Structural and optical properties of alternately-strained ZnSSe/ZnCdSe superlattices with effective band-gap 2.5 – 2.6 eV

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Integration of II-VI and III-V based cascades into a heterovalent multijunction solar cell can make it possible to increase energy conversion efficiency in comparison with the solar cells based on III-V semiconductors alone due to optimization of the captured spectrum of solar radiation [1]. Semiconductor alloys (Zn,Cd)(S,Se) can be lattice matched to GaAs and have direct band gap; hence they look most suitable for the application as the II-VI cascade material. To that end, it is important to be able to adjust band-gap of (Zn,Cd)(S,Se) flexibly within as wide energy range as possible, while maintaining low density of defects and efficient vertical transport of photoexcited carriers. In this work we have designed and grown the ZnSSe/ZnCdSe pseudomorphic superlattices (SL) with effective band-gap energy E_g in the range 2.5 - 2.6 eV (at 300 K) and investigated their structural and optical properties.

The structures were grown by molecular beam epitaxy (MBE) using a double-chamber set up (Semiteq, Russia) on undoped GaAs (001) substrates with epitaxial buffer layers of GaAs and ZnSe (~10 nm). They consist of 140 periods of SL with a wider CdSe/ZnSe quantum well (QW) inserted after first fifty periods. Nominal thicknesses of CdSe and ZnS_xSe_{1-x} (x=30-40%) in the SLs are in the ranges 1.3 – 1.5 and 4 – 6 monolayers (ML), respectively, while the CdSe nominal thickness in the extended QW is ~2.8 ML, which implies formation of self-assembled CdSe quantum dots. Transmission electron microscopy and X-ray diffraction measurements revealed negligibly small density of misfit dislocations in the structures emitting between 2.5 and 2.6 eV that confirms their pseudomorphic growth. Vertical transport of carriers was studied by measuring temperature dependences of photoluminescence (PL) intensity detected either in the SL or in the enlarged QW. We observed the following typical features: (i) an increase (steep decrease) of the PL intensity in the QW (SL) with temperature increasing in the range 30-85 K (Fig. 1), (ii) non-monotonous (s-shaped) temperature dependence of the Stokes shift of the SL PL line, and (iii) non-monotonous behavior of a peak spectral width for PL detected in the SL. Analysis of these dependences allowed us to estimate the energy scale of fluctuations of the localization potential for photoexcited carriers in the SLs and to demonstrate effective Bloch-type transport in the SLs at temperatures above 100 K.

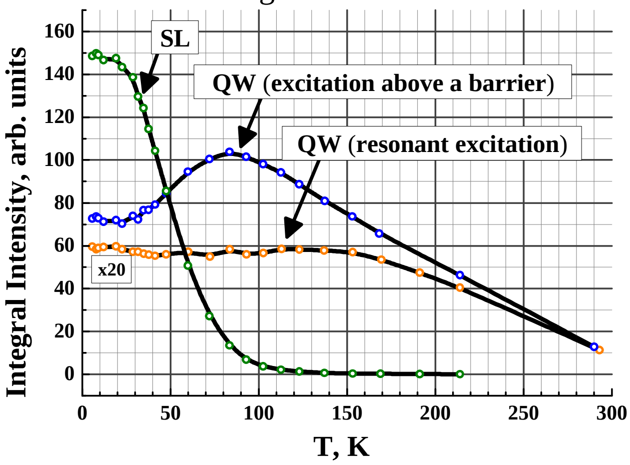

Fig. 1. Temperature dependence of integral intensity of PL in the SL and enlarged QW under resonant excitation and excitation above the SL band-gap.

[1] Y. H. Zhang, S. N. Wu, D. Ding, S. Q. Yu and S. R. Johnson, *Proc. 33rd IEEE Photovoltaic Specialists Conference San Diego, CA, USA* (2008).
[2] S.V. Ivanov, A.A. Toropov et al., *J. Appl. Phys.* **83**, 3168 (1998).