Growth and structure-property correlations in perpendicular exchange biased $(Co/Pt)_n$/FeMn multilayers

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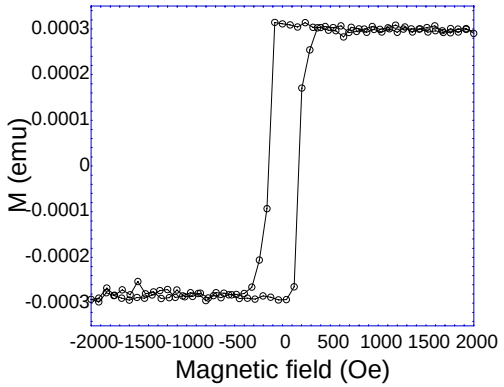
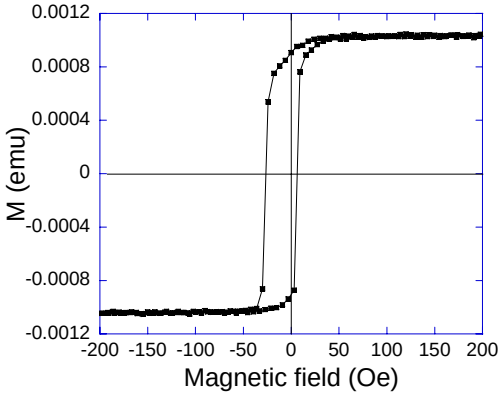
Outline

- Motivation of perpendicular exchange bias
- Growth of Co/Pt multilayer with perpendicular anisotropy and $(Co/Pt)_n$/FeMn with perpendicular exchange bias by ion-beam sputtering
- Structure-property correlations of $(Co/Pt)_n$/FeMn multilayer
- Conclusions

Motivation of perpendicular exchange bias



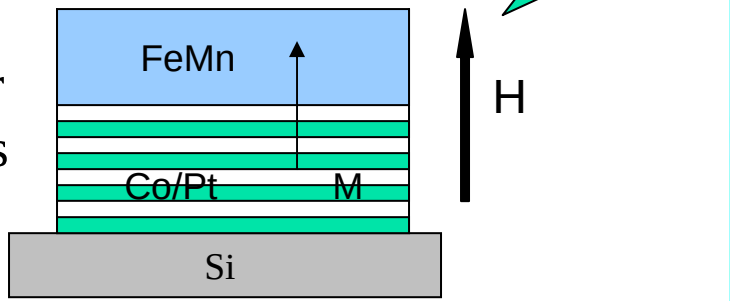


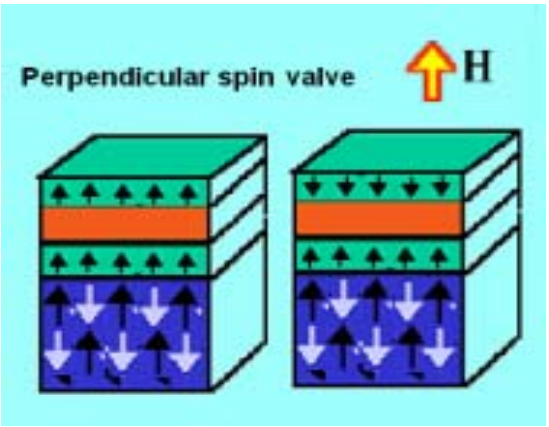
Multilayers with perpendicular anisotropy

