Electronic Structure of the *p*-type Ferromagnetic Semiconductor (Ga,Fe)Sb

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Fe-doped GaSb is a newly synthesized *p*-type ferromagnetic semiconductor, which exhibits ferromagnetism at a relatively high temperature of 340 K [1-3].

In order to reveal the mechanism of the ferromagnetism, we have studied its electronic structure and magnetic properties by soft x-ray resonance photoemission spectroscopy (RPES), x-ray absorption spectroscopy (XAS), and x-ray magnetic circular dichroism (XMCD). The measurements were performed at BL23SU of SPring-8. Figure 1(a) shows the RPES spectra of an Fe 13.7%-doped sample (T_C = 180 K) taken with the photon energies across the Fe L_3 absorption edge from 705 eV to 715 eV. The color and the baseline positions represent the photon energies as depicted by triangles on the XAS spectra shown in Fig. 1(c). Here, the off-resonance spectrum taken with the photon energy of 704 eV shown in Fig. 1(b) has been subtracted to emphasize the resonance behavior. One can see a strong normal Auger peak dispersing with incident photon energy, and we observed an enhancement of the photoemission intensities at E_F, both of which suggest the itinerant nature of the Fe 3*d* electrons. On the other hand, one can also see resonantly enhanced non-dispersive structures around 1.7 eV and 10.3 eV, denoted by α and β, respectively, indicating the localized nature of the Fe 3*d* electrons as well. This kind of non-dispersive structures were not seen in the previous measurements on Fe-doped Ge, suggesting stronger localization of Fe 3*d* electrons in (Ga,Fe)Sb than in Ge:Fe. From XMCD measurements, the magnetic moment of Fe was found to be ~1.5 μ_B at H = 7 T and T = 5 K, much smaller than the ionic value of Fe^{3+}, indicating the existence of paramagnetic or antiferromagnetically coupled Fe atoms.

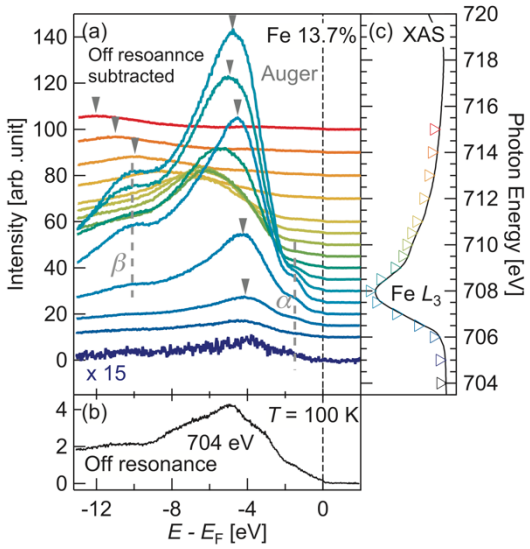

Fig. 1 (a) Resonance photoemission spectra of $Ga_{1-x}Fe_xSb$ (x = 13.7%). Off-resonance spectrum and x-ray absorption spectrum are shown in panels (b) and (c).

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