Investigating dynamic magnetic properties of Co_2FeAl/IrMn bilayers for spintronics applications

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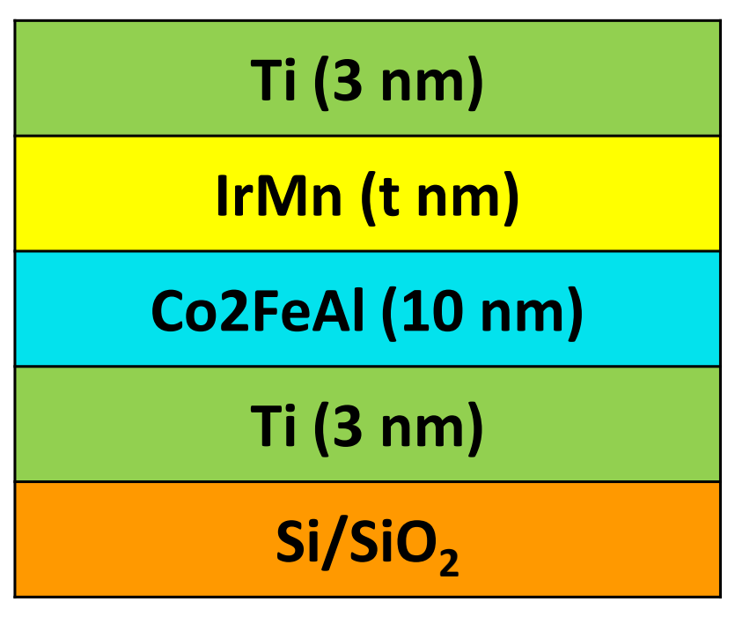
Introduction: **The exchange coupling between antiferromagnetic (AF) and ferromagnetic (FM) layers, coming from the interfacial AF/FM interaction, has received increasing attention due to its key role in magnetic tunnel junctions and spin valves among others [1,2, 3]. In the following study, we perform a systematic study of the static and dynamic magnetic properties of exchange-biased Co2FeAl/IrMn films. Specifically We analyse the evolution of the coercive field, exchange bias field, rotatable anisotropy and magnetic damping, using broadband ferromagnetic resonance, as a function of IrMn antiferromagnet film thickness. Our results shows an increase of exchange bias and rotatable anisotropy with the thickness of the IrMn layer. These anisotropies reach nearly constant values for thickness above 20 nm of IrMn, and surprisingly the rotatable anisotropy does not decrease as observed in other systems. Interestingly, the observed magnetic damping parameters α for the CoFeAl/IrMn systems, has no clear correlation with the thickness of the IrMn layer or the rotatable anisotropy. The present study brings interesting new results on the behavior of the rotatable anisotropy and magnetic damping of Co2FeAl/IrMn systems, and open new challenges for theoretical explanation of the observed effects.**

EXPERIMENTAL DETAILS

The exchange biased **CFA (10)/IrMn (t)** bilayers were deposited by dc magnetron sputtering technique. Where **t** = 5, 10, 15, 20, 30 and 50 nm.

Sample Fabrication



Room temperture

Deposition conditions :
- **Lowest vacuum < 3x10^{-8} mTorr**
- **working pressure:**
  - **5 mTorr**
  - **50 sccm of Ar**
- **Applied magnetic field 200 Oe**

