Electro-optical characterization of ZnO/ZnMgO multiple quantum wells grown on Si (111) by MBE method

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The object of our investigations were 10-period ZnO/ZnMgO multiple quantum wells (MQWs) that have been fabricated on (111) Si by molecular beam epitaxy (MBE) at very high temperatures [1]. The thickness of barriers was kept constant to 2 and 15 nm, whereas the well thicknesses was varied from 1.7 to 3.0 nm. Complex characterization of the obtained samples has been performed using various measurement methods. The optical properties were analyzed by photoluminescence (PL) and cathodoluminescence (CL) techniques. Based on the grown structures, diodes were processed and their electrical properties have been checked by means of current-voltage (I-V) and capacitance – voltage (C-V) measurements. To study the origin of defects in the junctions a deep level transient spectroscopy (DLTS) has been also applied.

CL analysis revealed that the MQWs show excitonic near-band edge emission at room temperature. Panchromatic and monochromatic spectra of CL show the emission from the ZnMgO barrier at 3.341 eV and from the MQWs at 3.373 eV. PL results measured as a function of temperature yield the MQWs peak shift. Namely, we observe the exciton localization effect which may induce red-blue-red shift of the peak energy with increasing temperature. The latter indicates inhomogeneity due to interface fluctuation and the band tail states originating from the high density of defects. The presence of the defects was confirmed by the electrical measurements.

The studied diodes exhibit rectifying properties, however the obtained ideality factor value is greater than unity suggesting that possible mechanisms of current transport in the junction can be e.g.: generation-recombination, tunneling or carrier trapping by the surface states or impurities etc. The double logarithmic forward bias dark I–V plots indicate that the charge transport mechanism is governed by the space charge limited current with the participation of deep traps which are exponentially distributed in the band gap. From the temperature dependence of saturation current the activation energies of the traps present in the studied junctions were calculated and their possible origin has been ascribed. The C-V characteristics that exhibit the so called plateau due to the charge accumulation at quantum wells. The DLTS spectra reveal three deep traps of activation energies equal to 0.017 eV, 0.07 eV and 0.18 eV. Their possible origin has been discussed. DLTS signal analysis let us assume that the defects are located either with the Si or ZnO side of the junction or they can be related also to the heterointerface – most probably the interface ZnMgO-Si.

[1] M.A. Pietrzyk, M. Stachowicz, A. Wierzbicka, P. Dluzewski, D. Jarosz, E. Przezdziecka and A. Kozanecki, *J. Cryst. Growth* **408,** 102-106 2014

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