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Antiferromagnetic Interface Magnetism of Nickel Thin Film Layers on Magneto-Optical Cobalt-Platinum Surface

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Are atomic scale Ni monolayers ferromagnetic or antiferromagnetic? In this research, we conducted some experimental results of the effect of Ni layers on investigating the magnetic properties of layered Co/Pt(111) films. Magnetic properties were measured by the in-situ Kerr magneto-optic measurement. Magnetization of the ultrathin film displays strong perpendicular magnetic anisotropy under the thickness of Co smaller than three monolayers. Magnetic character of the film is strongly dependent on temperature as being the Co/Ni/Pt samples. It was much unexpected to observe the Kerr hysteresis being wholly counteracted when the interfaces still contain the ferromagnetic constituents. We assumed that unusual behaviour may originate from the antiferromagnetic spins between Co, Ni and even the polarized Pt interfaces. The samples are also compared into one group with Ni layers and the other without Ni layers. The effect of Ni can be concluded in two groups that one is the magnetic eliminatoras well as another is the magnetic protector. If the spins of the Co layers directs perpendicular up to the surface, the increment of Ni spins gradually cancels the net magnetization with the opposite perpendicular down spins. As the film was thermally annealed, compositionsbetween interfaces intermix to Co-Pt and Ni-Pt alloys. The spin direction of the two alloys might be opposite to each other, causing the Kerr signals being weakened. Thus, the interface of the film can be treated as possessing an antiferromagnetic-like behaviour. Besides, the films reveal interesting temperature independence only forthe film with the number of Co layers is smaller than Ni ones. On the contrary, the thickness ratios for Co and Ni layers larger than one then contribute to an enhanced Kerr signal close to the Curie temperature after over 800 K (Fig. 1). In order to examine the postulate of antiferromagnetic coupling model we addressed, a measurement of Ni/Co/Pt phase was performed in a comparison. In this case, more proportions of Ni layers than Co indeed increase the antiferromagnetic coupling in the annealed alloy films at a range of temperature. From the application of view, the artificial structure can be used for the recording industry, especially for the state-of-the-art perpendicular magnetic recording. We can easily apply the material properties to resist from external high magnetic field and keep the feedback signal well if the film has been once annealed at high temperature.

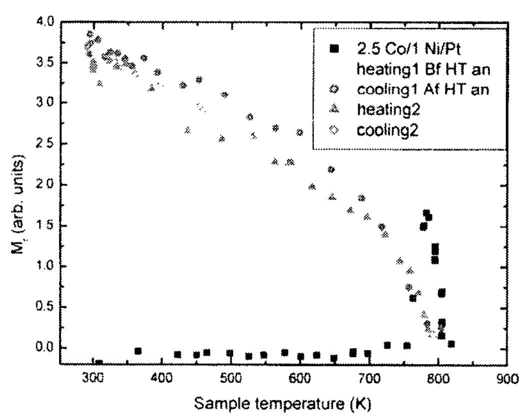

Fig. 1. Magneto-optic properties of 2.5 ML Co/1 ML Ni/Pt(111) films within heating-cooling back and forth process.

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Atomistic and Macrospin Models of Ultrafast Reversal

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With magnetic materials becoming increasingly nanostructured, there is a developing need for models of magnetisation processes that go beyond the normal micromagnetic approach, so as to include the additional physical phenomena associated with finite size systems. This need is made more pressing by the fact that ultra-high density information storage may require Heat Assisted Magnetic Recording (HAMR), which involves heating beyond the Curie temperature, and it is known that micromagnetics is not capable of dealing with phase transitions without introducing some atomic level information. Atomistic models are currently under development and have already given important insight, for example into the properties of FePt [1]; an important candidate for ultra-high density recording media. We will introduce the physical problem in the context of the approach to ultra-high density recording, going on to describe the current state of development of atomistic models. The basis of atomistic models will then be outlined. Essentially this consists of the use of a Heisenberg effective spin model and the Langevin dynamic approach (the LLG equation augmented by a random field to include the effects of temperature) to describe the time evolution of the ensemble of coupled spins. The model enables representation of the temperature dependent magnetic properties and complete magnetic excitation spectrum.This is important because it allows the magnetic phase transition to occur at a realistic Curie temperature. The model will then be applied to studies of fast laser heating of magnetic materials. In particular it will be demonstrated that the magnetisation vanishes in a timescale of picoseconds, whereas the recovery of the magnetisation can take of the order of 1ns because of the necessity for the magnetisation to grow from a large number of small nuclei, which leads to strong frustration effects. Simulations of the heat assisted magnetisation reversal process in FePt will be presented, demonstrating a new reversal mechanism involving the destruction and recovery of the magnetisation into the reverse direction. The timescale of the recovery is an important factor in relation to the heat-assisted recording process.

Finally we will review the progress in linking atomistic and micromagnetic models in a step toward creating macroscopic models of magnetic materials at temperatures approaching the Curie temperature. This is important as regards the understanding of macroscopic reversal process cannot realistically be achieved with atomistic models. Our previous work has shown [2] that the (macrospin) Landau-Lifshitz-Bloch (LLB) equation describes the physics of high temperature processes better than the LLG equation. Here we show that the LLB equation gives a reasonable description of the heat assisted reversal process for a single grain, but fails to predict the correct timescale for recovery of the magnetisation due to the frustration effects observed in the atomistic simulations. Possible solutions to this problem will be discussed.

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