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Structural analysis of Bi-containing III/V-compound semiconductors and heterostructures

Abstract: III/V semiconductors containing small amounts of Bi – as III/V semiconductors, which contain a small fraction of N – are metastable due to the large difference in covalent radius between Bi (N) and the group V elements, which are replaced by these alloying elements. Hence, these mixed semiconductors have to be grown under extreme non-equilibrium conditions to incorporate even small amounts of Bi or N, respectively. Under those growth conditions, local atomic ordering, element clustering or even phase separation on a small length-scale might occur. In addition, ordered structures might become thermodynamically stable due to the highly different diameter of Bi- and the As-atoms, which are replaced in an alloyed Ga(AsBi) crystal. Transmission electron microscopy (TEM), X-ray diffraction (XRD) and scanning tunnelling microscopy (STM) can be used to address the composition and structure of III/V semiconductors on different length scales. The present contribution will summarize the ordering effects known for mixed III/V semiconductors and elucidate Bi incorporation into GaAs grown by molecular beam epitaxy (MBE). We will furthermore depict structural characteristics of dilute bismide alloys and compare them to the structure formation processes for other highly metastable III/V semiconductors, like dilute nitride materials.