# Spectroscopy of Excitons in a Single ZnO/(Zn,Mg)O Quantum Well

**J. Suffczyński[1], H. Teisseyre[2,3], K.P. Korona[1], J. S. Bihałowicz[1], D. Jarosz[2], A. Kozanecki [2]**

[1] *Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw Poland.*
[2] *Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/34,02-668 Warsaw Poland*
[3] *Institute of High Pressure Physics, Polish Academy of Sciences, Sokołowska 29/37,01-142 Warsaw, Poland*

Zinc Oxide is a wide-bandgap material with a high exciton binding energy of 60 meV. As a result, binding energies of charged excitons in ZnO based low dimensional structures should be substantially larger than in their counterparts based on other semiconductors.

The sample used in our studies contains a single 2 nm wide ZnO quantum well embedded between $Zn_{0.79}Mg_{0.21}O$ barriers. It is grown by molecular beam epitaxy on a-plane sapphire substrate. Measurements of transmission and photoluminescence (PL) in magnetic field up to 10 T applied in Faraday geometry, as well as of time-resolved PL have been performed at cryogenic temperatures.

The PL spectra indicate that the QW emission consists of a strong peak at 3.41 eV and a much weaker peak at 3.43 eV (see Figure 1). Absorption spectra confirm presence of two transitions related to the QW. Both transitions exhibit lifetime of about 4 ns, but different dependencies of emission intensity on excitation power suggest their different formation mechanism.

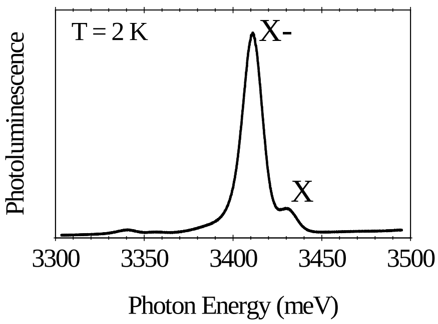


Figure 1. Photoluminescence spectrum of the studied single ZnO/(Zn,Mg)O Quantum Well.

The PL transition at 3.41 eV exhibits a clear circular polarization in the magnetic field with much stronger σ+ component. The 3.43 eV transition practically does not polarize in the magnetic field. These findings can be explained in a consistent manner if 3.41 eV transition originates from recombination of negatively charged exciton X-, while 3.43 eV of neutral exciton X, both related to the highest valence subband of $\Gamma_7$ symmetry. In such a case, the X- spin splitting is defined by a negative Landé factor of the minority carrier, that is $\Gamma_7$ hole. In consequence, the X- thermalization to the state of lower energy, involving the hole with $m_J = +1/2$, enhances the X- signal in σ+ polarization. Accordingly, Landé factor of the X is negligible due to cancellation of positive Landé factor of electron with the negative one of the $\Gamma_7$ hole (both assumed as for bulk ZnO). This results in negligible splitting and lack of apparent emission polarization of the X in magnetic field.

The X- binding energy extracted from the optical spectra attains a record value of 20 meV. It is much more than a few meV typical for other QW systems and than 13 meV found previously for 4.5 nm wide ZnO/(Zn,Mg)O multiple Quantum Wells [1]. The reported on X- binding energy agrees very well with the prediction from the semi-empirical formula published by Sergeev [2], what supports the presented interpretation.

Observed large X- binding energy and resulting increased stability of charged exciton complex is beneficial for coherent control of a QW confined carrier spin and for implementation in low-threshold lasing devices.

[1] J. Puls, S. Sadofev, and F. Henneberger, *Phys. Rev. B* **85**, 041307(R) (2012).
[2] R. A. Sergeev *at al.*, *Eur. Phys. J. B* **47**, 541 (2005).