

X-ray absorption spectroscopy and x-ray magnetic circular dichroism study of Cr-doped CdMnTe

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Introduction

Diluted magnetic semiconductors (DMSs) have attracted considerable attention in the past few years from the view point of utilizing both charge and spin of electrons [1]. Cr and Mn are the most interesting 3d transition metals because of its magnetic properties in compounds and alloys. Cr-based magnetic semiconductors were theoretically investigated by Sato *et al.* [2] and Blinowski *et al.* [3]. Recently, Shen *et al.* [4] observed ferromagnetic behavior of quaternary Cd_{1-x-y}Mn_xCr_yTe crystals. Here, we report on Mn $L_{2,3}$ x-ray absorption and x-ray magnetic circular dichroism (XMCD) experiments of Cd_{1-x-y}Mn_xCr_yTe thin films in order to study the electronic structure and magnetic properties of Mn and Cr ions embedded in the lattice of Cd_{1-x-y}Mn_xCr_yTe which show ferromagnetism.

Experiment

The samples studied here are thin films of Cd_{1-x-y}Mn_xCr_yTe. We varied y from 0 to 0.04 while keeping x fixed around 0.20. The thin films were fabricated on GaAs (001) substrates by molecular beam epitaxy (MBE). The sample surface was capped with a 2 nm thick Al layer to avoid the oxidization. The XAS and XMCD measurements were done at BL-16 of KEK-Photon Factory (PF), Japan. The XAS spectra were taken in total fluorescence yield (TFY) mode.

Results and Discussion

The XAS spectra were taken in the magnetic field 1T, 3T and 5T at temperature 15K and are denoted by μ_- and μ_+ for left and right circularly polarized light, respectively. The XMCD spectrum was observed by taking difference between negative and positive helicity of the circular polarized light. Figure 1 shows the Mn 2p-3d XAS and the XMCD spectra for Cr-doped Cd_{1-x}Mn_xTe thin films, taken in the TFY mode. The main two groups of the peaks shown in XAS spectra are due to the Mn 2p_{3/2} (L_3 edge) and 2p_{1/2} (L_2 edge) spin-orbit components and are in good agreement with the Mn XAS reported by Ohldag *et al.* [5]. The magnetic field dependence of the XMCD intensity shows clear ferromagnetism at temperature 15K. The Cr ions were in the 2+ states and the direction of the

magnetic moments of Cr and Mn was found to be in the same direction. From the magnetic field dependence of the XMCD intensities, we conclude that the ferromagnetism in Cd_{1-x-y}Mn_xCr_yTe thin films is due to the Mn²⁺ ions.

Conclusions

We have performed XAS and XMCD measurements on the Cr-doped CdMnTe thin films in the TFY mode. The XAS and XMCD results suggest that the ferromagnetism in Cr-doped CdMnTe thin films is mainly due to the Mn²⁺ ions. The presence of Cr ions enhances the contribution of the magnetic moments of the Mn ions to the total magnetization in this material.

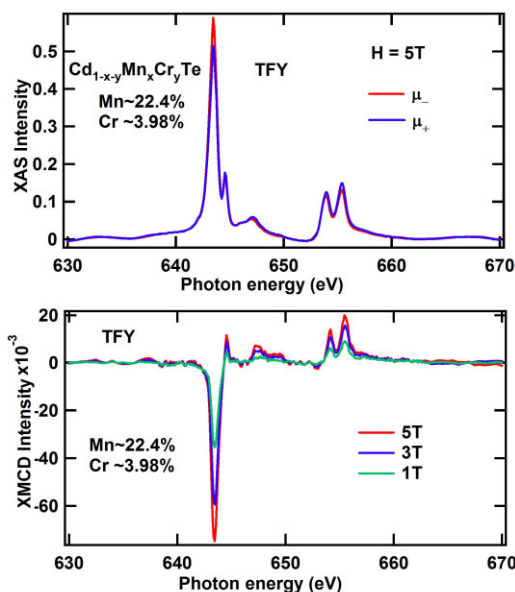


Figure 1: Mn $L_{2,3}$ -edge XAS and XMCD of Cd_{1-x-y}Mn_xCr_yTe

References

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