TD05

Spin-dependent tunneling and spin decay in a Bi inserted magnetic tunnel junction

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The electrical spin injection and detection in the field of spintronics has continued to be of central importance over the past decade. A typical device structure for spin-injection experiment is a lateral spin-valve system consisting of laterally separated ferromagnetic electrodes and a spin-transport channel layer. It is essential to rule out plausible artefacts, e.g. anisotropic magnetoresistance (AMR), local Hall effect and other geometrical effects, in the lateral spin devices. By contrast, a magnetic tunnel junction (MTJ) is a kind of a vertical structure in which the geometrical artefacts may not be involved with tunneling effects. There have been several reports on the spin-dependent tunneling and the spin decay length in non-magnetic interfacial layers in magnetic tunnel junctions (MTJs) [1, 2]. In this work, we present the spin-dependent tunnelingeffect in Bi inserted MTJs as a function of thickness of the Bi layer.

The generic structure of bismuth (Bi) inserted MTJs was [Ta(50)/$Ni_{81}Fe_{19}$(60)/$Ir_{50}Mn_{50}$(80)/$Co_{84}Fe_{16}$(40)/Al_2O_3(16)/Bi(t)/$Co_{84}Fe_{16}$(100)/Ta(50)] (in Å). The Al_2O_3 tunnel barrier was formed by using an in-situ DC plasma oxidation process after growing 16 Å-thick Al film. The thickness (t) of Bi layer inserted at insulator / ferromagnet interface was varied from 20 Å to 200 Å. The deposition of the whole stacks was followed by a combination of photolithography, ion milling, and lift-off process.

A 100 Å-thick Bi inserted MTJ was found to show 4.8 % tunneling magnetoresistance (TMR) at room temperature, indicating that effective spin tunnelinginto the Bi layer as well as spin transport via the inserted Bi layer give rise to the electrical spin detection in the MTJ. It was also found that TMR values exponentially decreases with the thickness of the inserted Bi layer. Interestingly, a MTJ with 200Å-thick Bi layer was found to still exhibit larger than 1 % TMR. The spin decay length (λ_{Bi}) in the Bi inserted MTJs was quantitatively estimated to be approximately 41 Å. It should be noted that the λ_{Bi} value is five times larger than that in a Cu inserted MTJ [1]. Our results contrast with a previous study [1] reporting that the estimated spin decay length in interfacial metallic layers is limited to only a few monolayers. The origin of the very long spin decay length in the Bi inserted MTJs is addressed. The temperature dependence of TMR and the annealing effects are also discussed. Our results demonstrate an extension of successful spin tunnel injection and detection to a novel material system, semi-metallic Bi.

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TD06

Tunneling Spin Polarization of Co2MnSi Heusler Alloy

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Full-Heusler alloys are the promised materials to be half-metallic ferromagnets, which possess completely spin-polarized conduction electron due to energy gap of one spin-band at Fermi energy. One of the most expectable alloys is Co_2MnSi since it has both half-metallic properties and high Curie temperature of 985K. In our previous works, we have demonstrated giant tunnel magnetoresistance (TMR) effect in magnetic tunnel junctions with Co_2MnSi electrodes and Al-oxide barrier [1]. The giant TMR ratio strongly suggests half-metallic property of Co_2MnSi, however, no one revealed the tunneling spin polarization (TSP) of Co_2MnSi film quantitatively. Superconducting tunnelling spectroscopy (STS) is one of the most powerful techniques to determine TSP of various materials [2]. In this study, we measured TSP of both polycrystalline and epitaxial Co_2MnSi films.

We prepared samples by magnetron sputtering system. The stacking structures of the tunnel junctions are SiO_2 substrate/Al-Si/Al-oxide/Co_2MnSi and MgO (001) sub./epitaxial-Co_2MnSi/Al-oxide/Al-Si. The tunnel junctions were fabricated using metal shadow masks which were changed in ultra-high vacuum chamber, without breaking vacuum. Dynamic conductance (dI/dV) - voltage (V) curves for fabricated junctions were measured using a lock-in technique at 0.4 K, and to estimate TSP a certain field (~ 3 T) was applied to the in-plane direction of the films.

Figure 1 shows a typical result of dI/dV - V curve for the Al-Si/Al-oxide/Co_2MnSi junction. In zero-field (circles), dI/dV spectra shows clear shape corresponded to the energy gap of superconductive density of states (DOS) of Al-Si, and at a field of 2.5 T (triangles) it shows four maxima (σ_1 to σ_4, pointed with arrows) which correspond to Zeeman splitting of DOS. We estimated the value of TSP as 34% from the ratio of these four maxima [2]. This low TSP value is attributable to the atomic disorder in the Co_2MnSi. We confirmed that the structure of Co_2MnSi on Al-oxide is completely disordered *A2* structure, and that the Co_2MnSi on MgO (001) sub. has *B2* or $L2_1$ ordered structure. We discuss the relationship between the TSP value and atomic order in the Co_2MnSi films.

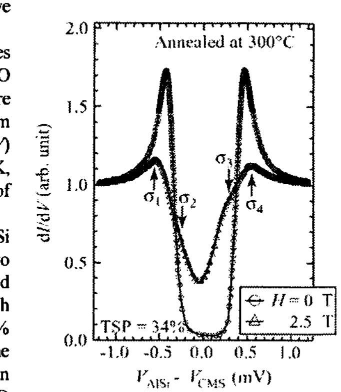

Fig. 1. *dI/dV-V* curves for a Al-Si/Al-ox./Co_2MnSi junction. Circles stand for the data points in zero-field (H = 0 T), and triangles are that in field of 2.5 T.

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