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Designing the Composition of Amorphous Free Layer of Magnetic Tunnel Junction

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The development of soft magnetic metallic glass has become an important research topic because the soft magnetic properties are promising for many applications [1-2]. The excellent soft magnetic properties (high saturation magnetization Ms and low coercivity Hc) of metallic glass improve the performance of magnetic tunnel junctions (MTJs) when the metallic glass is used for a free layer in magnetic random access memory [3]. The CoFeSiB and NiFeSiB quaternary amorphous free layer were studied to correlate glass characterization of amorphous alloys and the magnetic properties which control the performance of free layer. The characteristics of these amorphous materials are compared with crystalline materials composed of CoFe and NiFe and other ternary amorphous alloys composed of CoFeB. Results based on x-ray diffraction (XRD), vibrating sample magnetometer (VSM) and differential scanning calorimetry (DSC) are presented. These alloys exhibit the soft magnetic properties of high M_s and low H_c in hysterisis loops. The thermal properties were represented by the values of glass transition temperature (Tg), crystallization temperature (Tx), Enthalpy (ΔH), Trg (=Tg/Tm) and ΔT(=Tx-Tg). Compared with other alloys which were produced, the amorphous CoFeSiB alloys exhibit low M_s, high H_c, low saturated field (H_s), and estimated low Tg, ΔT, Trg, ΔH. Correlations between glass characterization and magnetic properties of amorphous free layer were discussed.

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Rapid Thermal Annealing Effect on the Properties of CoFeB/MgO/CoFeB Junctions

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It has been well known that very high tunneling magnetoresistance (TMR) effect in magnetic tunnel junctions (MTJs) with the MgO barrier is very sensitive to the crystallographic orientation of the ferromagnetic electrodes (FM), as well as of the interfacial structure of the FM/MgO [1, 2]. To determine whether the diffusion of B in the CoFeB electrodes and/or of Mn in antiferromagnetic layer in the MTJs can be controlled by the thermal treatment process, the annealing effect on the structural and transport properties of the MTJs were investigated. The conventional thermal annealing (CTA) and the rapid thermal annealing (RTA) [3] were performed under vacuum conditions ($<10^{-6}$ Torr) at various temperatures for various process time. The compositional changes of the MgO barrier and the structural changes of CoFeB electrodes due to the annealing process were studied. The crystallization of FM electrodes and the diffusion of Mn were found to be different after the CTA and RTA processes. The detailed mechanisms for the RTA effects on the properties of CoFeB/MgO/CoFeB MTJs are addressed.

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