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Growth and Characterization of $In_xGa_{1-x}N$ Multiple Quantum Wells Without Phase Separation

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Efficient conversion of photon energy into electricity is a crucial step toward a sustainable solar-energy economy. Likewise, solid-state lighting devices are gaining prominence because of benefits such as reduced energy consumption and reduced toxicity. Among the various semiconductors investigated, $In_xGa_{1-x}N$ alloys or superlattices are fervently pursued because of their large range of bandgaps between 0.65 eV and 3.4 eV. This paper reports on the fabrication of multiple quantum wells on $LiGaO_2$ (001) substrates by plasma-assisted molecular beam epitaxy. Metal modulated epitaxy was utilized to prevent formation of metal droplets during the growth. Streaky patterns, seen in reflection high-energy electron diffraction, indicate two-dimensional growth throughout the device. Postdeposition characterization using scanning electron microscopy also showed smooth surfaces, while high-resolution x-ray diffraction and high-resolution transmission electron microscopy confirm the epitaxial nature of the overall quantum well structure.

Key words: Group III nitride, MBE, solar cell, quantum well, InN, GaN, superlattice

INTRODUCTION

Group III nitrides have been studied for various optoelectronic devices such as light-emitting diodes (LEDs), photodetectors, and solar cells. Mixing of InN with GaN to form pseudobinary $In_{1-x}Ga_xN$ alloys allows one to tune the bandgap to match with various ranges of the solar spectrum.[1] In today's modern world, the demands for clean energy and proper energy usage with minimum wastage have made InGaN a viable candidate. So, InGaN-based photovoltaic solar cell devices provide a promising path to green energy technologies[2] as the efficiency of conversion continues to improve and the cost of fossil energy keeps rising. Moreover, III-nitride heterostructures can now be grown on Si wafers with proper buffers,[3] enabling integration of III-nitride solar cells with the better-developed traditional Si technology. Multijunction solar cells are considered to be more efficient than single-junction solar cells because, in theory, they could concurrently convert photon energies in various regions of the solar spectrum into electric current. Likewise, InGaN-based LEDs are also useful for green energy because of their low power consumption, long life, nontoxicity, and other attractive features. One of the key points is the effective tunability of the bandgap of group III nitrides that would be obtained if InN and GaN were to form homogeneous alloys without phase separation. Unfortunately, $In_xGa_{1-x}N$-based nitrides are notorious for their

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