

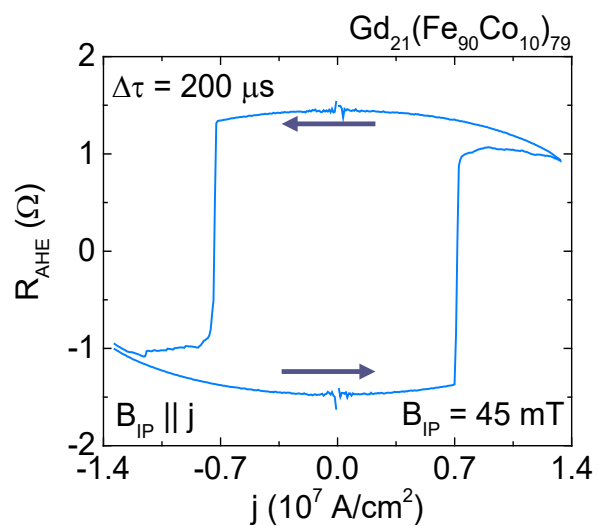
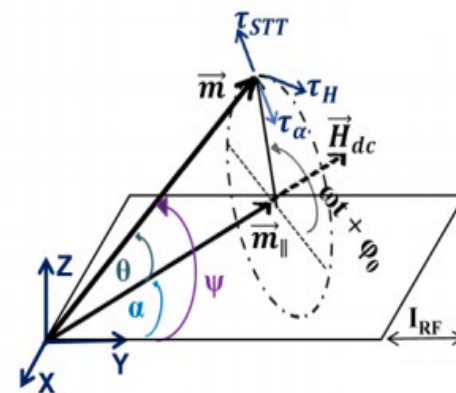
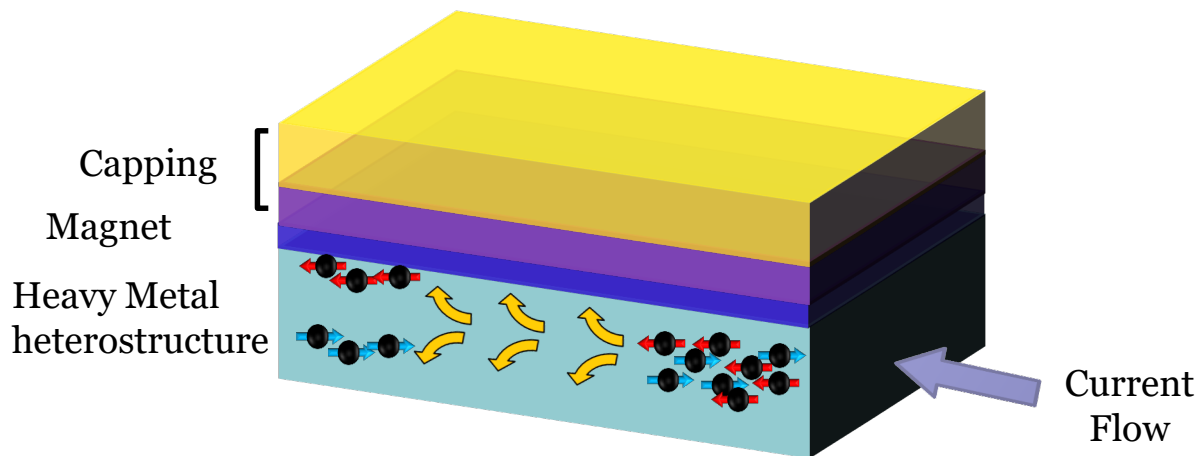
Ultralarge thickness Spin Orbit Torque Switching



