Aukštos optinės kokybės GaAsBi/GaAs kvantinių duobių fotoliuminescencijos tyrimas

Photoluminescence study of high optical quality GaAsBi/GaAs quantum wells

Evelina Dudutienė[1], Algirdas Jasinskas[1], Bronislovas Čechavičius[1], Sandra Stanionytė[1], Martynas Skapas[1], Dominykas Sanda[1], Monika Jokubauskaitė[1], Joshya Shyamala Rajagopal[1,2], Helene Carrere [1,2], Renata Butkutė[1], Gintaras Valušis[1]

[1]Center for physical sciences and technology, Saulėtekio av. 3,10257 Vilnius
[2]LPCNO, Institut National Des Sciences Appliquées, de Rangueil av. 135, 31077 Toulouse, France
evelina.dudutiene@ftmc.lt

Bismide-based material systems are an attractive candidate to develop GaAs-platform applications for long wavelength optoelectronics, such as infrared lasers [1], photodetectors [2], solar cells [3], terahertz devices [4] etc. This is mainly due to the large band gap reduction possible with incorporation of small amounts of Bi, relatively temperature insensitive band gap, high electron mobility, and the large spin–orbit splitting. In order, to design and optimize GaAsBi-based devices it is essential to know their optical properties, electronic structure, nature of defects, the emission channels, and the efficiency of carrier recombination. In recent years, luminescent properties of GaAsBi quantum wells (QW) are extensively studied. However, the exploitation of those GaAsBi heterostructures has been hampered by the practical difficulties of growing GaAsBi quantum wells with high emission at room temperature (RT).

This work presents temperature-dependent photoluminescence (PL) study of three GaAsBi/GaAs multi-quantum wells (MQW) structures (samples: B862, B871 and B905) grown by molecular beam epitaxy. Carrier recombination in GaAsBi/GaAs MQW were investigated by time-resolved photoluminescence spectroscopy (TRPL) at room temperature (see 1 fig. (a)).

All three MQW structures exhibit exceptionally high room temperature emission intensity. The RT PL spectra dependences on photoexcitation power exhibit a linear behavior. The slopes estimated by fitting the experimental data with the power law $I_{\mathrm{PL}} \propto P_{\mathrm{exc}}^{m}$, are $m = 1.25$, $m = 1.24$ and $m = 1.08$ for the samples B862, B871 and B905, respectively. The index m value around 1 indicates that radiative recombination is dominant even at room temperature. However, RT PL decay times for three investigated structures are different: 52 – 196 ps (B862), 50 – 90 ps (B871) and 200 – 400 ps (B905). Also, temperature-dependent PL measurements showed that all three structures have different temperature dependencies of PL band position. PL peak position versus temperature was analyzed using combined Varshni–Eliseev equations [5]. S-shape character of PL peak position variation with temperature of sample B905 (see 1 fig. (b)) with parameter $\sigma = 24.65 \pm 1.19$ meV indicates effect of carrier localization. That corelates well with longer PL decay time for sample B905. As further matter, activation energies derived from PL measurements together with numerical calculations provided an in-sight into thermal quenching processes of the luminescence intensity.

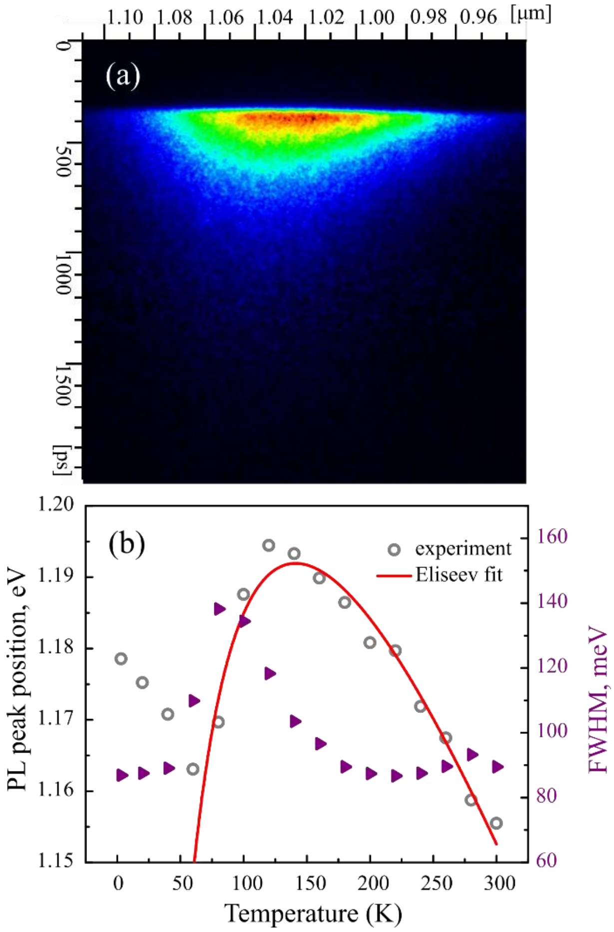

Fig. 1. Streak camera image of temporal decay of the PL of GaAsBi/GaAs MQW at room temperature (a); The energy of GaAsBi/GaAs MQW PL maximum and FWHM as the function of temperature (b).

Keywords: bismide, quantum well, decay time, photoluminescence, carrier localization.

Literature

[1]X. Wu, W. Pan, Z. Zhang, Y. Li, C. Cao, J. Liu, ... & S. Wang, ACS Photonics, **4**(6), 1322-1326 (2017).

[2]Y. Gu, R. D. Richards, J. P. David, and Y. Zhang, *Bismuth-Containing Alloys and Nanostructures*, p. 299-318,(Springer Nature Singapore Pte Ltd. 2019).

[3]A. Muhammetgulyyev, O. G. Erbas, B. Kinaci, O. Donmez, Y. G. Celebi and A. Erol; Semicond. Sci. Technol., **34**(8) 085001 (2019)

[4] M. Karaliūnas, A. Udal and G. Valušis; Lith. J. Phys. **60**(2) 113-124 (2020).

[5]] P. G. Eliseev, P. Perlin, J. Lee, and M. Osiński, Appl. Phys. Lett. **71**(5), 569–571 (1997).