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Helical domain structure in laser-annealed Co-riched amorphous microwires

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1. Introduction

The magnetic anisotropy of amorphous wires plays a decisive role in the giant magnetoimpedance(GMI) behavior. The magnetoelastic anisotropy caused by internal stress, that are frozen in during the fabrication process, results in an axial easy axis in the core region and in a circular easy axis in the shell region [1]. It leads to a simple domain structure consisting of circular domains in the shell and axial domains in the core. For a more realistic domain structure, it has been suggested that the helical anisotropy exists due to an internal helical stress [2]. However, the effect of helical anisotropy and its effect on the GMI behavior of Co-riched microwires are not yet well understood.

In this paper, we investigate the angular dependence of GMI in Co-riched amorphous microwires annealed by illuminating with a pulsed Nd:YAG laser, and discuss the results in terms of the presence of helical anisotropy.

2. Experimental

A set of commercial glass-covered Co-riched amorphous microwires sample has been prepared. A microwire with metallic core diameter of 27.6 ㎛ and glass cover thickness of 3 ㎛ were etched to remove glass cover in 60.51 % hydrofluoric acid solution. After glass removal, the microwire, about 3 cm long, is annealed by illuminating the pulsed Nd:YAG laser beams with wavelength of 1.064 ㎛ with an energy **E** of 48 mJ/pulse in air. The field H was applied in different directions (angle θ) with respect to the wire axis by using a rotatable Helmholtz coil. The data set $Z(H)$, at given f and θ, was obtained during linear and cyclic sweeps of H from about -40 Oe to +40 Oe. The GMI ratio, $\Delta Z/Z$, is calculated with the relation of $\Delta Z/Z = \{Z(H)-Z_{min}\}\times 100/Z_{min}$, where Z_{min} is the minimum value of $Z(H)$.

3. Results and Discussion

Figures 1 and 2 show the GMI ratio profiles at 100 kHz and at 10 MHz, respectively, for as-etched sample and laser-annealed samples at E = 48 mJ/pulse with H_l = 0 and H_l = 20 Oe. The plots in left and right hand sides of Fig.1 and Fig.2 are profiles at θ = 0° and 100°, respectively. We note that the peak in the profiles at f =100 kHz and the dip of profiles at f =10 MHz are not centered at H = 0. Since the peak and dip will be centered at H = 0 for the circular domain structure due to circular symmetry, the shifts of the peak and dip from H = 0 reflect that an anisotropy exist in the samples, giving rise to an asymmetric domain structures in circular direction.

Here, we define the H values at the peak and the dip as H_p and H_d, respectively as indicated in Fig.1 and 2. The signs of H_p and H_d for all samples are negative at θ = 0° as shown in Fig.1 and 2. On the other hand, the signs of H_p and H_d become positive at θ = 100°. In order to analyze the angular dependence in detail, we have plotted H_p and H_d as a function of θ in

Fig.3(a) and (b), respectively.

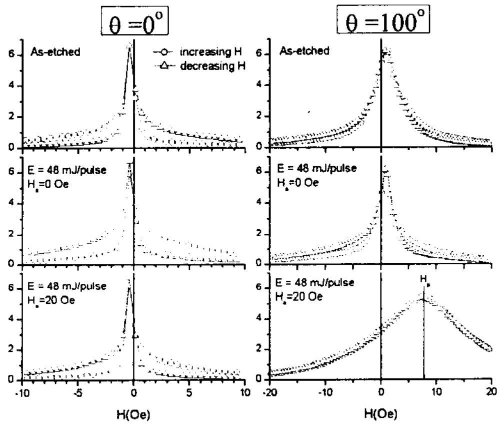
The laser annealed sample with E= 48 mJ/pulse and H_l = 0 exhibits a change in sign of H_p and H_d at the same interval between θ=85° and 90° as that of the as-etched sample, which means that the laser annealing without annealing field does not give a significant effect on the angle of the helical domains. On the other hand, the variations of H_p and H_d with θ for the sample with E = 48 mJ/pulse and H_l = 20 Oe show a change in sign of H_p and H_d at θ= 90° ~ 100° as shown in Fig.3, reflecting that the tilt angle of the helical domains is decreased by about -10° compared to that of the as-etched sample.

4. Conclusion

The existence of a helical domain structure in glass-covered Co-riched amorphous microwire is suggested by the angular dependence of the GMI profile. The tilt angle of the helical domains is about 5°~10° for as-etched sample and can be controlled by laser annealing under magnetic field.

5. References

[1] H. Chiriac and T. A. Ovari, Progress in Materials Science , Vol. 40, pp. 333-407, 1996.
[2] C.G. Kim, S.S. Yoon, M. Vazquez, *J.Magn. Magn. Mater.*, Vol.223, pp. L199-L202, 2001.



Fg.1.GMI ratio profiles at f = 100 kHz for as-etched and laser-annealed samples at θ = 0° and 100°.

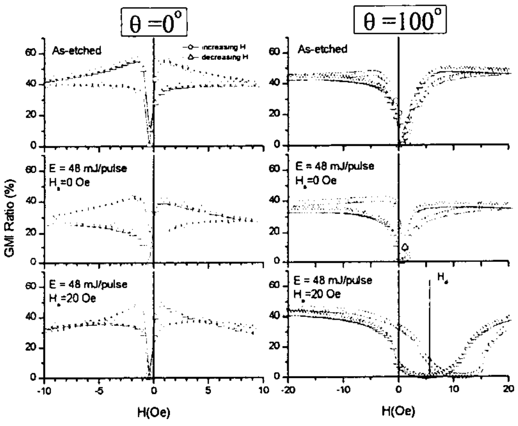


Fig.2. GMI ratio profiles at f = 10 MHz for as-etched and laser-annealed samples at θ = 0° and 100°.

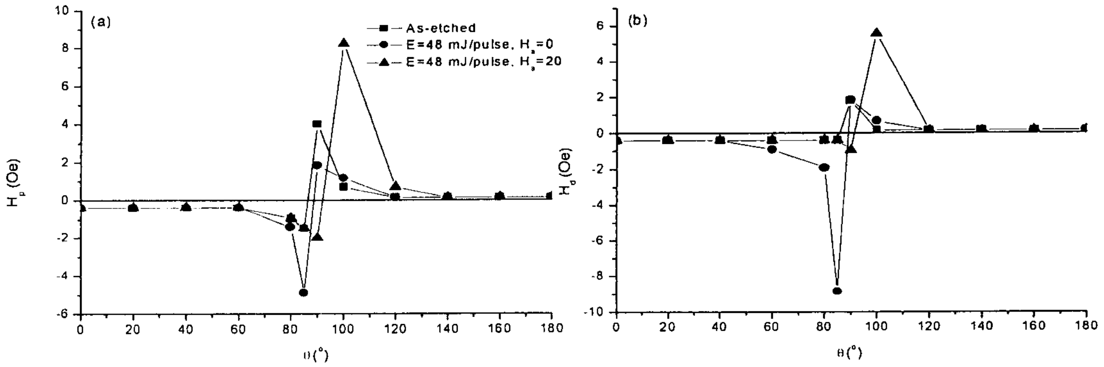


Fig.3. Variations of (a) Hp and (b) Hd with θ.