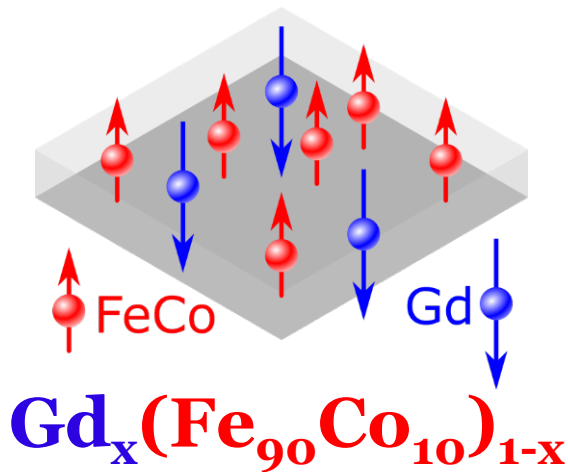
E3S Retreat Sept. 7th 2017

Charles-Henri Lambert
– Prof. Salahuddin's Group –

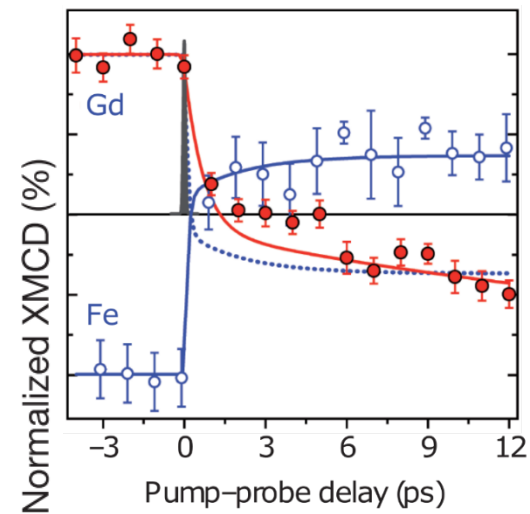
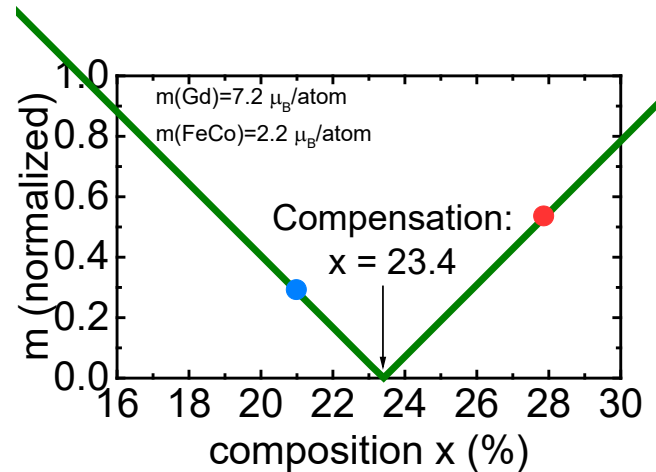
Spin orbit torque Switching



