

Investigation of thickness induced magnetic anisotropy in ultrathin Cobalt films

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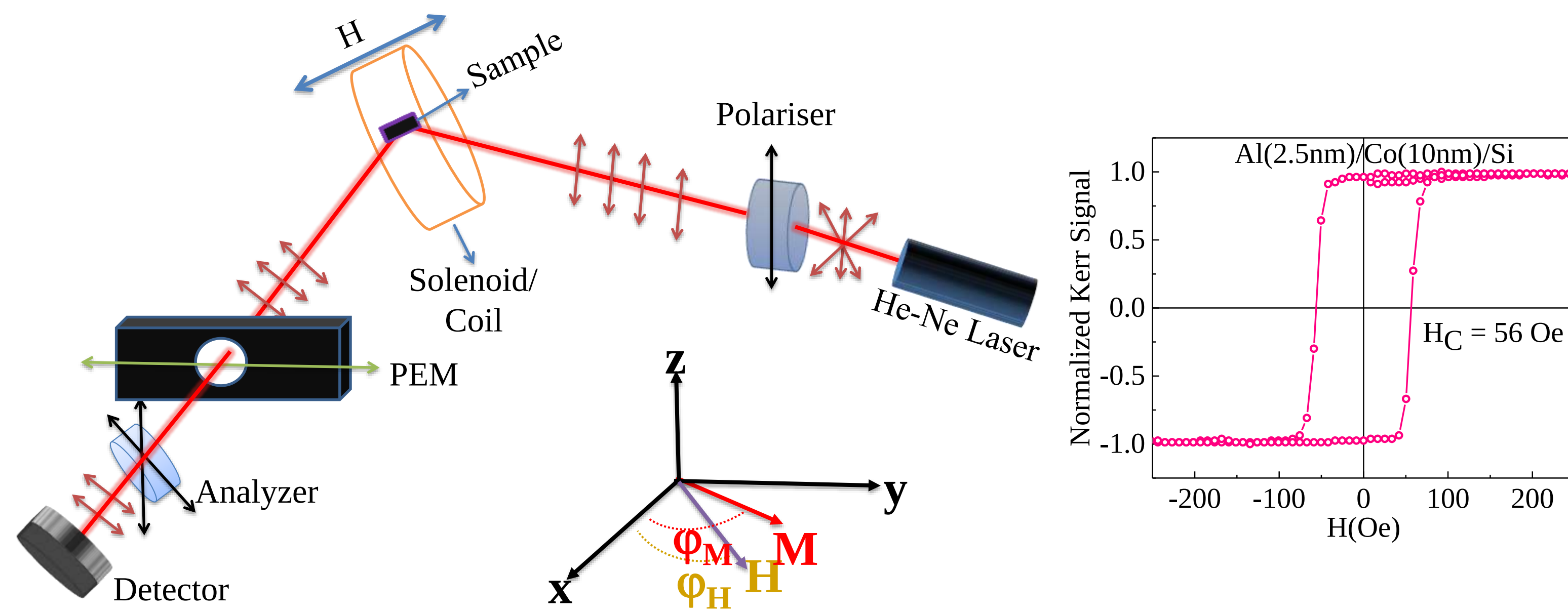
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Abstract

- Thickness induced magnetic anisotropy behavior of sputtered Cobalt thin films grown by pulsed dc magnetron sputtering is investigated.
- The highly textured Co thin films with preferred orientation along c-axis are grown as confirmed from the XRD.
- Existence of magnetic anisotropic behavior is established by exploring **the static and dynamic magnetization** properties, via MOKE and FMR measurements.

