The Hebrew University of Jerusalem
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ACRC
Advanced Circuits Research Center

2020 Research Day

Low damping materials for STT-MRAM

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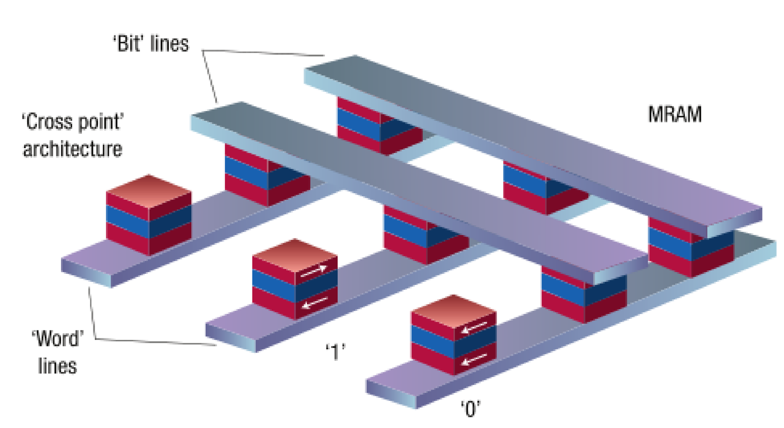
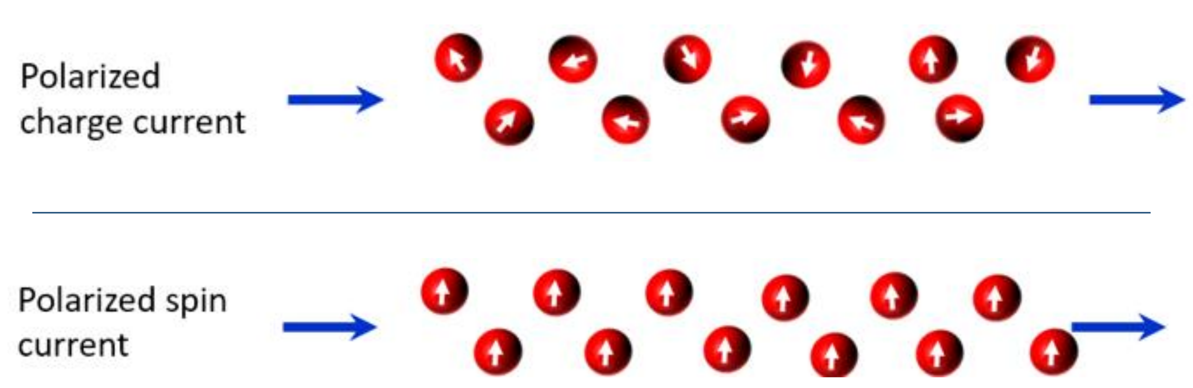
1 STT-MRAM: Gen 2

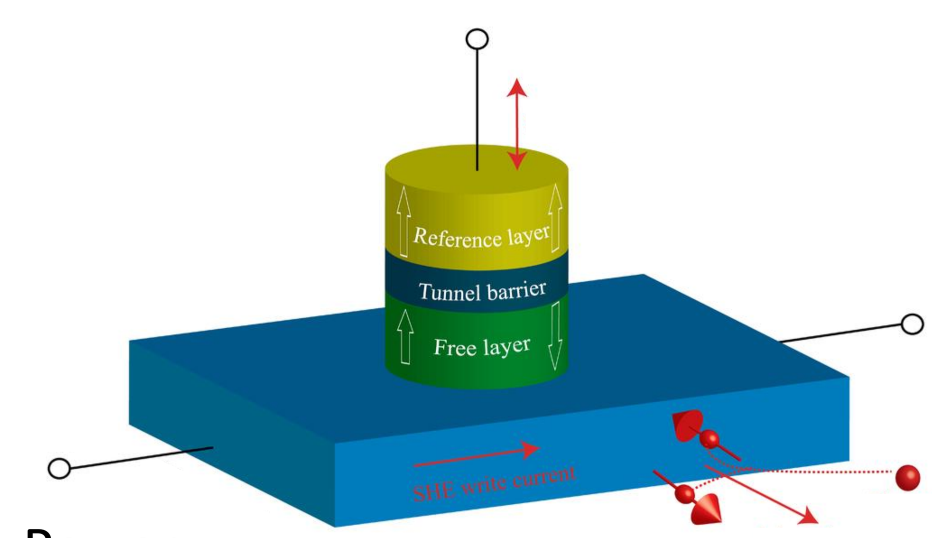


* Picture from Chappert, C., Fert, A (2007)