exchange bias FM/AFM

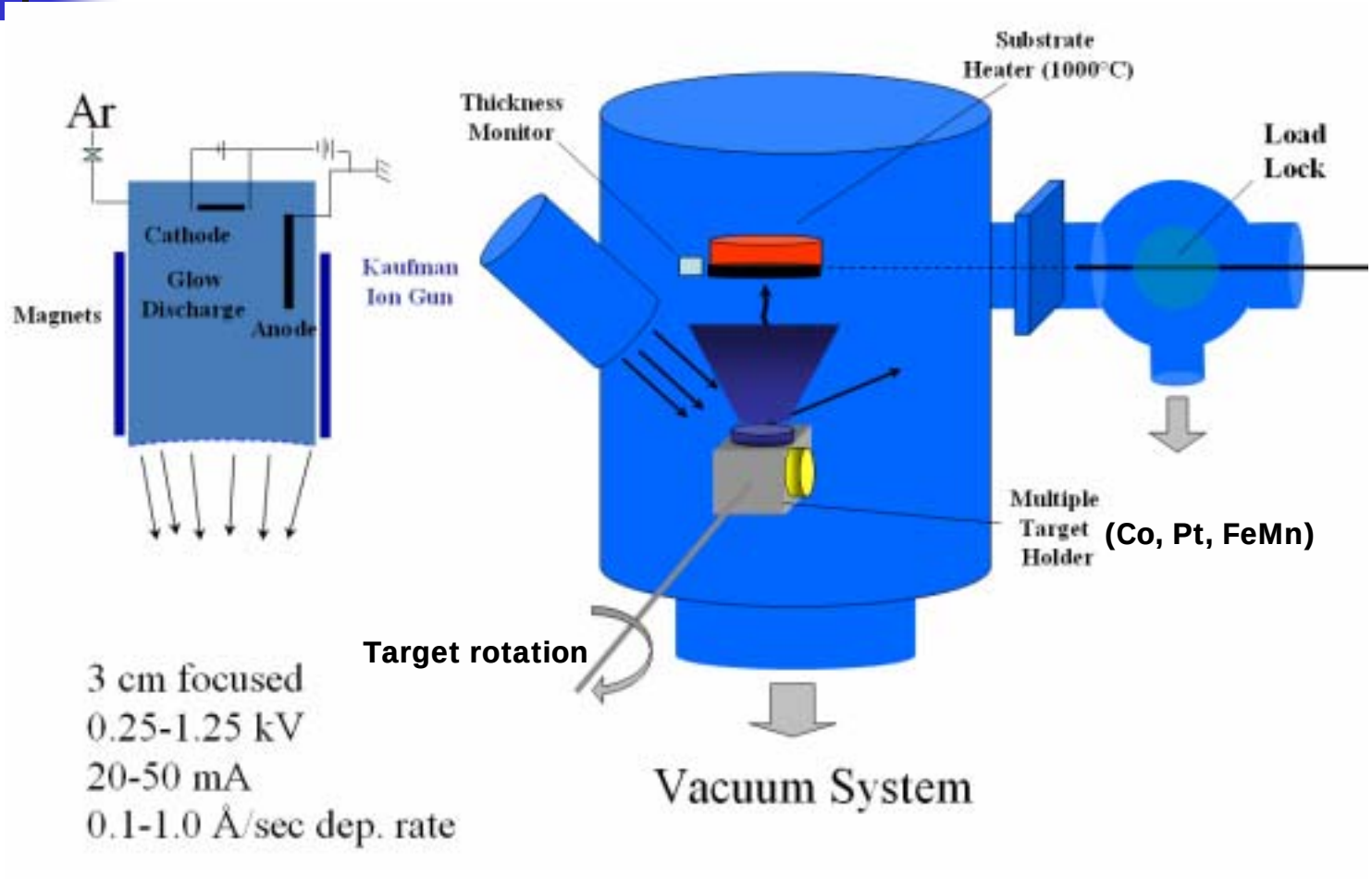
$$K_{eff} = -2\pi M_s^2 + K_v + \frac{2K_s}{t_F}$$