Introduction

Static Magnetization (MOKE)

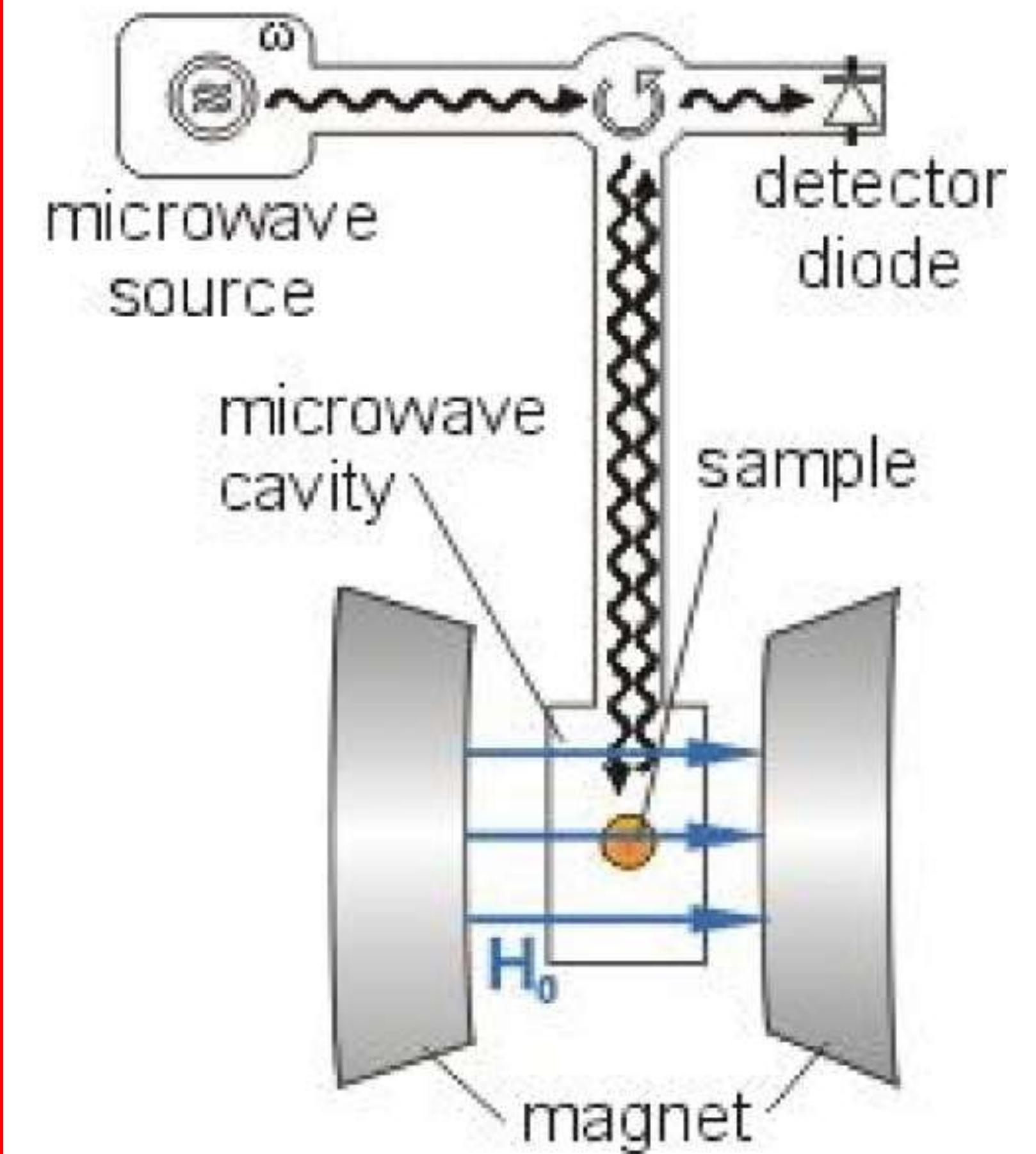