GiXRD

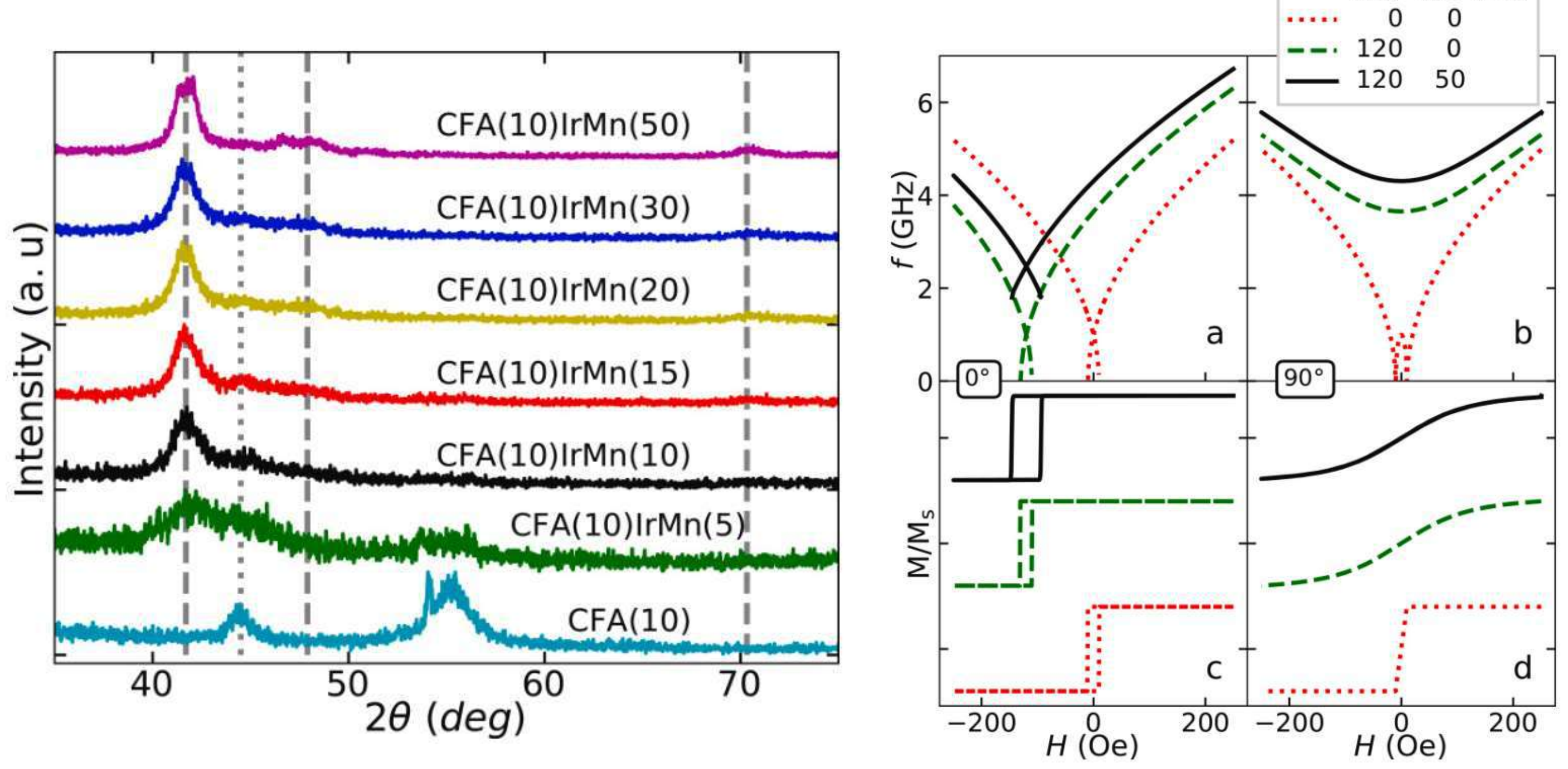


Figure 1 – GiXRD measurements for all samples (left), and the numerical fittings of the kittel equations for different cases of Exchange bias and Rotatable anisotropy (right).

