MBE ZnO:Sb layers – structural and optical properties

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Due to its wide direct band-gap of 3.3 eV (at 300 K) and high exciton binding energy (60 meV at room temperature), Zinc oxide (ZnO) is considered to be suitable for optoelectronic devices dedicated for UV-blue range. Because it is a natural n-type semiconductor, its p-type conductivity remains quite a challenge, therefore the literature lacks reports about high-quality p-ZnO. The p-type conductivity can be induced in ZnO by introducing group I or group V elements, however the mechanism standing behind the p-type conductivity in ZnO is still unclear.

In this work we present the results of investigation on ZnO samples with varying concentration of Sb dopant. The structures were grown on *a*-Al_2O_3 substrates with the use of MBE method. The investigation includes X-Ray Diffraction (XRD), Secondary-Ion Mass Spectrometry (SIMS), X-ray Photoelectron Spectroscopy (XPS) and Raman spectroscopy. Based on High Resolution XPS measurements three chemical states of Sb were observed: the dominant which we correlated with Sb^{3+} (BE 539,7 eV) and a small (~10%) amount of Sb^{5+} (BE 540,5 eV) as well as Sb^{3-} (BE 538,03 eV). Experiments including Raman scattering measurements were conducted using the 514 nm line of Ar laser without polarization detection. Besides typical sapphire and zinc oxide modes, Raman spectra revealed additional modes at around 509, 532 and 575 cm^{-1}, associated with the presence of Sb dopants, with intensities increasing with Sb doping. The values of in-plane stress were calculated based on the ZnO E_2^{High} Raman mode. Simultaneously, the FWHM of the E_2^{high} phonon mode increases with Sb concentration which is indicative of an increase in the disorder in the samples. Also annealing effect on the ZnO:Sb layers on Raman spectra was analyzed and the visible presence of compressive in-plane stress was attributed mostly to thermal residual stress, resulting from differences in thermal expansion coefficients of ZnO and Al_2O_3.

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