研 究 速 報

Experimental Investigation of the Bending and Torsional Motion of a Magneto-Elastic Bimorph for a Micro-Scanner

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1. Introduction

The dynamic motion of a micro-cantilever based on magneto-elastic bimorph has been studied. The bimorph is composed of an amorphous TbDyFeCo active material[1], having a well-defined in plane easy axis, sputtered onto a Silicon passive substrate. The response of such micro bimorph to an external static/dynamic field was studied, in particular the very specific feature of those thin films to create bending and torsion motion of the Si-based. In contrast with piezoelectric or thermal bimorph (including those based on shape memory alloys) bimorphmagnetostrictive one do not seem much familiar to the microsystems community[2]. Although they bear several advantages.

2. Technological process

Contrary to piezoelectric films, which are mostly oxides, magnetostrictive materials are metallic alloys that are easy to deposit upon almost any substrate at room temperature. In particular, their magnetic properties (direction of the in-plane easy axis with respect to the main axis of the cantilever) are well controlled during the deposition and post annealing under magnetic field. The thin film is deposited on the structure, without masks, after the releasing of the micro Si-based cantilever, allowing a simple process.

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3. Experimental results

Since the magnetostriction effect produces anisotropic in-plane deformation, a magnetostriction bimorph produces a torsion as well as a bending which is impossible with piezoelectric one. We studied the effect of the direction of the magnetization with respect to the main axis of the cantilever on the amplitude of the deflection achieved for the bending and the torsion deformation. When applying a static magnetic field along the length of the cantilever, the bending and the torsion are following the expected behavior given by considering a uniaxial thin film, as shown in figure1.

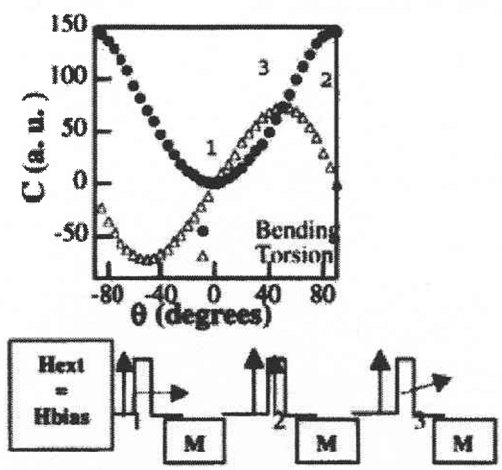


Fig.1 Deformation achieved when applying a static magnetic-field along the length of the cantilever. The deformation is divided into a torsion and a bending deformation. The dimension of the cantilever are 3μm*22μm*200μm.

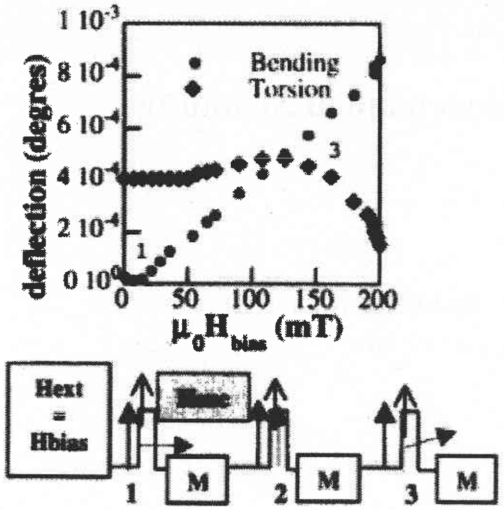
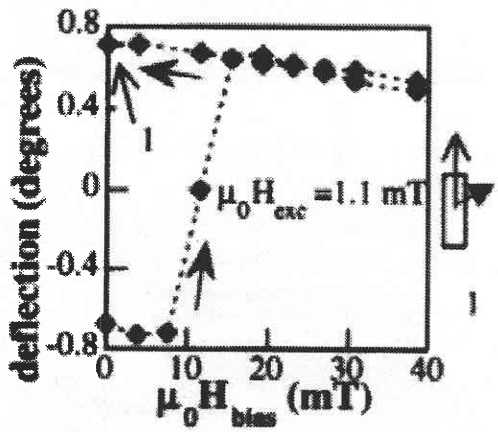


Fig.2 Deformation achieved when applying a low AC (H_{exc}) excitation field and a static (H_{bias}) magnetic field along the length of the cantilever. Both motions are decoupled at the resonant frequencies. The dimension of the cantilever are 450μm* 1000μm* 15μm.



Fog.3 Deflection achieved when applying a static (H_{dias}) magnetic field along the easy axis of the cantilever and a AC magnetic field along its length. The dimension of the cantilever are 450μm* 1000μm* 15μm.

Figure 2 shows the behavior achieved when applying a dynamic field and a static field along the length of the cantilever. Figure 3 shows the behavior of the torsional motion when applying a bias field along the direction of the easy axis fixed during the deposition of the thin film.

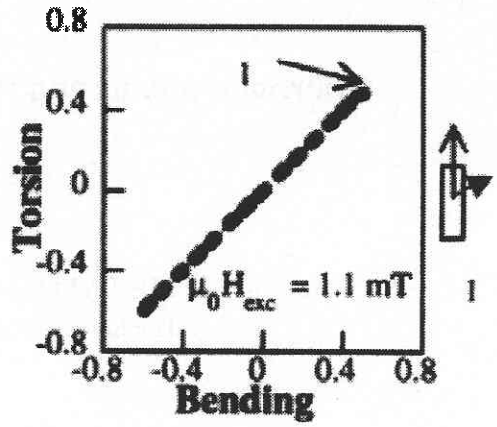


Fig.4 Deflection due to the torsion versus the deflection due to the bending, as a function of the static (H_{bias}) magnetic field. The dimension of the cantilever are 450μm* 1000μm* 15μm.

Figure 4 refers to a sample with the same orientation of the easy axis. Here. it is verified that as expected the bending mode as well as the torsion mode can be excited by an excitation field directed along the length of the micro-cantilever. Depending on the direction of the easy axis and avoiding the steady application of a bias field, one can control the ratio between the amplitude due to the torsion and the amplitude due to the bending.

4. Conclusion

A 2D scanner, using the original feature of this thin film to produce torsion and bending motion, can be designed. Depending on the specificity of applications the orientation of the magnetization can be fixed to achieve, for instance, the same amplitude of deflection for the torsion and bending mode under the same amplitude of excitation field. Using coercivity of the thin film should allow to omit the steady application of the bias field. Both modes can be excited with a single coil without physical contacts between the driving source and the bimorph.

(Manuscript received, June 28, 1999)

Reference

1) N. Duc, K. Mackay, J. Betz, and D. Givord, J. Appl. Phys., 79(2), pp973-977, 1996.

2) E. Quandt, A. Ludwig and K. Seeman, Proc of Sensors and Actuators, pp.1089-1092, 1996.