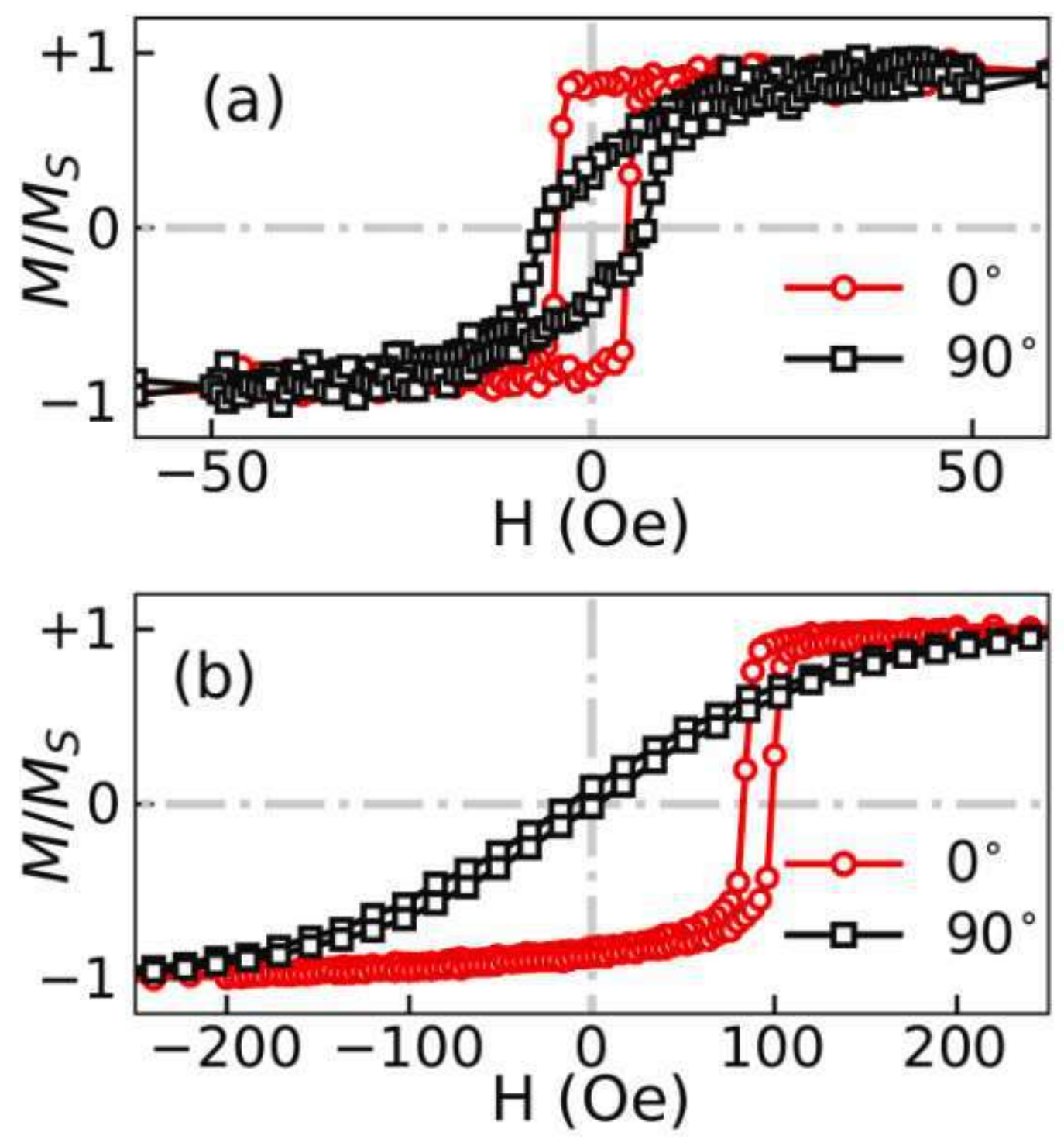
Kittel equations:

$$f_r(\theta=0^\circ)=\frac{\gamma}{2\pi}\left[(4\pi M_{eff}+H+H_K+H_{rot}+H_{ex})(H+H_K+H_{rot}+H_{ex})\right]^{1/2}$$

$$f_r(\theta=90^\circ)=\frac{\gamma}{2\pi}\left[(4\pi M_{eff}+H+H_K+H_{rot}+H_{ex})(H-H_K+H_{rot}+H_{ex})\right]^{1/2}$$

Static Magnetization (M x H)

For $\theta = 0^o$ and 90^o the magnetization curves with AGFM magnetometer.



