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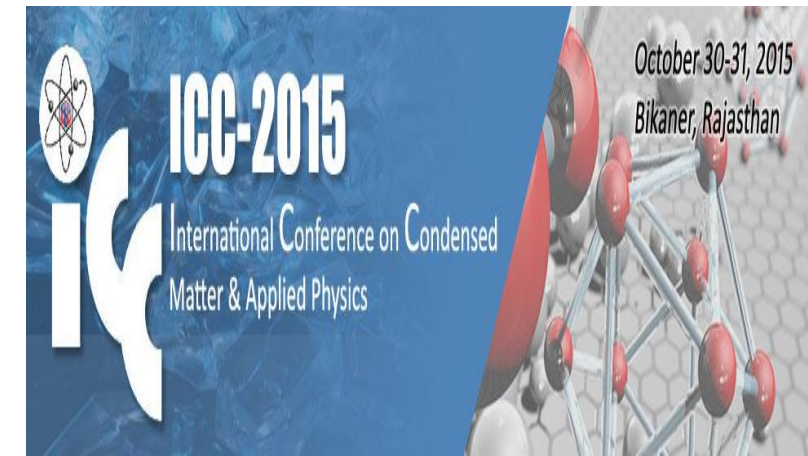
Structural and Magnetic Properties of Ion Beam Sputtered Co₂FeAl Heusler Alloy Thin Film

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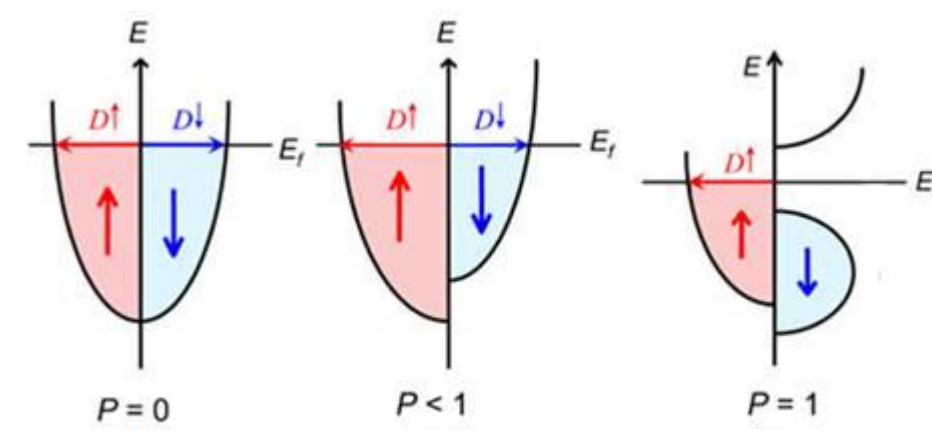
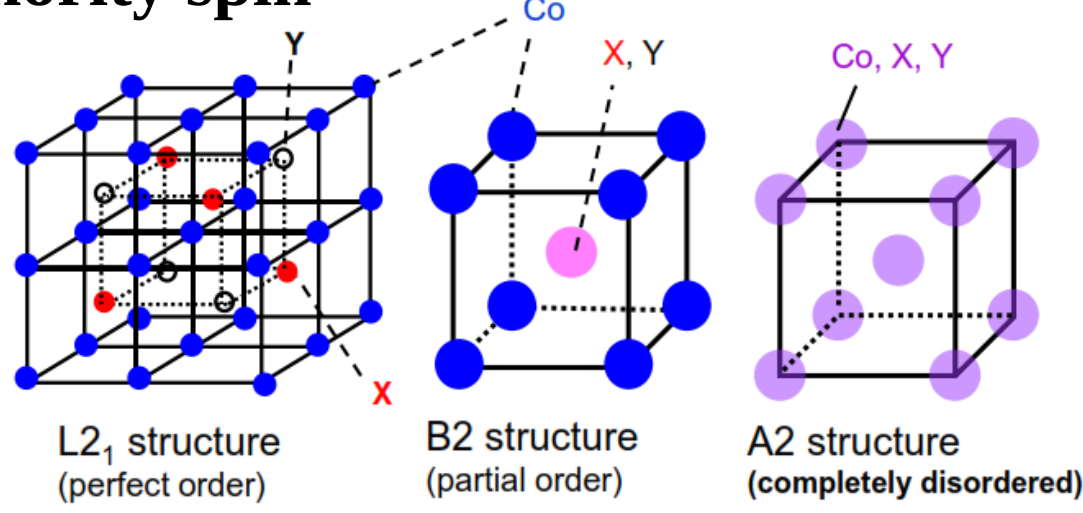
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INTRODUCTION