Perpendicular exchange bias

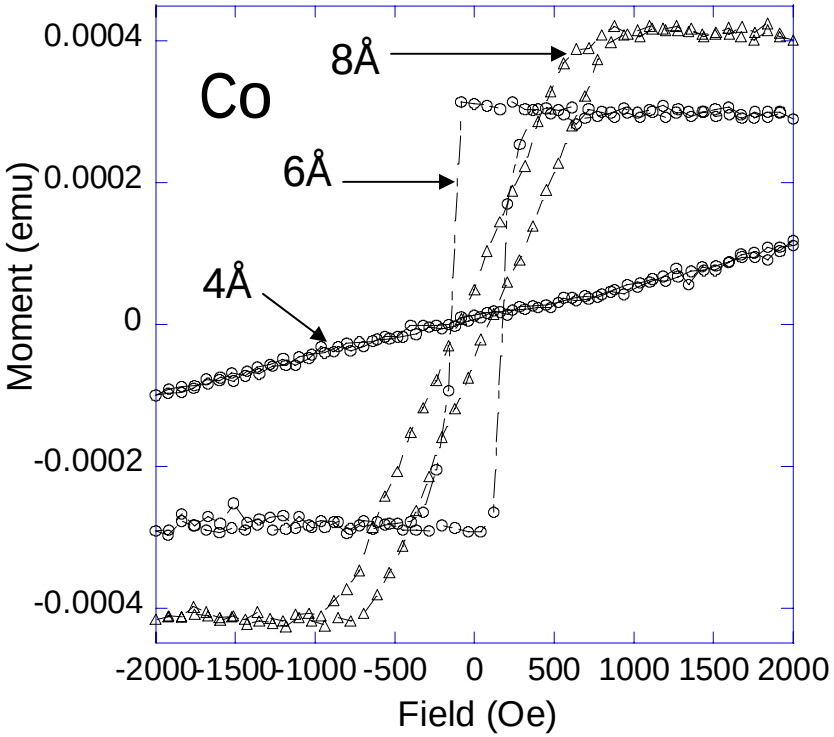




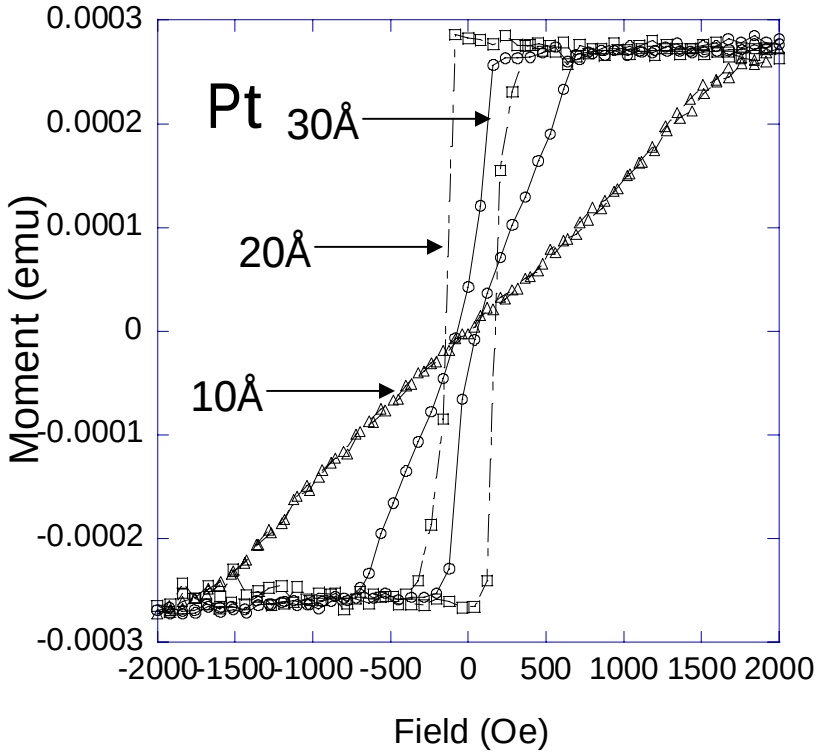
Thin film deposition, Ion beam sputtering system



Perpendicular anisotropy of Co/Pt multilayer as a function of Co and Pt thickness