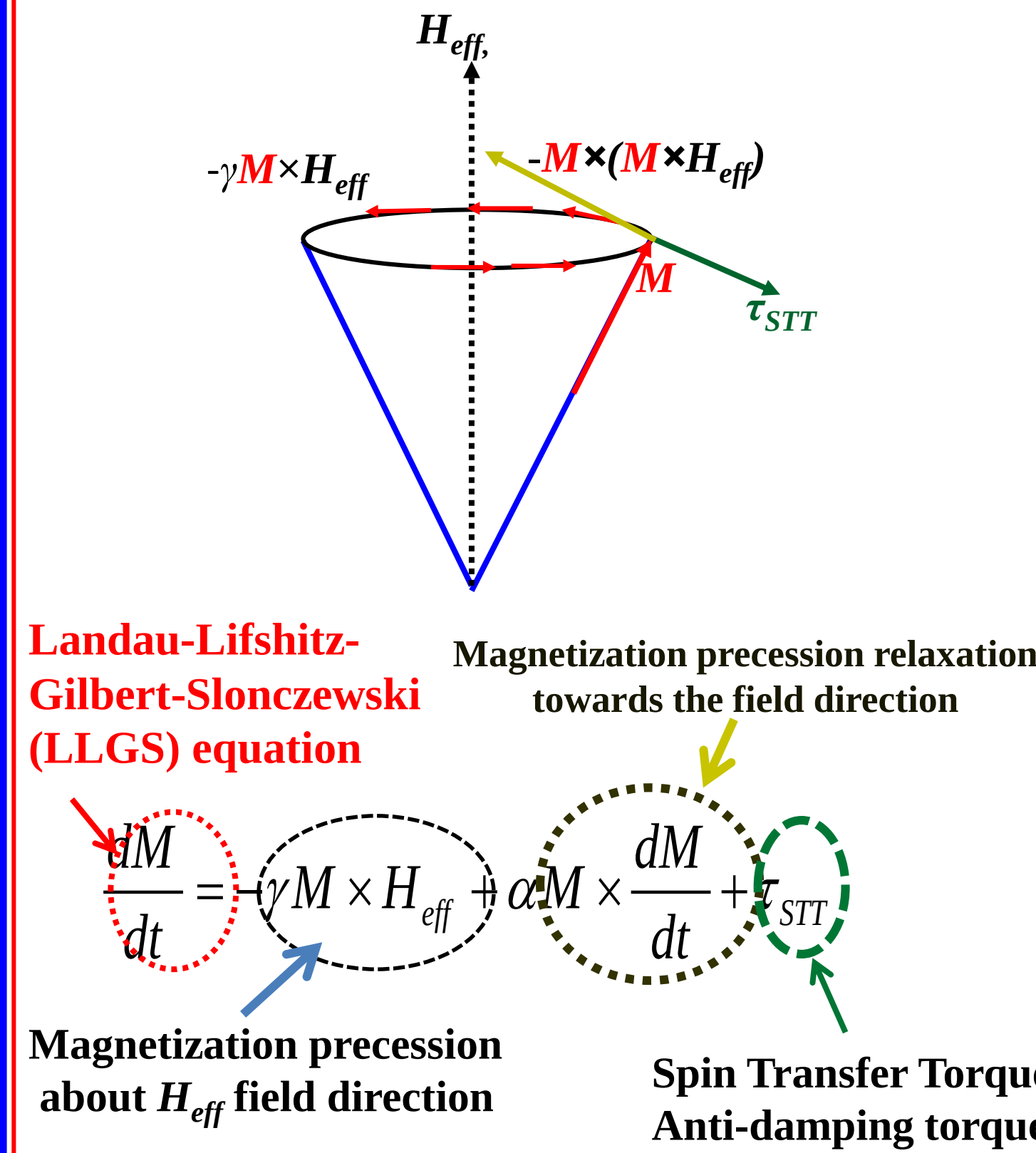


