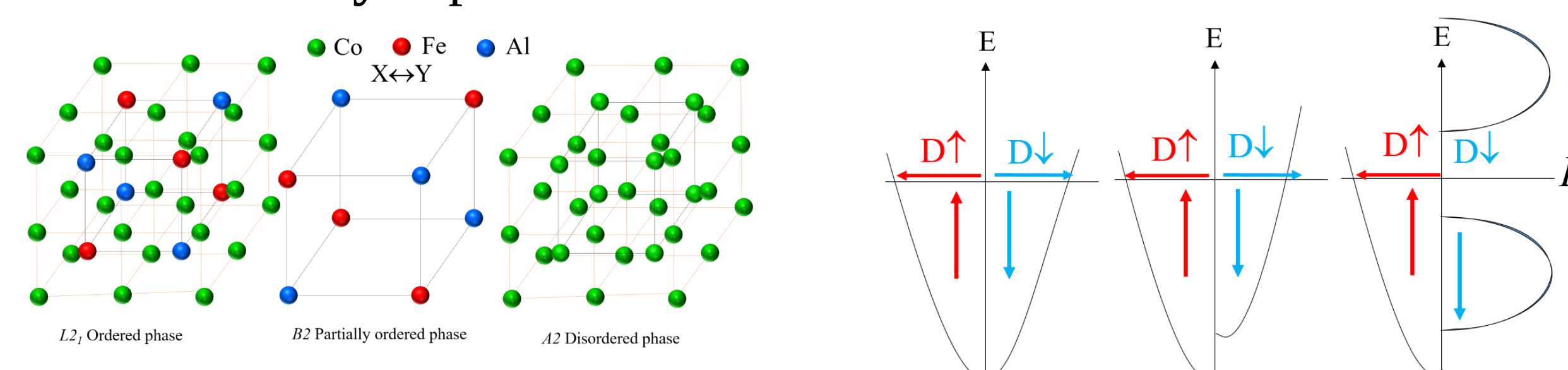


Abstract:

The influence of MgO and Ta capping layers on the static and dynamic magnetic properties of Co₂FeAl (CFA) Heusler alloy thin films needs to be investigated
Static and dynamic magnetization response of Si/Ta/CFA/[MgO,Ta] structures be explored in view of potential spintronic applications owing to PMA and low magnetization damping

Heusler Alloy(X₂YZ)

Half Metallicity: Spin band structure exhibits different behavior for the two spin orientations - **Metallic** for majority spin band and **semiconducting** for minority spin band



Various Ordered Phases of **Full Heusler alloy** (X₂YZ)

Spin band structure

Why Heusler alloys ?

- ✓ 100% spin polarization (Theoretically)
- ✓ High Curie temperature (~1000K)
- ✓ Very small damping constant (~0.001)

Storage
Materials requirement for high density storage
PMA

Writing
Magnetization switching with low current
Low damping constant

Reading
High sensitivity for large data reading
MTJs and CPP-GMR

Applications:

- ✓ In High density memory devices owing to *perpendicular magnetic anisotropy* (PMA)
- ✓ In STT devices owing to *very low damping constant*
- ✓ In MRAMs due to *high sensitivity* using CPP-GMR at room temperature

FERROMAGNETIC RESONANCE (FMR)