Heusler Alloy

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



Spin band structure

Why Heusler Alloy?

- 100% spin polarization
- High Curie temperature
- Structural similarity to the binary semiconductors

Applications:

- In MRAMs owing to high TMR at room temperature
- In STT devices owing to very low damping constant

FABRICATION PROCESS

Dual ion-beam sputtering

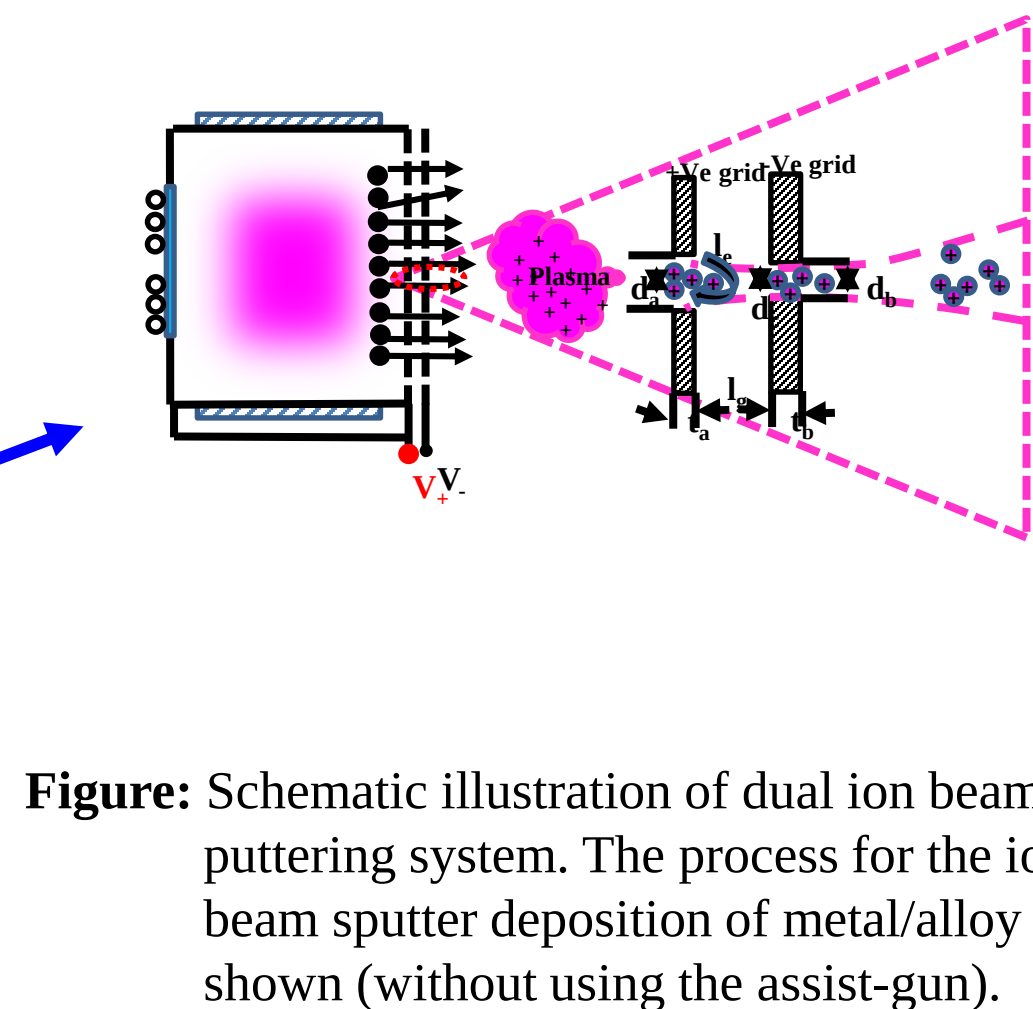
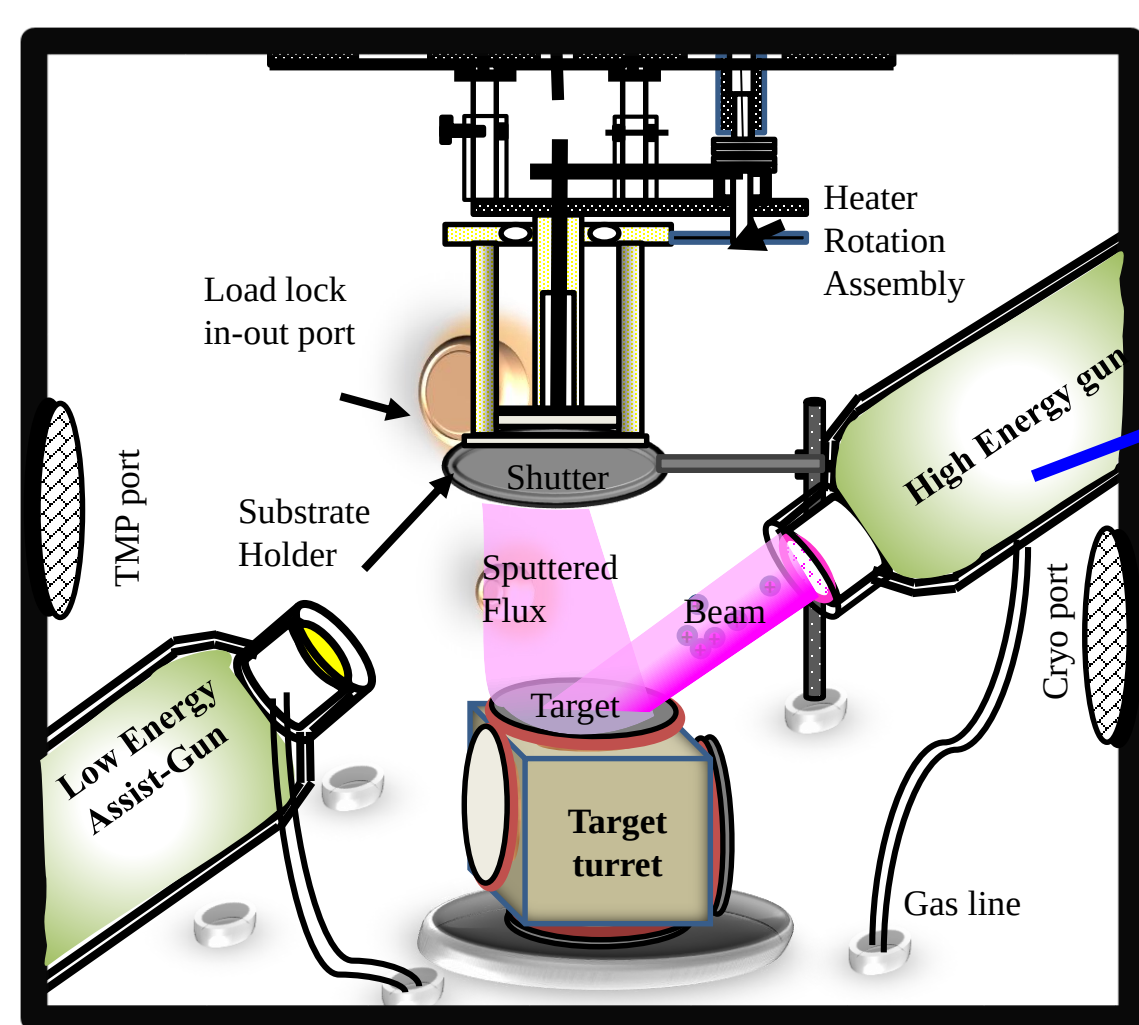
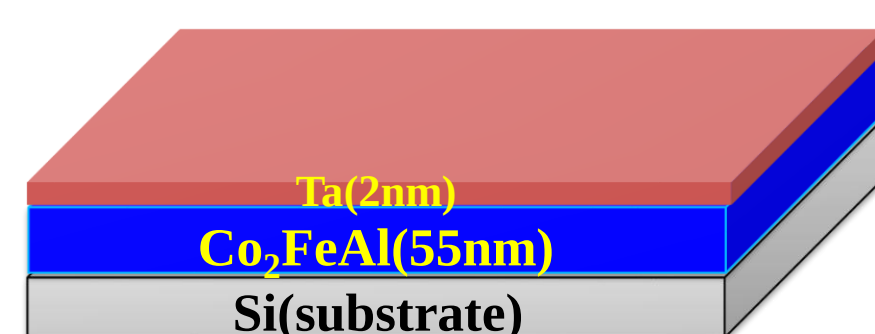


