

論文 / 著書情報  
Article / Book Information

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種別(和文)	論文要旨
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# 論文要旨

THESIS SUMMARY

専攻 : Department of	材料工学	専攻	申請学位 (専攻分野) : Academic Degree Requested	博士 (D. Eng.) Doctor of
学生氏名 : Student's Name	高藤華		指導教員 (主) : Academic Advisor(main)	中村 吉男
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words )

We have studied the structural and magnetic interaction in  $L1_0$  FePt based heterostructures with some special design. For FePt/AlN multilayer structure, the sharp interface makes it possible to study the effect of the interfaces and strain/stress in ultrathin FePt layer. With the well understanding of FePt ordering process, we have successfully fabricated perpendicular exchanged biased FePt/NiO bilayer structure. Comparing three different structures: FePt single layer, FePt/NiO bilayers before and after field cooling (FC), we find that the angle between ferromagnetic (FM) and antiferromagnetic (AFM) spin at compensated AFM interface may be not exact  $90^\circ$ . Taking into account the favorable FM/AFM coupling configuration, the obtained results and origin of exchange bias can be well understood through our proposed AFM spin canting mechanism. To further verify this finding, we designed a  $\text{FePt}_{\text{Oop}}/\text{NiO}/\text{FePt}_{\text{Ip}}$  trilayer structure, in which the bottom and upper FePt layer are partially ordered and disordered, respectively, giving rise to a “naturally”  $90^\circ$  FM interlayer coupling configuration. By performing an in-plane FC to modify the Ni spin, the magnetic behavior changes on both FePt layers have been observed. Through this approach, it offers a sensitive way to study the coupling at FM/AFM interface.

For each  $L1_0$  based FePt ultrathin structure, the detailed results and main findings are summarized as follows:

## **The FePt/AlN multilayer structure**

The preferred growth orientation and ordering of FePt has been controlled through introducing interstitial nitrogen atoms during FePt deposition. In both two cases, i.e., the FePt

deposited with and without N, the FePt layers show strong (111) texture. However, comparing these two cases, for the FePt deposited with N, it exhibits a weaker (111) texture and experiences much more in-plane compressive strain during grain growth, e.g., at 600°C the calculated strain is -1.22% and -0.26% for the FePt deposited with and without N, respectively. Taking into account the grain-orientation-specific driving forces for grain growth, the stress condition will definitely affect the preferred growth orientation of the film. In this viewpoint, a decrease in the driving force for the (111) grain growth can be expected in the case of FePt deposited with N.

For the FePt deposited without N, as the annealing temperature increases from 500 to 700°C, the degree of order rapidly increases from 0.337 to 0.743, which shows the same tendency as annealing temperature-dependent coercivity. Comparing with the FePt deposited with N, it shows a larger coercivity with the same annealing temperature, indicating a more pronounced ordering in this case. Since the ordering transformation is a recrystallization process, same as (111) texture evolution, a decrease of driving force is considered to be the reason for the weaker ordering of FePt deposited with N.

### **The FePt/NiO bilayer structure**

The perpendicular exchanged biased FePt/NiO bilayer structure has been successfully established. After perpendicular FC, for FePt(2.5 nm)/NiO(21 nm) film the exchange field is -41 Oe at RT and increases to -301 Oe at 20 K. Besides, this bilayer structure shows interesting structural features. For FePt layer, it is well epitaxially grown on MgO(001) single crystal substrate with a strong (001) texture. While the NiO layer exhibits a strong (111) texture and twined microstructures in the film plane, which experiences in-plane anisotropic strain. This stress condition is considered to give rise to a compensated AFM interface in FePt/NiO bilayer structure.

Through performing initial magnetization curve measurement and magnetic domain imaging, the results show that for as-grown bilayer structure, the FePt layer experiences a small-angle magnetization rotation when it is magnetized near to saturation in film normal

direction. After FC, the bilayer structure shows a significant enhancement of perpendicular magnetic anisotropy, indicating the field mediated coupling between the spins across FePt/NiO interface. According to Koon's theoretical calculation on the basis of lowest energy ferromagnetic/antiferromagnetic coupling configuration for compensated spins at antiferromagnetic side, the Ni spins at the interface is considered to slightly deviate off the  $(\bar{1} \bar{1} 1)$  easy plane. Consequently, this spin configuration stabilizes the coupling between FePt and NiO and result in the observed exchange bias. This consideration was further confirmed by stripe domain width calculation.

### **FePt/NiO/FePt trilayer structure**

A ferromagnetic interlayer coupled FePt/NiO/FePt trilayer structure has been fabricated, in which the bottom and upper FePt layer are partially ordered and disordered, respectively. Owing to the strong perpendicular magnetic anisotropy for ordered FePt and dipolar anisotropy for disordered FePt, this structure shows that regardless of AFM (NiO) layer, it gives rise to a “naturally” 90° FM interlayer coupling.

Performing FC to only modify the NiO spin structure, the corresponding effects on two FePt layers were studied. For upper FePt layer, the in-plane FC induces an in-plane magnetic anisotropy, showing a dependence of remanence on the angle between the directions of the measurement and the field during FC, which is not observed in as-grown trilayers. It is worth noting that this anisotropy also cannot be observed for the trilayers with two disordered FePt layers. For bottom FePt layer, after in-plane FC, the magnetic stripe domain changes from random distribution to a tendency of aligning along the direction of the field during FC with decreased stripe width. In the viewpoint of coupling at FePt/NiO interface, the obtained results can be well explained by the spin canting mechanism proposed from FePt/NiO bilayer structure.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

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