Large Modulation of the Fermi Energy in an Iron-Based Alloy

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There are three transition elements having Curie temperatures (T_c) higher than a room temperature (RT) due to the Stoner criterion: cobalt, nickel, and iron (Fe).[1)] An obstacle to the application is their little variation of the Fermi energy, E_F: they locate at within only 0.7 eV (ranging from −4.5 to −5.2 eV below the vacuum level), which hampers progress in spintronic devices involving the manipulation of Schottky barriers or Rashba fields. Spintronics researchers desire new ferromagnetic/ferrimagnetic materials (FMs) satisfying T_c > RT and widely variable E_F. Here we present an Fe-based alloy, FeGd.

$Fe_{100-x}Gd_x$ thin films were prepared by the co-evaporation of Fe and Gd. To examine the E_F, ultraviolet photoelectron spectroscopy was carried out to measure the work function, Φ, i.e., the difference between E_F and a vacuum level. The total thickness of the sample film was 60 nm, and the deposition rate of each source was changed during the evaporation to make a variety of x in the film. We observed a large change of Φ depending on x (the atomic percent of Gd) as shown in Fig. 1. Surprisingly, only 20 % of Gd incorporation in Fe raised the E_F dramatically from −4.8 to −3.0 eV — out of the scope of the conventional understanding based on the image force model.[2,3)] We confirmed the $Fe_{80}Gd_{20}$ alloy has magnetization and spin polarization at RT: the magnetization was confirmed at RT as shown in Fig. 2a by using a vibrating sample magnetometer, and the spin polarization was confirmed at 300K as shown in Fig. 2b by measuring the anomalous Hall effect. The finding provides a new insight for designing new spintronic devices.

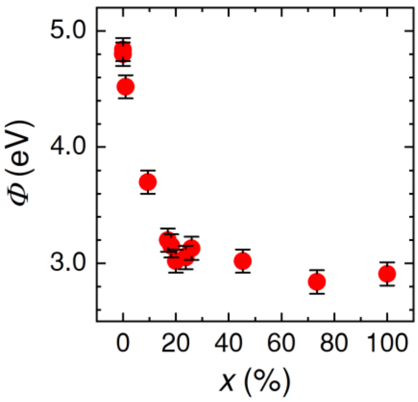

Figure 1: Work functions of the $Fe_{100-x}Gd_x$ alloys

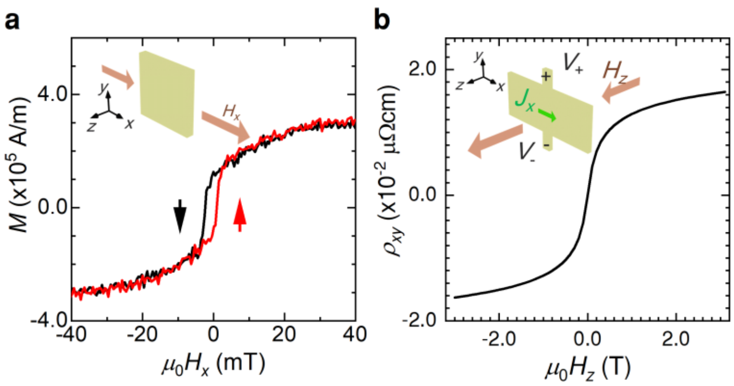

Figure 2: Magnetization and anomalous Hall effect of $Fe_{80}Gd_{20}$ alloy measured at a room temperature.
(a) *M-H* curve and **(b)** ρ_{xy}-H_z curve measured at 300K.

Reference

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3) S. Halas and T. Durakiewicz, J. Phys.: Condens. Matter **10**, 10815 (1998).