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In-situ 高分解能 ARPES でみる(Ga,Mn)As の価電子帯電子状態

Valence-band electronic structure of (Ga,Mn)As studied by high-resolution ARPES

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Carrier-induced nature of ferromagnetism in a ferromagnetic semiconductor, (Ga,Mn)As, offers a great opportunity to observe novel spin-related phenomena as well as to demonstrate new functionalities of spintronic devices [1]. Many experimental observations in (Ga,Mn)As have been well explained by the model based on the exchange interaction among localized Mn moments mediated by itinerant holes, the so-called *p-d* Zener model, in which holes reside in the GaAs host-like valence band. On the other hand, several spectroscopic studies suggested that the Fermi level (E_F) is pinned in the impurity band inside the bandgap formed by Mn doping. Despite intensive studies, no conclusive consensus has been reached yet..

In this talk, we report an *in-situ* high-resolution ARPES study on epitaxially-grown (Ga,Mn)As thin films [2]. To overcome the possible surface problems, MBE-grown films were directly transferred to the ARPES vacuum chamber without being exposed to the air. For $Ga_{0.95}Mn_{0.05}As$ with Curie temperature T_C of ~100 K, we observed a holelike valence band at the Γ point as seen in Fig. 1. The Fermi level E_F is located in the valence band, as evident from the clear Fermi-edge cutoff. Comparison with a tight-binding calculation (gray dashed line) and also with ARPES result of nonmagnetic n-type GaAs demonstrate the hole-doped nature of the valence-band states for $Ga0_{.95}Mn_{0.05}As$. We also observed a disorder-induced soft Coulomb gap at E_F as well as the close link between the T_C and the metallic spectral weight at E_F. We discuss these experimental results in comparison with theoretical models proposed to explain the ferromagnetism in (Ga,Mn)As.

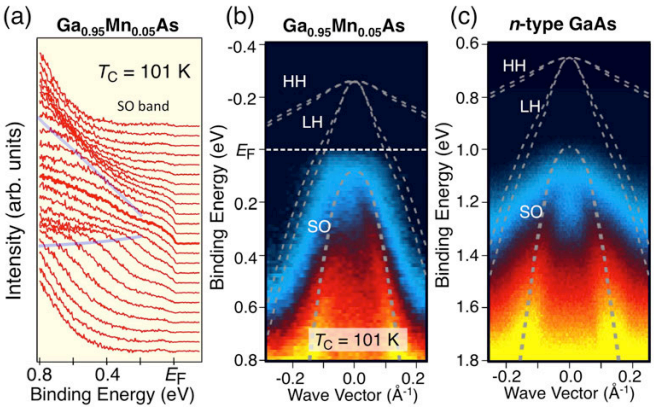

Fig. 1 (a) Near-E_F ARPES spectra of $Ga_{0.95}Mn_{0.05}As$ (T_C = 101 K) around the Γ point [2]. (b) ARPES-intensity plot of (a). Dashed curves are calculated band dispersion within tight-binding approximation. (c) Same as (b) for n-type GaAs.

[1] T. Dietl and H. Ohno, Rev. Mod. Phys. **86**, 187 (2014).

[2] S. Souma *et al*., Sci. Rep. **6**, 27266 (2016).