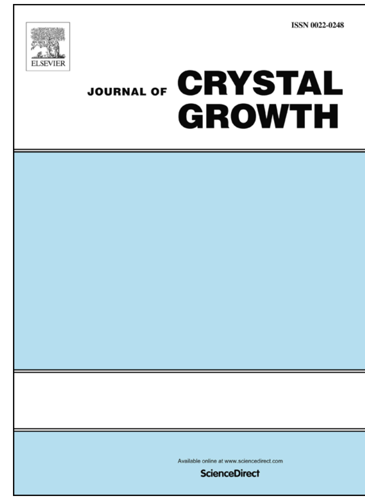
Accepted Manuscript



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PII: S0022-0248(17)30250-6
DOI: http://dx.doi.org/10.1016/j.jcrysgro.2017.04.020
Reference: CRYS 24149

To appear in: *Journal of Crystal Growth*

Received Date: 8 December 2016
Revised Date: 6 April 2017
Accepted Date: 17 April 2017

Development of InAlAsSb growth by MOVPE

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Abstract

The growth of InAlAsSb by metal-organic vapor phase epitaxy has been demonstrated, with a controllable antimony fraction exceeding 6%. Calculations have shown that InAlAsSb with Sb contents greater than 5-7% in the quaternary are within the miscibility gap, however this work demonstrates specific growth conditions that allow compositions well within the miscibility gap. From a study of the growth of AlAsSb and an evaluation of two aluminum precursors (TMAl versus TTBAl), growth temperature, and V/III ratio, a foundation is developed to optimize the growth of InAlAsSb. By tailoring V/III ratio, growth conditions were found to achieve high crystalline content of both indium and antimony. InAlAsSb was grown on InP with antimony fractions from 32% to 48%, for which indium fraction varied from 10% to 19%, which provides an expected direct bandgap ranging from 1.75 to 1.98 eV.

Keywords: InAlAsSb, AlAsSb, MOVPE, miscibility, photovoltaics

1. Introduction

For many years the high quality crystal growth of InAlAsSb has been desired for both optoelectronic [1], and electronic [2] devices due to its high direct band-edge for a material lattice matched to InP. Recent work has focused on the development of a triple junction solar cell lattice matched to InP that has the potential of breaking 50% efficiency under concentration [3]. Analytical drift-diffusion models have shown that an InP based lattice matched triple junction solar cell with an InAlAsSb top cell can achieve efficiencies exceeding 36% at one sun and 52% at 500 suns [4]. In order to achieve the target efficiency in a multi-junction solar cell a direct bandgap of 1.7-1.8eV is required, which corresponds to a lattice matched composition of $(AlAs_{0.56}Sb_{0.44})_{1-z}(In_{0.52}Al_{0.48}As)_z$ where z is between 0.4 and 0.5.

Historically there has been a significant amount of progress on the growth of InAlAsSb by molecular beam epitaxy (MBE) [5][6], however initial results by MOVPE have either demonstrated growth of low Sb content alloys with Sb fraction not exceeding 3% [7] or higher Sb fractions of 15% [1] that were not reproducible in our lab. The target quaternary for photovoltaic applications with $z \approx 0.45$ has an elemental composition of $In_{0.23}Al_{0.77}As_{0.74}Sb_{0.26}$, which exceeds the Sb fraction that has been demonstrated to date by MOVPE.

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