Figure: Schematic illustration of dual ion beam sputtering system. The process for the ion-beam sputter deposition of metal/alloy is shown (without using the assist-gun).

Deposition Conditions:

Base pressure	: 8×10^{-7} Torr
Working pressure	: 2.5×10^{-4} Torr
Ar ion energy	: 500 eV
Target substrate gap	: 27 cm



Deposited layer stack

CONCLUSIONS

- A combined presence of cubic and uniaxial anisotropies has been evidenced in CFA Heusler alloy films grown by Ion-beam sputtering on Si substrates
- Cubic anisotropy is found to vanish at higher growth temperature
- Anisotropy constant K_{eff} increases with growth temperature, which is the key material requirement for use in the MRAM applications.

ACKNOWLEDGMENT

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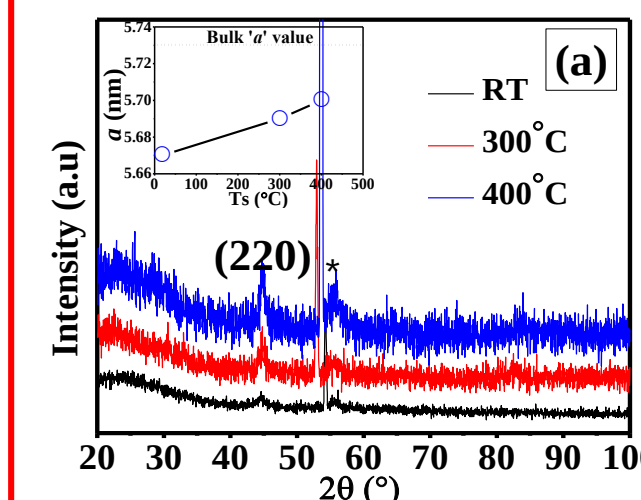
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RESULTS AND DISCUSSION

