Cubic Ferrimagnetic Full-Heusler Mn_2Fe_xGa Thin Films with Strong Perpendicular Magnetic Anisotropy

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Large perpendicular magnetic anisotropy (PMA), high spin polarization at the Fermi level, and a low Gilbert damping constant are the crucial properties of magnetic thin films for developing high density fast switching magnetic random-access memory (MRAM). Whilst ferromagnetic materials can show high spin polarization and large PMA, they are also sensitive to stray fields which can influence their performance in spintronic devices. Ferrimagnetic materials, specifically those which demonstrate a partially to fully compensated magnetic moment, are not only insensitive to stray field effects but also possess extremely low Gilbert damping constants around the compensation temperature [1]. The first demonstration of a fully compensated ferrimagnetic material was in the full-Heusler Mn_2RuGa (MRG) compound [2]. However, MRG thin films suffer from problems such as thickness dependency [3] and relatively low spin polarization [4], and therefore there has been a push to explore a wider range of Mn_2YZ Heusler alloys to find the optimal ferrimagnetic material for MRAM applications.

In this study we present the first demonstration of cubic full-Heusler Mn_2Fe_xGa (MFG) thin films with strong PMA. By using a Cr buffer layer, our thin films with a structure of MFG(30 nm)/Cr(20 nm)/MgO(001) substrate show not only highly epitaxial growth of cubic MFG but also significant PMA at room temperature (Figure 1). We found that a large tetragonal lattice distortion ($\boldsymbol{c}/\boldsymbol{a} \simeq 1.06$) is induced in the cubic MFG thin films by introducing a Cr buffer, compared to the small positive strain ($\boldsymbol{a} > \boldsymbol{c}$) in the films grown directly on MgO(001) substrates. This tetragonal distortion consequently influences the magnetic anisotropy of the MFG thin film. We also found that the film thickness can be reduced to ~5 nm whilst keeping high crystallinity contrary to the MRG thin films [3]. Our present results show that cubic MFG is a promising system for MRAM applications.

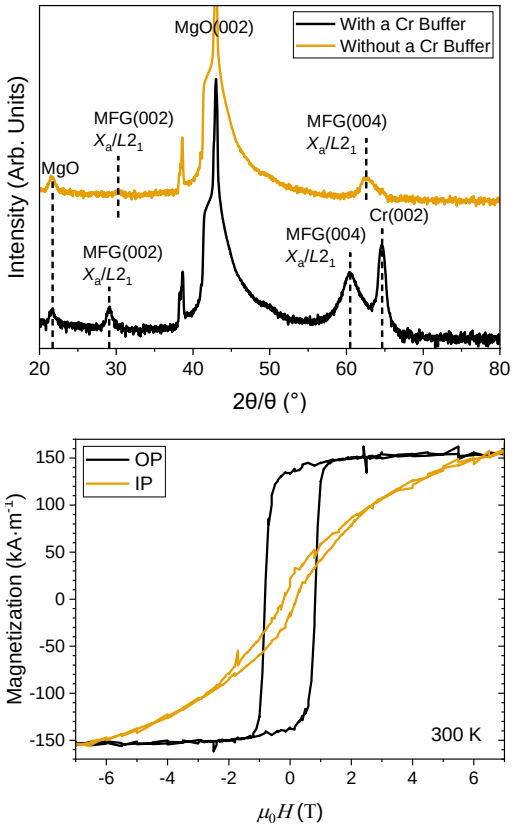

Figure 1 (upper panel) XRD profiles of cubic MFG grown with (black) or without (gold) the use of a Cr buffer layer. (lower panel) In- and out-of-plane magnetic hysteresis loops measured at room temperature using SQUID for cubic MFG/Cr/MgO.

[1] T. Gasi *et al.*, **Appl. Phys. Lett.**, 2013, **102**, 202402; [2] H. Kurt *et al.*, **Phys. Rev. Lett.**, 2014, **112**, 027201; [3] J. Finley *et al.*, **Adv. Mater.**, 2019, **31**, 1805361; [4] K. E. Siewierska *et al.*, **Phys. Rev. B**, 2021, **104**, 064414.