Substrates of Ternary and Quaternary III-V Compounds

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Substrates of compound semiconductors (III-V, II-VI, IV-IV) with variable band gaps and lattice constants are desirable to obtain high performance electronic and optoelectronic devices. Unfortunately, at the present time device grade, single crystal, substrates of *only* a few binary compounds (such as GaAs, GaSb, InP, CdTe) with discrete energy band gaps and lattice constants are commercially available. Ternary and quaternary based devices are fabricated on thin epitaxial layers grown by non-equilibrium techniques (from vapor or solid phase) on binary substrates. Either alloys lattice-matched to the substrate (specific quaternary compositions) or buffer layers are required. The buffer layer technology necessary to relieve misfit (lattice mismatch) related stresses at the epilayer-substrate interface is not optimized for all systems and often devices exhibit poor characteristics due to interfacial defects.

Availability of substrates with tunable band gap and lattice constant will open up numerous possibilities of interesting band gap engineering in homo- and hetero-epitaxial devices with improved performances, new features, reduced fabrication complexity and cost effective. Some appropriate examples are that of (a) GaInAs laser diodes on lattice matched substrates with high characteristics temperature, low cost, high quantum efficiency photodetector with diffused p-n homo-junction on GaInSb bulk substrates, high efficiency tandem Si-Ge/GaAs solar panels on Si-Ge lattice matched substrates, high efficiency lattice-matched GaInAsSb thermophotovoltaic devices on GaSb substrates antimonide based quantum well and superlattice structures lattice matched to GaSb for high efficiency mid-infrared sources and detectors.

In this talk, I will review the fundamental problems encountered during the growth of multi-component semiconductor alloys: this will explain why lattice matched ternary substrates are not yet available in the commercial market. Some of the recent advances made in the area of bulk ternary and quaternary growth will be discussed. Various options for alloy substrates fabricated using established concepts in melt growth and alloy bonding will be described. A list of alloy substrates successfully grown from melts will be shown. Results of substrate preparation and surface evaluation of antimonide based compounds (critical for epitaxial growth of device structures) will be presented.