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교환바이어스형 스핀밸브 다층박막 제조시 기판의 초기 거칠기에 의존한 층간 결합 자기장 및 교환바이어스의 특성

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The dependence of the interlayer coupling and the exchange bias on the initial roughness of substrate in spin valve films

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Introduction

Spin valves using the GMR effect have played important roles in read heads for high-density magnetic recording and high sensitive magnetic field sensors. Spin valves require high MR ratio, low interlayer coupling field of free layer and high pinning effect(exchange bias) to reference layer for small size device applications. The pinning effect and interlayer coupling field among required properties are very important for the stable signal output of spin valve devices. The initial substrate situation and buffer layer for texture improvement determines the these properties of spin valve films. Thus, we deposited spin valves of same condition on different substrates, and compared the MR response of each films. We also discussed the relationship between MR properties and AFM image of samples.

Experiment

We prepared the different substrate: Si(100) with natural oxide, glass, Si(100)/SiO2(1500 Å) by thermal oxidation. We investigated the initial roughness of substrates and roughness of as-deposited spin valve film on each substrate by using AFM, and compared the AFM surface images of films. The spin valve films deposited by UHV d.c. magnetron sputtering have the structure of substrate/Ta(50)/NiFe(45)/CoFe(15)/Cu(26)/CoFe(40)/FeMn(80)/Ta(50), of which unit is Å. The base pressure was below 3×10^{-8} torr. MR response was measured by d.c. four point probe method. Roughness and surface image of each samples were observed by AFM(atomic force microscope).

Result and Discussion

Fig. 1 show the representive MR responses of spin valves deposited on the different substrate. The spin valve on glass has very large interlayer coupling field(H_f) of 25~30 Oe, while the spin valves on Si/SiO_2 and on Si substrate have small interlayer field as 6~7 Oe and 10~12 Oe, respectively. In the case of exchange bias field, the spin valve on Si/SiO_2 has high value as 210 Oe, while the spin valve on glass has small value as 130 Oe. It is considered that this phenomena is very related to microstructure of sample. In order to explain these difference, we observed AFM

images. The difference of H_f could be explained by the initial roughness of substrates, that is, the glass substrate has very high RMS roughness(5.9 Å), which induces a large orange peel coupling. AFM images also show that the spin valve on Si/SiO2 has very uniform distribution of large grain size(250~300 Å) shown as Fig. 2(a), and the spin valve on Si has uniform distribution of small grain size(100~180 Å) and the spin valve on glass has the non-uniform distribution of small and large grains shown as Fig. 2(b). These surface morphology influence on the exchange bias field, which could lead to the spin valve on Si/SiO_2 with high exchange bias field as 210 Oe. Therefore, uniform large grain growth induces the higher exchange bias, and is highly related to very small initial substrate roughness.

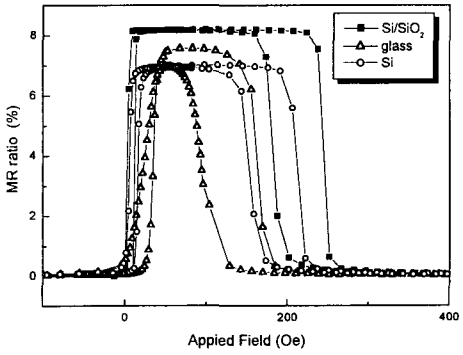

Fig. 1. The MR responses of spin valves deposited on the different substrates.

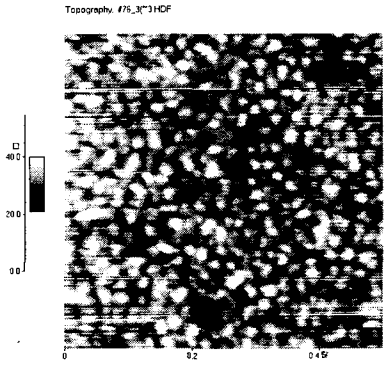

Fig 2(a) AFM image of spin valve on Si/SiO_2

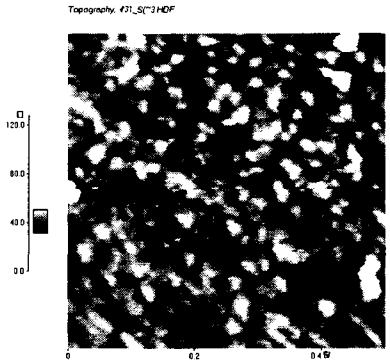

Fig 2(b) AFM image of spin valve on glass