Acceptor and Donor Related Photoluminescence from ZnO Films Doped with Nitrogen

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The stable *p*-type conductivity of zinc oxide has still encountering problems and is the main obstacle in a wide application of this material in optoelectronics. Regardless a considerable number of papers reporting *p*-type conductivity in ZnO films, in many cases the obtained results remain controversial and the interplay between point and/or extended defects and acceptor states needs to be clarified. It has been reported that doping ZnO with group V elements results in enhancement of luminescence intensity around 3.30-3.32 eV. However, this emission line is commonly observed in a ZnO material irrespective on the chemical nature of dopant or even in a ZnO material without any intentional doping. It has been shown that in epitaxial films the 3.31 eV luminescence is related to structural defects as it is emitted from distinct lines on sample surfaces and cross-sections representing intersections with basal planes of wurzite hexagons [1]. Even in this case the 3.31 eV emission is unambiguously related to a shallow acceptor state located 130 meV above the valence band.

In this paper we report on a photo- and cathodoluminescence study on intentionally undoped and nitrogen doped ZnO layers. The 2 μm thick polycrystalline ZnO films were grown on a highly resistive silicon substrate at low temperature (100^{o}C) under oxygen rich conditions and doped with nitrogen during the Atomic Layer Deposition process [2]. Photoluminescence spectra reveal two dominant emission bands in the excitonic region. Apart from the D^{o}X line at about 3.36 eV also a characteristic emission around 3.30 – 3.32 eV appears. The 3.31 eV emission band appears both in undoped and nitrogen-doped samples, however the RTP annealing in oxygen atmosphere leads to a considerable enhancement of this band only in samples intentionally doped with nitrogen and this enhancement is accompanied by shifting the conductivity towards *p*-type.

The SEM and related spatially resolved low-temperature CL studies show that the area showing donor-related 375 nm emission is complementary to the area showing acceptor-related 370 nm band, which suggests that both *p*-type and *n*-type regions simultaneously coexist in this material. This points out that the 3.31 eV band cannot be clearly associated with structural defects as was suggested before [1].

Acknowledgements. The work was partially supported by the Polish NCN project DEC-2012/07/B/ST3/03567. The Author D.S. acknowledges the partial support from the EU 7th Framework Programme Project No. REGPOT-CT-2013-316014 (EAgLE).

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