Chemical properties and GMR improvement of specular spin valves with nano-oxide layers, formed in ambient mixed gases

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Abstract: Specular spin valves (SVs) containing nano-oxide layers (NOLs) structured as substrate/seed/AF/P_1/NOL/P_2/Cu/F/NOL, have been fabricated. The NOLs were formed by natural oxidation in different ambient atmospheres of pure oxygen, oxygen/nitrogen and oxygen/argon gas mixtures. The fabrication conditions were optimized to enhance the magnetoresistance (MR) ratio, to suppress the interlayer coupling fields (H_f) between the free and pinned layers, to suppress the high interface density of the NOL, to ease the control of the NOL thickness and to form a smooth NOL/P_2 interface for promoting specular electron scattering. The characteristics of our specular SVs are the MR ratio of 14.1%, the exchange bias field of 44-45 mT, and H_f weaker than 1.0 mT. The optimal conditions for oxidation time, total oxidation pressure and the annealing temperature were found to be 300 s, 0.14 Pa (oxygen/argon = 80/20) and 250?C, respectively. Also, the origin of thermal stability of MMn-based (M = Fe, Pt, Ir, etc) specular SVs has been explained in detail by chemical properties of NOL using secondary-ion mass spectroscopy and x-ray photoelectron spectroscopy depth profile analyses. Thermal stability turns out to be caused by a decrease in MR ratios at high temperatures (>250?C), which is a serious problem for device applications using the SV structure as a high density read head device.

Index Keywords: Annealing; Argon; Electron scattering; Ferromagnetism; Giant magnetoresistance; High temperature effects; Interfaces (materials); Oxidation; Secondary ion mass spectrometry; Thermodynamic stability; X ray photoelectron spectroscopy; Ferromagnetic coupling; Interlayer coupling fields; Nano-oxide layers (NOL); Specular spin valves; Nanostructured materials

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