Spin Orbit Torque in Ferrimagnetic $Gd_x(Fe_{90}Co_{10})_{1-x}$

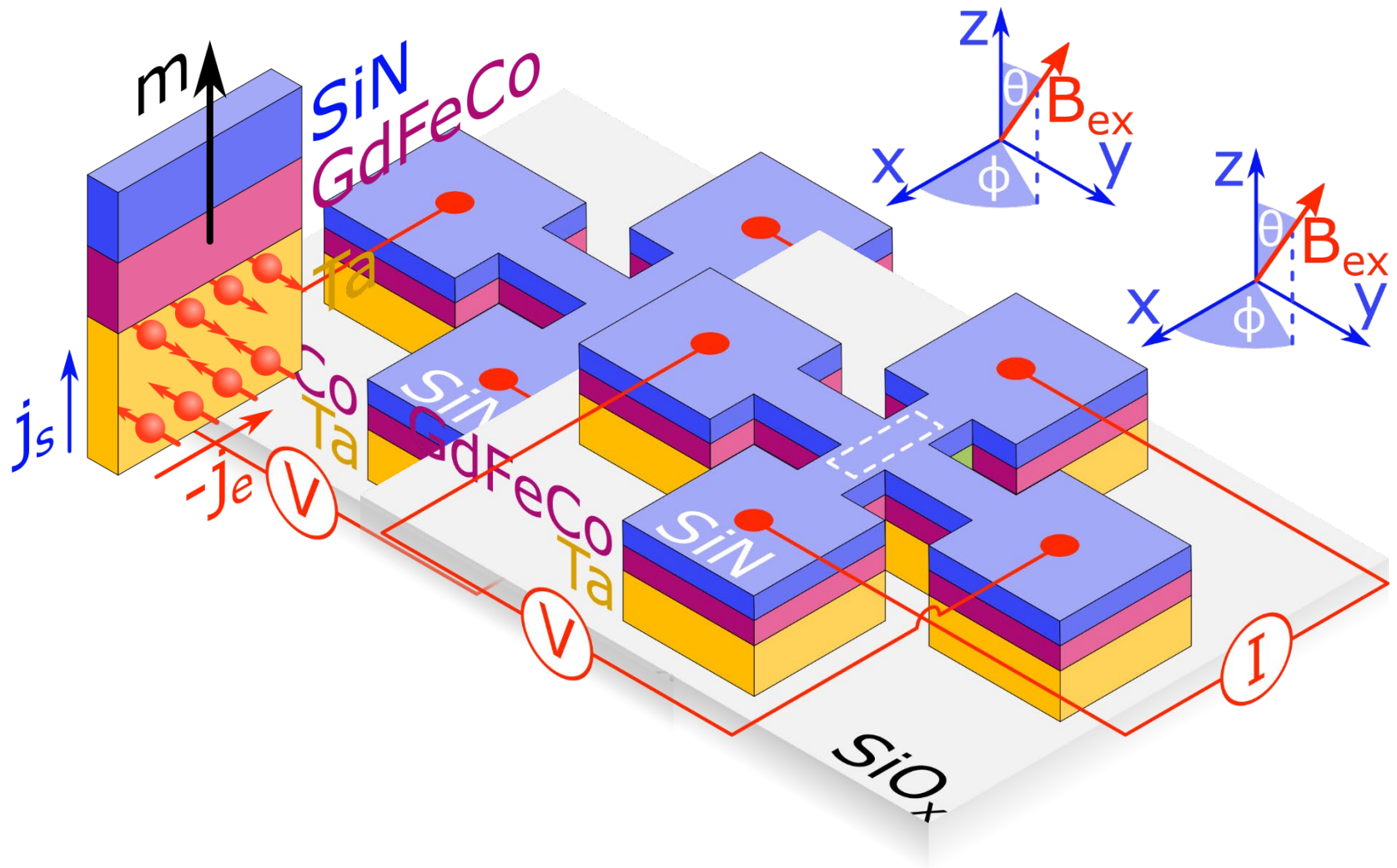


Gorchon et al, arxiv:1702.08492
Yang et al. arxiv: 1609.06392
Wilson et al. arxiv: 1609.05155
arxiv: 1609.00758