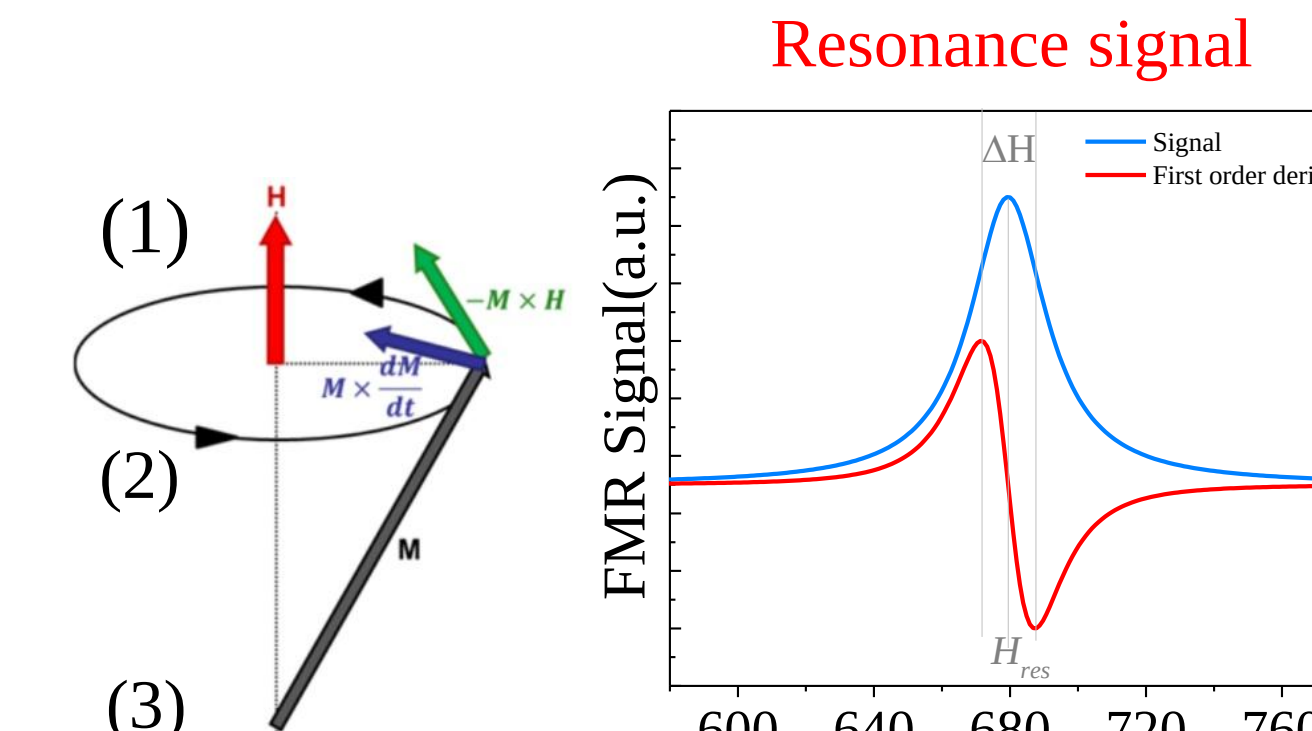
LLG Equation:

$$\frac{d\mathbf{M}}{dt} = -\gamma \mathbf{M} \times \mathbf{H} + \frac{\alpha}{M} \mathbf{M} \times \frac{d\mathbf{M}}{dt}$$

Kittel Equation:

$$f = \frac{\gamma}{2\pi} \sqrt{(H_r + H_K)(H_r + H_K + 4\pi M_{eff})}$$

Linewidth (General expression):

