DLTS investigations of (In,Ga)(As,N)/GaAs quantum well structures before and after rapid thermal annealing

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The (In,Ga)(As,N) semiconductor alloys so called dilute nitrides are currently of great interest due to their unique properties such as a huge and negative band gap bowing coefficient and large conduction band offset, which result from a large size and electronegativity difference between N and As atoms. These features make III-V-N alloys very promising material for applications in 1.3-1.55μm telecommunication lasers [1] and photodetectors [2], as well as high efficient multi-junction solar cells [3]. The introduction of small amounts of nitrogen into GaAs considerably decreases band gap energy of GaAsN down to ~1eV and simultaneously reduces the lattice parameters of the crystal. Moreover, incorporation of indium to GaAsN additionally compensates the mechanical strains and improve crystal quality, which could be lattice matched to common substrates such as GaAs or Ge. Unfortunately, the small amount of nitrogen strongly deteriorates the material quality of diluted nitrides due to a high concentration of impurities (carbon, hydrogen, oxygen) and native point defects (vacancies, interstitials, antisities), which can be the centers of non-radiative recombination and cause low luminescence efficiency or influence on poor minority-carrier diffusion lengths, their mobilities and lifetimes. Therefore, the fundamental goal is to correlate the properties of defects with the electrical and optical properties of (In,Ga)(As,N) alloys.

The purpose of this paper is to present the investigations of deep-level defects by means of deep level transient spectroscopy (DLTS) in (In,Ga)(As,N)/GaAs multi quantum well (MQW) structures grown by atmospheric pressure metal organic vapour phase epitaxial (APMOVPE) technique. In the experiment, three samples grown at the same temperature 575°C with different indium and nitrogen contents, were investigated. Every sample contains three quantum wells of InGaAs, GaAsN and InGaAsN, separated by GaAs barrier, respectively. The DLTS investigations, performed for as-grown and annealed samples revealed a combination of traps that disappear or remain on annealing or even new traps that appear on annealing. Particularly, an additional trap (denote E2/H1) was observed in GaAsN/GaAs structures only after annealing, which can act as both an electron and hole trap, being responsible for the observed very poor optical quality among all the investigated MQW structures.

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This work was co-financed by Polish Ministry of Science and Higher Education under the grant no. N N507 552938.

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