THE DETERMINATION OF THE CHEMICAL COMPOSITION PROFILE OF THE GaAs/AlGaAs HETEROSTRUCTURES DESIGNED FOR QUANTUM CASCADE LASERS BY MEANS OF SYNCHROTRON RADIATION

Jarosław Gaca [1*], Marek Wójcik [1], Maciej Bugajski [2], and Kamil Kosiel [2]

[1] *Institute of Electronic Materials Technology, ul. Wolczyńska 133, 01-919 Warsaw, Poland*

[2] *Institute of Electron Technology, Warsaw, Al. Lotnikow 32/46, 02-668 Warsaw, Poland*

Keywords: QCL, HRXRD, heterostructure, chemical composition

**) e-mail:gaca-jr@itme.edu.pl*

The determination of the chemical composition profile of GaAs/AlGaAs heterostructures designed for quantum cascade lasers is crucial for the development of the special procedures of their growth. The core of the heterostructure makes combined injector and active regions. These dual regions are repeated typically 25-70 times (fig. 1). Each region contains series of ultra-thin AlGaAs and GaAs layers. The thickness of each layer is in the range of a few nanometers. So high-resolution X-ray diffractometry and reflectometry using synchrotron radiation along with the computer simulation is an excellent tool for achieving this goal. Nonetheless, because of high degree of complication of the final structure, it is advisable, to start to investigate each part of the heterostructure separately, beginning with simple units such as injector and active region, and next moving on to the more complicated structures. To this end, samples containing: injector, active region, combined injector and active region, the later repeated 30 times and full quantum cascade laser structure had been grown by means of MBE device with reactor Riber Compact 21T at the Institute of Electron Technology, Warsaw, Poland [1]. As a next step, rocking curves were registered for each sample using synchrotron radiation with wavelength λ = 0.154114 nm at the ROBL-CRG beamline BM20 at the ESRF Grenoble (France). Collected rocking curves were analyzed by means of numerical analysis. Computer program designed for simulating rocking curves, based on Darwin dynamical theory of X-ray diffraction was employed [2]. For the purpose of simulation, a heterostructure was modeled as a stack of parallel atomic planes with different chemical composition. The analysis was performed so that, the chemical composition of each atomic plane had been varied until the best fit between experimental and simulated curves was achieved. The developed method has enabled: to optimize the process of epitaxy, to work out the chemical composition profile as well for the whole heterostructure of the quantum cascade laser as for its parts, to detect and identify the departures from designed structure. The great advantage of this method is the fact that it is nondestructive one, can be used as a method of verification of the quality of the heterostructures without any special prior arrangements a and allows for the correction of errors made during the process of epitaxy.

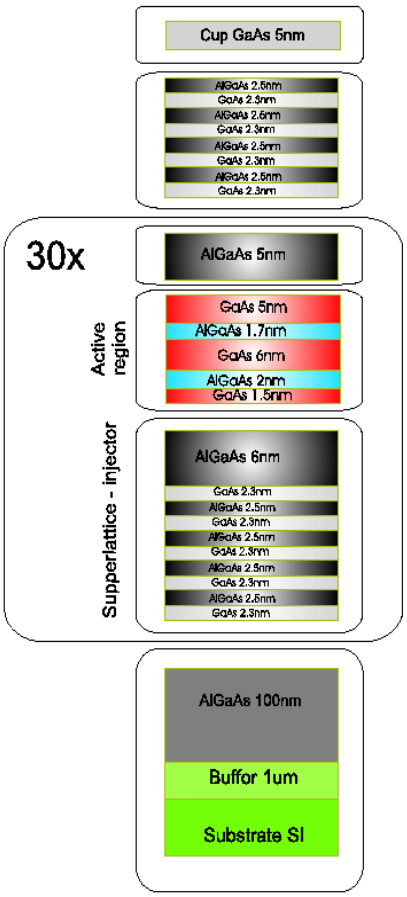

Figure 1. The sample heterostructure for AlGaAs/GaAs quantum cascade laser.

References

[1] K. Kosiel, J. Kubacka-Traczyk, P. Karbownik, A. Szerling, J. Muszalski, M. Bugajski, P. Romanowski, J. Gaca, M. Wojcik, "Molecular-beam epitaxy growth and characterization of mid-infrared quantum cascade laser structures", *Microelectron. J.* **40** (2009) 565–569.

[2] J. Gaca, M. Wojcik, A. Jasik, K. Pierscinski, M. Kosmala, A. Turos, A.M. Abdul-Kader, "Effects of composition grading at heterointerfaces and layer thickness variations on Bragg mirror quality", *Opto-Electron. Rev.* **16** (1) (2008) 12–17.