luxtron 880 nm reflectometer and an optical fiber thermometry-light-pipe assemble providing information about growth rate, reflection intensity (thus surface quality), and substrate/surface