Mn K-edge RIXS Study of Magnetic Phase Transition in Mn_3GaC

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Mn_3GaC perovskite shows a first-order phase transition from ferromagnetic (F) to anti-ferromagnetic (AF) phase accompanied by lattice expansion at T_t=170K with decreasing temperature. It is well known that this phase transition sensitively depends on both magnetic field and pressure.[1-4] Since the response to the external fields has attracted basic interest in itinerant magnetism, the electronic property under various conditions has been studied. We have previously recorded XMCD at the Mn K-edge in Mn_3MC (M=Zn and Ga) system and reported that covalency in Mn atom may be closely associated with the phase transition.[3] However, there is a little amount of information about Mn valence state related to the phase transition. X-ray emission spectroscopy (XES) at the Mn K-edge further allows us to enhance and separate specific states related to local symmetry, valence states, or spin states.

To study the magnetic and valence states of Mn atom, we measured Kβ emission spectrum of Mn_3GaC in AF, F and paramagnetic (P) phases. A spherically bent Si(440) crystal was employed as an analyzer, by which total energy resolution of 0.85 eV was achieved. Kβ emission spectra in MnO and pure Mn metal were also recorded as reference.

Figure 1 shows the Mn Kβ emission spectrum in each phase of Ma_3GaC in comparison with those in MnO and Mn metal. Excitation energy ($h\nu_{ex}$) was tuned to 6560 eV, which corresponds to the main-peak of the Mn K-edge absorption spectrum. The emission spectra are characterized by an intense peak ($K\beta_{1,3}$) at 6492 eV and a broaden satellite peak (Kβ') on lower energy side. As seen in Fig. 1, the overall profile in Mn_3GaC is very similar to that in Mn metal; in particular, the Kβ' profile is very diffused. This characteristic is clearly different from that in MnO. This is attributed to a metallic property of Mn_3GaC. Surprisingly, for the temperature variation, the spectral profile in P, F and AF phases very resembles in spite of the different magnetic state. Hence, the following considerations may be led: (1) Because the Mn 3d spin states are stable, the 3d-3p hybridization could be insensitive to the magnetic structure; (2) the Kβ' XES is not effective for studying metallic substance due to electron screening; (3) we should pay attention to the pre-edge region as the excitation energy for studying Mn 3d states in context the magnetic phase transition. Therefore, we have also measured the Kβ emission spectrum with the excitation energy around the pre-edge region. The analysis is now in progress.

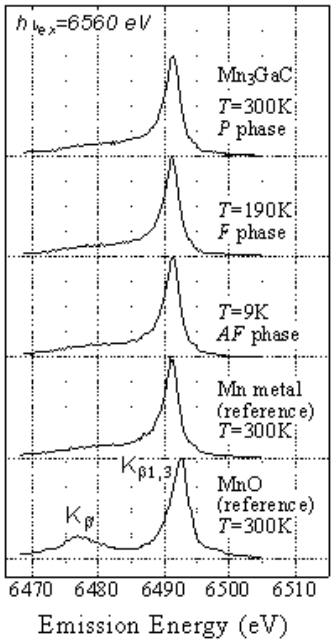

Figure 1. Kβ emission spectra.

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