Metastable bcc-CoFeMn alloy thin film fabricated by sputtering

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Magnetoresistive random access memory (MRAM) is a promising next-generation memory. It is strongly demanded to increase a tunnel magnetoresistance (TMR) ratio of a magnetic tunnel junction (MTJ) in MRAM in order to improve their performance. In the early noughties, Zhang et al. have calculated that a system with fully epitaxial bcc-Co(001)/MgO(001)/bcc-Co(001) MTJs exhibits an extremely high TMR ratio over 10^4 % [1]. In addition, Yuasa et al. have demonstrated experimentally a giant TMR ratio of 410% at room temperature (RT) in such MTJs [2]. From these studied we expect that MTJ electrodes fabricated with bcc-Co based alloys would show a similar huge TMR ratio. CoFeMn ternary alloys have a fcc structure which is stable for a large compositional space, and those fcc alloys show weak ferromagnetism or antiferromagnetism [3]. By contrast, Snow et al. have recently reported that a metastable bcc CoFeMn alloy thin films can be grown by a molecular beam epitaxy [4]. They demonstrated that $Co_{62}Fe_9Mn_{29}$ films exhibited the magnetization as large as 2165 kA/m, which is in excess of the Slater-Pauling rule [4]. However, various magnetic properties are not clear yet, and an attempt to fabricate the bcc-CoFeMn films by sputtering deposition has not been reported. Here, we carried out experiments to fabricate the bcc CoFeMn films by a sputtering technique and to clarify the crystal structure and the magnetic properties. The samples were fabricated by the magnetron sputtering. The film stacking was MgO(001) substrate/CoFeMn(10 nm)/Cr(3 nm). The crystal structure and the magnetic properties were evaluated by X-ray diffraction (XRD) and vibrating sample magnetometer (VSM), respectively. The bcc (001) diffraction peak was observed for the samples with a wide range of compositions and annealing temperatures, suggesting that the bcc CoFeMn films were obtained even with the sputtering. A maximum saturation magnetization of about 1900 kA/m was obtained for the composition of $Co_{53}Fe_{30}Mn_{17}$, which is close to that of $Co_{50}Fe_{50}$ and suggested that the magnetic moment of Mn is similar to that of Fe in magnitude and ferromagnetically coupled to that of Co and Fe. The correlation between the saturation magnetization for the films and the *d* electron number approximately followed the Slater-Pauling rule, as well as CoFe binary alloys, for the samples studied here. This work was partially supported by JST CREST (No. JPMJCR17J5).

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