Photoluminescence and Optical Properties of Ga-doped ZnO Thin Film Grown on (0001) Sapphire Substrate by rf Magnetron Sputtering through Rapid Thermal Annealing

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Transparent and conductive Ga (1wt%)-doped ZnO (GZO) films for UV emission device were deposited at 600°C by rf magnetron sputtering on α-Al2O3(0001). To improve the electrical and optical properties, photoluminescence (PL), and the mobility of GZO thin films, a rapid thermal annealing was performed between 800°C ~ 1000°C in N2 atmosphere. Annealed GZO thin films at 800°C showed low resistivity of ρ=2.6 x 10-4 Ω cm and n_e=3.9x1019/cm3, and high mobility of μ=60 cm2/V s. These properties are explained in terms of translation of Ga atoms from interstitial to substitutional site. After annealing, optical band gap was also increased from E_g=3.27 eV to 3.35 eV by Moss-Burstein effect. As n_e is increased, all the binding energies of O1s, Zn2p1/2, and Ga2p3/2 core-levels in XPS spectra were shifted to lower binding energy. After annealing, PL spectra of GZO films show dominant near-band edge emission corresponding to free exciton emission.