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Electrical and optical properties of P and As doped ZnO films prepared by pulsed laser deposition

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Tremendous efforts in making *p*-type ZnO thin films by using various techniques and studying their doping properties have recently been under focus of interest. The limitation for the achievement of reliable and reproducible *p*-type ZnO with the high hole concentration, however, was found to be influenced mainly by self-compensation effect and a low solubility of the acceptor dopants. Controlling the electronic properties via doping is a key issue in exploiting ZnO. Among acceptors, which can produce efficient p-doping in ZnO, nitrogen has proven to give shallow acceptor level. However, to date, a few issues related to N incorporation have not been overcome. Aside from the N doping in ZnO, both phosphorus and arsenic appears to be the potential candidates for p-type doping in ZnO. In an effort to incorporate the phosphorus and arsenic in ZnO films, in this work, we used Zn_3P_2 and Zn_3As_2 respectively, as new *p*-type dopant source materials during pulsed laser deposition. Undoped, phosphorus and arsenic doped ZnO films were prepared on Al_2O_3 (0001) substrates at 600°C. X-ray diffraction patterns showed that all of the films were highly c-axis oriented with the ZnO single-phase. The X-ray photoelectron spectroscopy (XPS) results revealed the presence of phosphorus and arsenic in the grown films. The PL results showed a peak corresponding to the recombinations of neutral-acceptor bound excitons emission. Both the P and As-doped ZnO films that had been annealed exhibited p-type conductivity with hole concentrations ~ 1.5×10^{14} - 1.18×10^{18} cm^{-3}.