Structural Analysis

XRD



XRR

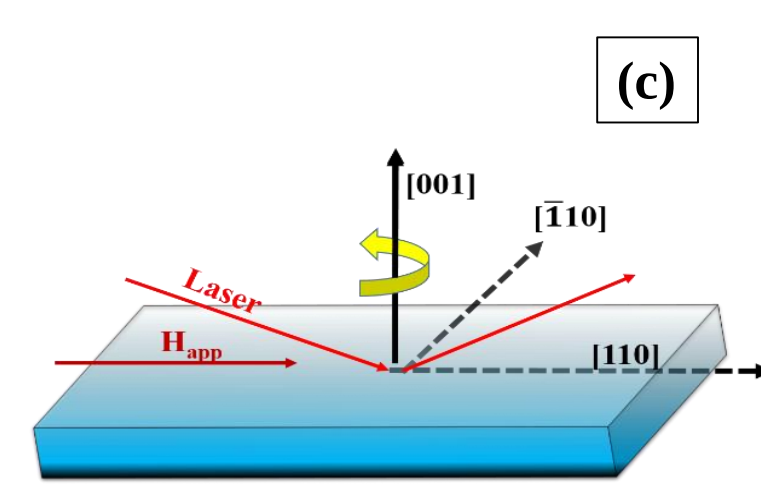
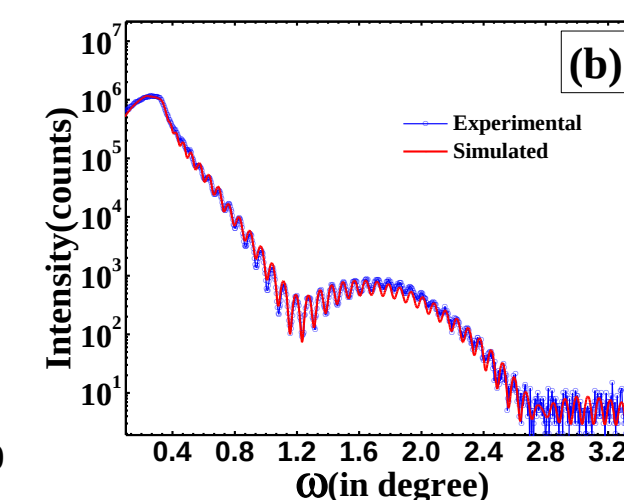


Figure: (a) GAXRD patterns of Si/Co₂FeAl/Ta films grown at different T_s . Inset shows the variation of calculated lattice constant a with T_s , (b) X-ray reflectivity spectra of the bilayer thin film, and (c) MOKE configuration - schematic of laser incidence with directions of Si(100).

