

Study on Magnetic Properties and Electronic Structures of Diluted Magnetic Semiconductor Multilayers

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1 Introduction

Dilute magnetic semiconductor (DMS) is an attractive material for the spin-dependent semiconductor or so-called spintronics. In the DMS the transition metal are diluted within the non-magnetic materials [1]. Although the origin of ferromagnetism in the DMS has been reported and accumulated now, the unique properties of the DMS have not revealed perfectly yet. The DMS are fabricated with the sol-gel method, the ion-implantation method, molecular beam epitaxy and so on [2~4].

We have been studying the unique properties of the DMS composed of multilayered structure of the Fe doped ZnO layers (ZnOFe) and the host layer (ZnO) with XRD, XPS and RBS analysis [5]. In this study, we investigated the local structure of the ZnOFe/ZnO multilayer DMS by using the XAFS spectroscopy.

2 Experiment

The ZnOFe/ZnO multilayer was deposited on a Si (111) substrate with the helicon plasma sputtering process. The ZnOFe layer was deposited by co-sputtering of the ZnO and the Fe targets, while the ZnO layer was deposited by the ZnO target. The two targets have same deposition rate of 0.057 nm/sec in the sputtering process. The layer structure is 30 bilayers of ZnOFe/ZnO layers. The six samples were fabricated, where the thickness of the ZnOFe layer are changed to 0.34 nm, 0.68 nm, 1.03 nm, 1.37 nm, 1.82 nm and 2.28 nm, although the thickness of all ZnO layers are constant of 6.84 nm. Thus, the nominal Fe atomic concentrations of ZnOFe/ZnO multilayers indicate 1.2 at%, 2.3 at%, 3.3 at%, 4.3 at%, 5.4 at% and 6.5 at%, respectively.

The XANES measurements of the ZnOFe/ZnO thin film were performed with the 19-elements Ge-SSD (silicon drift detector) at the BL-12C, KEK-Photon factory. The XANES spectra in this experiment were measured at the fluorescent-XAFS mode for the diluted samples. The energy range is 4 ~23 keV and the energy resolution is 2×10^{-4} (dE/E). The Ge-SDD detector for the fluorescent measurement was placed to the perpendicular to the incident X-ray beam.

3 Results and Discussion

Fig. 1 shows the Fe K-edge XANES spectra for the ZnOFe/ZnO multilayer thin films. The main peak around 7118 eV correspond to the 1s to 4p transition and pre-edge peaks around 7110 eV can be assigned to 3d-4p hybridized state. The main peaks around 7120 eV were shifted to the lower energy with increasing of the Fe concentration.

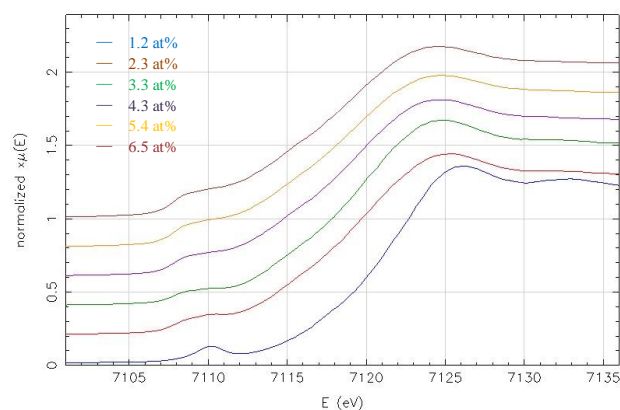


Fig. 1: XANES spectra of ZnOFe/ZnO multilayered DMS which are the nominal Fe atomic concentrations indicate 1.2 at%, 2.3 at%, 3.3 at%, 4.3 at%, 5.4 at% and 6.5 at%

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