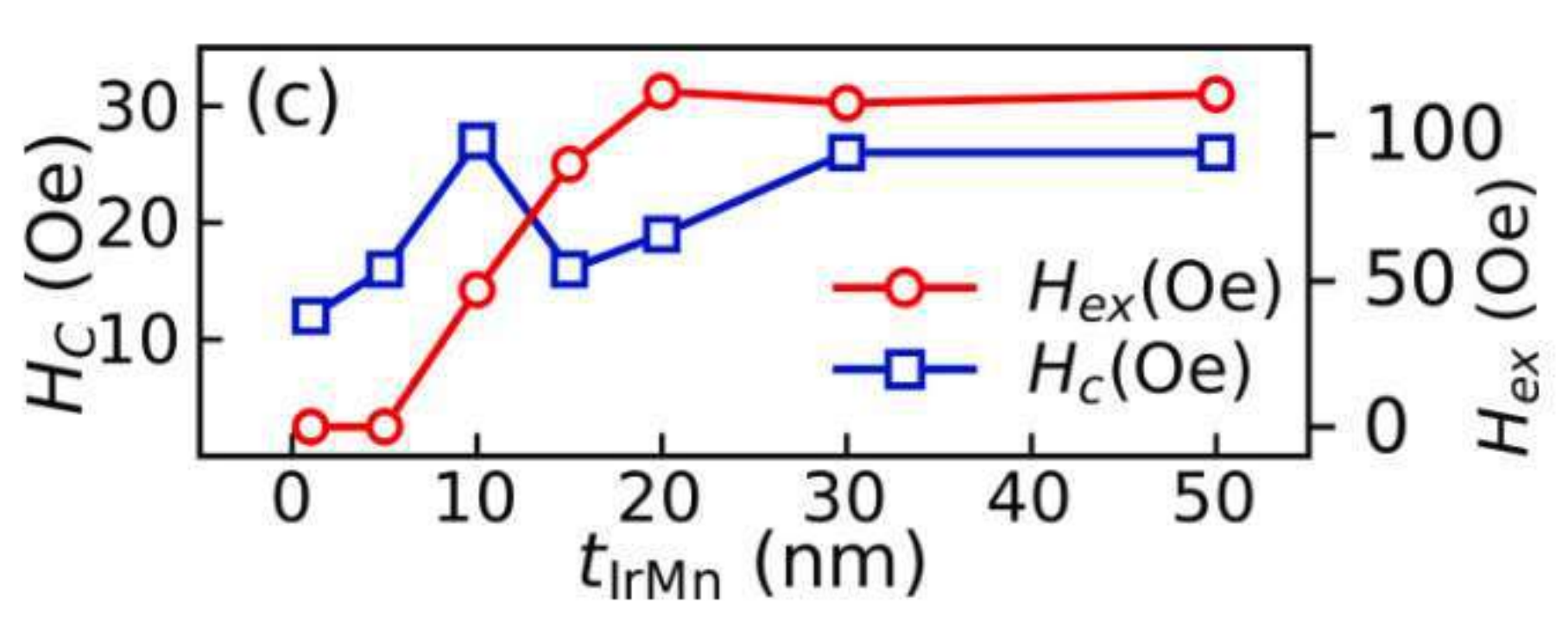


Figure 1 – Static magnetization curves for CFA(10) and CFA(10)/IrMn(15) at 0° and 90°

MxH Results:
Coercive fields **Hc** and **Hex** becomes saturated after 20 nm.