MOKE Results

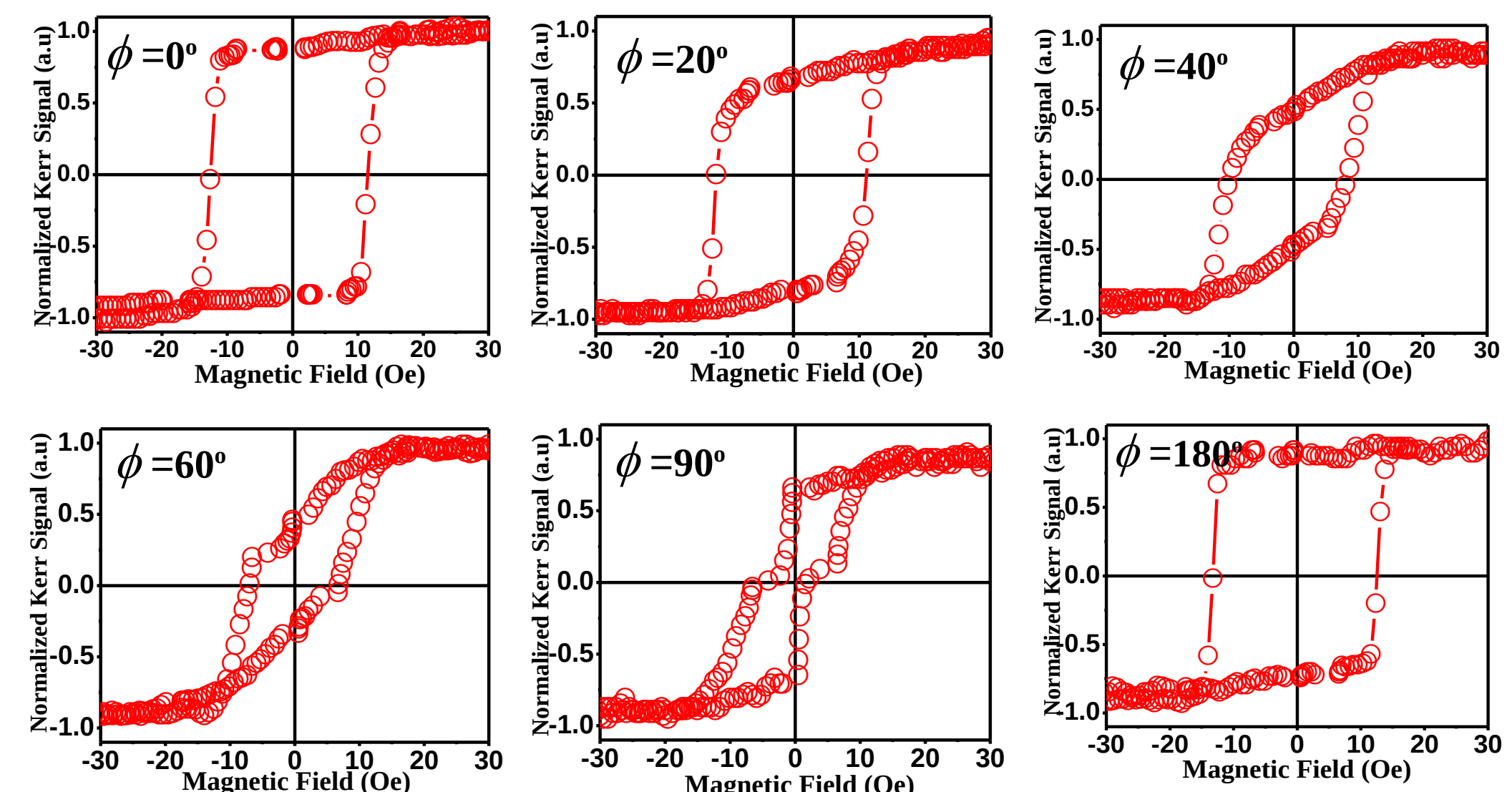


Figure: MOKE M-H loops recorded on sample deposited at RT at different azimuthal angles ϕ in the range of 0-180°

