n 型強磁性半導体(In,Fe)As の電子構造に対する Be 添加効果

Effect of Be Doping on the Electronic Structure of *n*-Type Ferromagnetic Semiconductor (In,Fe)As

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Ferromagnetic semiconductors (FMSs) have attracted much attention as key materials for spintronics because of their properties of both semiconductors and ferromagnets. (In,Fe)As:Be is a new *n*-type FMS discovered recently [1]. Here, Fe ions isovalently substitute the In site providing local magnetic moments to the system and Be dopants act as double donors. Therefore, one can control both the concentrations of magnetic moments and of carriers independently in (In,Fe)As:Be [1,2], thus it is a promising material for spintronic device applications and can be a model system for fundamental understanding of the carrier-induced ferromagnetism in FMSs.

Since Be dopants substitute the cation sites in III-V semiconductors, they are usually acceptors supplying holes. However, Be dopants in (In,Fe)As grown by low-temperature MBE are located at interstitial sites and act as double donors supplying electron carriers [1,2]. In this work, to investigate the effects of Be doping on the electronic structure of (In,Fe)As, we have performed resonant inelastic X-ray scattering (RIXS) measurements on (In,Fe)As thin films with and without Be doping. RIXS enable us to distinguish slight changes of the electronic structure which is undistinguishable in X-ray absorption spectroscopy [3].

Figure 1 shows the Fe L_3 RIXS spectra of a paramagnetic $In_{0.95}Fe_{0.05}As$ film without Be doping and a ferromagnetic In0.95Fe0.05As with Be doping (T_C ~ 40 K) film. We have observed the fluorescence component with high intensity and the Raman component independent of the excitation (incident photon) energy. There are clear differences of the Fe 3*d* Raman components between the two samples, although the Be concentration proportional to the carrier concentration is of the order of 10^{19} cm^{-3}. This result suggests that the Be doping strengthens the hybridization between the Fe 3*d* and the InAs bands.

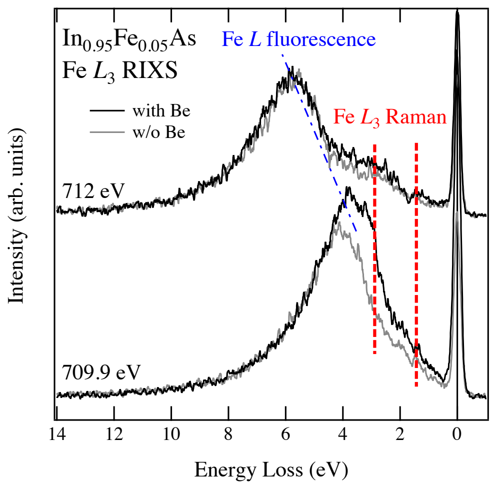

FIG.1 Fe L_3 RIXS spectra of (In,Fe)As plotted against energy loss. The thickness of films was 20 nm. The spectra were taken at 709.9 eV and 712 eV. These spectra are composed of the Fe fluorescence and Raman components.

References:
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