arxiv: 1609.00648



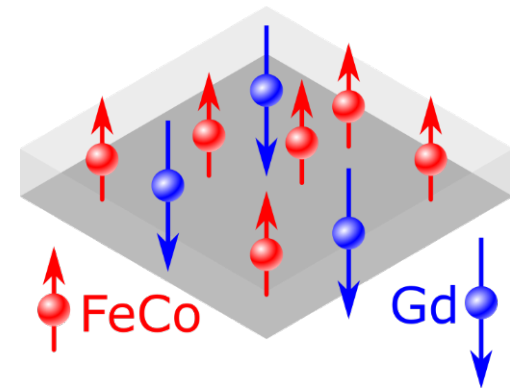
Radu et al., *Nature* 2011.

Experimental setup

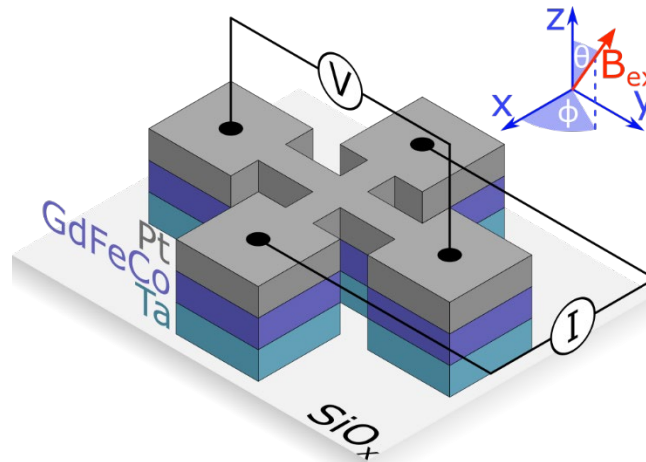
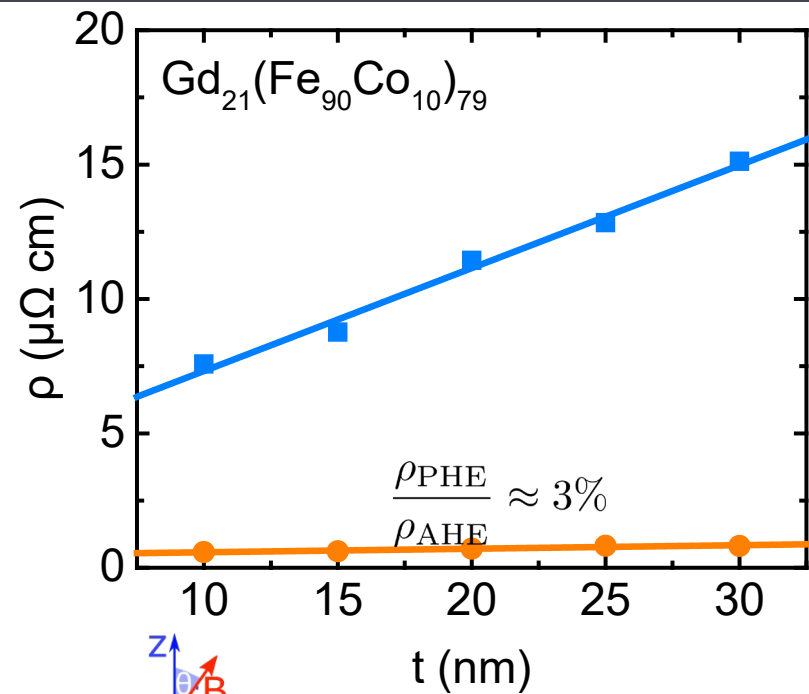
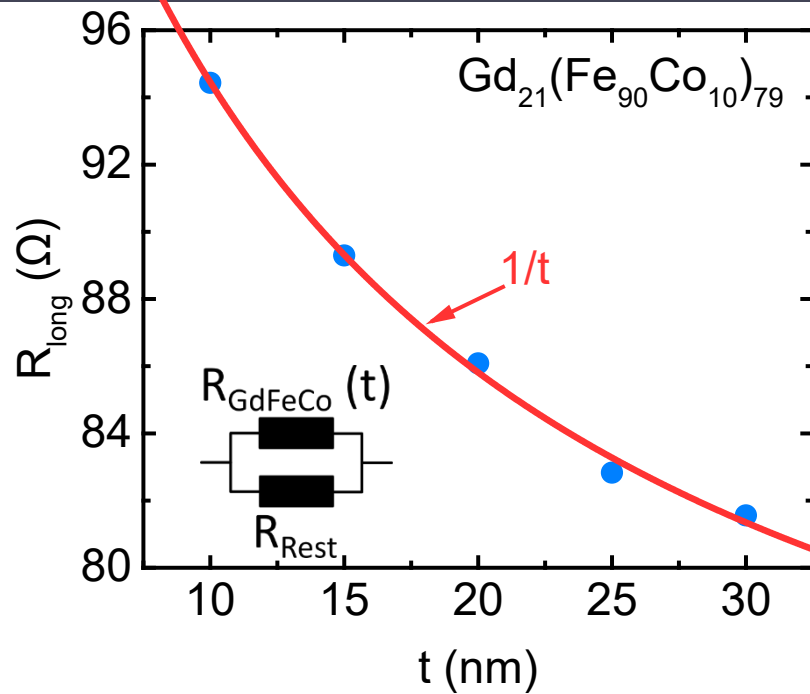


