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Defects in Zinc Oxide Grown By Pulsed Laser Deposition

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ZnO is a wide band gap semiconductor having excellent properties for fabricating optoelectronic devices operating at the wavelength of ultra-violet (UV). The realization of fabricating UV optoelectronic devices with ZnO based technology is hindered by the asymmetric p-type doping difficulty, which is related to the poor understanding of the defects, defect compensation, and defect control in ZnO materials.
Using pulsed laser deposition (PLD), undoped ZnO films with (002) orientation are grown on c-plane sapphire with the systematic variation of the fabrication parameters including the substrate temperature and oxygen pressure during the growth, as well as the post-growth annealing temperature [1]. Defects in the films were characterized by the positron annihilation spectroscopy (PAS), Raman spectroscopy, secondary ion mass (SIMS) and photoluminescence (PL). The electron concentration (˜1018 cm-3) is similar to the hydrogen concentration measured by SIMS. SIMS study also reveals thermal induced Zn out-diffusion into the sapphire substrate and leaves out the VZn related defects at the ZnO film. Oxygen deficient defect related Raman lines 560 cm-1 and 584 cm-1 are identified and with their origins being discussed. PAS reveals two kinds of VZn related defects having different microstructures in the PLD grown films, which are different from those identified in the ZnO single crystals.
Green luminescence (GL) with more than one origin is found in the films with annealing temperature lower than 900oC. At the annealing temperature of 900oC, the defect emission spectra (measured at 10 K) of all the films irrespective of the initial growth condition exhibit a GL peaked at 2.47 eV and originated from a single defect, and simultaneously the ˜3.23 eV donor-to-acceptor-pair (DAP) emission is introduced. PAS study shows that the GL at 2.47 eV and the DAP are correlated to VZn defect having the ionization levels at EV+0.15 eV and EV+0.97 eV [2]. The result is compatible with the LDA+U calculation [3].

References

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