A model of radiative recombination from quantum well in potential fluctuations

Piotr A. Dróżdż[1,2], Krzysztof P. Korona[1], Marcin Sarzyński[2], Robert Czernecki[2], Czesław Skierbiszewski[2], Grzegorz Muzioł[2] and Tadeusz Suski[2]

[1] *Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*
[2] *Institute of High Pressure Physics "Unipress", Polish Academy of Sciences, Sokołowska 29/37, 01-142 Warsaw, Poland*

Anomaly behavior of photoluminescence energy dependence on temperature is very often observed in InGaN/GaN quantum wells. The energy first decrease in low temperatures, than increase while the temperature grows up, and decrease again at high temperatures which gives so called S – shape. Such behavior is explained by existence of potential fluctuations caused by inhomogenities of indium content in quantum wells.

In last 15 years, several attempts were made to describe the PL energy dependence on temperature. The first approach, in which Gaussian density of states in potential minima was assumed, was done by Eliseev *et al.* [1]. The PL dependence on temperature was obtained by using Boltzmann distribution, however, this theory does not fit to experimental data in range of low temperatures. Theory of Eliseev was later improved by Li *et al.* [2]. Li and collaborators showed that the PL energy dependence on temperature can be described properly by using Fermi-like distribution, however, they assume radiative recombination time to be independent on energy and temperature.

Since experimental evidence points to significant thermal dependence of lifetime, we propose an improved approach to problem of fluctuation-induced S – shape. Our model is next development step of theories presented by Eliseev *et al.* and Li *et al.* Gaussian density of states in potential minima and continuos delocalization of carriers are assumed. Radiative recombination time dependence on temperature and energy is taken into account and formula describing luminescence decay time is proposed. In this model, it is also assumed that the effective temperature of exciton gas is changing with the temperature of crystal lattice. From this assumptions, formula to describe S – shape is obtained, that fits to experimental data in range from helium temperature (4 K) to room temperature as can be seen in Fig. 1.

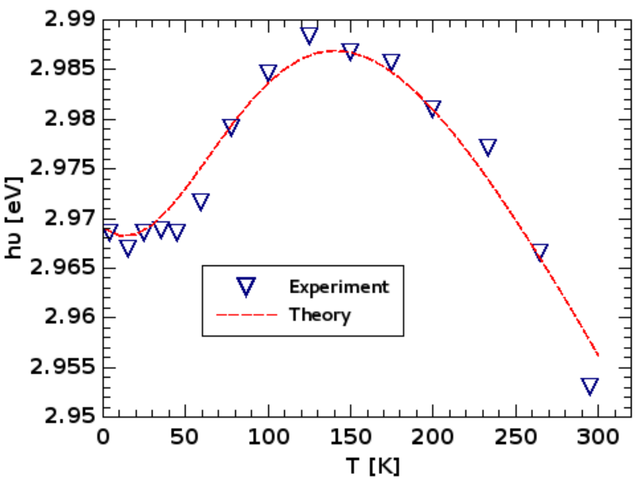

Fig. 1: PL energy dependence on temperature for the sample with 10 nm GaN alloy sandwiched between AlGaN and AlInGaN layers. Experimental data are marked by triangles, whereas dashed red line corresponds to presented theory.

[1] P. G. Eliseev, *J. Appl. Phys.* **93**, 5404, (2003).
[2] Q. Li, S. J. Xu, W. C. Cheng, M. H. Xie, S. Y. Tong, C. M. Che, and H. Yang, *Appl. Phys. Lett.* **79**, 1810 (2001).