$$\Delta H = \Delta H_0 + \frac{4\pi\alpha f}{\gamma}$$


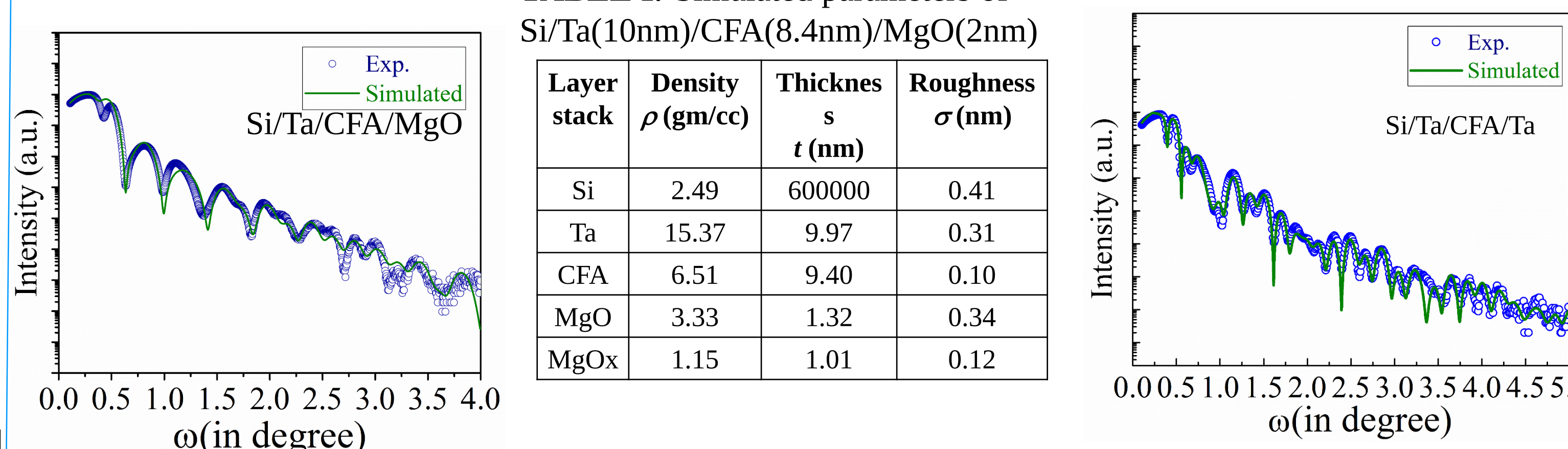
RESULTS

TABLE I. Simulated parameters of Si/Ta(10nm)/CFA(8.4nm)/MgO(2nm)

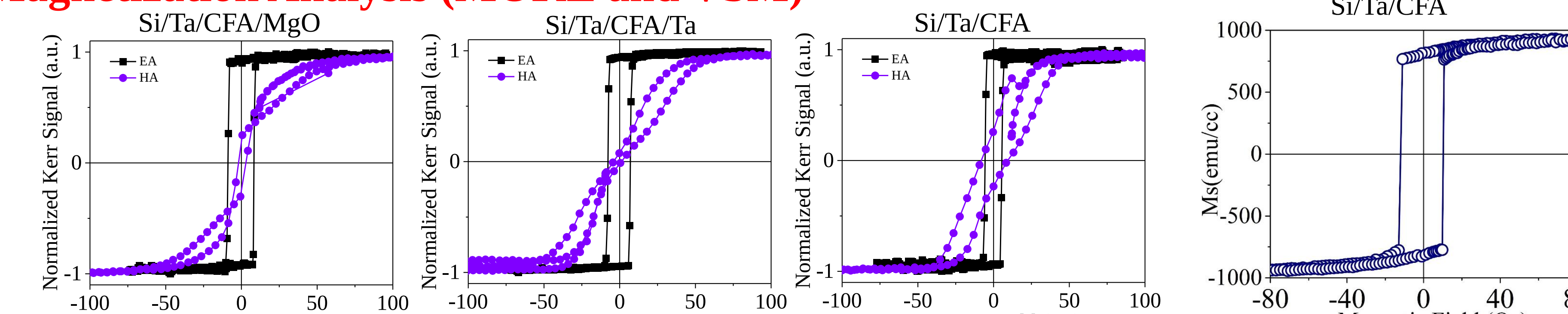
Layer stack	Density ρ (gm/cc)	Thickness t (nm)	Roughness σ (nm)
Si	2.49	600000	0.41
Ta	15.37	9.97	0.31
CFA	6.51	9.40	0.10
MgO	3.33	1.32	0.34
MgOx	1.15	1.01	0.12

TABLE II. Simulated parameters of Si/Ta(10nm)/CFA(8.4nm)/Ta(2nm)