2 Spin currents



3 STT-MRAM: Gen 3

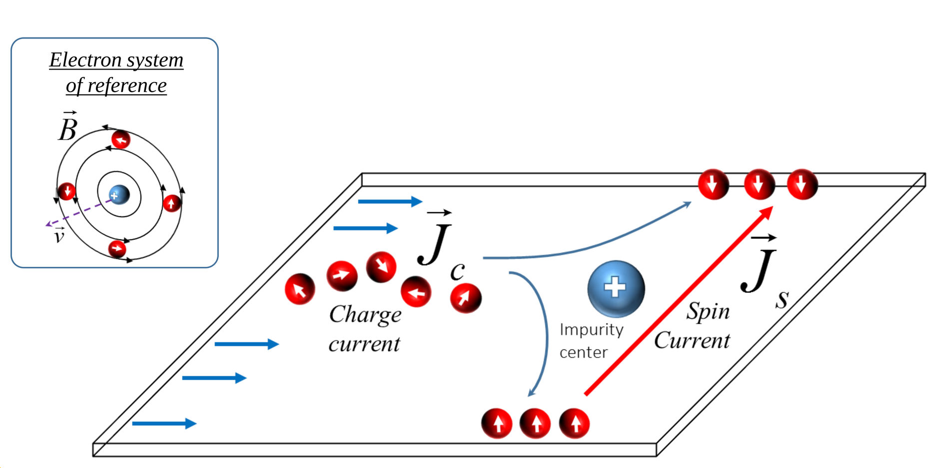


Low Power

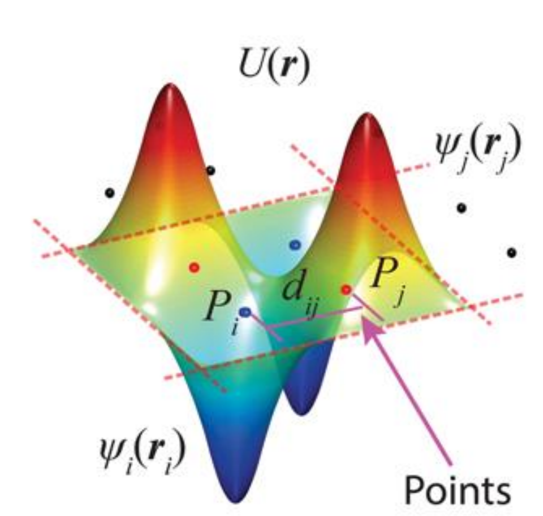
* Picture from Zhao W. (2015)

4 Spin Hall effect

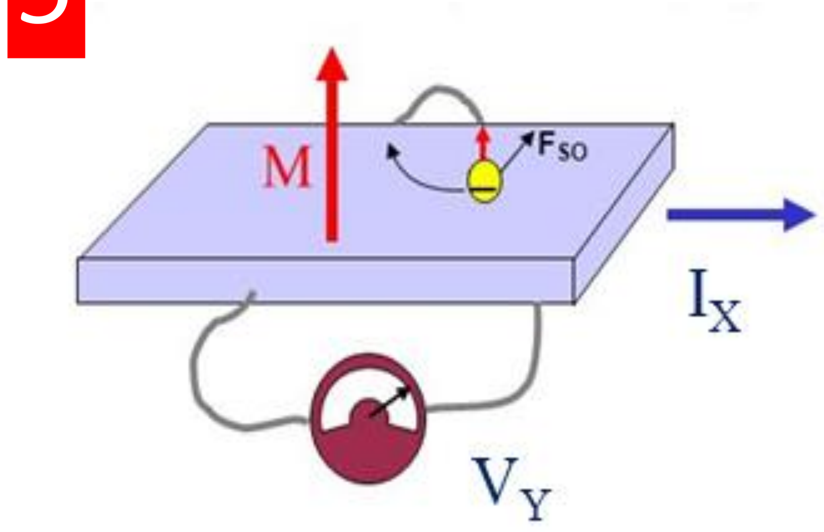
Extrinsic:

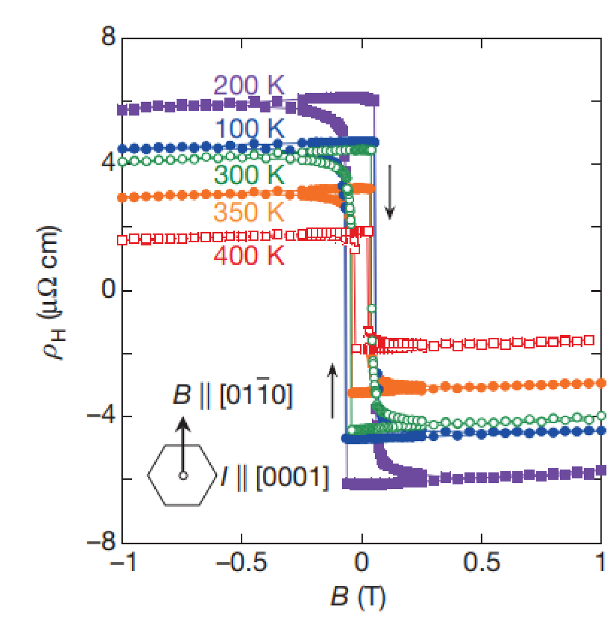


Intrinsic:



5 Anomalous Hall effect





Nature, 527, pp. 212 (2015)

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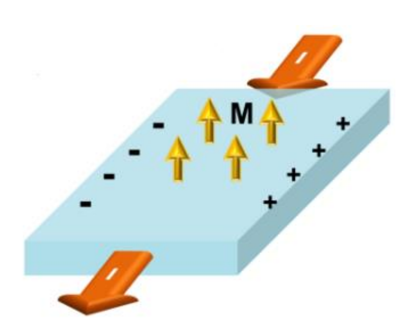
Berry curvature

$$\Omega_{n,\alpha\beta}(\vec{k}) = 2i\hbar^2 \sum_{m\neq n} \frac{\langle \psi_{n\mathbf{k}} | \hat{v}_\alpha | \psi_{m\mathbf{k}} \rangle \langle \psi_{m\mathbf{k}} | \hat{v}_\beta | \psi_{n\mathbf{k}} \rangle}{(E_n(\vec{k}) - E_m(\vec{k}))^2}$$

Hall conductivity

$$\sigma_{xy} = \frac{e^2}{\hbar} \int \frac{d\mathbf{k}}{(2\pi)^d} f(\varepsilon_{\mathbf{k}}) \Omega_{k_x k_y}$$

