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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The microstructure, magnetic anisotropy and exchange bias of CoNi/(Co,Ni)O layered structures has been systematically studied in this thesis. The CoNi/(Co,Ni)O layered structures were fabricated by magnetron sputtering. Three types of structures has been studied in this work: CoNi/(Co,Ni)O multilayer structures prepared on glass substrate, (Co,Ni)O/CoNi/(Co,Ni)O trilayer structures prepared on MgO (001) structure and (Co,Ni)O/CoNi/(Co,Ni)O trilayer structures prepared on glass substrate. To realize the perpendicular magnetic anisotropy and room temperature perpendicular exchange bias, microstructures and magnetic properties of the multilayer structures prepared on glass substrate have been investigated. The origin of perpendicular magnetic anisotropy is disclosed by studying the interface effect on the magnetic anisotropy of trilayer structures prepared on MgO substrate. The relationship between the magnetic anisotropy and exchange coupling has been studied in trilayer structures prepared on glass substrate. The main findings and detailed results are summarized and concluded as follows:

To realize the perpendicular magnetic anisotropy and room temperature perpendicular exchange bias, microstructures and magnetic properties of the multilayer structures prepared on glass substrate have been investigated. Microstructure analysis shows that the (Co,Ni)O layer exhibiting fcc polycrystalline structure of high quality (002) texture. On the other hand, the CoNi layer is of poor crystallinity. Interface structure analysis shows that the as-deposited multilayered structure exhibits highly smooth metal/oxide interface. The magnetic anisotropy of the multilayer structure is sensitive to the CoNi layer thickness, but bot sensitive to the (Co,Ni)O layerer thickness. Strong perpendicular magnetic aniostorpy is obtained when the CoNi layer is around 1.8 nm thick. The bulk anisotropy energy and interface anisotropy energy are estimated. A large positive interface anisotropy energy is found. Since the CoNi layer is of a poor polycrystallinity, magnetoelastic anisotropy is considered to be very small. The total bulk anisotropy is not sufficiently large to overcome the demagnetization energy. Therefore, the origin of the PMA of the CoNi/(Co,Ni)O multilayer structure is mainly from the interface anisotropy. Room temperature PEB is observed in the multilayer structure after perpendicular field cooling. These results are attributed to the successful role playing of Co and Ni in the (Co,Ni)O layer.

There are two possible contributions to the perpendicular magnetic anisotropy : the metal/oxide interface anisotropy and the FM/AFM exchange coupling energy. To clarify which is the major contribution to the perpendicular magnetic anisotropy, we use MgO single substrate to control the texture of the AFM layer and the interface morphology. The (Co,Ni)O/CoNi/(Co,Ni)O trilayer structures deposited on the MgO single substrates exhibit different interface morphologies and magnetic anisotropies when deposited at different temperatures. Film deposited at room temperature produces the results of CoNi/(Co,Ni)O layered structure prepared on glass substrate in the previous chapter. However, increasing the bottom (Co,Ni)O layer deposition temperature to as high as 200℃ results in a film with in-plane anisotropy. Interestingly, after post-deposition annealing, the annealed trilayer film presents PMA. Temperature dependent study shows that such perpendicular magnetic anisotropy sustains at temperature as high as 260℃, which is much higher than the Néel temperature of the antiferromagnetic (Co,Ni)O layer. It indicates that the FM/AFM exchange coupling energy is not the main contribution to the PMA. The most striking structural feature is after annealing at 200℃, a metal/oxide interface smoothing is observed. XRR results reveals a CoNi layer thickness reduction. However, the CoNi layer thickness reduction can not well explain the large enhancement of the perpendicular magnetic anisotropy. An obvious enhancement of the interface anisotropy is observed, which is considered due to the interface smoothing. Thus, the metal/oxide interface effect is considered

as the main origin of the perpendicular magnetic anisotropy. The mechanism of the interface smoothing is considered as follows: oxygen accumulates at the interface area, preferentially oxidize CoNi lattice plane of high energy, yielding a (001) plane with the lowest energy and the smallest curvature. As a result, a smooth metal/oxide interface is obtained.

To study the relationship between the FM/AFM exchange coupling and the magnetic anisotropy, we investigate the exchange coupling effect on the magnetic anisotropy of the CoNi/(Co,Ni)O trilayer structures prepared on glass substrate. For trilayer structure with slightly thicker CoNi layer (around 2.1nm), the film shows an "isotropic" magnetization. The magnetic anisotropy of such film can be tuned to perpendicular magnetic anisotropy after perpendicular field cooling or in-plane magnetic anisotropy after in-plane field cooling. The (Co,Ni)O thickness effect on the exchange coupling induced magnetic anisotropy transition is also investigated. It is shown that the maximum transition is achieved when the AFM layer is of a medium thickness, where the maximum coercive field is obtained. Based on the polycrystalline exchange bias model, the exchange coupling induced magnetic anisotropy transition is attributed to the uncompensated spins at the FM/AFM interface with rotatable anisotropy.

This CoNi/(Co,Ni)O layered structures can serve as a promising building block for future spintronic devices.