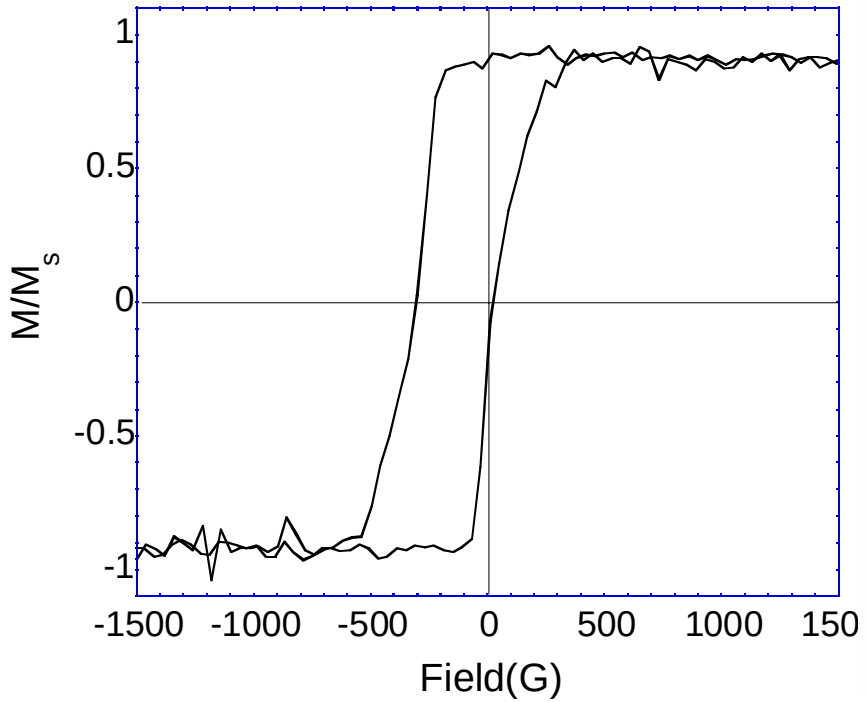


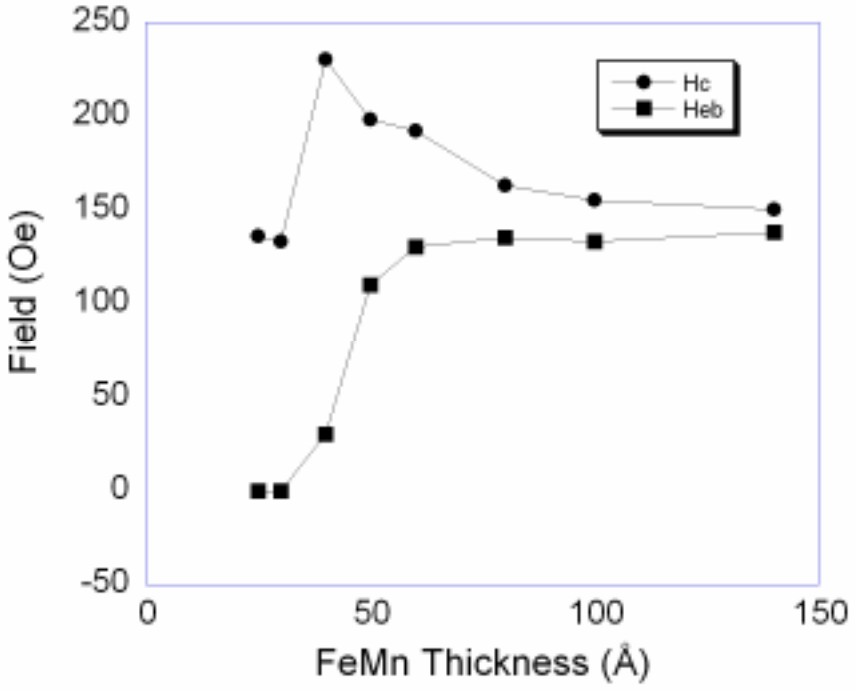
Co thickness $(\text{Co (x)/Pt(20 Å)})_{\times 5}$



Pt thickness $(\text{Co (6 Å)/Pt(x)})_{\times 5}$

FeMn thickness effect on exchange bias





Si(001)/Pt(200Å)/(Co(6Å)/Pt(20Å))$_{\times 5}$/FeMn(xÅ)/Pt(20Å)

Discussion

- The growth parameters for perpendicular exchange biased $(Co/Pt)_n$/FeMn multilayer have been optimized

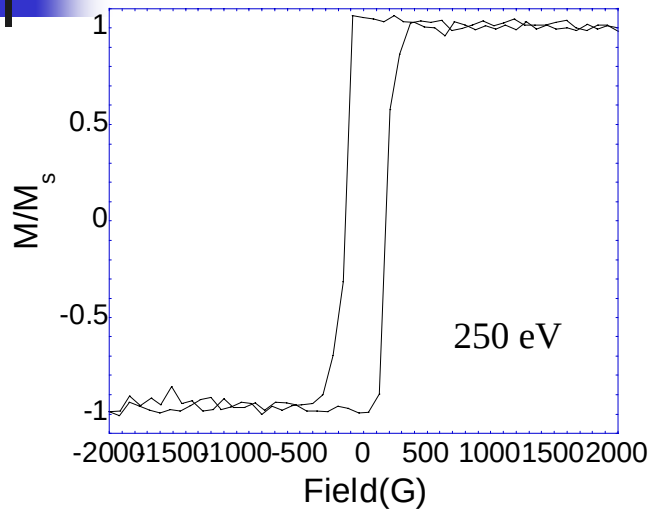
  thickness of Co, Pt and FeMn, thin film orientation, seed layer, number of bilayers, growth temperature

