Using Femtosecond Lasers for Investigating Magnetization Dynamics and Sound Velocity in Magnetic Multilayers

T Fernandes[1], F M Matinaga[1], J Zarpellon[2], D H Mosca[2], L H F Andrade[1], and M D Martins[1]

[1] *SENAN - Serviço de Nanotecnologia, CDTN/CNEN, 31270901, Belo Horizonte, Brazil.*
Contact Phone: +553134399794
[2] *Physics Department, Universidade Federal do Paraná, 80060000, Curitiba, Brazil.*
Contact Phone: +554133613092
Contact Email: tiago.fernandes@cdtn.br

Spectroscopy with fs lasers appeared as a powerful method to study fundamental properties in magnetic materials, as well as new magneto-photonic devices. *E.g.*, we have many works showing ultrafast spin dynamics on ferromagnetic multilayers, [1] sub-ps polarization switching in ferromagnetic materials [2].On the other side, through the electron phonon coupling process, coherent phonons are generated not only at the incidence surface, but also propagate as coherent phonons waves.

In this work we used a 100 fs laser in a non degenerated pump and probe spectroscopy setup to measure spin dynamics (TRMOKE) and reflectivity spectra (TRR) to study a magnetic Co/Pt multilayers. We measured a fast demagnetization ($t1 = 0.26$ ps) and re-magnetization ($t2 = 0.69$ ps) followed by a slow damping with a precession ($tp = 280$ ps) regime in the Co/Pt multilayer (Fig. 1 a,b). We observed also the generation of coherent phonons in those thin capping layers with similar behavior, *i.e.* a fast reflection change followed by slow relaxation on the reflectivity curve, with a difference on the presence of the oscillations due to the phonons modes (Fig. 1 c). Such modes allow us the determination of the sound speed ($v = 3464$ m/s) in those Pt spacer layers with high precision (Fig. 1 d).

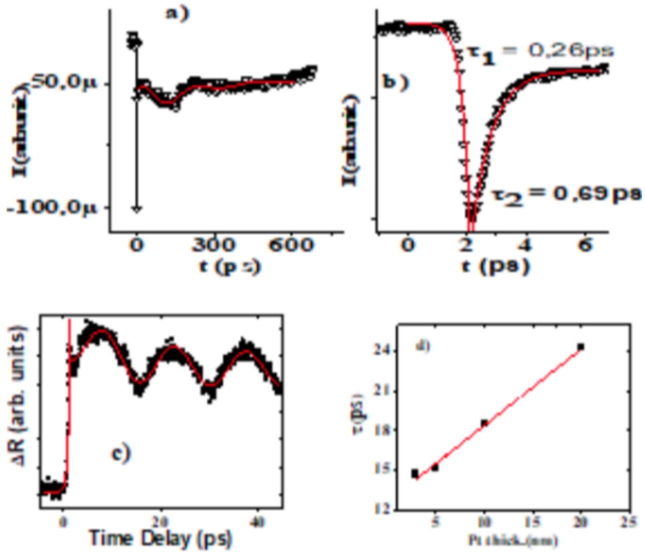

Figure 1: TRMOKE Measurements of Co/Pt (3 nm) showing a magnetic dynamics (a,b) and TRR behavior data (c,d)

For this work, a set of 4 samples: [Co(0.6 nm)/Pt(0.8 nm)]5/Pt(dnm) multilayered film (Co/Pt-ML) with Pt cover-age layer with thickness of 3, 5, 10 and 20 nm, were grown by sputtering as described previously.[3] These samples showed a perpendicular magnetization anisotropy (PMA) observed by variable scanning magnetometry (VSM), and the structural properties were measured by X-ray diffraction shown on pre-vious work.[3]

The magnetic and phonon dynamic of the Co/Pt-ML films were characterized using a 100 fs pulsed laser, in a non-degenerated collinear pump and probe setup, and the same system was used for the TRR.

Fig. 1 a,b shows a dynamic behavior in the TRMOKE measurement for the sample with 3 nm Pt cover (S1). The data fitting give us a precession frequency of 9.5 GHz and a high damping rate ($t = 147$ ps) for this CoPt multilayer. Also, we saw a fast demagnetization time of $td = 0.26$ ps, followed by a re-magnetization time of $tr = 0.69$ps (Fig. 1b).

Fig. 1 c shows TRR measurements for the sample S1. The observed oscillation was observed for all samples, as resumed in table 1, and those data were used for estimation of the phonon velocity as shown on Fig. 1 d.

These observed oscillation periods for samples S1 to S4 were plotted as a function of the thickness, which shows a linear behavior as shown on Fig. 1 d, which give us a phonon wave velocity of 3464 m/s for the Pt coverage layer which are in agreement with values reported by other similar metallic films.

The coherent phonon generated on the magnetic films (Fig. c,d) show us an useful method to analyze mechanical property of the thin magnetic films, as well as a possibility to explore such phonon wave on magnetic switching devices.

References

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