BL-16A/2021G501

Room Temperature Ferromagnetism in Copper-doped Zinc-oxide

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1.INTRODUCTION: Zinc-Oxide (ZnO) is a wide band gap semiconductor with the band gap of 3.37 eV. A very large number of publications are there based upon the photocatalytic activities of ZnO. Although the present study is mainly focused on the room temperature ferromagnetism by having copper (Cu) as the dopant. Room temperature ferromagnetism has been confirmed in the copper doped zinc oxide (Cu:ZnO) and the same is attributed to the dopant profiles [1]. In this study, we performed x-ray absorption spectroscopy (XAS) technique to measure the XMCD profiles for both the surface sensitive TEY mode and bulk sensitive TFY mode of nanocrystalline ZnO:Cu powder. The ferromagnetic behaviour of the sample can be truly witnessed for both the modes and is consistent with the previous studies. The ferromagnetic behaviour of the sample is because of the ion-induced interaction between the different oxidation states of the dopant.

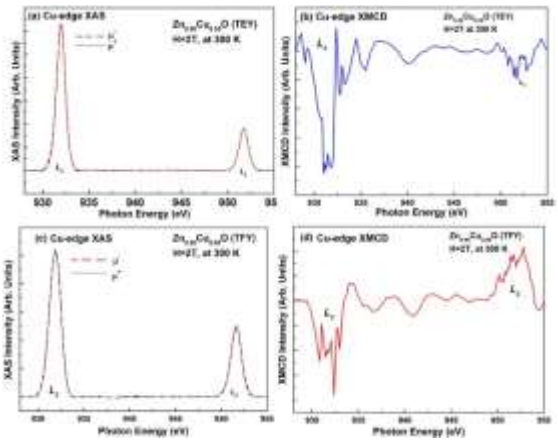

Fig. 1. Room temperature XAS and XMCD spectra of Cu:ZnO, with the doping concentration of 5%, at the field intensity of 2T; (a) XAS in TEY mode, (b) XMCD in TEY mode, (c) XAS in TFY mode, and (d) XMCD in TFY mode.

2.EXPERMENTAL**:** The purpose of the present study is to detect the room temperature ferromagnetism in the nanocrystalline Cu:ZnO powder through the measurements of the spin and orbital magnetic moments using x-ray magnetic circular dichroism (XMCD). Cu:ZnO nanocrystalline powder with the doping concentration of 5% was achieved via sol-gel method with precise control of the doping concentration. X-ray absorption spectroscopy (XAS) and soft x-ray magnetic circular dichroism (XMCD) measurements were performed at the undulator beamline BL-16A of Photon Factory, KEK.

3.RESULTS AND DISCUSSIONS: Figure 1 shows the Cu $L_{2,3}$ XAS and XMCD spectra of Cu:ZnO nanocrystalline powder with the doping concentration of 5% at a magnetic field of H = 2.0 T at 300K for both TEY and TFY modes. There is a very clear and distinct XMCD profile for TFY mode whereas for the TEY mode, the XMCD profile is very weak and ambiguous. This is consistent with the previous study of Kataoka *et al* [2]. The calculated values of orbital and spin magnetic moments using the sum rule are 0.00111 μ_B/Cu, 0.07281 μ_B/Cu, respectively. The study not only confirms the ferromagnetic behaviour of the sample but also suggests that the same is clearly observable for the bulk. For the surface, the ions are actually non-magnetically coupled to each-other, i..e., Cu^{3+} ions are mainly on the surface while in the bulk Cu^{2+} ions result in the ferromagnetism. These Cu^{2+} ions are coupling together via zinc vacancy [3] to establish the ferromagnetic nature of the sample which even gets enhanced with the increase in the field strength.

ACKNOWLEDGEMENTS: The experiment at the Photon Factory was approved by the Program Advisory Committee (Proposal Nos. 2021G501. Authors acknowledges support from UGC-BSR Start-up Research Grant F.30-395/2017(BSR).

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