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Growth and Characterization of $In_xGa_{1-x}As/GaAs_{1-y}P_y$ Strained-Layer Superlattices with High Values of y (~80%)

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Strained-layer superlattice (SLS) structures, such as InGaAs/GaAsP lattice matched to GaAs, have shown great potential in absorption devices such as photodetectors and triple-junction photovoltaic cells. However, until recently they have been somewhat hindered by their usage of low-phosphorus GaAsP barriers. High-P-composition GaAsP was developed as the barrier for InGaAs/GaAsP strained-layer superlattice (SLS) structures, and the merits of using such a high composition of phosphorus are discussed. It is believed that these barriers represent the highest phosphorus content to date in such a structure. By using high-composition GaAsP the carriers are collected via tunneling (for barriers ≤30 Å) as opposed to thermionic emission. Thus, by utilizing thin, high-content GaAsP barriers one can increase the percentage of the intrinsic in a *p-i-n* structure that is composed of InGaAs wells in addition to increasing the number of periods that can be grown for given depletion width. However, standard SLSs of this type inherently possess undesirable compressive strain and quantum size effects (QSEs) that cause the optical absorption of the thin InGaAs SLS wells to shift to higher energies relative to that of bulk InGaAs of the same composition. To circumvent these deleterious QSEs, stress-balanced, pseudomorphic InGaAs/GaAsP staggered SLSs were grown. Staggering was achieved by removing a portion of one well and adding it to an adjacent well. The spectral response obtained from device characterization indicated that staggering resulted in thicker InGaAs films with reduced cutoff energy. Additionally, these data confirm that tunneling is a very effective means for carrier transport in the SLS.

Key words: Superlattice, strain-balanced, tunneling, InGaAs, GaAsP, photovoltaic

INTRODUCTION

III–V semiconductors are useful in optoelectronic applications; however, not all desired band gaps are available in alloys lattice matched to available substrates. This limitation can be overcome by using metamorphic and pseudomorphic structures. Metamorphic structures have issues with defects which can be alleviated but not eliminated. Individually, pseudomorphic layers are limited by the critical layer thickness, after which relaxation occurs. This deleterious relaxation limits the total thickness of an individual pseudomorphic layer to the range of a few nanometers to a few tens of nanometers. To avoid relaxation, many pseudomorphic layers can be grown by balancing compressive and tensile layers in a structure termed a strain-balanced, strained-layer superlattice (SLS) structure. The concept of the strain-balanced InGaAs/GaAsP superlattice, lattice-matched to GaAs,

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