Thickness dependence of SOT

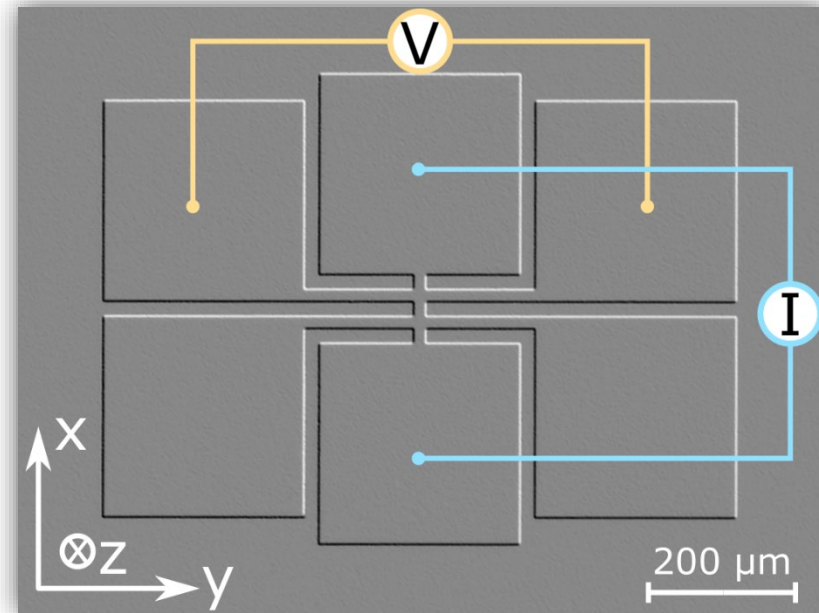
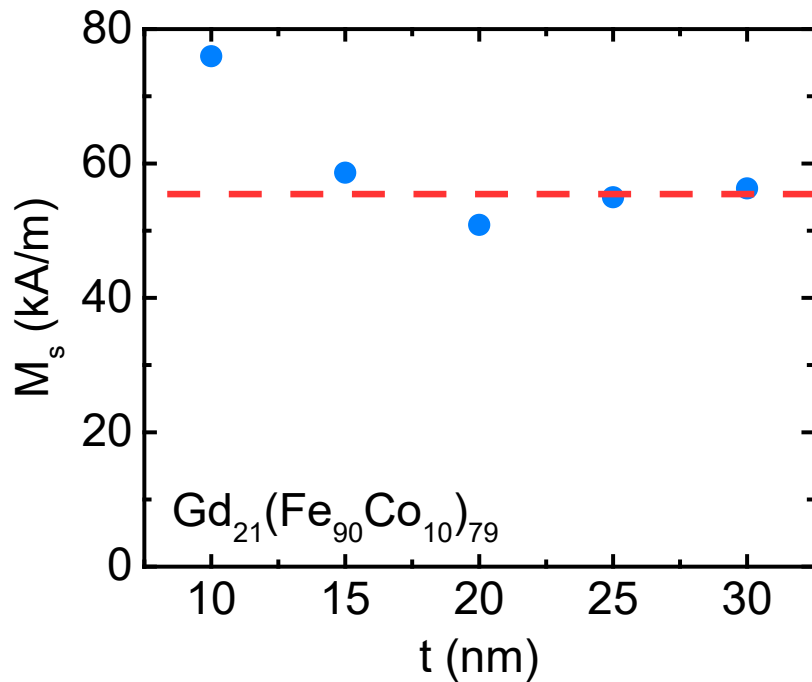
- GFC is a Bulk PMA material
- Thermal stability can be retained by increasing thickness, unlike interfacial PMA, when the areal footprint is scaled → can be very important for ultra scaled memory technologies
- *But can we switch a large thickness GFC?*