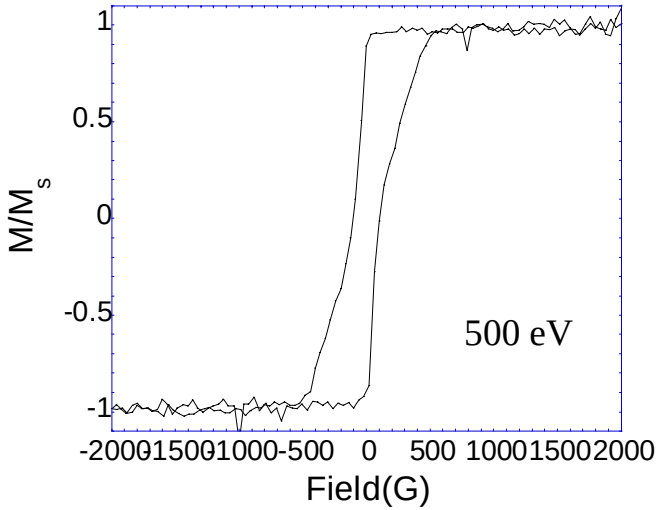
  $Si(001)/Pt(200Å)/(Co(6Å)/Pt(20Å))_{\times 5}/FeMn(80Å)/Pt(20Å)$

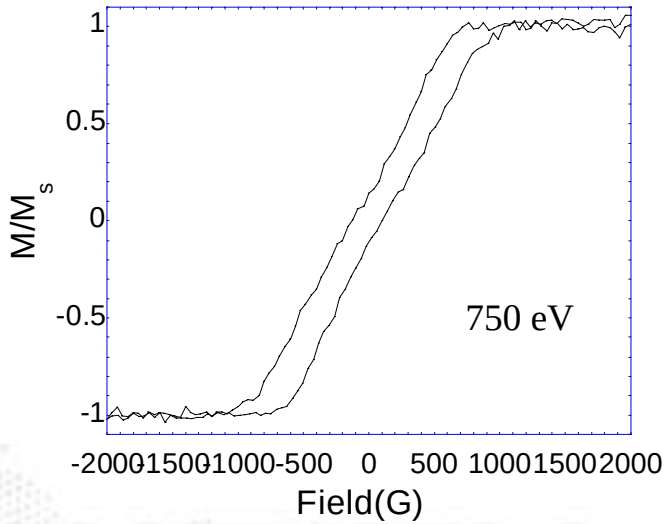
Question?

- Because perpendicular anisotropy and exchange bias are all interface effects. How do the structural properties, especially the interface conditions, affect the perpendicular anisotropy and exchange bias?