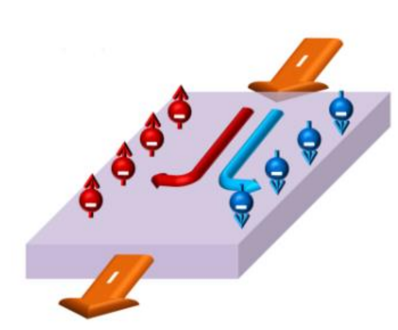


Spin Berry curvature

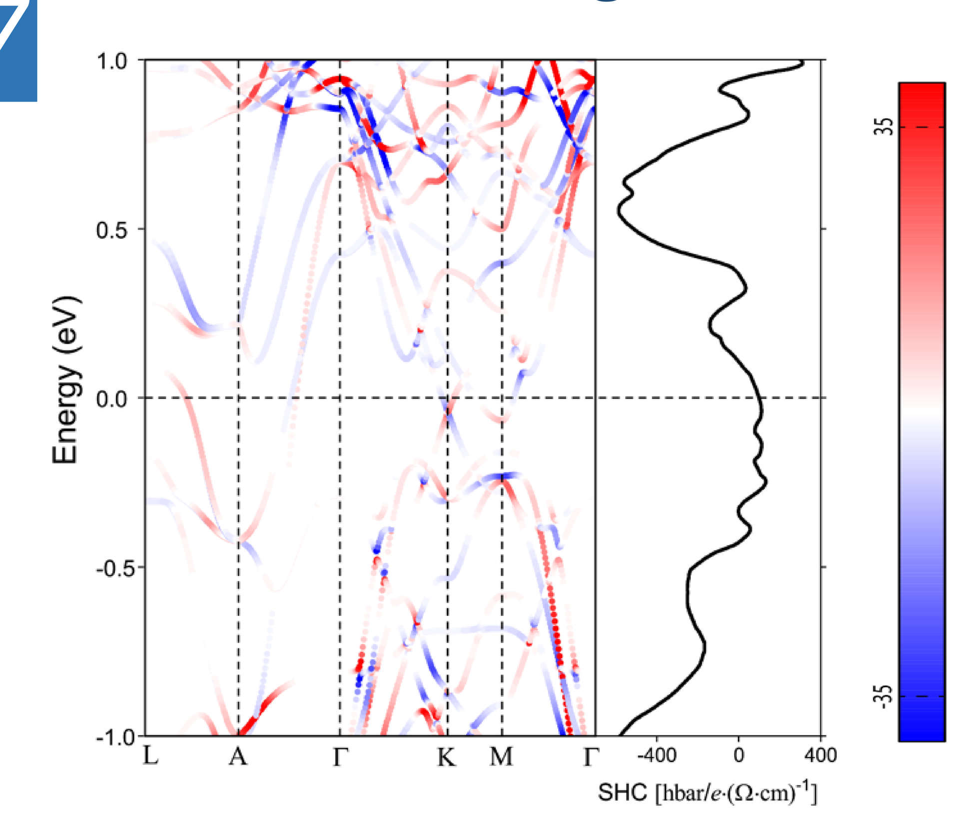
$$\Omega^{\gamma}_{n,\alpha\beta}(\mathbf{k}) = 2i\hbar^2 \sum_{m\neq n} \frac{\langle \psi_{n\mathbf{k}} | \hat{J}^{\gamma}_\alpha | \psi_{m\mathbf{k}} \rangle \langle \psi_{m\mathbf{k}} | \hat{v}_\beta | \psi_{n\mathbf{k}} \rangle}{(E_{n\mathbf{k}} - E_{m\mathbf{k}})^2}$$

Spin Hall conductivity

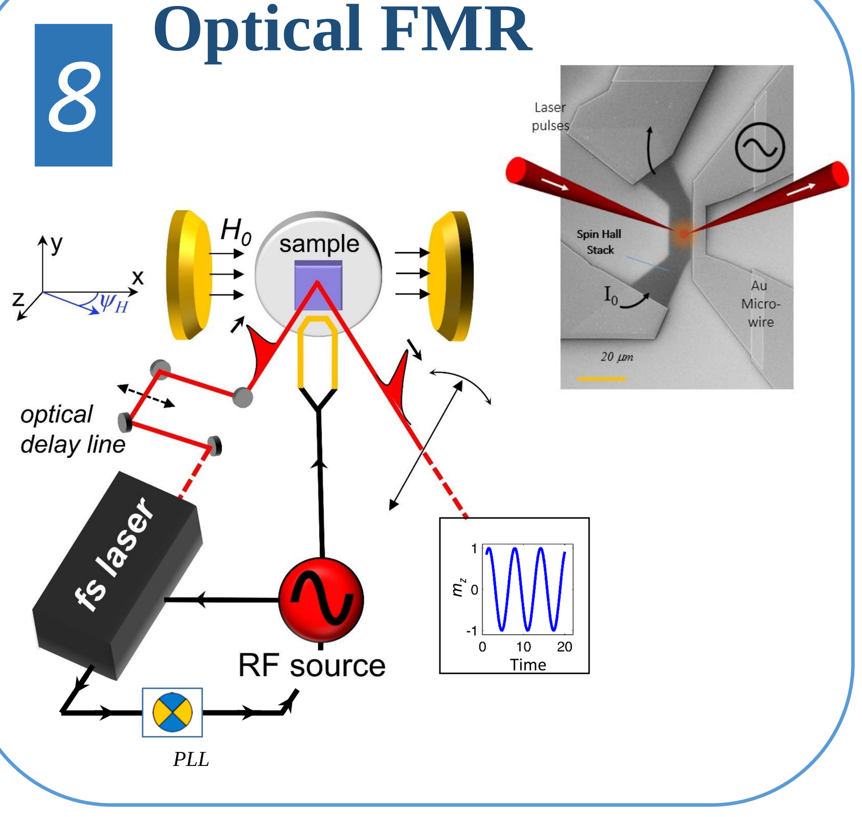
$$\sigma^{\gamma}_{\alpha\beta} = \frac{e}{\hbar} \sum_n \int_{BZ} \frac{d^3\mathbf{k}}{(2\pi)^3} f_n(\mathbf{k}) \Omega^{\gamma}_{n,\alpha\beta}(\mathbf{k})$$