Transport Characteristics

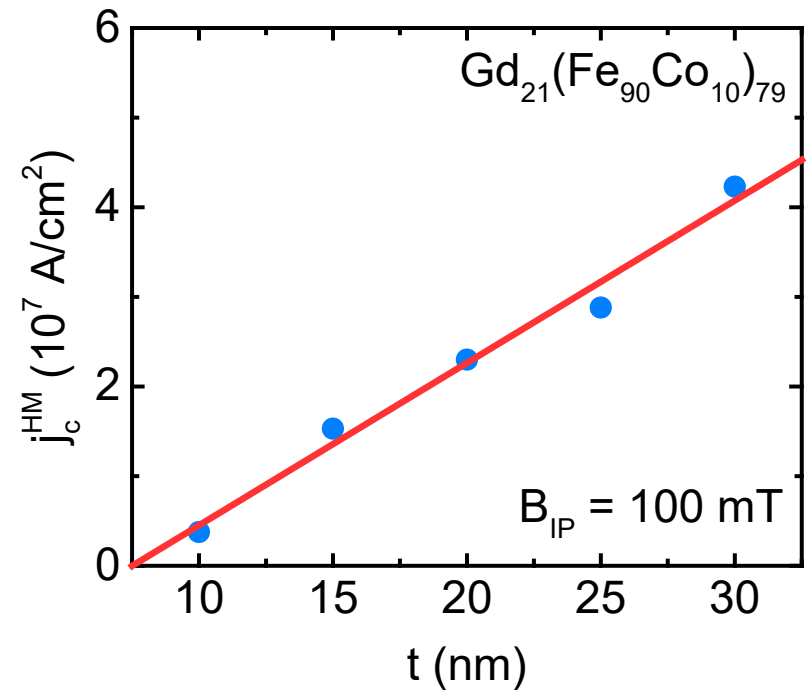
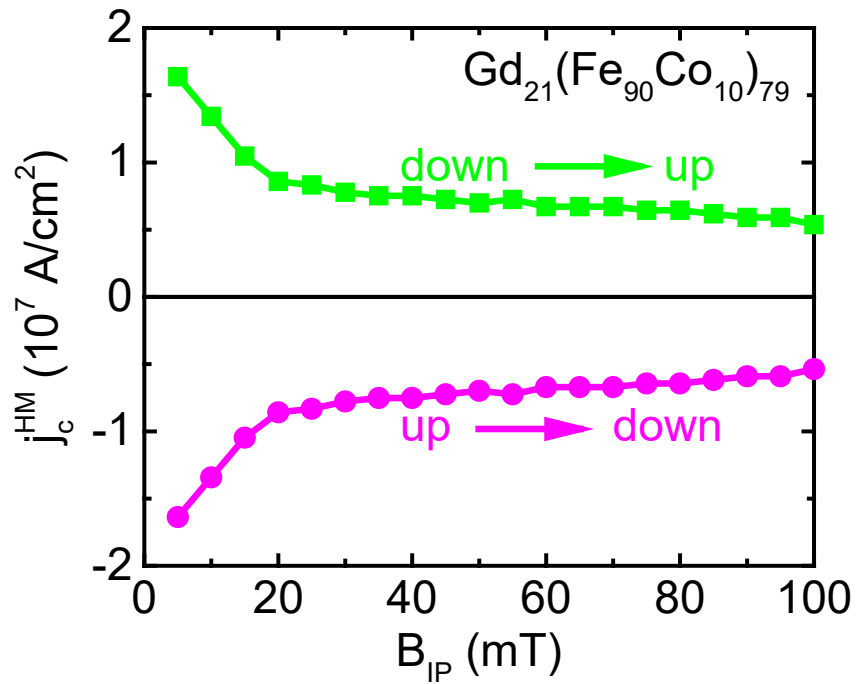