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FAPERJ
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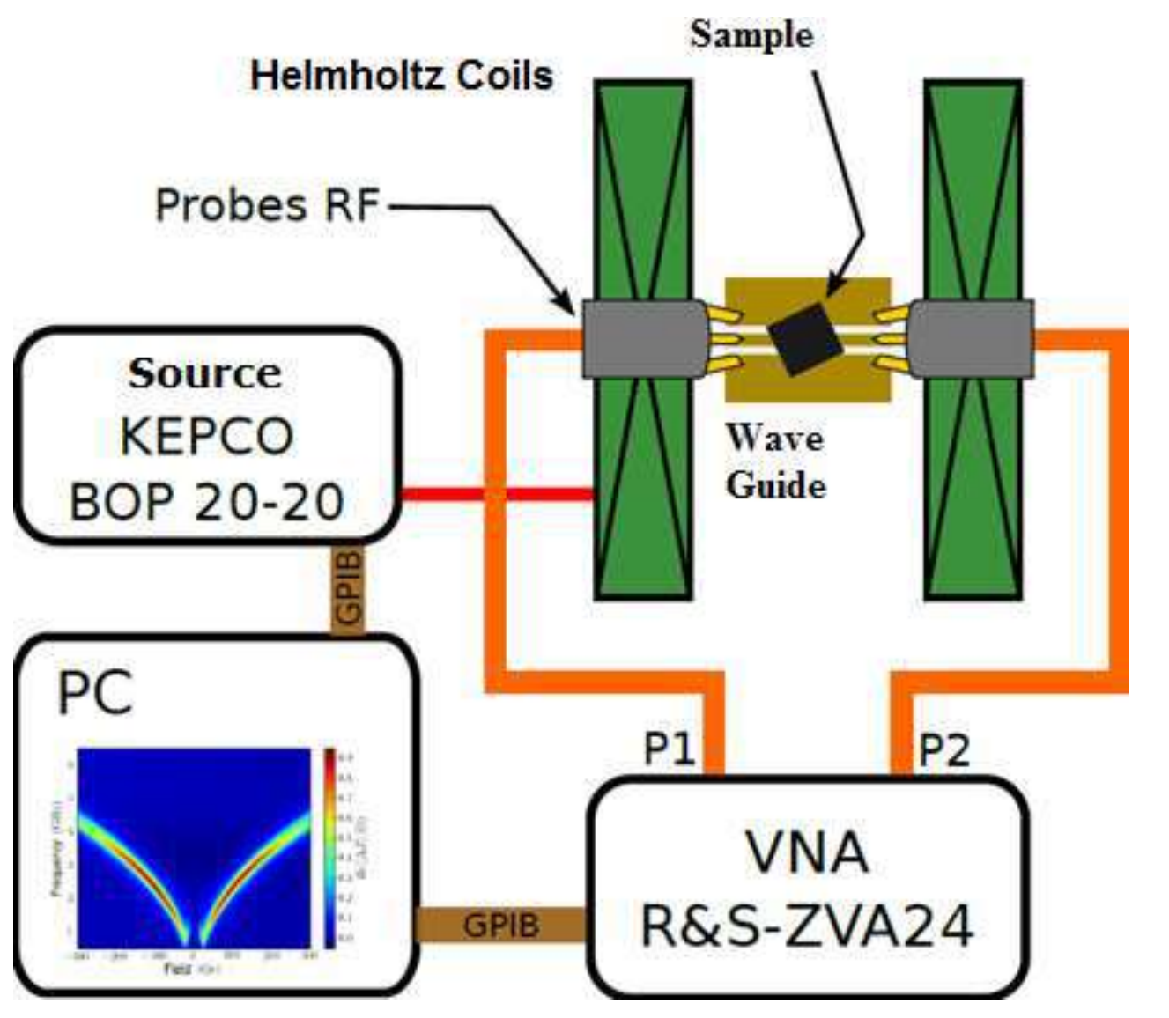
