Dynamic behavior of magnetic hybrid films of polyvinyl butyral/iron oxide nanoparticles (PVB/Fe_2O_3) for their control as microactuators

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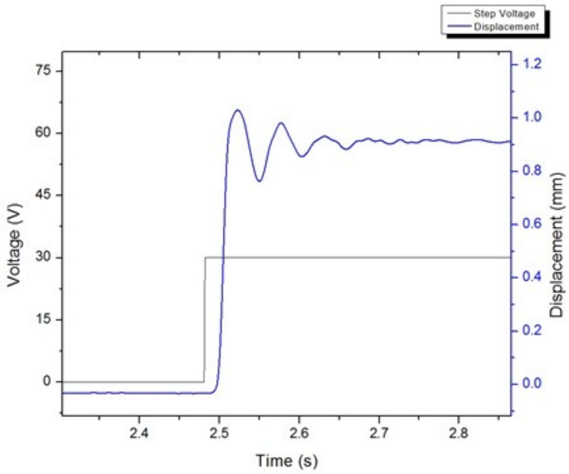
Magnetic hybrid materials (organic/inorganic) are a motivating research topic for microactuator technologies as flexible magnetic devices or contactless manipulation, useful for many applications [1,2]. However, the control of these microactuators remains a challenge due to the severe performances required in the specifications and at the same time to the nonlinear dynamics that typify the materials. [3]. This study performs an exhaustive experimental characterization of the nonlinear dynamics of a magnetic hybrid film as a cantilever actuator. The magnetic hybrid film consists of a polyvinyl butyral (PVB) matrix and iron oxide (Fe_2O_3) nanoparticles synthesized *in-situ* [1,4] with two different concentrations of Fe_2O_3 nanoparticles (40% and 50% wt of its precursor, iron (II) chloride $FeCl_2$).

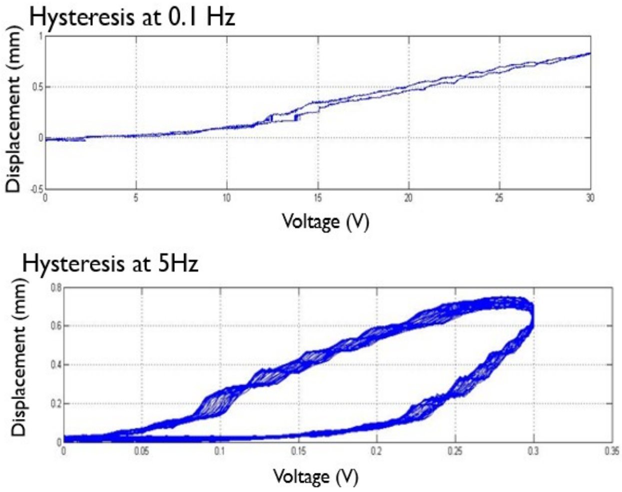
This work presents first the synthesis of the magnetic hybrid films (PVB/ Fe_2O_3), their magnetic and morphological characterization, and then the dynamics characterization considering two different geometries for the cantilever and various percent of Fe_2O_3 nanoparticles. To carry out the characterization, constant and sine magnetic fields at various amplitudes and frequencies were applied to the cantilever actuator.

Magnetic and morphological characterizations showed a superparamagnetic-like behavior of the material at room temperature and a well dispersion of nanoparticles (Fe_2O_3) into the PVB matrix, in accordance with previous works [1,3]. A damped-like behavior is exposed with a maximum displacement of 0.99 mm when a constant magnetic field of 0.96 kOe is applied (Fig. 1a). These results correspond to the films with the highest Fe_2O_3 content (50%wt $FeCl_2$) and dimensions of 15 mm in length, 2 mm in width, 0.02 mm in thickness. In the sine magnetic field test, a hysteretic rate-dependent behavior was observed. Test performed at 0.1 Hz of frequency apparently presents a quasi-nonhysteretic response unlike the response at higher frequencies (Fig. 1b).

Future work will consider the physical model of the dynamic behavior of the (PVB/ Fe_2O_3) films and a control system to reduce the hysteresis nonlinearities.



(a)



(b)

Fig.1: Response of the PVB/Fe_2O_3 films (a) in constant magnetic field test (b) in sine magnetic field test.

References

[1] B. López-Walle, J. Romo-Rico, J. Puente-Córdova, M. Reyes-Melo, *Mater. Res. Soc. Sym. Proc.* **1708,** pp 1-4 (2014) link.

[2] Micky Rakotondrabe, *'Smart materials-based actuators at the micro/nano-scale: characterization, control and applications'*, edited book, Springer - Verlag, New York, ISBN 978-1-4614-6683-3, 2013.

[3] M. Grossard, M. Rakotondrabe, Actuators **5**, pp 18, (2016) link.

[4] J. Luna, E. Reyes, V. Gonzáles, C. Guerrero, A. Torres, S. Sepúlveda, *J. Appl. Polym. Sci.* **127**, pp. 2325–2331 (2013) link.