【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering Ⅰ)

Title of Project： Variety of physical properties of hetero-junction with ordered alloys and the spin devices

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Research Area：Applied Solid State Physics
Keyword：Spintronics

【Purpose and Background of the Research】

In the research area of spintronics, improvement of thin film growth technology and micro-fabrication technology was accelerating. Early magnetic tunnel junctions have the structure of polycrystalline ferromagnet/amorphous insulator/polycrystalline ferromagnet. But recently, full-epitaxial ferromagnet/insulator/ferromagnet can be prepared. So that ordered alloy materials can be use for device application. As the result, preparation of variety of physical properties in the thin film and the devices were possible.

Research work of $L2_1$ ordered structure of Heusler alloys are not enough despite of the variety of the materials. As for the $L1_0$ ordered alloy, the high magnetic anisotropy is expected to be applied to the high density recording media and memory devices. Especially for application to memory, the limitation of the switching current requires low magnetic damping materials. These studies have been just started and more systematic material research is needed.

In this work, our own techniques of thin film preparation, micro-fabrication, and measurement of spin devices will be carried out following two-step milestones.

【Research Methods】

(1) Research of new materials, thin film preparation, structure of the multilayers will be done for high quality ordered alloys and the interfaces. The goal of the work is to achieve high spin polarization (> 90%) and the low damping constant (<0.01) in $L1_0$ of ordered alloys.
(2) Among the variety of hetero-structure of ordered alloys, the goal is to achieve both high magnetic anisotropy > 10^7 erg/cc, high spin polarization > 90%, and low damping constant < 0.01 for $L2_1$、$L1_0$ ordered alloy films.
(3) After this, high frequency spin-torque oscillator devices (> 50 GHz), high output (μW) and high speed (ns) and low current (10^5 A/cm^2) spin torque magnetization reversal

【Expected Research Achievements and Scientific Significance】

Recent main spintronics devices are CoFeB/MgO/CoFeBtype MTJs. This structure expects > 300% TMR, so that this is applied to read head of Hard Disk Drive and magnetic memories. However, the CoFeB has amorhous structure and the semi-stable structure becomes disadvantage after annealing. On the other hand, ordered alloys are stable after long time. From the view point of technology, this is very important.

This work becomes key technology for future microwave devices. Also, the technologies become the breakthrough for low switching current and high speed spin torque magnetization reversal. It must be important for innovation in industry.

【Publications Relevant to the Project】

M. Oogane, T. Kubota, Y. Kota, S. Mizukami, H. Naganuma, A. Sakuma, and Y. Ando, Gilbert magnetic damping constant of epitaxially grown Co-based Heusler alloy thin films, Appl. Phys. Lett., 96 (2010) 252501-1-3.

T. Hiratsuka, G. Kim, Y. Sakuraba, T. Kubota, K. Kodama, N. Inami, H. Naganuma, M. Oogane, T. Nakamura, K. Takanashi, and Y. Ando, Fabrication of perpendicularly magnetized magnetic tunnel junctions with $L1_0$-CoPt/Co_2MnSi hybrid electrode, J. Appl. Phys., 107 (2010) 09C714-1-3.

【Term of Project】 FY2012-2016

【Budget Allocation】 167,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.apph.tohoku.ac.jp/spin/