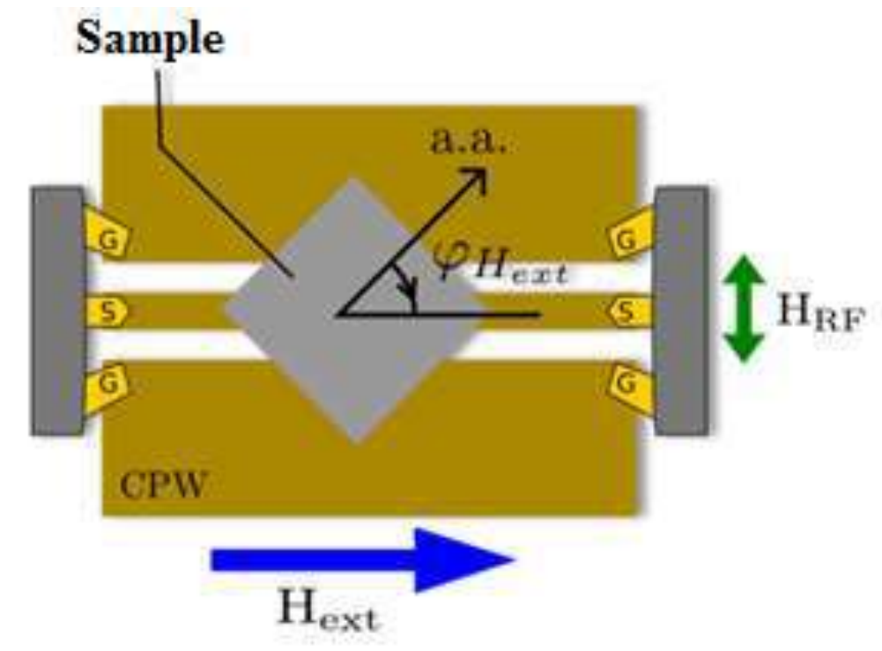
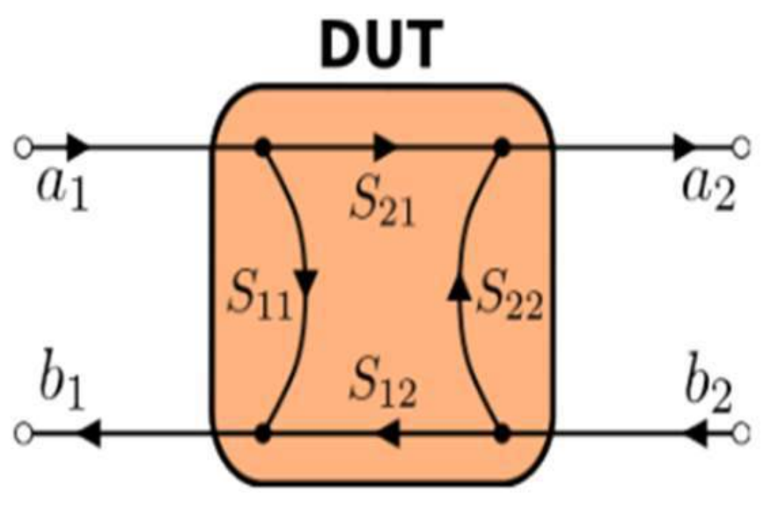
Magnetization dynamics properties

