GROWTH OF THICK LATTICE MISMATCHED LAYERS OF $GA_XIN_{1-X}AS_YSB_{1-Y}$ ON GAAS SUBSTRATES FROM QUATERNARY MELTS

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ABSTRACT

Compound semiconductors (III-V, II-VI, IV-IV) with variable band gaps are desirable to obtain high performance electronic and optoelectronic devices. Currently, lattice mismatched epilayers of variable bandgap semiconductors are grown on commercially available binary substrates by non-equilibrium growth techniques (such as MOCVD and MBE) using a variety of buffer layer schemes. Although thick epilayers are observed to result in lower dislocation densities even for large lattice mismatches, achieving thick epitaxial layers remains a challenge due to the slow growth rates of MBE and MOCVD techniques that are commonly used in the industry. Hence, there is a necessity for devising a technique that will grow thick layers of lattice mismatched compounds at high growth rates.

In this research, we have demonstrated a new quaternary melt thermochemistry to grow thick layers of uniform composition of desired ternaries and quaternaries on commercially available binary substrates (such as GaAs). Using this approach, we have achieved the growth of thick ($\sim 100\ \mu$m) uniform composition $Ga_xIn_{1-x}As$, $In_xGa_{1-x}Sb_yAs_{1-y}$ and $InAs_ySb_{1-y}$ layers on GaAs substrate. The growth rates achieved in our growth experiments are significantly higher than any other traditional epitaxial growth process. One of the interesting features observed in our growth experiments is the occurance of a compositionally graded quaternary buffer layer between the substrate and the final layer (of uniform composition). This is found to efficiently relieve misfit strain and lead to lower dislocation densities in the epilayers. It is important to point out that no specific efforts were made to change growth conditions (during epi-growth) to compositionally grade the buffer layers, making this growth scheme extremely simple to implement for large scale applications.

One of the key achievements of this work is the growth of thick $In_xGa_{1-x}As_ySb_{1-y}$ layers of constant composition with cut off wavelength of 10 μm on GaAs substrates. The dislocation densities were found to be as low as 7×10^5 cm^{-2} for a lattice mismatch of 13.08% which is considerable less than any reported value for

similar mismatches. The layers had a room temperature electron mobility as high as 1.4×10^4 cm^2/Vs and carrier concentration of 4.2×10^{16} cm^{-3} has been achieved indicating the high quality of the grown epilayers and potential applications for infra-red detectors.

Transmission electron microscopy studies have been used to investigate the interfacial and crystalline quality of the epilayers. It is observed that the dissolution of GaAs by the InSb melt leads to the delineation of the (111) family of planes. Twinning is also observed within the epilayer. These observations have helped us arrive at a model for the growth mechanism and the explanation of the polycrystallinity of the epilayer.