Layer stack	Density ρ (gm/cc)	Thickness t (nm)	Roughness σ (nm)
Si	2.49	600000	0.41
Ta	15.73	10.22	0.33
CFA	5.51	10.74	0.64
Ta	16.9	1.67	0.13
Ta ₂ O ₅	8.56	3.31	0.33

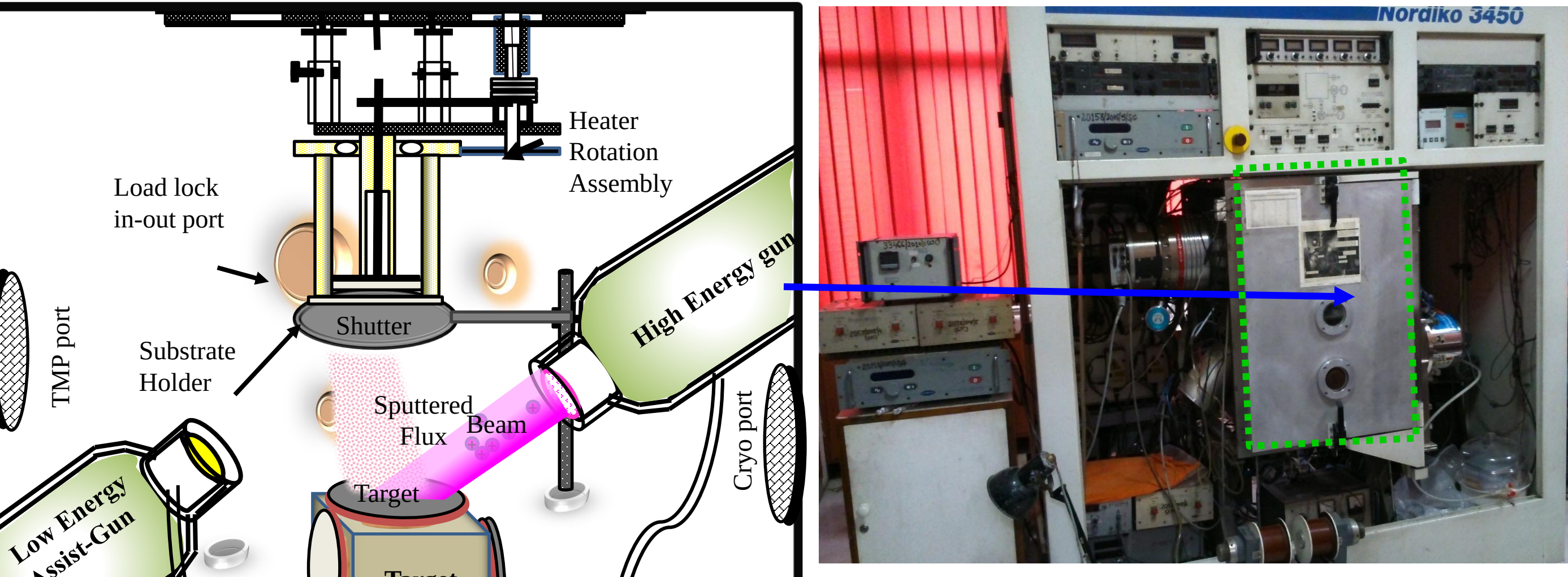


Static Magnetization Analysis (MOKE and VSM)



FABRICATION PROCESS

Dual Ion-Beam Sputtering (NORDIKO-3450)



