Tunnel magnetoresistance effect in the magnetic tunnel junctions with compensated ferrimagnetic Mn_2(Co-V)Al Heusler alloy

Tomoki Tsuchiya[1,2] and Shigemi Mizukami[3,1,2]
[1]*Center for Science and Innovation in Spintronics (Core Research Center), Tohoku Univ.*
[2]*Center for Spintronics Research Network, Tohoku Univ.*
[3]*WPI Advanced Institute for Materials Research, Tohoku Univ.*
E-mail: tomoki.tsuchiya.d1@tohoku.ac.jp

Half-metallic fully compensated ferrimagnets have attracted attention because they can be used as a spin injector with no stray field. Mn-Co-V-Al Heusler alloy is one of the candidates. Recently, the magnetization compensation for Mn_2(Co-V)Al Heusler alloy was experimentally showen and the Curie temperature was estimated to be around 650 K which was higher than room temperature [1-2]. The half-metallicity of Mn_2(Co-V)Al was demonstrated by first principles calculation [2]. However, there are no reports to fabricate the Mn_2(Co-V)Al film and to investigate the spin polarization experimentally. In this study, we investigated the magnetic properties of the Mn_2(Co-V)Al films and the tunnel magnetoresistance (TMR) effect for the magnetic tunnel junctions (MTJs) with its electrode to gain insight into its half-metallicity.

Samples were prepared by a magnetron sputtering technique. The stacking structures of the single layer samples and MTJs were MgO(001) sub./ Mn-Co-V-Al (30)/ MgO (2)/ Ru (2) and MgO(001) sub./ Mn-Co-V-Al (30)/ Mg (0.4)/ MgO (2)/ CoFe (5)/ IrMn (10)/ Ru (8) (thickness is in nm), respectively. The composition of Mn-Co-V-Al layer was changed by co-sputtering technique. The Mn-Co-V-Al layer was deposited at 700ºC and the other layers were deposited at the room temperature (RT). The crystalline structures were characterized by x-ray diffraction (XRD). The magnetic properties were measured by a vibrating sample magnetometer (VSM). The microfabrication of the MTJs were performed using a standard photo-lithography technique. The TMR effect was measured by a four-probe method.

Mn_2VAl and $Mn_2Co_{0.5}V_{0.5}Al$ samples showed (111) super lattice diffraction peak, which indicating the $L2_1$ or XA ordering. The saturation magnetization for Mn-Co-V-Al films for each composition were smaller than the bulk values. However, its composition dependence was similar to that for bulk experiments, and the magnetization compensation was confirmed for $Mn_2Co_{0.5}V_{0.5}Al$. The TMR effects were observed for Mn-Co-V-Al films and the TMR ratios were -0.5%, 0.12% and 0.05% at room temperature for Mn_2VAl, Mn_2CoAl and $Mn_2Co_{0.5}V_{0.5}Al$, respectively. These signs of TMR effects for Mn-Co-V-Al were consistent with the spin polarization for those alloys predicted from the first principles calculation. The origin of the small TMR ratio is discussed.

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