Magnetic properties and magnetic tunnel junctions of equiatomic quaternary CoFeCrAl Heusler alloy epitaxial films

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Equiatomic quaternary CoFeCrAl Heusler alloy is predicted to be a ferrimagnetic half-metal with low saturation magnetization. The high spin polarization of this material has been experimentally observed [2], however, tunnel magnetoresistance (TMR) effect has not yet been reported. In this study, we investigated magnetic properties, in particular, the Gilbert damping constant for CoFeCrAl alloy films, and also we studied magnetic tunnel junctions (MTJs) with the electrode of CoFeCrAl. Films were prepared by the magnetron sputtering. The stacking structures of the single layer sample and MTJs were MgO(100) sub./ Cr (40)/ CoFeCrAl (30)/ Ta (3) and MgO(001) sub./ Cr (40)/ CoFeCrAl (30)/ Mg (0.4)/ MgO (2)/ CoFeB (5)/ IrMn (10)/Ta (3)/ Ru (5) (thickness is in nm), respectively. All layers were deposited at the room temperature (RT) and the in-situ post annealing temperature (T_a) for the CoFeCrAl layer was changed from RT to 700ºC. The film composition was $Co_{25.5}Fe_{23.1}Cr_{28.1}Al_{23.3}$ (at.%). The crystalline structures were characterized by x-ray diffraction (XRD). The magnetic properties were measured by a vibrating sample magnetometer. The Gilbert damping constant was measured by the broadband ferromagnetic resonance. The TMR effect was measured by a four-probe measurement after the microfabrication. The XRD measurements indicated that the CoFeCrAl films have the *B2* ordered phase for any T_a. Saturation magnetization was 380 emu/cm^3 at RT, which was close to the value evaluated with the Slater-Pauling rule. The Gilbert damping constant was 0.0047 for the sample annealed at T_a = 700ºC, which was similar to that for CoFeMnSi Heulser alloy [3]. The TMR ratios were 15% and 35% at RT and 10 K, respectively. These small TMR ratios will be discussed with the first-principle theoretical calculations and transmission electron microscope (TEM) characterization.

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