Investigation of negative spin-polarization in Fe_xCr_{1-x} thin films for spin-torque oscillator

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Magnetic materials having negative spin polarization have recently attracted attention because of potential application[1)] in the spin torque oscillator (STO) for Microwave assisted magnetic recording (MAMR). FeCr is one of the candidate materials showing negative spin polarization. Experimentally, Vouille *et al*. reported the spin polarization of $Fe_{70}Cr_{30}$ at low temperature (4.2 K) to be -0.28[4)]. Shimizu et al. have already demonstrated[1)] the reduction of threshold current density for the spin transfer torque (STT) induced magnetization precession using FeCr as a spin injection layer (SIL) of STO. However, for practical application, fundamental study of this material is necessary to answer the following several questions. ; What is the optimal composition of Fe_xCr_{1-x} for maximum MR ratio? How much is the theoretical bulk spin polarization (β) and the experimental β at room temperature? To answer these questions, we performed systematic study on the Fe_xCr_{1-x} film and those-based CPP-GMR devices.

The electronic conductivity of majority and minority spin electrons in Fe_xCr_{1-x} was calculated based on Kubo-Greenwood formula employing a method similar to the one previously reported for CoFe[3)]. Our result shows very large negative spin-polarization ($\beta < -0.8$) for $Fe_{1-x}Cr_x$ for $x > 0.1$, with progressively increasing β *as x* increases. Experimentally, we made a series of several current perpendicular-to-plane giant magnetoresistance (CPP-GMR) devices as shown in figure 1(a) using $Fe_xCr_{1-x}(t_{FeCr})$ as the spin injection layer where x is chosen among {x=0.2, 0.3 and 0.4}, t_{FeCr} (thickness of Fe_xCr_{1-x} layer) is varied from 2 nm to 15 nm . For each thin film structure, we microfabricated pillar shaped CPP-GMR devices using as-deposited films and performed electrical characterization. Figure 1(b) shows an example of negative sign of GMR arising from the negative spin polarization of Fe_xCr_{1-x}. Our study showed that the best composition of Fe_xCr_{1-x} is x=0.4 for maximum negative MR ratio. We also estimated the bulk spin-polarization (β) of $Fe_{70}Cr_{30}$ to be -0.13, which is much lower than the theoretical value. The possible reason for large deviation of experimental β from theoretical value was examined by microstructure and element-resolved analysis for the Fe_xCr_{1-x} films.

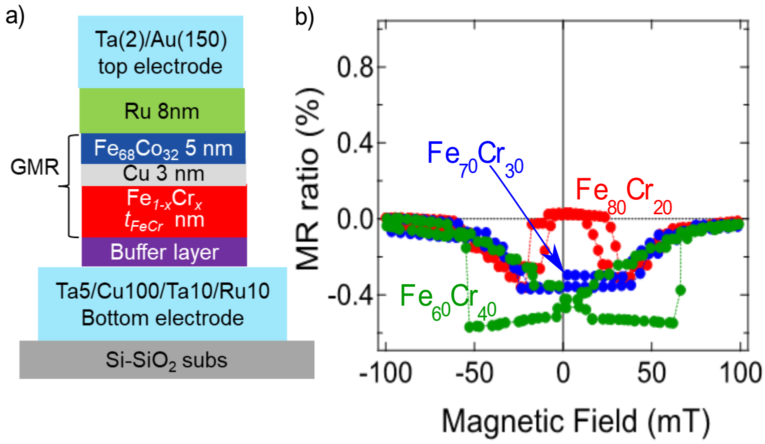

Figure 1. Negative sign of magnetoresistance (MR) in $Fe_{1-x}Cr_x(t_{FeCr})$ /Cu(3 nm)/$Fe_{68}Co_{32}$(5 nm) (a) Film structure (b) MR curves showing negative MR ratio for Cr buffer layer and t_{FeCr}=5nm

References:

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