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Spectroscopic studies of the plasma for the preparation of Al-N co-doped ZnO films

Wu Zhang[1],Peipei Liang[1], Hui Li[1], Xu Yang[1], Yining Qiu[1], Ning Xu[1,2], Jiada Wu[1,2,3,*], Jian Sun[1,2,*]

[1]*Department of Optical Science and Engineering, Fudan University, Shanghai 200433, China*

[2]*Shanghai Engineering Research Center of Ultra-Precision Optical Manufacturing, Fudan University, Shanghai 200433, China*

[3]*Engineering Research Center of Advanced Lighting Technology, Ministry of Education, Fudan University, Shanghai 200433, China*

Abstract

Using optical emission spectroscopy measurements, the plasma formed for the preparation of zinc and aluminum co-doped ZnO films is studied. The O_2/N_2 mixed gas is excited by electron cyclotron resonance microwave discharge, generating an oxygen-nitrogen plasma. A zinc plume and an aluminum plume are induced by pulsed laser ablation of a zinc target and an aluminum target. The expansion of the plumes in the oxygen-nitrogen plasma enhances the excitation of the species of the oxygen-nitrogen plasma, while the ablated zinc and aluminum species are frequently excited at the same time, forming a highly reactive oxygen-nitrogen-zinc-aluminum plasma containing active oxygen- and nitrogen-related species excited from the O_2/N_2 gas and zinc and aluminum species ablated from the zinc and aluminum targets, as well as nitric oxide molecules produced in the plasma. The active oxygen species compose a reactive oxygen-containing gaseous environment for oxide formation, and the active zinc species react with the active oxygen species for ZnO film deposition, while the active nitrogen and aluminum species are *in situ* co-doped in the growing ZnO film. The optical properties of ZnO films are improved by zinc and aluminum co-doping including blue shifting of absorption edge, widening of band gap and preserving of high transparency.