VSM Measurement of Magnetization



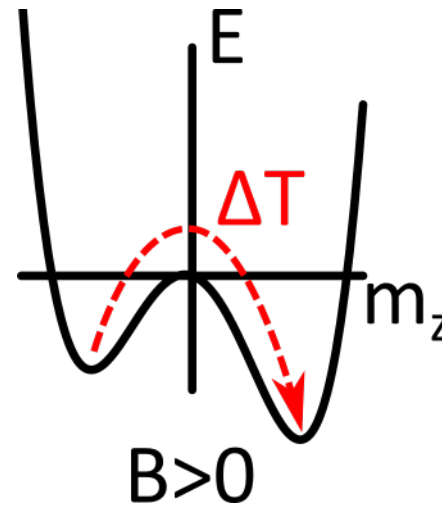
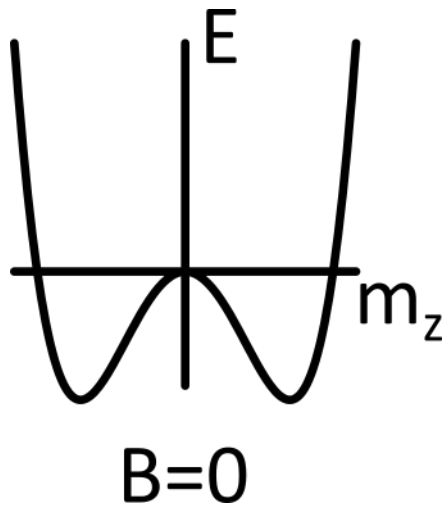
Magnetization does not depend on thickness

Current Driven SOT Switching



j_c scales linearly with thickness

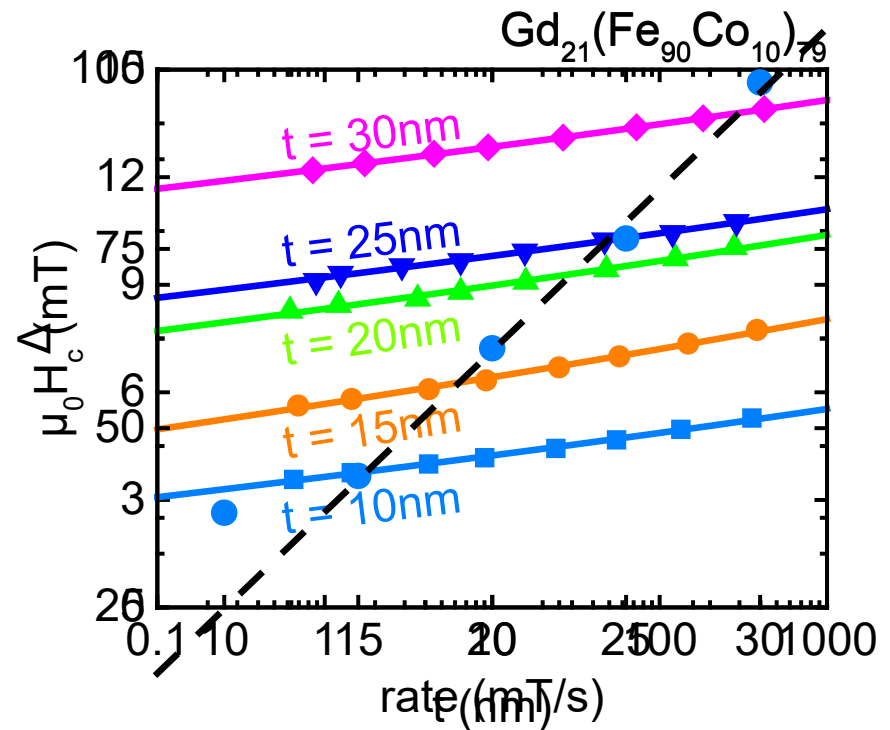
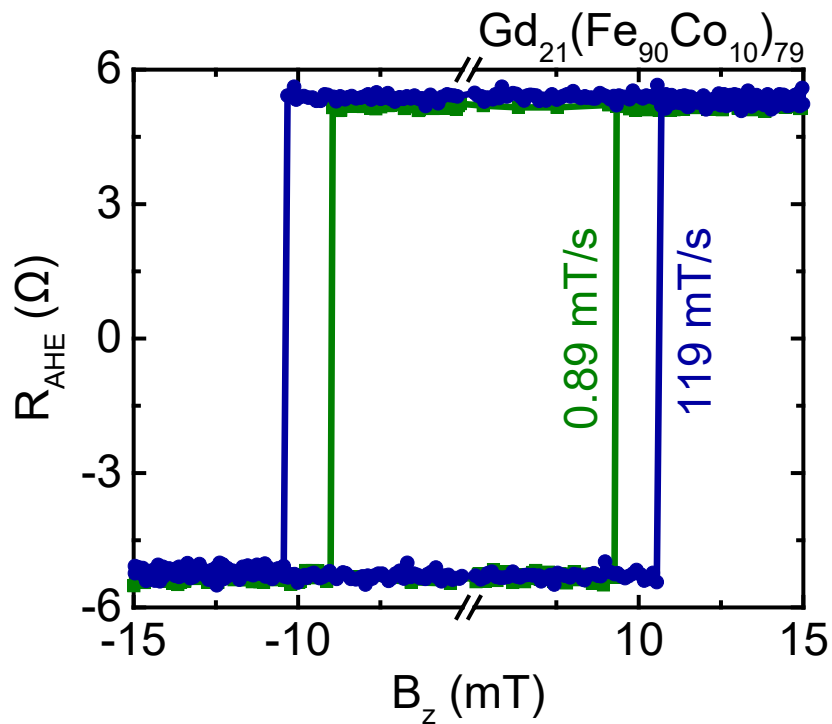
Thermal Stability Δ



