10TH JOINT MMM/INTERMAG CONFERENCE

JANUARY 7-11, 2007

BALTIMORE, MARYLAND

ABSTRACTS

FR-09. Synchrotron radiation spectroscopy study of valence states and electronic structures of transition-metal ions in $Fe_{1-x}Cu_xCr_2S_4$ spinel sulfides. *J. Kang[1,2], S.S. Lee[1], G. Kim[1], S.W. Han[2], S.J. Kim[3], C.S. Kim[3], J.Y. Kim[4], H.J. Shin[4] and B.I. Min[5] 1. Physics, The Catholic University of Korea, Bucheon, South Korea; 2. CSCMR, Seoul National University, Seoul, South Korea; 3. Physics, Kookmin University, Seoul, South Korea; 4. Pohang Accelerator Laboratory, Pohang, South Korea; 5. Physics, POSTECH, Pohang, South Korea*

The observation of the very large negative magnetoresistance (MR) and the metal-insulator (M-I) transition in $Fe_{1-x}Cu_xCr_2S_4$ (x=0, 0.5) spinel sulfides has invoked much interest in spinel sulfides. In order to elucidate the origin of giant MR and the M-I transition in $Fe_{1-x}Cu_xCr_2S_4$ (x=0, 0.5), it is important to understand their electronic structures. In this work, we have investigated the valence states and the electronic and magnetic structures of transition-metal (T) ions in $Fe_{1-x}Cu_xCr_2S_4$ ($0.1 \le x \le 0.5$) by using synchrotron radiation spectroscopies, such as soft x-ray absorption spectroscopy (XAS), photoemission spectroscopy (PES), and soft x-ray magnetic circular dichroism (XMCD). The measured T 2p XAS spectra show that the valence states of Cr and Cu ions do not change with x in $Fe_{1-x}Cu_xCr_2S_4$ ($0.1 \le x \le 0.5$), and that they are nearly trivalent (Cr^{3+}) and monovalent (Cu^{1+}), respectively. The Fe 2p XAS spectra of $Fe_{1-x}Cu_xCr_2S_4$ are very similar to that of Fe metal, indicating that the Fe 3d electrons have the metallic-like bonding. The T 2p XMCD spectra provide evidence that the magnetic moments of Cr and Fe ions are aligned antiparallel to each other. Valence-band PES measurements reveal that the Fe 3d states consist of the occupied majority-spin ($\uparrow$) $t_{2g\uparrow}$ and $e_{g\uparrow}$ states below E_F, and the partially occupied minority-spin ($\downarrow$) $e_{g\downarrow}$ states very close to E_F. The Cr 3d states, with the $t_{2g\downarrow}^3$ (Cr^{3+}) configuration, are located at ~1.5 eV below EF. The Cu 3d states are found to be nearly filled ($3d^{10}$) and they are located at ~2.5 eV below EF. The S 3p states are very broad, indicating the large hybridization to Fe 3d states. These findings suggest that the metallic character of $Fe_{1-x}Cu_xCr_2S_4$ for x>0 is determined mainly by the hybridized Fe 3d-S 3p states.