Ion-beam energy effect on perpendicular anisotropy of Co/Pt



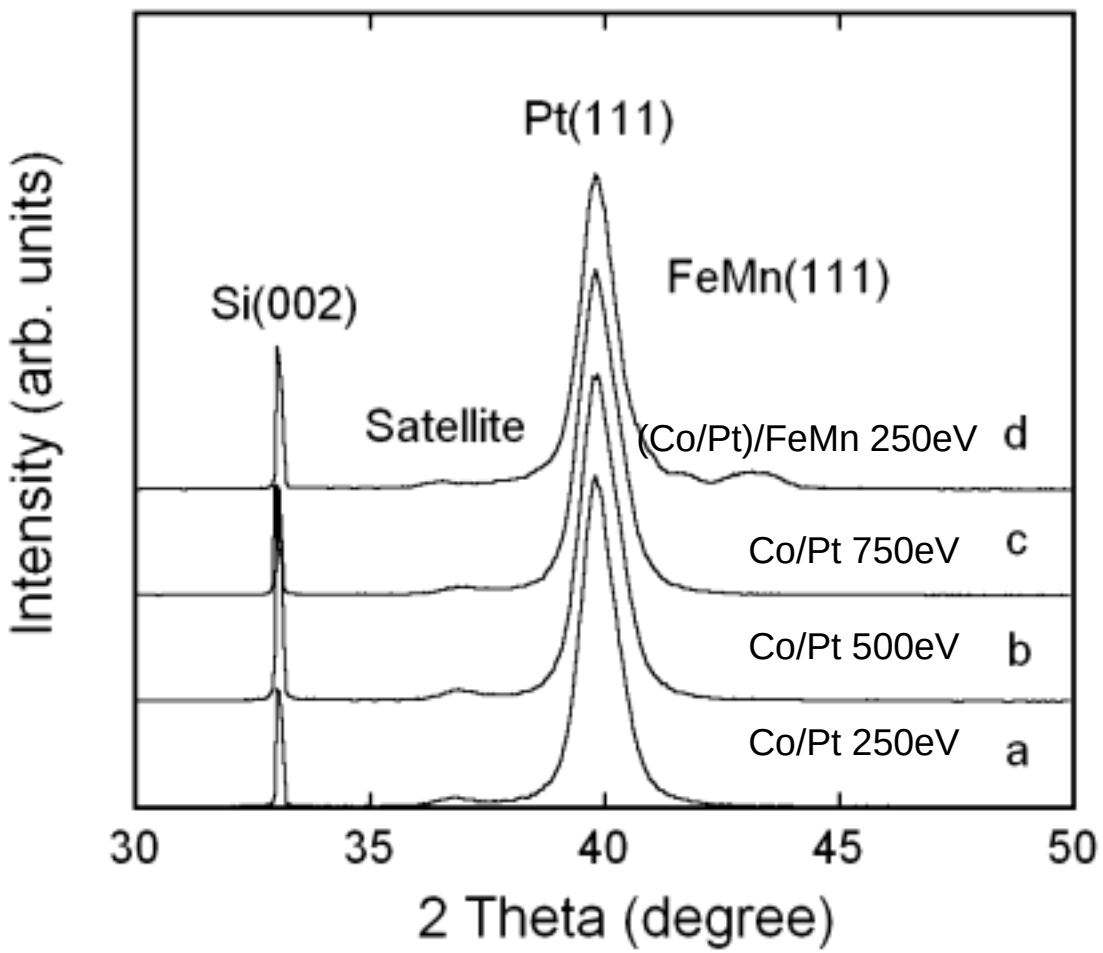


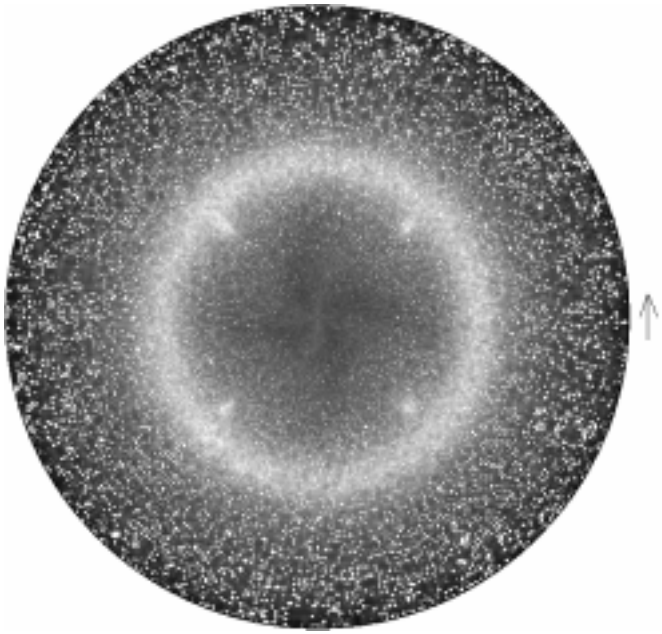


$Si(001)/Pt(200Å)/(Co(6Å)/Pt(20Å))_{*5}$ growth with different ion-beam energy

Lower ion-beam energy, higher perpendicular anisotropy

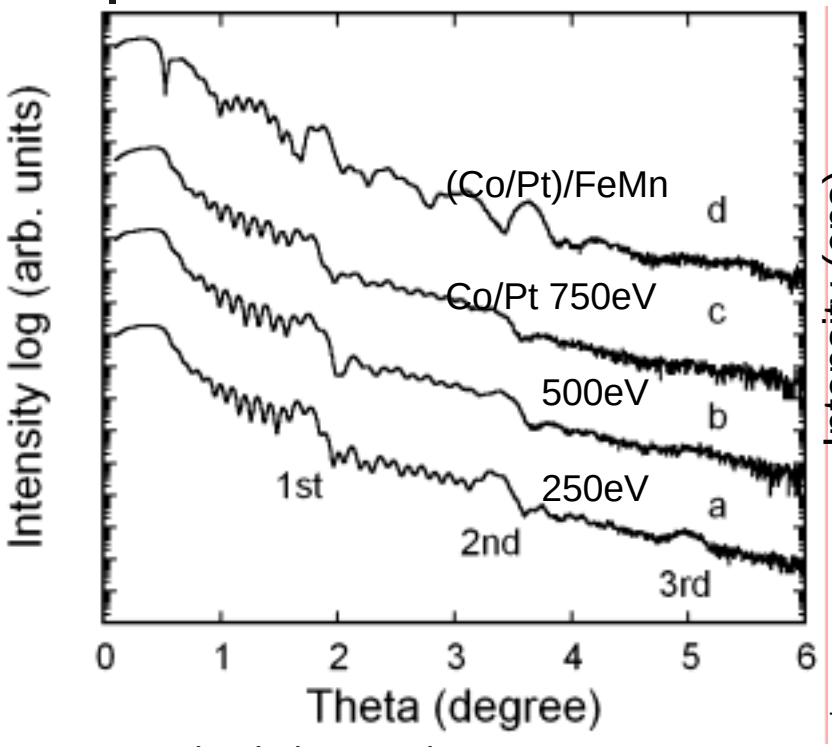
XRD and pole figure of Co/Pt and (Co/Pt)/FeMn multilayers

