Structural properties of GaAsBi layers grown on GaAs by molecular beam epitaxy

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The semiconductor alloy $GaAs_{1-x}Bi_x$ has recently attracted attention due to its potential applications in optoelectronics. Adding small amounts of Bi to the GaAs lattice leads to a large reduction of the band gap, allowing access to important wavelengths in the infrared region. Due to the tendency of Bi to surface segregate, successful incorporation of Bi in the GaAs lattice requires nonconventional growth conditions, such as growth temperatures below 400°C and precise control of As beam equivalent pressure, which are nonoptimal in terms of quality of the host material [1, 2]. In particular, low growth temperatures are known to lead to formation of various defects in GaAs [3]; the defect formation mechanisms are expected to be even more complicated in the case of GaAsBi. In attempt to reduce the defects one can use annealing that is a common method to improve the quality of semiconductor materials.

Here, we summarize our recent studies concerning the effects of thermal annealing on the properties of GaAsBi materials grown at different temperatures. $GaAs_{1-x}Bi_x$ bulk layers with Bi composition x of ~1.2-1.5% were grown on GaAs by solid-source molecular beam epitaxy at temperatures of 220-315°C. Samples were subsequently annealed ex-situ in a rapid thermal annealing (RTA) oven at temperatures between 500°C and 800°C using a GaAs proximity cap, and characterized with X-Ray diffraction, Rutherford backscattering spectroscopy and transmission electron microscopy.

The lattice constant of GaAsBi samples grown at the lower temperatures (220-270°C) decreased significantly towards the GaAs lattice with post-growth annealing, while the samples grown at higher temperatures did not exhibit this behavior. Similar GaAs samples exhibited smaller changes with annealing due to diffusion of excess As. We relate this behavior to the formation of clusters with high Bi content in lower-temperature grown GaAsBi samples.

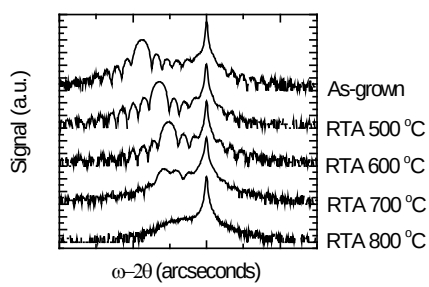

Fig 1: XRD spectra of a GaAsBi sample grown at 220°C and annealed at various temperatures.

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