TD03

TMR effect of Fe-MgO granular films with MgO buffer layer

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Extensive studies have been focused on the magnetic tunnel junctions (MTJs) from the view point of practical applications such as magnetic reading head and magnetic rondom access memory. The MTJs with MgO insulating layer is the most promising material owing to their relatively low junction resistance and large magnetoresistance ratio of over 200 %.[1] The granular films consisting of ferromagnetic metal nano-granules embedded in an insulating matrix are alsopromising materials because of their hi-frequency permeabilities and large tunnel magnetoresistance effects.[2][3] In this study, Fe-MgO granular films were prepared in order to investigate their magnetoresistance effects and resistivities depending on the film structures.

The granular films were prepared by the rf magnetron sputtering method onto glass substrates. The base pressure was less than 1×10^{-6} Torr. Ar pressure was 6 mTorr. SiO_2 or MgO buffer layer was deposited prior to the deposition of Fe-MgO granular layer. EDX, XRD and VSM techniques were employed to characterize the granular films. The composition of Fe was 40 - 50at.% in all samples. Magnetoresistance measurements were carried out under application of magnetic field of 400 Oe (low field system) and 16 kOe (high field system). All measurements were performed at room temperature.

From the magnetic hysteresis and MR loops, it was confirmed that the maximum resistance was obtained at the coercive field and the magnetic moments were not *saturated. Depending on the Fe composition, the granular films exhibited* resistivities ranged from 5.0 to 40 mΩcm. The MR ratio increased with increasing resistivity of the films. The low field MR loops for the films with various MgO buffer layer thickness are shown in figure 1. The shape of MR loop was different depending on the MgO buffer layer thickness. The sharp peaks near the coercive field become small. It may be due to a result of the change in the average size of Fe granules according to the MgO buffer layer thickness. The MR ratio slightly increased with increasing the MgO buffer layer thickness and the resistivity also increased. The maximum MR ratio of 2.3 % was obtained with the high field measurement system.

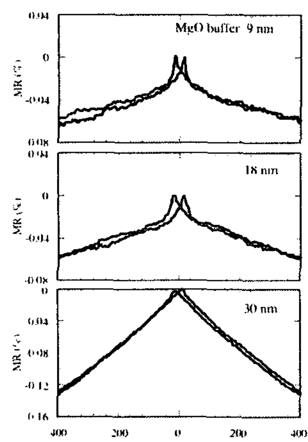

Fig. 1. MR loops of Fe-MgO.

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TD04

Thermal stability behaviour of synthetic magnetic tunnel junctions with TiAl-oxide barrier

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The important characteristics that affect magnetic tunnel junctions (MTJs) device performances are proper junction resistance, microstructural quality, stability of the tunnel barrier and the thermal stability [1]. Also, the under/capping layer materials used in MTJ, can affect on the interface uniformity, texture, and crystallinity of the upper stacked layers, the thermal stability, and their magnetoresistive (MR) properties. Recently, we developed new barrier materials for MTJs, such as ZrAl-oxide and TiAl-oxide that showed excellent thermal stability, surface uniformity, and low junction resistance [2,3]. Especially, TiAlalloy film showed an excellent surface uniformity and chemical stability [3].

In this study, we investigated thermal and electrical stability of the synthetic MTJs incorporating a TiAl-oxide barrier and TiAl under and capping layer. We prepared MTJ consisting of a SiO_2/(Ta 5 or TiAl 4)/CoFe 17/IrMn 7.5/(CoFe 3 or CoFe 1/Ru 0.8/CoFe2)/TiAl 1.6 + oxidation/CoFe 3/(Ta 5 or TiAl 4) (nm), using a dc magnetron sputtering under a base pressure of 1×10^{-8} Torr. The MTJs were annealed at 250~500 °C for 10 min. in a high vacuum. The magnetoresistive properties of the MTJs were measured using a DC-four point probe method.

In the as-deposited state, the TMR ratios of TiAl-based MTJs are similar to that of Ta-based MTJs. However, after annealed at 400℃ for 10min, the TMR ratio of Ta-basedMTJ decreased by 17.1 % (from 33.35 % to 27.06 %). On the other hand, the MR ratio of TiAl-based MTJs decreased 3.8 % (from 34.13 % to 32.81 %). Comparing the Ta and the TiAl-based conventional MTJs, the TiAl-based MTJs had better thermal stability because TiAl has dense microstructure, chemical stability and surface uniformity. The synthetic MTJs with TiAl-oxide barrier and TiAl under/capping layer showed a better thermal stability than the TiAl-based conventional MTJs. The highest TMR ratios of conventional MTJs revealed at 300 °C. But that of the synthetic MTJs revealed at 400 °C and decreased at above 400 °C. The most important factor of the thermal degradation is Mn diffusion from Mn-based antiferromagnetic layer to the active layer. The synthetic antiferromagnetic layer (SAF) plays a diffusion barrier effectively at around 400 °C. However, when the synthetic TiAl-based MTJs were annealed at above 400 °C, the TMR ratio decreased due to not only Mn diffusion but also SAF layer.

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