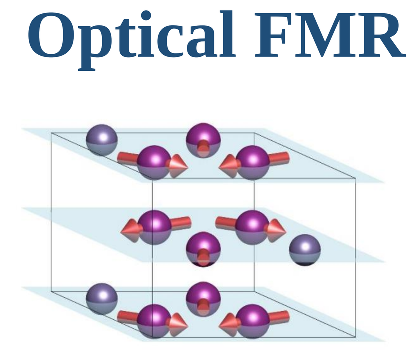
7 Non-collinear magnetic structure

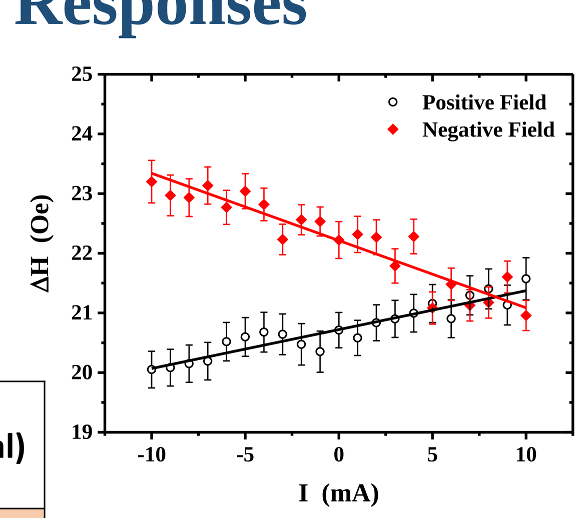


8 Optical FMR



9 Optical FMR Responses

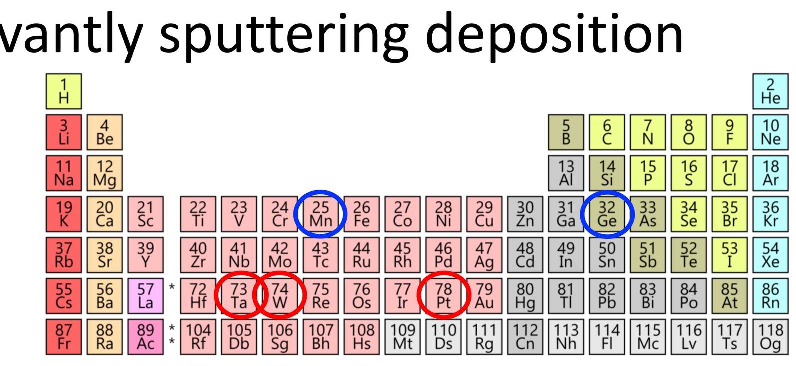




	Mn_3Sn	Pt (typical)
Damping	0.0028	0.147
Spin Hall angle	0.13	0.2

10 Summary

- Large SHE in light elements (SOC free!)
- CMOS compatible!
- No geometrical restriction of charge current and spin currents!
- Technologically relevantly sputtering deposition
- Novel low damping material system.



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