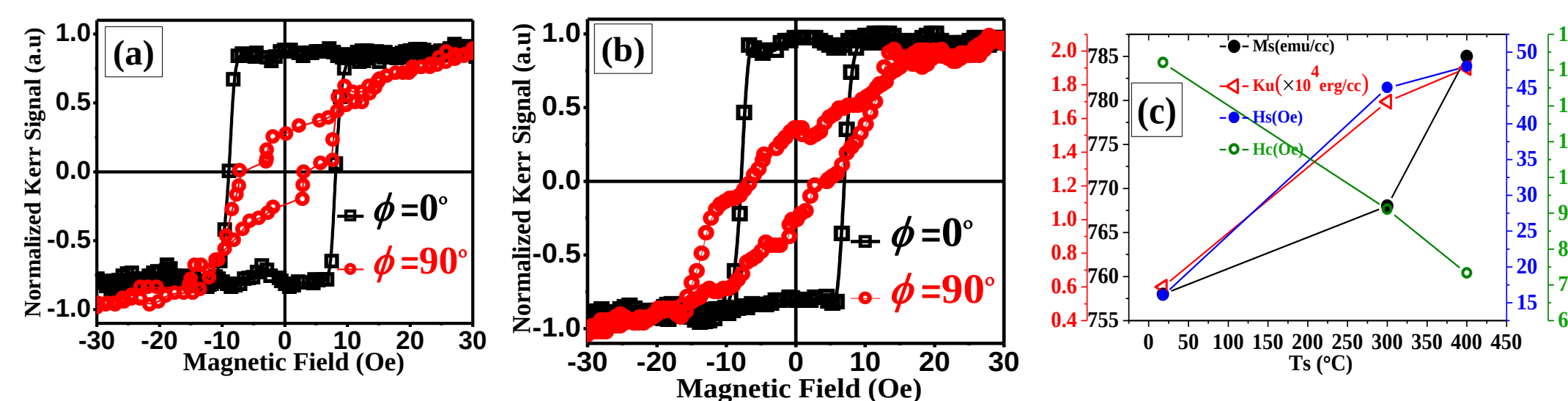


Figure: MOKE M-H loops recorded on samples deposited at $T_s=300$ (a) and 400°C (b), respectively for two azimuthal orientations 0° and 90° . (c) shows the variations of H_s , H_e , M_s and K_u for the three samples.

Effective uniaxial anisotropy constant K_{eff} can be written in terms of volume contribution (K_u^V) and an interface contribution (K_u^S)-

$$K_{eff} = K_u^V + 2K_u^S/t$$

Since the thickness of FM layer is large, therefore mainly contribution comes from the volumetric term.

The anisotropy constant can be evaluate

$$K_u^{eff} = 1/2 M_s H_K$$

Where M_s is the saturation magnetization measured from PPMS-VSM and H_K is the anisotropy field extracted from MOKE hysteresis loops.

Magnetization Results

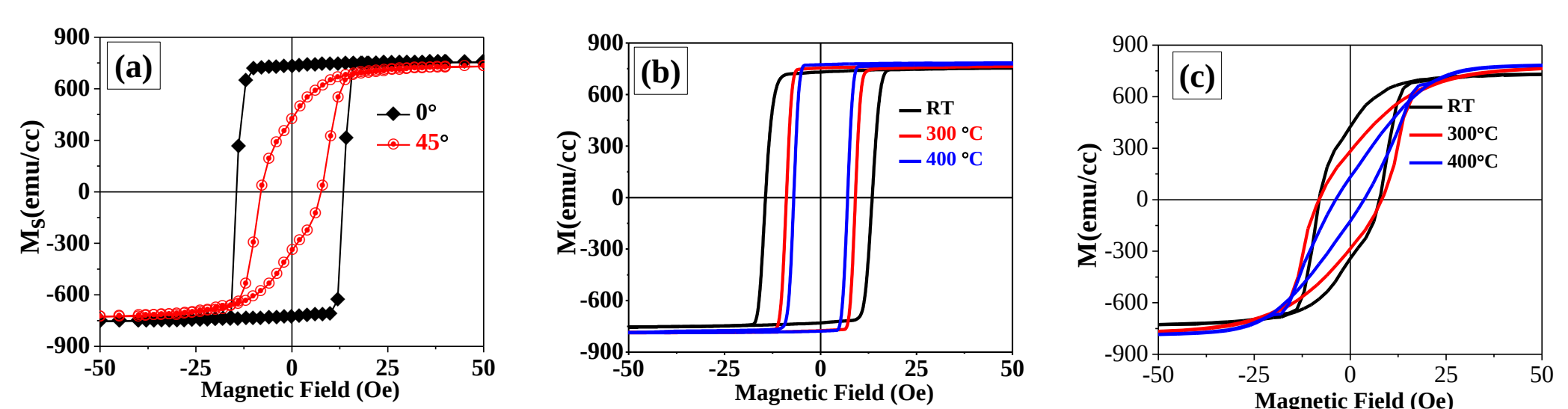


Figure: (a) M-H loops recorded at 0° and 90° on Co₂FeAl films deposited at RT. (b) and (c) show the MH loops along the hard and easy axes (EA and HA), for bilayers deposited at different T_s .