The Effect of Uniaxial Stress on the Dynamic Spin Reversal in Ferromagnetic Nano-Thickness Films : Monte Carlo Investigation

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ABSTRACT

In this work, we studied the uniaxial stress dependence of the ferromagnetic properties of nano-thickness films, i.e., bi-layered ferromagnetic films, where the films' in-plane direction is lying in the x-y plane. The Heisenberg Hamiltonian model being used in the study was modified to include the uniaxial stress effect, and both the uniaxial stress and the external magnetic field were applied on the z direction of the system. The observables, i.e., the magnetization along the out-of-plane (z) direction were taken as a function of temperatures, the magnitudes of the applied stress, the magnetic fields' period and the magnetic fields' amplitude via the dynamics of the spin reversal in the framework of the magnetic hysteresis. The study was taken by means of Monte Carlo simulations using a spin-flip algorithm. From our results, it was found that the remanent values of the hysteresis loop significantly decreased with increasing applied stress. On the other hand, the coercive field only slightly decreased. Moreover, the areas under the hysteresis loop also decreased with increased applied stress, indicating a smaller magnitude of energy dissipation. The results are in good agreement with related experiments.

Key words: Nanostructure, Magnetic thin-films, Monte Carlo, Heisenberg model, Uniaxial stress, Spin reversal, Hysteresis

INTRODUCTION

Magnetic multi-layers grown on non-magnetic substrates, especially thin-films with a thickness in nano-scale range, have recently been of wide interest in view of both technological and fundamental importance (Johnson et al., 1996). Of a particular interest is the technological applicability such as high-storage magnetic recording media which high areal densities of the recording media are in demand (Judy, 2001). Consequently, there comes an interest on the study of how to enable more data bits to be stored in a finite magnetic material while the magnetic domain switching under an influence of external magnetic field, during the read/write period, is controllable. Accordingly, to fulfill this objective, knowledge about magnetic spin reversal from one direction to its opposite direction of the magnetic multi-layers, under the effect of an external field, corresponding to specific material structures must be understood in details.

Nevertheless, for the sake of simplicity, theoretical studies on magnetic multi-layers are usually performed on an ideal structure, for instance, stress-free material. However, real materials being used in many applications especially in thin-films structures are often affected from crystalline anisotropy contributed from mechanical stress. Even in an unstrained lattice, this can be regarded as a strain on the crystal due to some slightly different atomic positions, for example, the lattice mismatch at the interfaces between the magnetic layers and