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Local reversal of exchange anisotropy using laser annealing in patterned NiFe/FeMn film

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1. Introduction

In recent years, the development of alternative logic and non-volatile memory based on ferromagnetic materials has been very active [1]. To improve a technical difficulty and simplify the design of the memory device, the current controlled magnetization reversal due to the movement of domain wall and spin transfer in magnetic thin films had been suggested [2, 3]. The general method for assigning a magnetic memory device and sensors is to orient the remanent magnetization of small patterned ferromagnetic elements in one of two opposite directions. An external magnetic field and current can control the magnetization reversal of a free ferromagnetic element. However, that of the ferromagnetic elements pinned by antiferromagnet should be realized through thermal annealing. This way is accompanied with the magnetization of the whole films. The locally annealing experiment was performed in ferromagnetic amorphous ribbons by laser [4]. To locally reverse a unidirectional anisotropy in exchange biased films, the laser annealing method was used. The local magnetization reversal of the exchange-biased films as a function of exposed intensity and time was investigated.

2. Experiment

Bilayer films were deposited using ion-beam sputtering system. Patterned films were exposed to the emission of Diode Pumped Solid State (DPSS, Nd:YAG) laser operating at a wavelength of 532 nm and having a continuous wave (CW) second harmonic generation (SHG) output under the applied field of 600 gauss. The laser beam was focused through an optical fiber into 1 mm circular spot, with the intensity increased up to 440 mW. The direction of applied field (H_a) during exposure was opposed to that of the magnetic field (H_d) during deposition.

3. Result and discussions

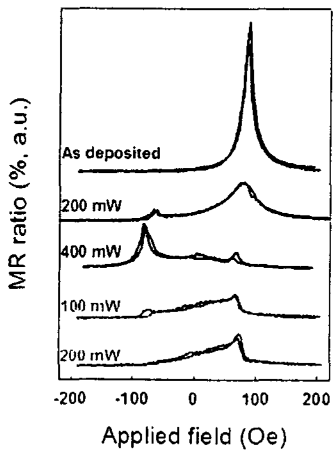

Fig. 1 The change of MR curves of the strip-patterned NiFe(11 nm)/ FeMn(16 nm) bilayer for a restored applied field.

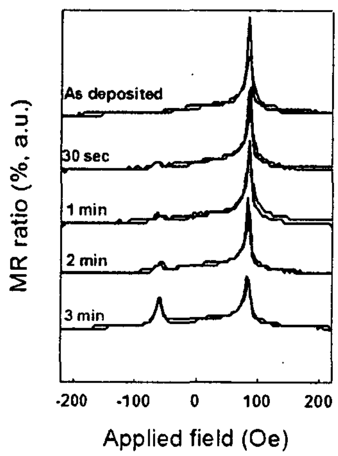

Fig. 2 The change of MR curves of according as the time of laser annealing up to 3 min, where the laser power is 300 mW.

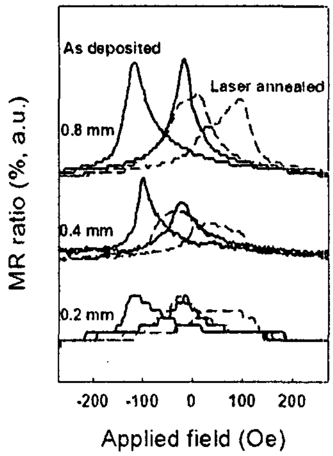

Fig. 3 The MR curves of the strip-patterned NiFe(11 nm)/ FeMn(16 nm) bilayer for a various strip width.

Fig. 1 shows the change of MR curves of the strip-patterned NiFe(11 nm)/ FeMn(16 nm) bilayer for a restored applied field. The MR curves of the mask-patterned and exchange-biased bilayer for a various laser power. The MR ratio and the exchange biasing field (Hex) of as-deposited bilayer were 0.9 % and + 87 Oe, respectively. As the power of laser annealing increased, the intensity of MR peak located in + 87 Oe shrunk. A new MR peak was generated at - 63 Oe due to local laser annealing of 200 mW. The location of positive MR peak (Hex) of 400 mW changed slightly from + 87 Oe to + 76 Oe, and MR ratio decreased from 0.9 % to 0.1 %. On the other hand, the new (negative) MR peak shifted from -63 Oe to -80 Oe, with the ratio increased up to 0.3 %. Because the reversal magnetization exposed by the local laser annealing is occurred, the positive peak does not vanish on increasing the laser power, and the rise of negative peak does not lead to amplitude comparable with that of positive peak in the as-deposited sample.

Fig. 2 shows the change of MR curves of according as the time dependence of laser annealing up to 3 minute, where the laser power is 300 mW. As the time of laser annealing is long, negative MR peak grows up and then it isespecially the complete reversal peak of local magnetic domain annealed in 3 minute because it does not grow up after 3 minute and the exchange bias does not change in the negative peak.

Fig. 3 shows the MR curves of the strip-patterned NiFe(11 nm)/ FeMn(16 nm) bilayer for a various strip width. As the strip width increases from 0.8 mm to 0.2 mm, all MR peaks move from negative field topositive field all the same. Finally strip patterned samples that is reduced in width do not influence exchange biases.

4. References

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