- MOKE detects the change in the polarization of laser when it is reflected off a magnetic material/film.
- The change of polarization state is directly related to strength of spin-orbit interaction in a material.

Introduction

Magnetization dynamics (FMR)

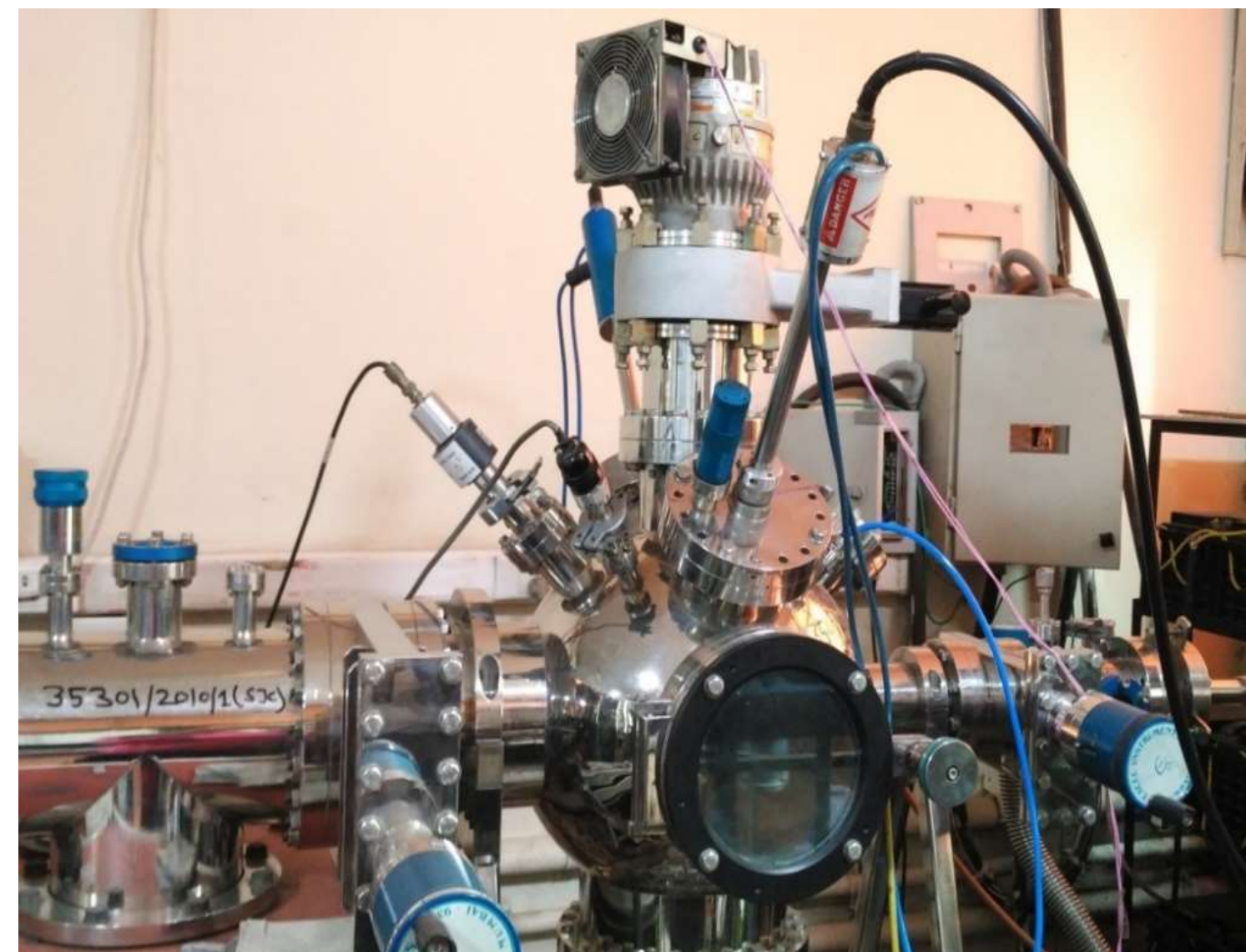
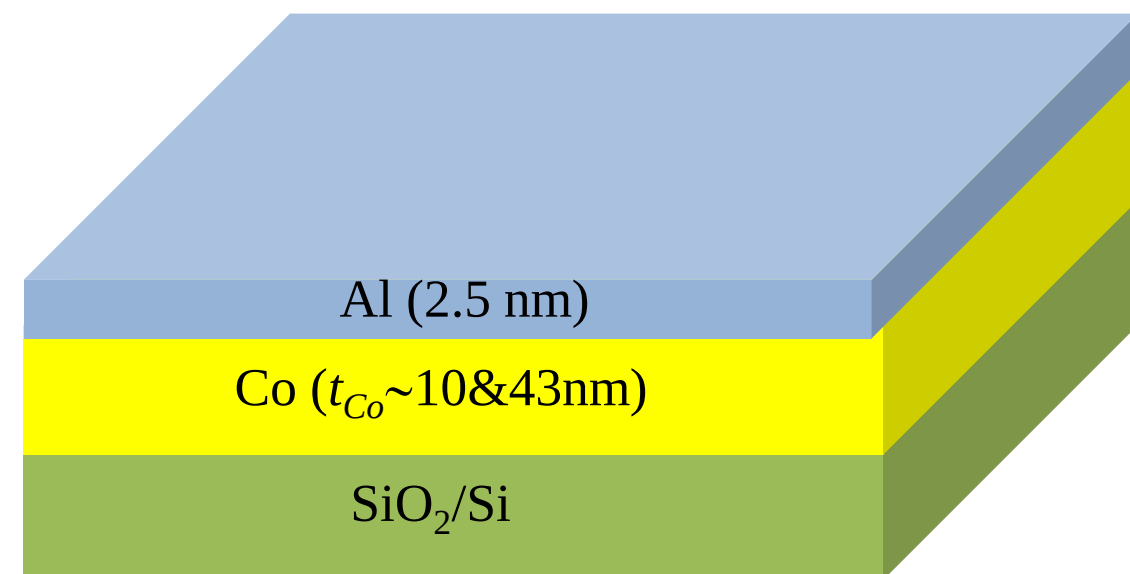
- The magnetization dynamics of a FM in FM/NM explained in terms of:



