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Fabrication Condition Effects on the Magnetostrictive Properties of Sputtered Tb-Fe Thin Films

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In proto-type microactuators driven by magnetostrictive Tb-Fe thin films, the deflection was observed to be much smaller than that expected from large-sized "standard" Tb-Fe thin films. A striking difference was observed when the results from a thin substrate of 28 μm for microactuator applications were compared with those from a standard substrate. At a standard substrate thickness (several hundred μm), an amorphous phase was formed and the coercivity was low being 80 Oe. On the other hand, at a substrate thickness of 28 μm, the crystalline $TbFe_2$ phase was formed and the coercivity was increased to 4000 Oe. The motivation of this study is to find the reason for the large discrepancy by examining the effects of fabrication condition such as substrate thickness, sputtering time and input power on the magnetic and magnetostrictive properties of amorphous Tb–Fe thin films. At conditions of a small substrate thickness and a high input power etc., the temperature of the thin film and substrate is "suitably" high due to poor dissipation of the heat generated during sputtering. Two benefits arise from this suitably high temperature condition. The first is a large macroscopic residual tensile stress due to the thermal expansion coefficient difference between the substrate and thin film, causing a good in-plane anisotropy, a necessary condition for good magnetic softness. The second is the stress-anneal effect, which relieves random compressive stress (one possible origin is the incorporation of Argon) generated during sputtering. Resultantly, thin films fabricated at this high temperature condition show excellent magnetostrictive properties (Fig. 1).

[1] S. H. Lim et al., IEEE Trans. Magn., vol. 34, pp. 2041-2044 , July 1998.

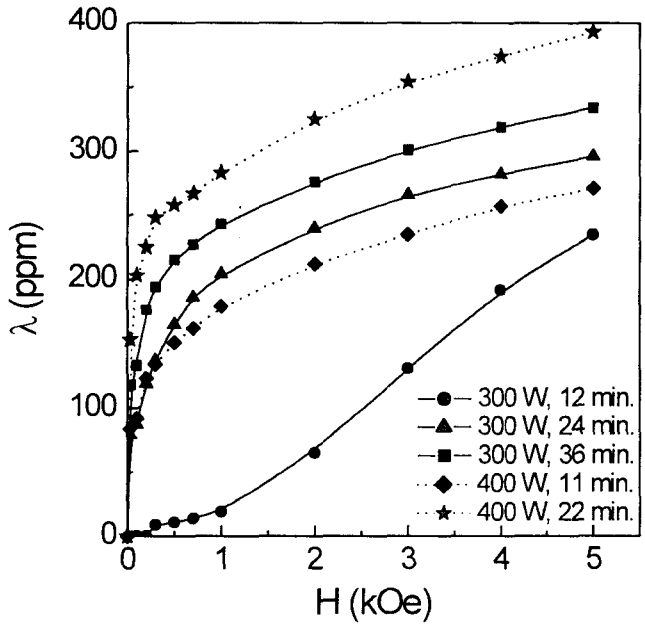

Fig. 1 The λ-H plots for Tb_XFe_{100-X} (51<X<56) thin films, showing the input power and sputtering time effect.