VNA-FMR







$$P_{abs}=P_0[1-(|S_{11}|^2+|S_{21}|^2)]$$

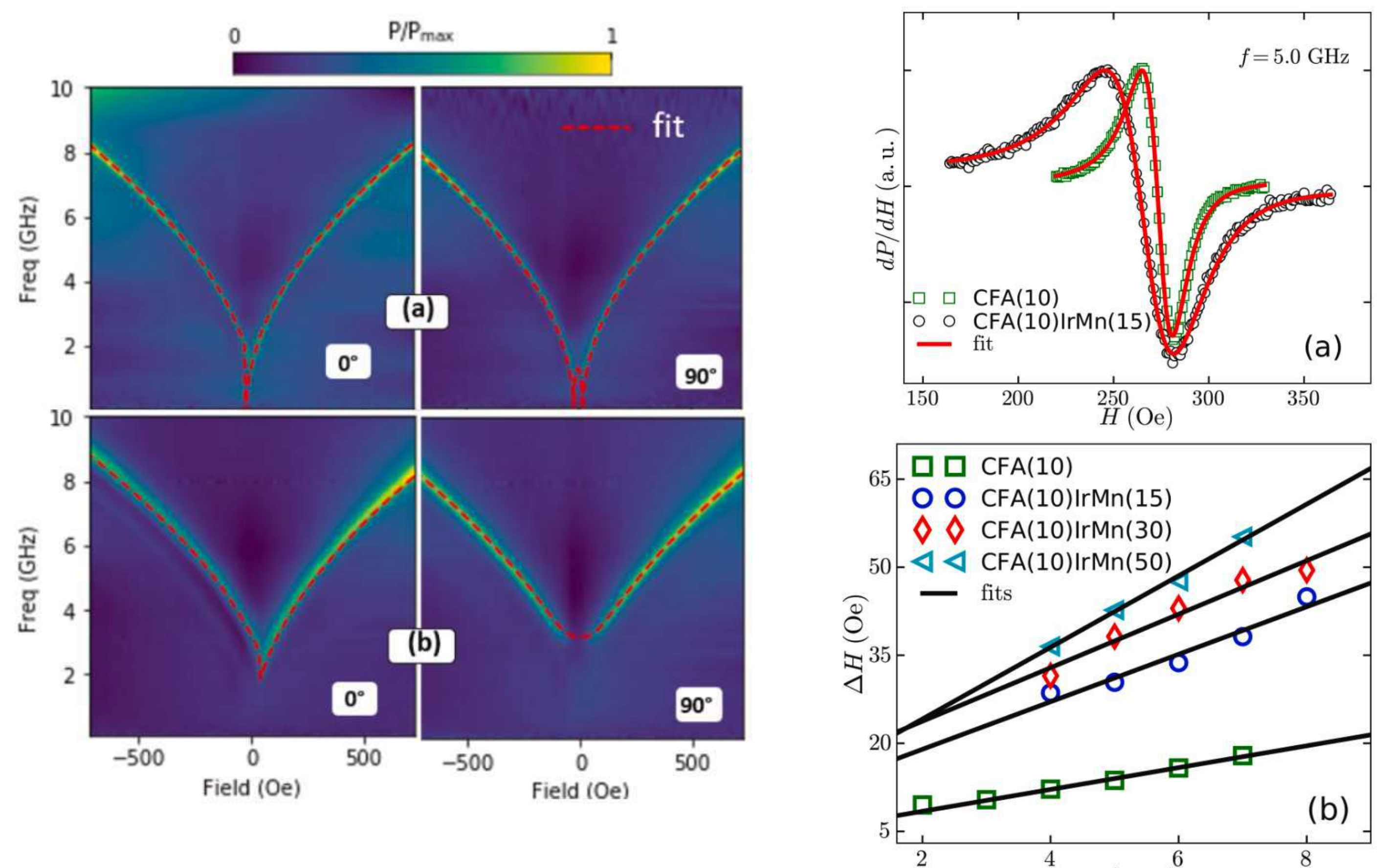


Figure 2– Experimental absorption spectra and dP/dH for selected samples at 0° and 90°

Summary of the Kittel fittings

Table 1– Summary of the results obtained from the fitting of the Kittel equations and the results of dP/dH measurements.

Sample	H_k	H_{rot}	H_{ex}	M_{eff}	α (10^{-3})	ΔH_0
CFA(10)	20	0	0	800	2.60 ± 0.19	5.1 ± 0.60
CFA(10)/IrMn(5)	30	10	0	750	6.58 ± 0.20	3.22 ± 0.56
CFA(10)/IrMn(10)	20	35	50	800	7.05 ± 0.42	3.11 ± 1.80
CFA(10)/IrMn(15)	20	40	60	800	5.47 ± 0.86	12.18 ± 3.16
CFA(10)/IrMn(20)	20	60	110	860	8.73 ± 0.35	2.91 ± 1.20
CFA(10)/IrMn(30)	20	60	115	860	6.73 ± 0.76	14.29 ± 2.86
CFA(10)/IrMn(50)	20	60	115	860	8.89 ± 0.52	12.95 ± 2.01

Conclusions

- We have investigated the structural and magnetic properties of exchange-biased CFA/IrMn bilayers
- we have explored the influence of the AFM layer thickness on the exchange bias and rotatable anisotropy
- Our results have shown counter intuitive behavior on the rotatable anisotropy, which does not decrease with the raise of the AFM layer, neither results in an increase of the damping parameter
- We show that the CFA/IrMn interface becomes stable for IrMn thickness above than 20 nm
- Our results thus provide further insights on the effect of antiferromagnetic thickness on the dynamical properties of CFA films and the role of rotatable anisotropy in these system

References

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