Experimental Details

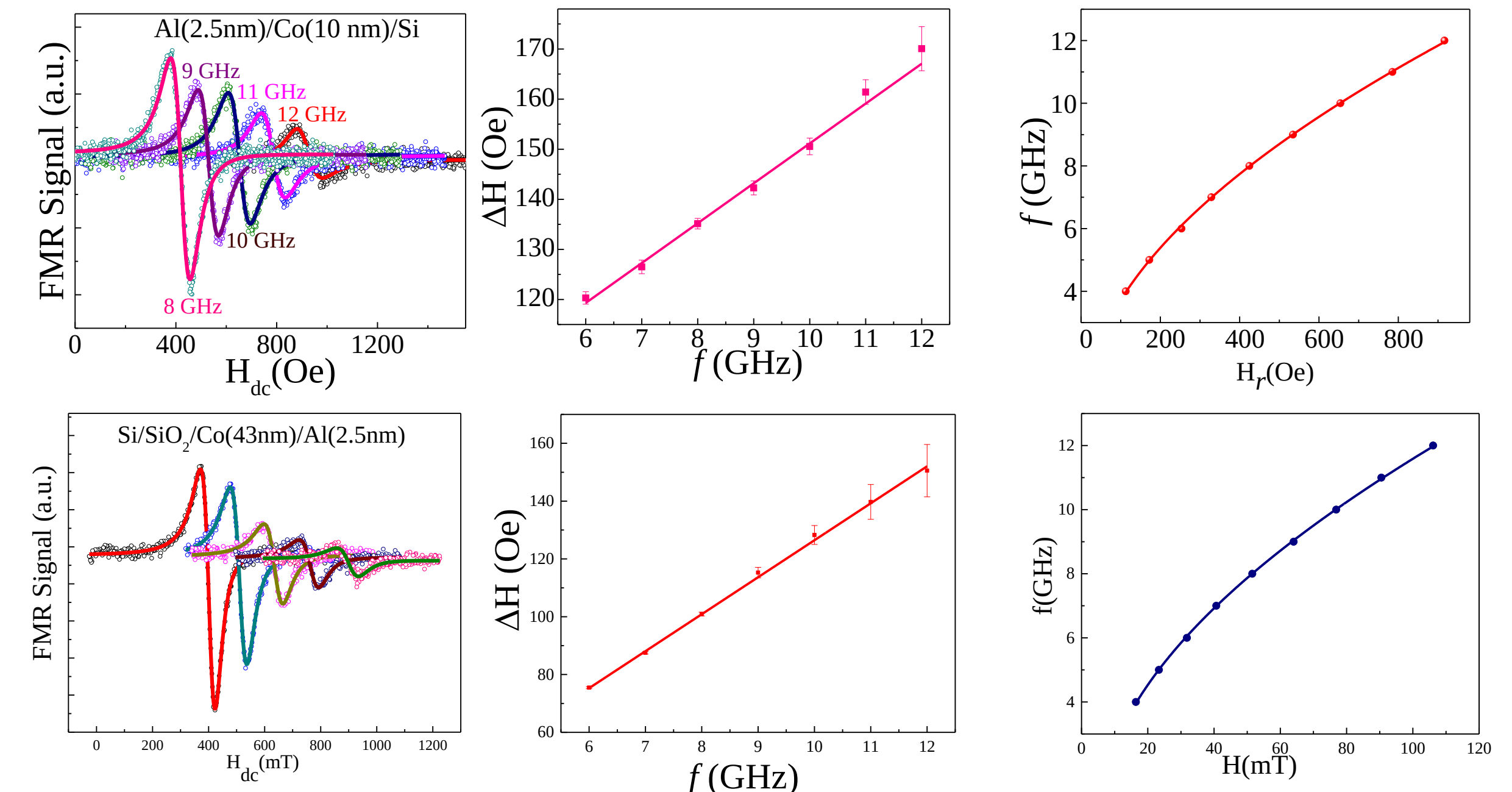
Deposition Conditions:

Base pressure : 2×10^{-6} Torr
Working pressure : 1×10^{-3} Torr
Target-substrate gap : 14 cm
Substrate Temperature : 300K