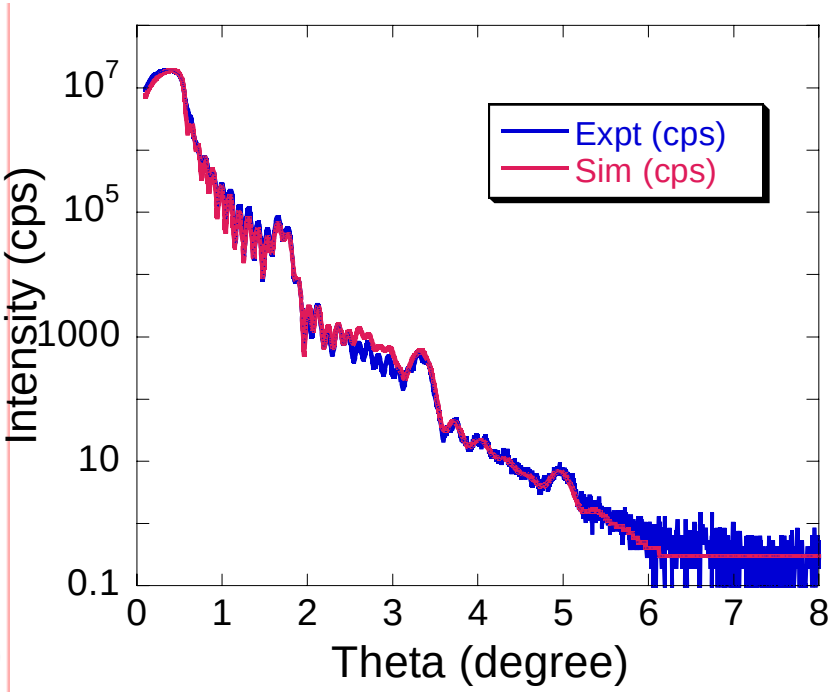




The multilayers have Pt(111) texture

X-ray reflectivity (XRR) and data simulation





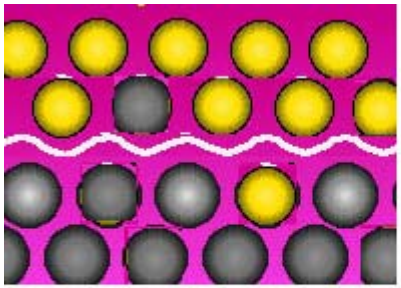
The simulation software program *REFS* (Build 4.00.13, Bede PLC, England)

XRR simulation results

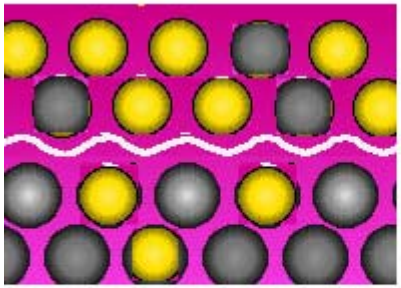
1. Co/Pt bilayer sequence is 26Å
2. Co/Pt interfaces roughness 2-4 Å and the Co/FeMn interface roughness 1.2 Å
3. The calculated Co layer density was ~150% of the bulk value for the sample grown at 250 eV, and increased to about 200% in sample grown at 750 eV.