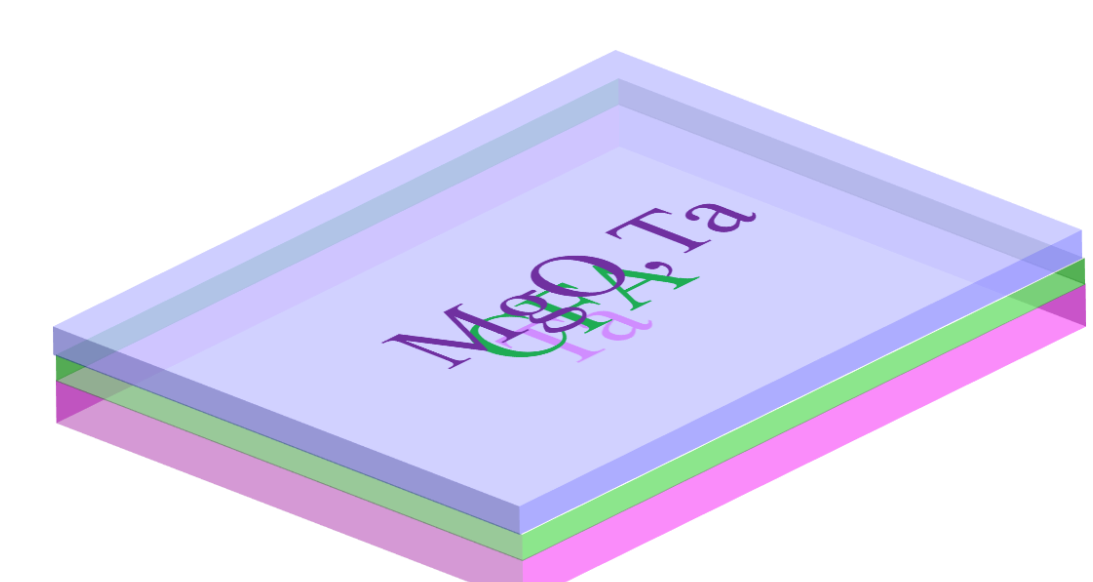
Deposition Conditions:

Base pressure	: ~1×10 ⁻⁷ Torr
Working pressure	: ~8.5×10 ⁻⁵ Torr
Ar ion energy	: 500 eV
Target-substrate gap	: ~27 cm
Substrate Temperature	: 573K for CFA

Assist energy gun (grid) parameters:

