IV.2.2

Vacuum 84 (2010) 1182–1186

Contents lists available at ScienceDirect

Vacuum

journal homepage: www.elsevier.com/locate/vacuum

# Characterization of $Al_xGa_{1-x}As$ layers grown on (100) GaAs by metallic-arsenic-based-MOCVD

J. Díaz-Reyes [a,*], M. Galván-Arellano [b], R.S. Castillo-Ojeda [c], R. Peña-Sierra [b]

[a] CIBA-IPN, Ex-Hacienda de San Juan Molino Km. 1.5, Tepetitla, Tlaxcala 90700, México
[b] Depto. de Ing. Eléctrica, SEES. CINVESTAV-IPN. Apdo. Postal 14-740, México, D. F. 07000, México
[c] Universidad Politécnica de Pachuca. Km. 20, Rancho Luna, Ex-Hacienda de Santa Bárbara, Municipio de Zempoala, Hidalgo. 43830, Mexico

*Keywords:*
MOCVD
Hall Effect
SIMS
Raman scattering
III-V semiconductor growth
GaAs

## ABSTRACT

We present the electrical and structural characterization of $Al_xGa_{1-x}As$ layers grown in a metallic-arsenic-based-MOCVD system. The gallium and aluminium precursors were the metal-organic compounds trimethylgallium (TMGa) and trimethylaluminium (TMAl), respectively. $Al_xGa_{1-x}As$ layers that were grown at temperatures less than 750 °C present a high electrical resistivity. Independent of the used III/V ratio the samples that were grown at temperatures greater that 750 °C were *n*-type with an electron concentration of around $10^{17}$ cm$^{-3}$ and a carrier mobility of 2200 cm$^2$/V-s. Chemical composition studies by SIMS exhibit the presence of silicon, carbon and oxygen as the main residual impurities. Silicon concentration of around of $10^{17}$ cm$^{-3}$ is very close to the free carrier concentration determined by the Hall-van der Pauw measurements. Composition homogeneity and structural quality are demonstrated by Raman measurements. As the growth temperature is increased the layers compensation decreases but the Raman spectra show that the crystalline quality of the layers diminishes.

## 1. Introduction

GaAs/AlGaAs heterojunctions are the fundamental elements for most optoelectronic devices: such as: semiconductor lasers, photodetectors, wave-guide optical modulators and solar cells. The crystalline quality of semiconductor epitaxial layers forming such heterojunctions and their interfacial quality are crucial parameters in the device performance [1]. Although GaAs and AlGaAs have been extensively studied in the past, nowadays new applications of these semiconductors in novel forms such as nanocrystallites, quantum wires (QW) and dots (QD) are under research. These new application fields were made feasible due to the use of growth techniques such as MOCVD and MBE, which provide very precise control of layer thickness in the range of subnanometric dimensions [2].

$Al_xGa_{1-x}As$ growth by MOCVD presents different problems such as the difficulty of growing it at low temperatures. It is of special importance to grow these layers at temperatures lower than 600 °C because the QDs are usually grown under this condition. For low temperatures poor arsine decomposition limits the growth process. One of the main problems during the growth process of $Al_xGa_{1-x}As$ by the MOCVD system is the control of incorporation of undesirable residual impurities, such as oxygen and carbon [3], which have a very high incorporation probability. Oxygen creates a deep trap which leads to a reduction in free carrier mobility [4]. On the other hand, carbon is a well-known shallow acceptor which determines the background carrier concentration [4]. Reducing or controlling the oxygen and carbon concentration incorporated in the layers is the key problem in realizing high-performance devices and, for this reason, understanding the effect of these two impurities is very important.

In order to solve these problems several attempts have been made to replace arsine in the growth of GaAs and its alloys by MOCVD. Precursors such as trimethylarsenic, triethylarsenic and the solid arsenic have been used [5]. When trimethyl- or triethylarsenic is used as arsenic precursor, the GaAs layers have a high background doping and a high compensation rate, due to the incorporation of carbon doping and a high compensation rate, due to the incorporation of carbon doping from the organic radicals [6]. During the growth of $Al_xGa_{1-x}As$ this problem becomes more complex due to the chemical affinity between aluminium and carbon; furthermore the groups of metal-organic precursors possess oxygenated radicals which could definitely degrade the epilayers properties [7].

The main interest of this work is the development of GaAs and $Al_xGa_{1-x}As$ epitaxial layers for applications in current quantum well

---

* Corresponding author.
*E-mail address:* jdiazr2001@yahoo.com (J. Díaz-Reyes).

0042-207X/$ – see front matter
doi:10.1016/j.vacuum.2009.10.021