Tunable dispersion relation in ultra-thin, low-loss YIG grown by Pulsed Laser Deposition

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It has been demonstrated experimentally that one way to achieve ultra-thin films of YIG with Perpendicular Magnetic Anisotropy (PMA) is to dope Y on the dodecahedral sites with a variety of possible atoms [1,2]. Bi-doped YIG is particularly promising as it combines low magnetic losses and high Faraday coefficient, the latter making it suitable for magneto-optical probing techniques. In Bi-YIG, the out-of-plane magnetic anisotropy constant K_u could be tuned thanks to a combination of a magneto-elastic contribution and a growth-induced contribution [3].
Recently, perpendicularly magnetized YIG thin films grown by sputtering and Pulsed Laser Deposition (PLD) were reported [4,5]. The PMA is there obtained by a second way: changing only the magneto-elastic contribution in highly strained films. Obtaining a large enough K_u to obtain PMA is however not enough, equally important is the ability to finely tune it.

In this work, we have developed two approaches to obtain tunable dispersion relation in ultra-thin YIG films. The first approach describes the growth of 22 nm Bi-YIG thin films by PLD. We varied the substrate growth temperature (T_G) and probed the films effective magnetization ($\mu_0 M_{eff}$) using Ferromagnetic Resonance (FMR): we firstly evidenced a magnetization state transition from in-plane to out-of-plane as T_G decreases from 475 °C to 405 °C (Figure 1). Interestingly, for thin films closest to the compensation ($\mu_0 M_{eff} = 0$, $\alpha = 4\text{x}10^{-4}$), FMR measurements performed within [260-400 K] range evidence a thermal drift of only: $\mu_0 \Delta_{Hres} =$ 4 mT, making the FMR frequency almost temperature independent. The second approach concerns un-doped YIG//GSGG thin films. The large epitaxial strain induced (Figure 2) is leading to tensile-strained thin films with PMA. Thickest fully tensile-strained film grown on GSGG (t = 27 nm) is characterized by $\mu_0 M_{eff} = -50$ mT and $\mu_0 \Delta_{Hpp} = 1.2$ mT at f = 6 GHz.

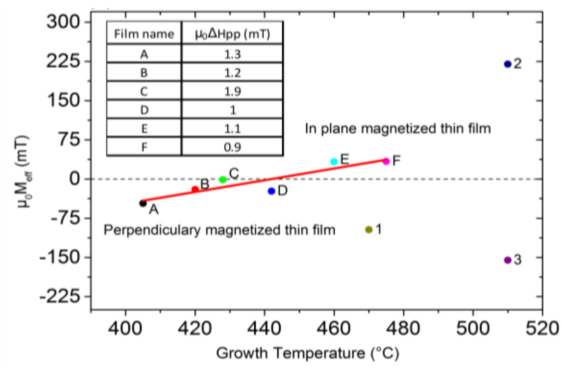

Figure 1: Effective magnetization as a function of growth temperature. The easy axis transition is evidenced.

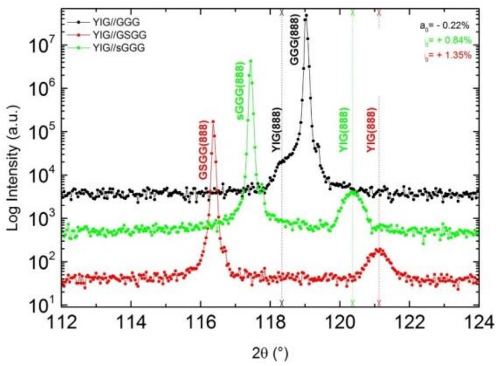

Figure 2: X-Ray Diffraction spectra evidencing the strain is maximised for YIG//GSGG.

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