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Positron beam study of Co doped ZnO films prepared by PLD

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Abstract

Slow positron beam are used to study defect structures in Co doped and undoped ZnO films prepared by Pulsed Laser Deposition (PLD) at 400° C, 600° C, 700° C on c-plane sapphire. Comparing with ZnO samples, Co doped ZnO samples have larger positron effective diffusion length (L_{eff}), which change in different tendencies depending on the growth temperature. Crystal structures of the samples are investigated by X-ray diffraction (XRD) and wurtzite ZnO could be observed in Co doped samples.

Introduction

As II-VI oxide dilute magnetic semiconductors (DMS), Co-doped ZnO has called people's much attention. Since Ueda et al. observed that Co-doped ZnO thin films grown by pulsed laser deposition (PLD) have ferromagnetic behavior with T_c above RT[1], several other groups also reported the high T_c of Co-doped ZnO. However, the value of saturation magnetization usually varies between 0.56μB/Co [2] to 2.6μB/Co[3] for different preparation techniques and conditions. So, issues about magnetic ions' distribution in the basic substance and their effects on the structure as well as the macro magnetic characters remain deserve further studies. In this work, slow positron beam are used to study Co doped ZnO thin film samples prepared by pulsed laser deposition (PLD). With the benefits of positron annihilation and variable beam energy, it is a sensitive probe to detect open-volume defects in various materials such as metals, semiconductors, polymers and nanomaterials [4][5].

Experimental details

Co doped ZnO films were fabricated on sapphire (0001) surface using PLD with a KrF laser having a thickness of 1μm at 400° C, 600° C, 700° C respectively. All targets are prepared from ZnO and Co_2O_3 powders and have a nominal Co content of 10 at. % . Three undoped ZnO films were also grown at the same condition, except the components of the targets.

Slow positron beam in University of Science and Technology of China (USTC) are used in this work. Its positron energy could vary from 0.25keV to 17keV. Defect sensitive linear parameter S is defined as the ratio of the integral of ray counts in central energy region to the total counts of the spectrum, while the W parameter is the ratio of the wing area to the total area.

Conventional X-ray diffraction (XRD) with Cu K_α radiation (λ=1.5406 Å) (MAC MXPAHF) were used to characterize the crystal structure and the surface morphology of samples.