Material	Dep. Rate	Power
Co	7.2 nm/min	50W
Al	3.0 nm/min	50W

FMR studies in Co/Al system

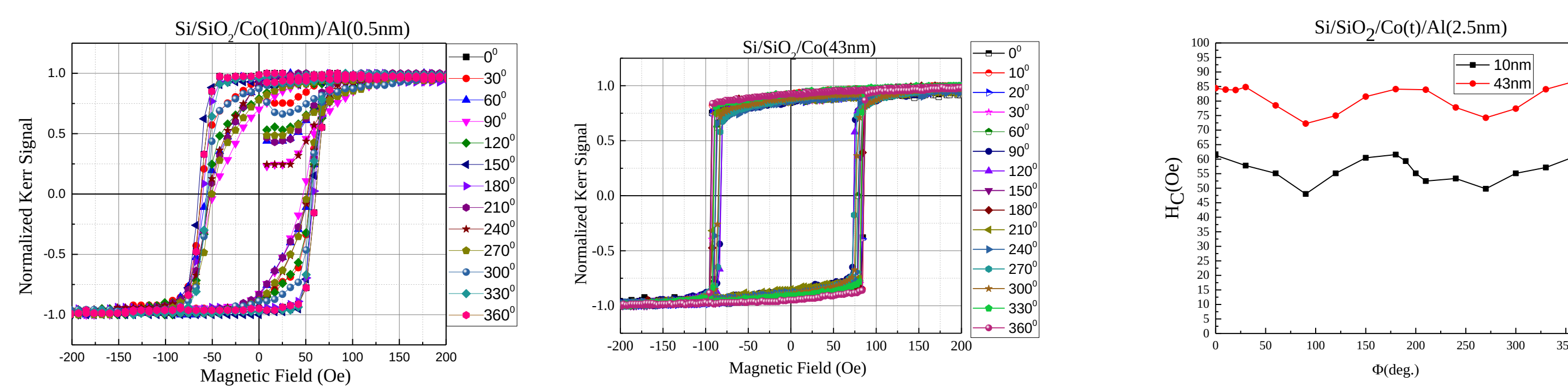


- $4\pi M_{eff}$ of thin films is determined from the fit of *in-plane* data to Kittel's equation.
- The value of α for these thin films is found to be almost equal to the bulk value.
- Slight variation observed in value of α for different thickness of cobalt may be attributed to the surface/interface induced anisotropy.
- The small value of $\Delta H_0 = 71$ Oe and 14.6 Oe indicate the good quality of the films.
- Line width of the films decreases as film-thickness increases.

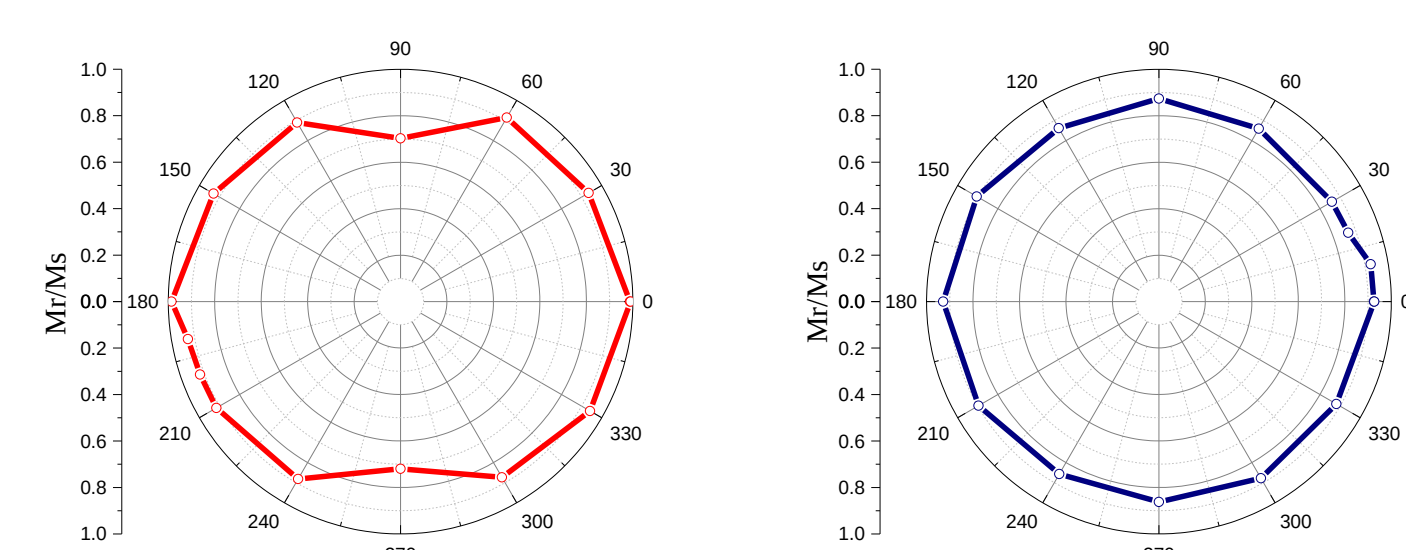
Results and Discussions

- XRD diffraction peak revealed Co films are found to be highly textured along c-axis.
- Thickness, density and interface roughness of the individual layers were accurately determined by specular x-ray reflectivity (XRR) measurements.

