Probing the Increased Hole Confinement in CdTe Quantum Dots

Małgorzata Pilat [1], Łukasz Kłopotowski [2], Piotr Wojnar [2], Krzysztof Fronc [2], Grzegorz Karczewski [2], Tomasz Wojtowicz [2] and Jacek Kossut [2]

[1] *Institute of Experimental Physics, Faculty of Physics, University of Warsaw, ul. Hoża 69, 02-681 Warsaw, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland*

In order to employ CdTe quantum dots (QDs) in optoelectronic devices, it is necessary to make their photoluminescence (PL) signal persist up to room temperature. The usual choice of the barrier material – ZnTe – provides relatively weak confinement in the valence band and small hole interband spacings resulting in the PL vanishing below 100 K. In this work, we show that applying a ternary ZnMgTe barrier significantly extends the temperature range where the PL is visible. We probe the increased hole confinement by comparing the temperature dependence of negatively and positively charged exciton PL of single QDs.

Low temperature single dot PL spectra exhibit four transitions related to recombination of the ground state, s-shell carriers: the neutral exciton (X^0), positively and negatively charged excitons (X^+ and X^-, respectively), and the biexciton (2X). With increasing temperature these PL peaks redshift, broaden, and decrease of intensity. The redshift is related to the bandgap shrinkage. Broadening results from increased exciton-acoustic phonon coupling [1]. The quenching of the PL intensity is due to thermal activation of carriers to other QDs or to excited states within the same dot [2, 3]. In order to study the influence of temperature on particular charge state and thus address the confinement conditions in the conduction and valence band separately, we investigate the temperature dependence of the PL intensities of the X^+ and X^- normalized to the X^0 intensity. For CdTe QDs in ZnTe barriers, we find that the PL vanishes at about 65 K. Importantly, we observe decreasing of the normalized X^+ intensity, while the X^- intensity remains approximately constant. On the contrary, for CdTe QDs in ZnMgTe barriers, the PL is visible up to 115 K and the decrease of the normalized X^+ intensity is substantially slower.

These results point out that upon Mg incorporation in the barrier the hole confinement along the growth axis is increased [2]. As a consequence, the hole states are moved further apart in energy compared to those in CdTe dots in ZnTe barriers, inhibiting the thermal activation of s-shell carriers to excited states. Therefore, our result demonstrate that a proper design of the valence band structure should lead to room temperature emission from CdTe (analogously to CdSe QDs [4]).

[1] L. Besombes, K. Kheng, L. Marsal, and H. Mariette, *Phys. Rev. B* **63**, 155307 (2001).
[2] F. Tinjod, S. Moehl, K. Kheng, B. Gilles, and H. Mariette, *J. Appl. Phys*. **95**, 102 (2004).
[3] S. Mackowski, G. Prechtl, W. Heiss, F. V. Kyrychenko, G. Karczewski, and J. Kossut, *Phys. Rev. B* **69**, 205325 (2004).
[4] O. Fedorych, C. Kruse, A. Ruban, D. Hommel, G. Bacher, and T. Kummell, *Appl. Phys. Lett.* **100**, 061114 (2012).