Deep-level defects in n-type $GaAs_{1-x}Bi_x$ with $0 \leq x \leq 2.3$ grown on GaAs by MBE

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The dilute bismide alloy $GaAs_{1-x}Bi_x$, containing a few percent of Bi atoms, grown on GaAs has attracted a lot of attention in recent years due to its unusual properties [1, 2] including a large band gap reduction (~50-90 meV per percent of Bi) and a strong enhancement of the spin-orbit splitting. These properties make this material system an attractive candidate to develop GaAs-based applications for long-wavelength optoelectronics as well as for spintronics. It is also complementary to the well-studied dilute nitride alloy $GaAs_{1-x}N_x$ because incorporating Bi in GaAs perturbs the valence band, whereas N in GaAs perturbs the conduction band [3]. It is due to the fact that isolated N forms resonant state in the conduction band and N pairs and clusters form bound states in the band gap. On the other hand, isolated Bi forms resonant state in the valence band and Bi pairs or clusters will form bound states in the band gap. Due to a strong carrier scattering at localized states, N alloying affects mainly the electron density and mobility, while Bi alloying affects the hole density and mobility in GaAs [4]. Unfortunately, efficient incorporation of Bi requires low temperatures and nearly stoichiometric growth conditions due to a large immiscibility between Bi atoms and GaAs compound, what then favours the increase of defect density and can further degrade the electro-optical properties of $GaAs_{1-x}Bi_x$ alloy.

In this paper, we present deep level transient spectroscopy (DLTS) measurements on n-type $GaAs_{1-x}Bi_x$ layers having $0 \leq x \leq 2.3$ grown on GaAs substrate by molecular beam epitaxy (MBE). In the experiment, four Bi-containing samples and one GaAs reference sample grown at the same low temperature equal to 378ºC were investigated. The DLTS temperature spectra show that incorporating Bi suppresses the formation of native electron traps revealed in GaAs, thus reducing the total trap concentration in dilute $GaAs_{1-x}Bi_x$ layers. Moreover, other electron traps are also formed when incorporating Bi, thus they may involve Bi as a constituent. The possible origin of the traps was analyzed with the use of the band gap diagram concept, which considers the reduction of the band gap energy with increasing Bi (or N) concentration. This approach was recently successfully applied for identification of deep electron traps in as-grown and annealed n-type $GaAs_{1-x}N_x$ layers grown by MBE.

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