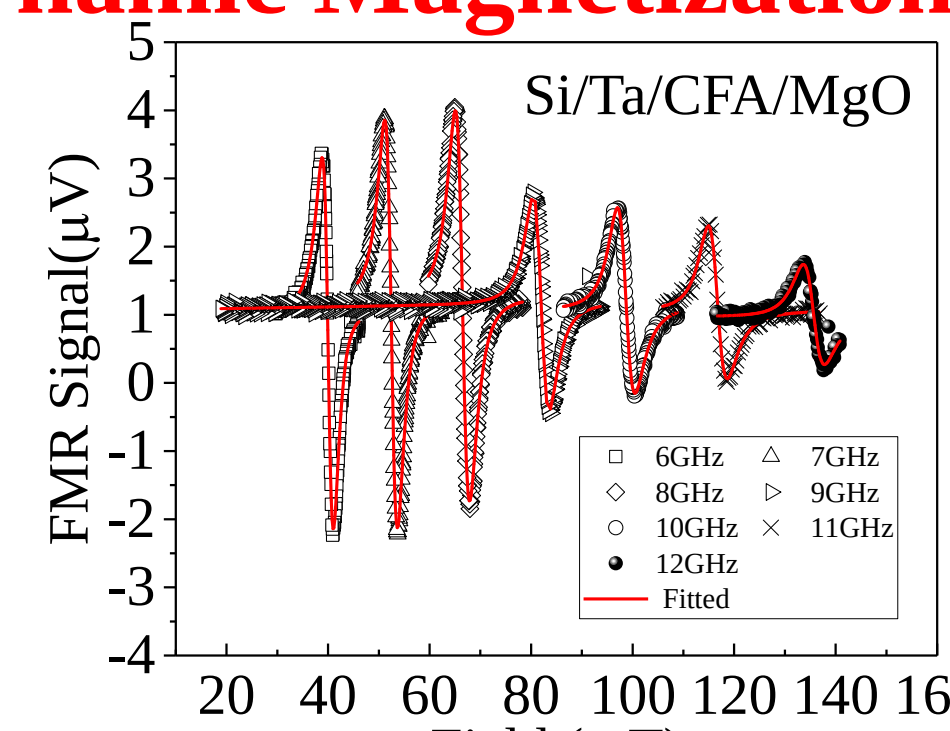
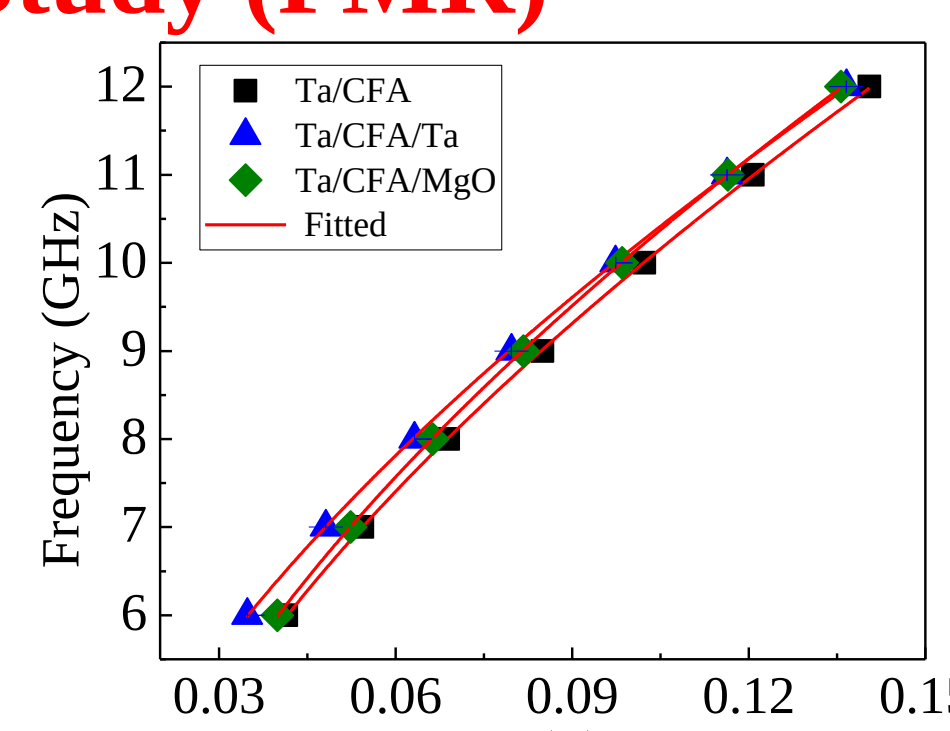
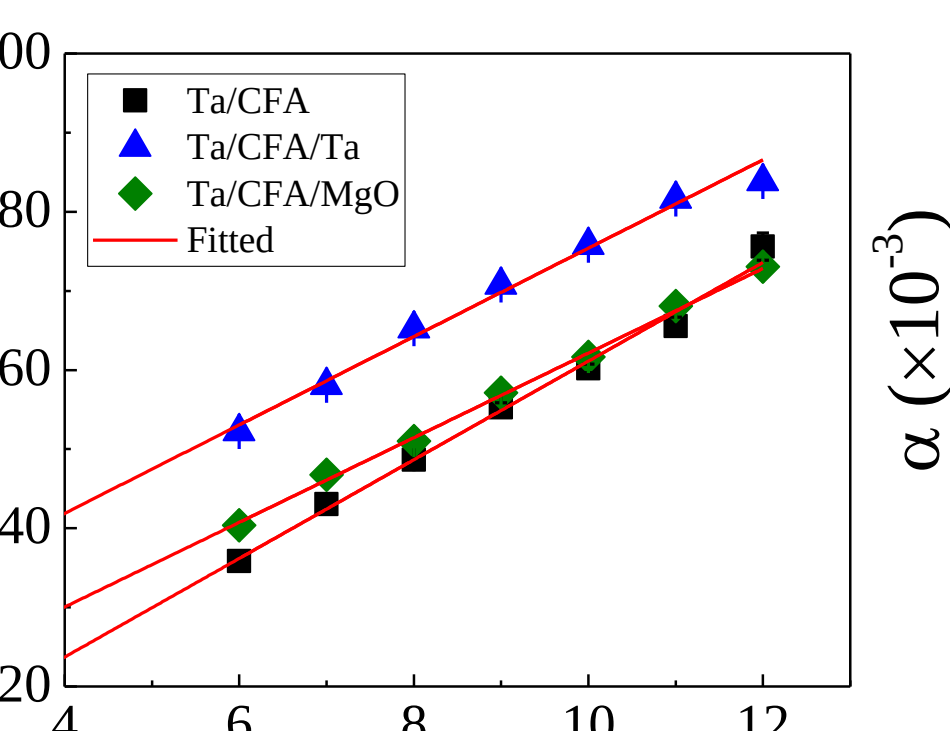
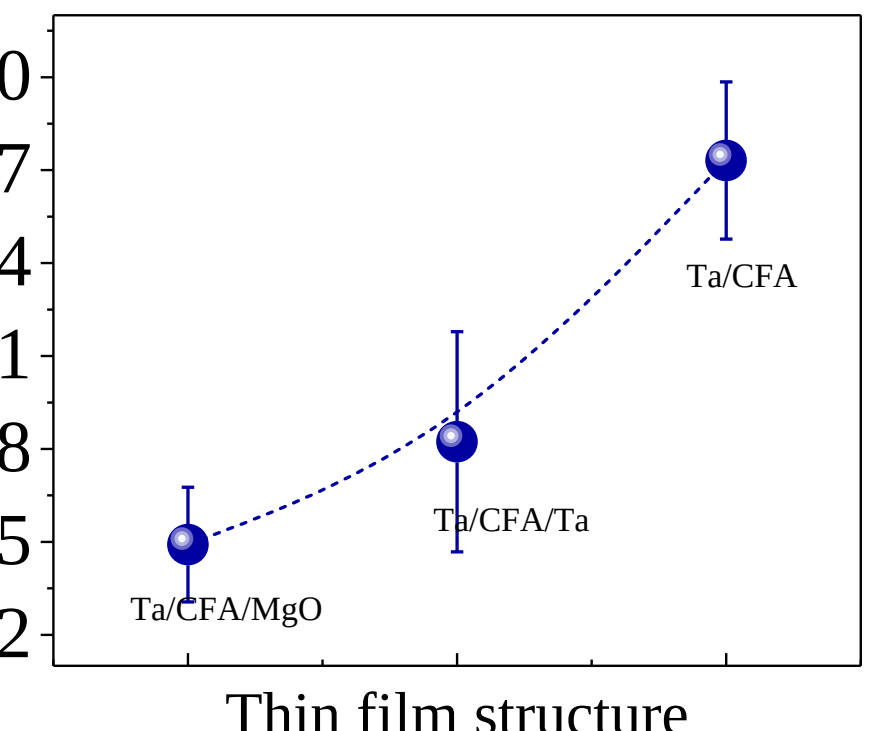
V+	:50V
V-	:30V

Working pressure~1×10⁻⁴ Torr with Oxygen partial pressure (5×10⁻⁵ Torr) for ion assisted deposition of MgO



Layer stack
Si(100)/Ta/CFA/[Ta, MgO]

Dynamic Magnetization Study (FMR)

The **lowest value of α** is found to be **0.0075±0.0001** for the sample Si/Ta/CFA
The increase in the value of α in case of Ta capping layer is due to *excess spin pumping induced reduction of the spin angular momentum* of the Co₂FeAl layer.
The observed highest value of α in case of the Si/Ta/CFA structure could be due to the *formation of an oxide layer* on the top of the CFA layer which is supported by the XRR findings.