$$H_c = H_k \left(1 - \sqrt{\frac{1}{\Delta} \ln \left[\frac{f_0 H_k}{2\Delta} \frac{1}{r} \right]} \right)$$

El-Hilo et al., *J. Magn. Magn. Mater.*
1992.

Thermal Stability Δ



$$H_c = H_k \left(1 - \sqrt{\frac{1}{\Delta} \ln \left[\frac{f_0 H_k}{2\Delta} \frac{1}{r} \right]} \right)$$

Scaling Trends Summary

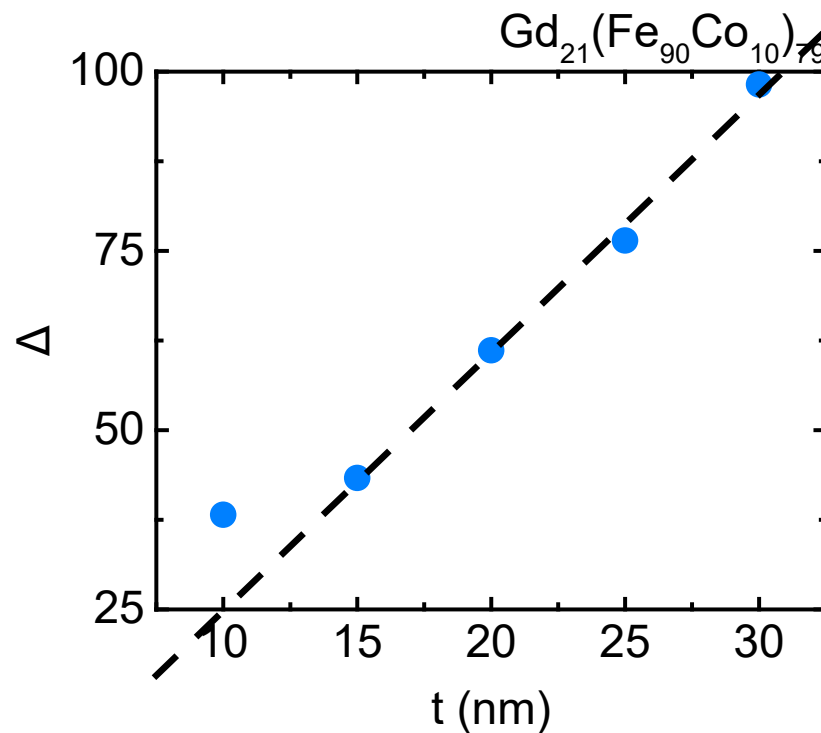
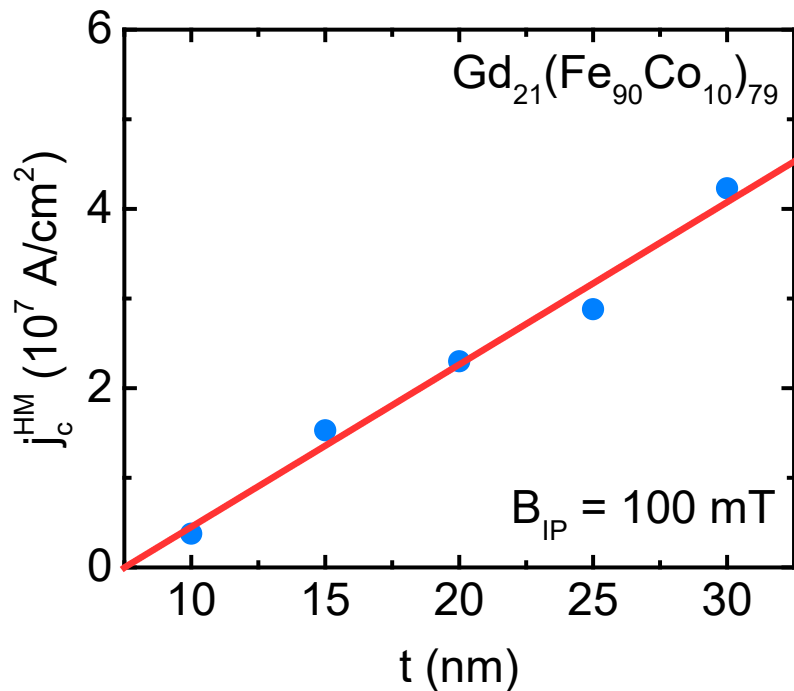
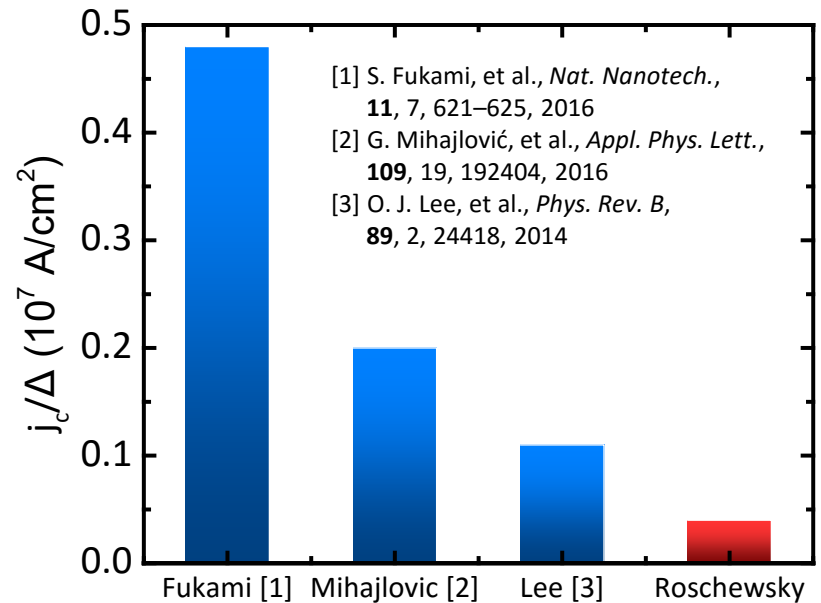
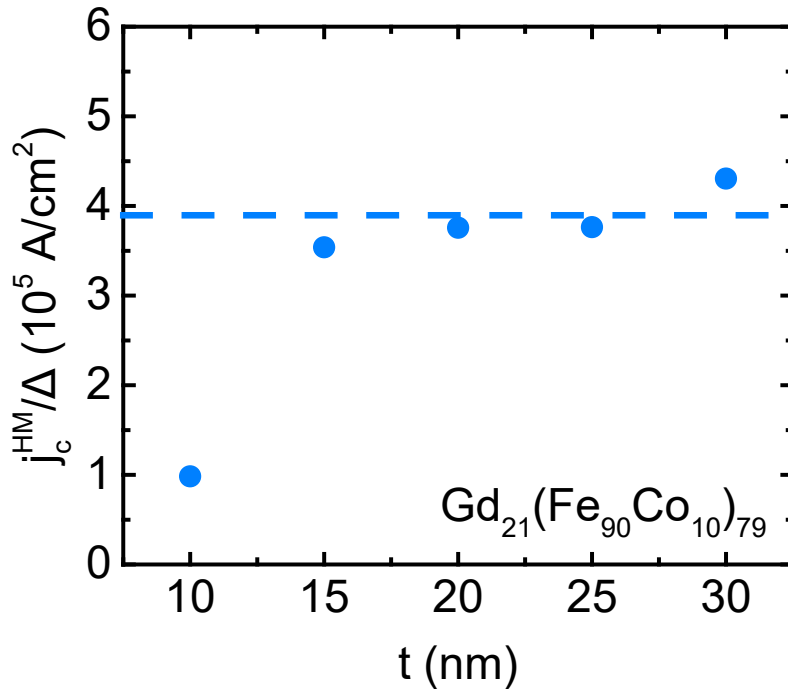


Figure of Merit of SOT Switching



Very high switching efficiency in ferrimagnetic GFC

(Roschewsky et al, submitted)

Summarizing the results so far

In GFC

- SOT depends on m_{Total} ---**how?**
- As thick as a 30 nm GFC with strong thermal stability can be switched
- Switching efficiency is much larger compared to known results – **why?**

Thank you for your attention !