UD07

Effect of capping layer on the crystallization of amorphous CoFeB

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CoFeB(001)/MgO(001)/CoFeB(001) texture development during annealing is a prerequisite for obtaining a high TMR ratio in amorphous CoFeB/MgO (001)/amorphous CoFeB MTJ. As a result, 1 bloch states in the $K_{//}=0$ direction filtering effect and coherent tunneling can occur [1]. Evolution of texture and crystallizationof amorphous CoFeB can be affected by annealing conditions, seeding effect of MgO texture, and crystallinity of the capping layer adjacent to CoFeB [2, 3]. However, the effect of capping layer on the texture development and crystallization of the adjacent CoFeB electrode is not yet clear. In this study, we investigate the effects of various capping layer on the crystallization of amorphous CoFeB/MgO (001) deposited on Si/SiO2 and glass substrate. Samples consisting of Si/SiO_2 (or glass) substrate/MgO/$Co_{56}Fe_{24}B_{20}$/capping layer were prepared using a rf and dcmagnetron sputtering system under typical base pressures below 1.0×10^{-8} Torr at room temperature and were annealed at 350 °C for 1 hour under 3×10^{-6} Torr. Capping materials are amorphous ZrAl-alloy, polycrystalline TiAl-alloy, and Ru. Al composite targets with Zr and Ti chips were used to obtain ZrAl and TiAl films of the desired composition. The composition of ZrAl-alloy was 10 at. % Zr and this alloy film possessed a single amorphous phase [4]. The composition of the TiAl-alloy was 5.33 at. % Ti and this alloy is a typical polycrystalline [5]. Crystal structure, texture, interface and lattice image of MTJs were analyzed using a XRD and cross-sectional high resolution transmission electron microscopy (HRTEM). The CoFeB layer adjacent to the (001) textured MgO layer could be induced a (001) texture generally during annealing treatment [2, 3]. This result indicates the epitaxial relation between MgO and CoFeB significantly influence on the texture development of the CoFeB. The crystallization of the CoFeB layer adjacent to the capping layer could be affected not only the MgO texture but the texture of the capping layer. When the (001) textured Ru layer was used as capping layer, the amorphous CoFeB electrode adjacent to Ru was developed (110) texture, which is not adequate for filtering effect. However, when an amorphous ZrAl capping layer was used, CoFeB crystallized to bcc with the (001) texture. These results reveal that the crystallinity and texture of the capping layer significant affect the evolution of the crystallization of CoFeB. Consequently, the texture evolution of the amorphous CoFeB electrode during annealing can be controlled by the texture and crystallinity of the adjacent capping layer.

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UD08

Microstructure and magnetic property of Fe/*X* (*X*=Au, Ag, Cu) multilayer film grown on MgO(001) substrate

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Magnetic thin films with $L1_0$ *ordered structure exhibit high magnetocrystalline anisotropy* [1]. *It has been reported that* $L1_0$ ordered thin films can be prepared for FePt [2] and FeAu [3] when epitaxial monatomic stacking of Fe(001) bccand Pt or Au(001)$_{fcc}$ layers are alternately formed on an MgO(001) substrate. The $L1_0$ ordered FePt alloys are fabricated at low temperatures below 230°C with this method. The L10 ordered phase of FeAu, which is a metastable phase and does not appear in the Fe-Au phase diagram, is successfully prepared. Fe and *X* (*X*=Au, Ag, Cu) atoms are immiscible and $L1_0$ ordered structure may also be realized in the Fe/Ag and Fe/Cu multilayer films. In this study, we fabricated Fe/*X* multilayer films under similar experimental conditions and investigated the effect of *X* atom on the microstructure and magnetic property of the Fe/X system.

Thin films were deposited on MgO(001) substrates using a molecular beam epitaxy (MBE) system under base pressures of lower than 3×10^{-8} Pa. An Fe seed layer of 2 nm and an *X* (*X*=Au, Ag, Cu) buffer layer of 5 nm were sequentially deposited. And then 1 ML thick Fe and 1 ML thick *X* were alternately deposited on the buffer layer. The total thickness of Fe/*X* *multilayer was fixed at 20 nm. The deposition rate was in a range of 0.005-0.008 nm/s for all materials. The layer thickness* was controlled by monitoring a quartz oscillator. The substrate temperature was kept at 300°C. The surface structure during film deposition was studied by in-situ reflection high energy electron diffraction (RHEED) and the epitaxial relationship was determined. The film structure was investigated by X-ray θ-2θ diffraction with Cu-Kα radiation. The surface morphology and the magnetic domain structure were observed by atomic force microscopy (AFM) and magnetic force microscopy (MFM), respectively. The magnetic property was measured by using a vibrating sample magnetometer (VSM).

Fe/*X* epitaxial multilayer film was obtained on an MgO(001) substrate for all elements, *X*, and the epitaxial relationship of *X*(001)[100] // Fe(001)[110] // MgO(001)[100] was confirmed from RHEED observations. The crystal plane of the Fe layer was rotated by 45 degrees with respect to that of the *X* layer. In this configuration, the lattice mismatches between Fe layer and Au, Ag, or Cu layer are +0.5 %, +0.8 %, and -12.4 %, respectively. An epitaxial growth took place for the Fe/Cu multilayer system, where a large misfit of -12.4 % existed between Fe and Cu layers. According to the RHEED and X-ray diffraction observations, Fe/Cu multilayer film is considered to include large strain and/or stress. The surface morphologies and the magnetic domain structures of Fe/*X* multilayer films were varied depending on the *X* element. The details of structural and magnetic properties will be presented at the conference.

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