Angle dependent static Magnetization Co/Al system



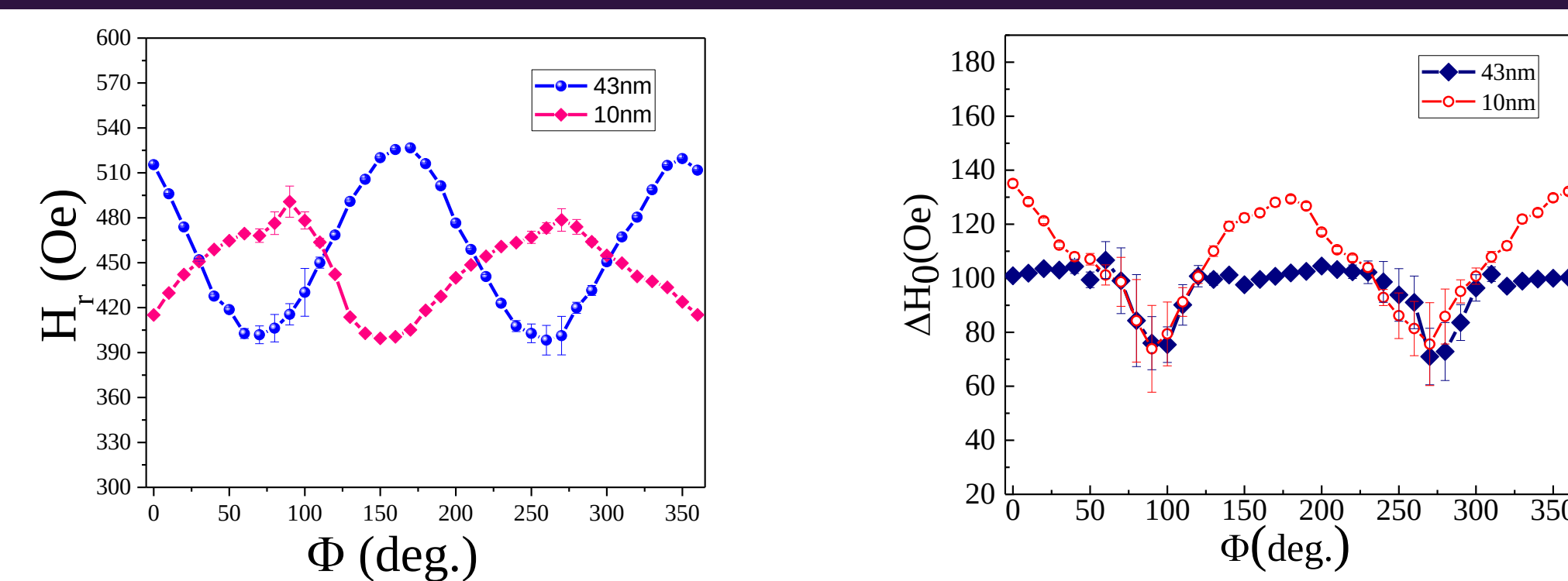
ϕ vs Mr in Co/Al system



- In plane angular dependence of MH reveals **the existence of uniaxial anisotropy** in the Co(10nm)/Al thin films.

- Rotation of substrate during deposition rules out the stress and strain anisotropies contribution.
- This magnetic anisotropy could be due to shape anisotropy (due to slow rotation rate dominates at low thickness) and/or magnetocrystalline anisotropy in Co(10)Al system.

In-plane ϕ vs H_r and ΔH in Co/Al system



- ϕ vs H_r at $f=8$ GHz shows completely **reverse behavior** on variation of film-thickness
- This small variation of ΔH at higher film-thickness as compared to low thickness of Cobalt might be due to presence of **small magnetocrystalline anisotropy** in the film.

Conclusions

- FMR measurements have been done on Al-capped Cobalt films having two different thickness, i.e., Co ($t_{Co}=10, 43$ nm)/Al(2.5 nm).
- In plane angular variation of resonance field measurement constitutes the **anisotropy terms**. The anisotropy is **intrinsic** to the ferromagnet for Co(10)/Al system.
- These type of anisotropies (shape and magnetocrystalline) leads to **decrease in the resonance field** in the **easy direction** of anisotropy and increase in **hard direction**.