Ion-beam energy effect on perpendicular exchange bias

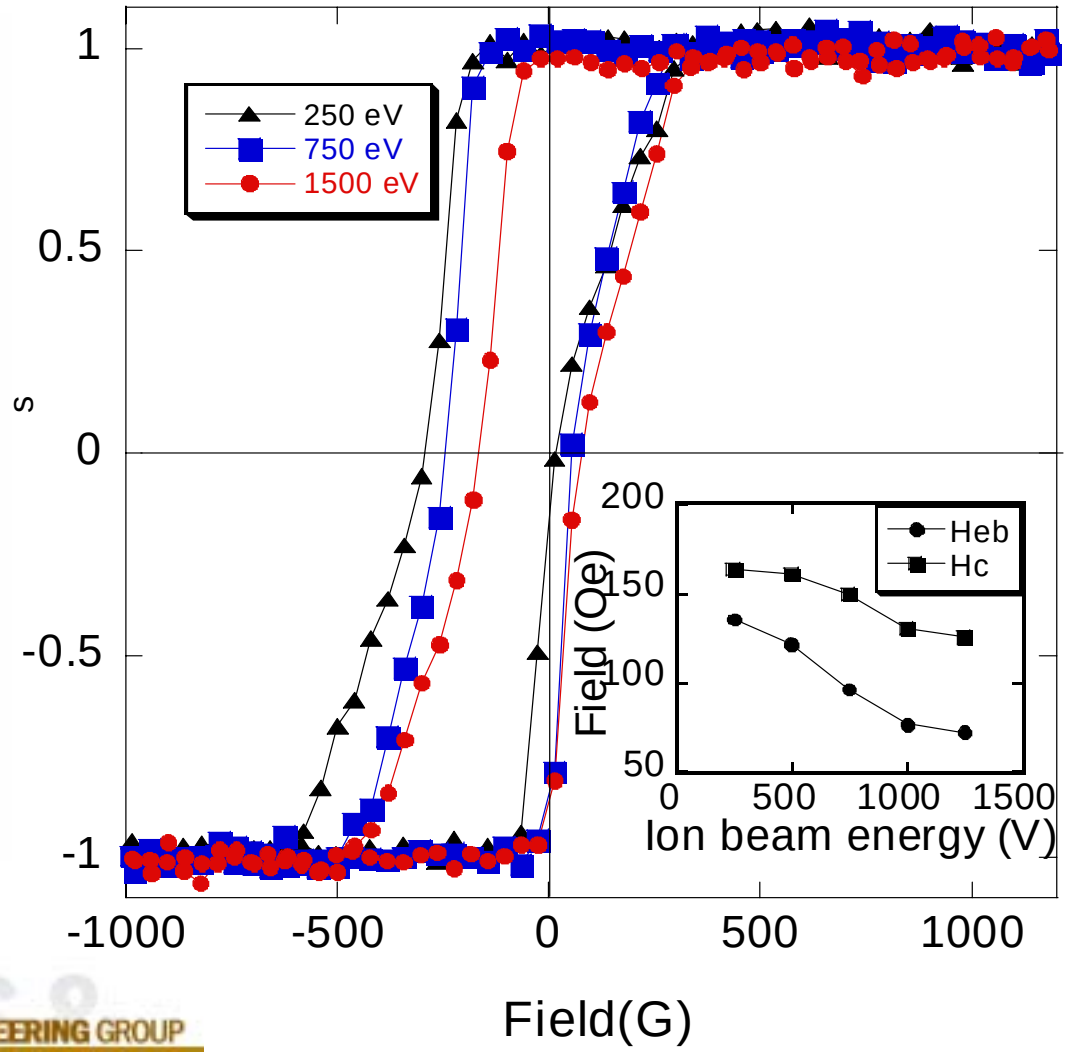
Si(001)/Pt(200Å)/(Co(6Å)/Pt(20Å))$_{\times 5}$/FeMn(80Å)/Pt(20Å)



Low energy



high energy



Conclusion

- High quality $(Co/Pt)_n$/FeMn with perpendicular anisotropy and exchange bias has been grown by ion-beam sputtering
- By varying ion-beam energy, the interdiffusion at the FM/NM and FM/AFM interface can be well controlled and characteristic x-ray reflectivity and simulation
- The structure-property correlations have been studied. The lower ion-beam energy deposited multilayers have lower interdiffusion at the interface, and thus have stronger perpendicular magnetic anisotropy and larger exchange bias.
- Work in progress include theoretical explanations of interdiffusion dependence of perpendicular exchange

Acknowledgements:
DoE grant #DE-FG03-02ER45987, Campbell Endowment at UW.
Pacific Northwest National Laboratory for the x-ray facilities and simulations