BC08

Electronic structure and spin-filter effect of spinel ferrites

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One of the important issues in the field of spintronics is spin injection into semiconductors. It is now known that the spin injection can be efficiently done from metallic ferromagnetic to semiconductors via tunnellingbarrier. Since the spin polarization of transition-metal ferromagnets is about 0.3~0.5, more efficient method of the spin injection is desired. A promising one is to utilize a ferromagnetic insulator as the tunnelling barrier.

Since the barrier height of ferromagnetic (or ferrimagnetic) insulators may be spin dependent, high efficiently of the spin-filter effect is expected for tunnel junctions with the ferromagnetic insulator. Eu chalcogenides, $BiMnO_3$, and La_2NiMnO_6 are typical ferromagnetic insulators, however, the Curie temperature is not high enough for technological applications. On the other hand, spinel ferrites MFe_2O_4 (M=Co, Ni) and a garnet ferrite $Y_3Fe_5O_{12}$ are ferrimagnetic insulators with Curie temperature higher than room temperature, and therefore can be promising candidates to realize efficient spin filtering. The purpose of the present work is to clarify the electronic structures of $CoFe_2O_4$ (CFO), $NiFe_2O_4$(NFO) and $Y_3Fe_5O_{12}$ (YFO) and to discuss the spin-filter effect in tunnelling junctions containing one of these ferrimagnetic insulators.

We calculate the electronic structures of CFO, NFO and YFO using the first-principles band calculation (GGA+U), and obtain a ground state of ferrimagnetic insulator. The calculated density of states of NFO is shown in figure 1. The energy gap of CFO, NFO and YFO are 0.6, 1.0 and 1.6 eV, respectively, when U=4.0eV. The results for CFO and NFO are in agreement with previous results [1].

On the basis of the electronic structure calculated, we discuss the spin filter effect, by applying the free electron model, and by a simplified tight-binding model which reproduces the electronic states near the band gap. We will show that these ferrimagnetic insulators work as the spin-filter with high efficiency.

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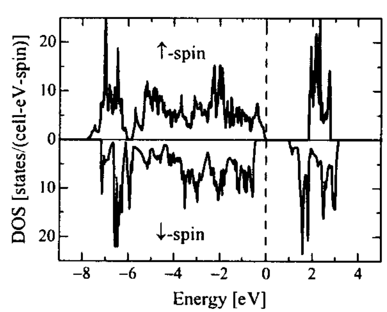

Fig. 1. Density of states of $NiFe_2O_4$. The dashed vertical line represents the position of the valence band top.

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BC09

Huge Quadratic Magneto-optical Kerr Effect and its Modification by Ion Irradiation in $Co_2FeSi(100)$

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Heusler alloys are promising candidates for spintronics devices providing high spin polarization. We report on magnetic and magneto-optical properties of thin $Co_2FeSi(100)$ Heusler films measured by means of magneto-optical Kerr effect (MOKE) [1].

$Co_2FeSi(100)$ films sputtered on MgO(100) grow in the fully ordered $L2_1$ structure. MOKE hysteresis loops measured on Co_2FeSi films with a thickness of 21 nm exhibit a large quadratic (QMOKE) and longitudinal MOKE (LMOKE) contribution, resulting in asymmetrical MOKE loops (Fig. 1(a)). The amplitude of the QMOKE signal was found to be 30 mdeg, the largest QMOKE amplitude found so far. It is a hint to the existence of an unusually large spin-orbit coupling of the second order in Co_2FeSi films with respect to other ferromagnetic materials.

In order to study the effect of structural disorder on the magnetic properties, we irradiated the Co_2FeSi samples with different fluences of 30 keV Ga+ ions. The coercivity as well as LMOKE signal is nearly constant up to fluences of about 10^{15} ions/cm^2 and decreases for higher fluences. This indicates that the ferromagnetism of Co_2FeSi is resistant to partial disorder inside its crystallographic structure. Although the LMOKE signal is nearly not affected by the small irradiation doses, the QMOKE signal is surprisingly reduced even for very small irradiation doses. It shows that small irradiation doses reduce the spin-orbit coupling of the second order while keeping the first order spin orbit coupling and the exchange interaction unmodified. This work has been financially supported by the DFG in the FG 559 and by the Japanese government in the NEDO grant 2004IT093.

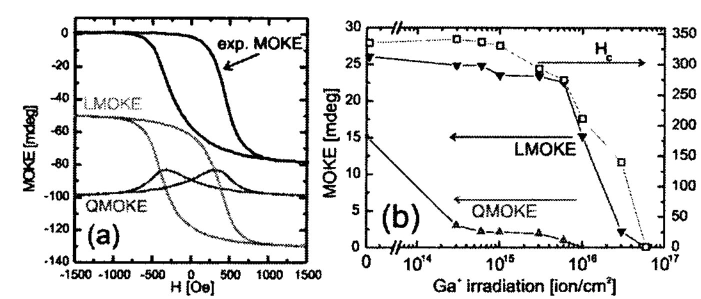

Fig. 1. (a) Example of MOKE hysteresis loop in $Co_2FeSi(100)$ (b) Dependence of coercivity H_c as well as amplitude of LMOKE and QMOKE of $Co_2FeSi(100)$ on the applied Ga^+ ion fluence.

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