UNSTRAINED MAGNETOSTRICTIVE $FE_{80}B_{20}$ FILMS FOR MEMS/NEMS ACTUATORS.

I. Fernández-Martínez and F. Briones

Instituto de Microelectrónica de Madrid, IMM-CNM-CSIC, Isaac Newton 8 PTM, 28760 Tres Cantos, Madrid, Spain

ivan@imm.cnm.csic.es

Magnetic thin films with large magnetostriction constant and low intrinsic stress are demanded for magnetically actuated MEMS and NEMS [1,2]. Amorphous $Fe_{80}B_{20}$ thin films are adequate candidates for MEMS operating in liquids, due to their low anisotropy and high magnetostriction, together with their excellent adhesion, stability and corrosion resistance properties. However, residual deposition stress for sputtered amorphous thin films tends to be large and causes undesirable bending or distortion of cantilevers and actuators. On the other hand, strain effects modify strongly magnetic anisotropy and consequent magnetic field dependent properties.

Therefore, a study on the sputtering conditions dependence of deposition induced strain for $Fe_{80}B_{20}$ amorphous has been carried out using an in-situ, real time, highly sensitive optical method monitoring substrate curvature. Results allow us to optimize mechanical and magnetic properties by controlling deposition parameters. In this way, nearly unstrained $Fe_{80}B_{20}$ amorphous alloy films have been grown by DC triode sputtering on glass substrates.

Our triode sputtering operates under a wide range of Ar sputtering pressures ($1x10^{-3}$–$2.5x10^{-2}$ mbar) and cathode voltages in the 0.5-2kV range, thus allowing to determine the influence of impinging atoms energy on thin film stress evolution during deposition. Main intrinsic stresses were compressive and related to local distortion induced by energetic particles striking the film (ion peening mechanism). A significant stress generated at the film-substrate interface during the early stages of growth (initial 2.5nm) we also observe. Finally, it is shown how the total residual film strain can be controlled by varying Fe80B20 target potential or by energetic particles thermalization by gas-phase collisions under enough gas pressures (Fig 1), and consequently totally unstrained films have been achieved.

To demonstrate the feasibility of using magnetostrictive in micrometer-scale and on fast time acting actuators scales, a path-stabilized Michelson interferometer was used to detect displacements of a GaAs microcantilever coated with amorphous $Fe_{80}B_{20}$ when an alternating magnetic field was applied (Fig 2). Results are discussed in view of the optimized magnetic properties which allow magnetic operation at high frequencies.

References:

[1] A. Ludwig and E. Quandt, J. Appl. Phys. **87**, 4691 (2000).
[2] K.L.Ekinci , Small **1**, 786 (2005).

Figure 1: Total accumulated stress in function of cathode voltage. Optimal conditions for near-zero stress is achieved below 1kV cathode voltage, at a sputtering pressure of $8*10^{-3}$mbar.

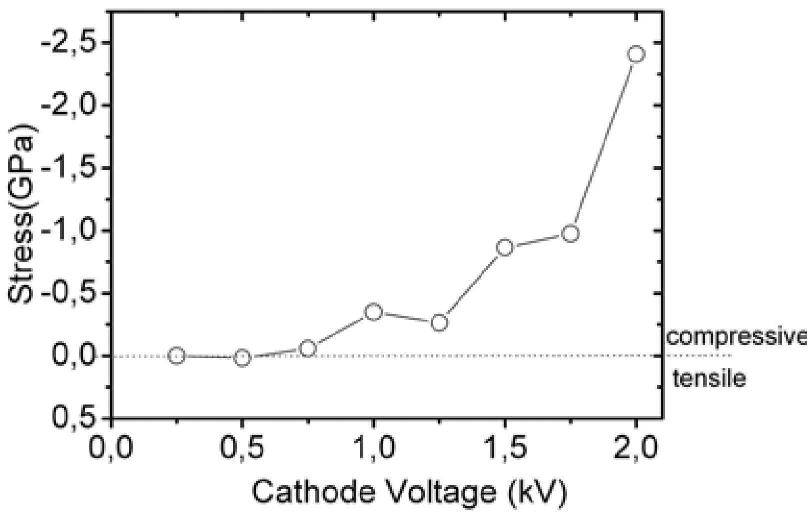

Figure 2: Left: SEM picture of GaAs microcantilever sputter coated with amorphous $Fe_{80}B_{20}$ film. Right: Fundamentalmagnetically actuated flexural resonance of a 20 μm long and 200nm thick beam measured in air by optical interferometric displacement detection .