Spin pumping in Al substituted Finemet/Pt wedge structures

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This work has been carried out within Project No. NANOSPIN PSPB-045/2010 supported by a grant from Switzerland through the Swiss Contribution to the enlarged European Union.

Outline

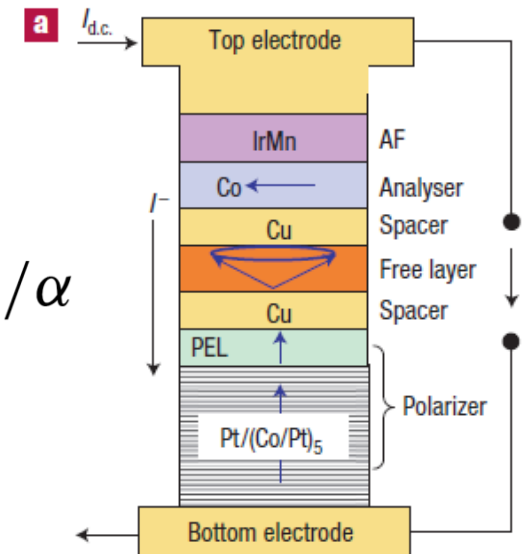
- Motivation
- Finemet
- Al substituted Finemet – a material for spintronics and magnonics
- Spin pumping in Pt/Al-Finemet
- Summary

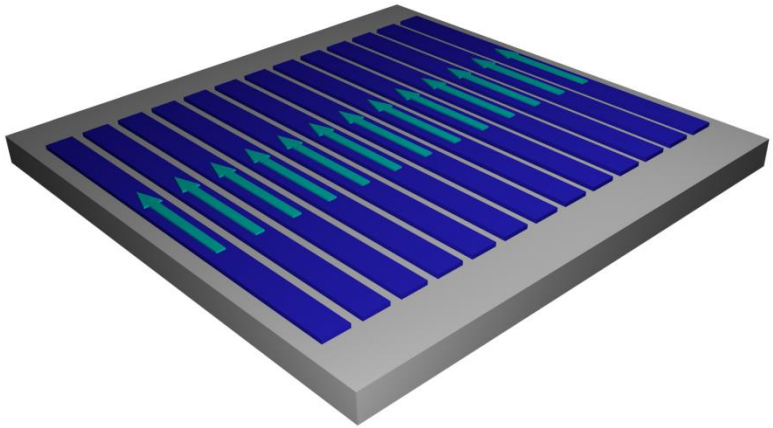
Motivation

A suitable material with a low damping constant for:

- Spintronics
  - Lower critical currents
- Magnonics
  - Waveguides
  - Magnonic crystals

$$df/d|I_{d.c.}| \propto g/\alpha$$

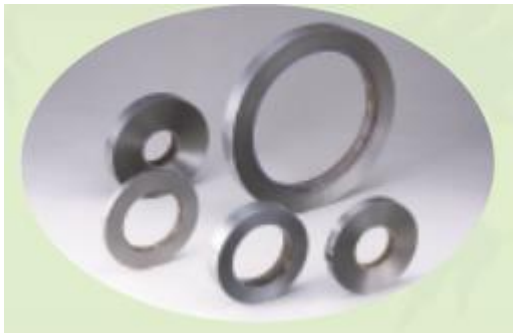


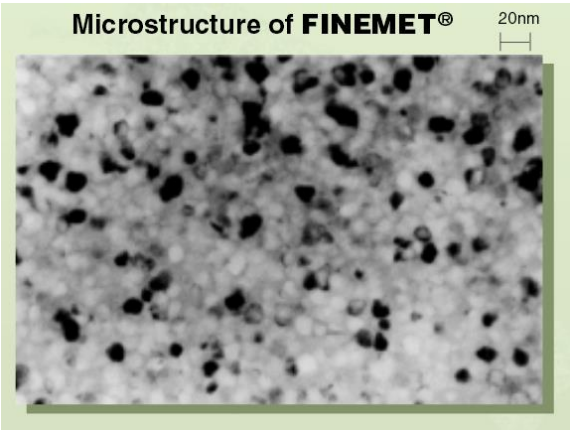


D. Houssameddine et al., Nat. Mater. 6, 447 (2007)

Finemet

- Finemet ($Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$) with its nanocrystalline microstructure provides:
  - High permeability (~10^5)
  - High saturation magnetization (~ 1.2 T)
  - High squareness
  - Low magnetostriction (~10^{-6})



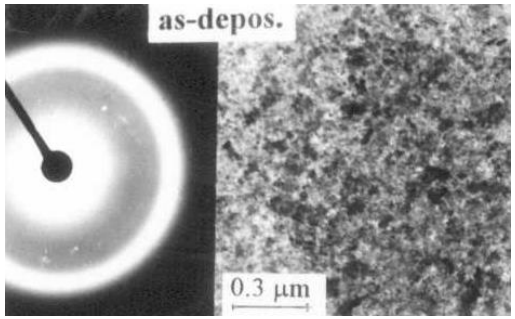


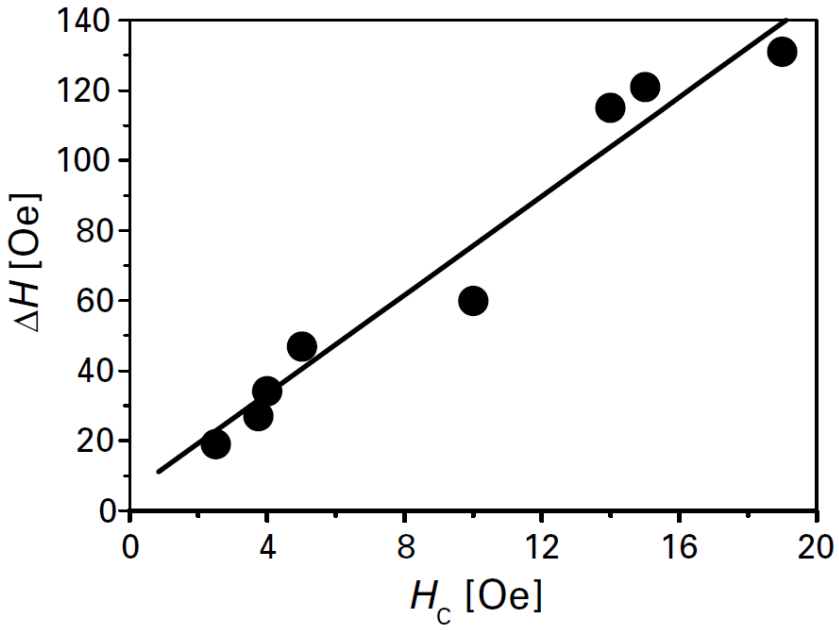
Y. Yoshizawa, S. Oguma, K. Yamauchi, J. Appl. Phys. 64 (10) (1988) 6044

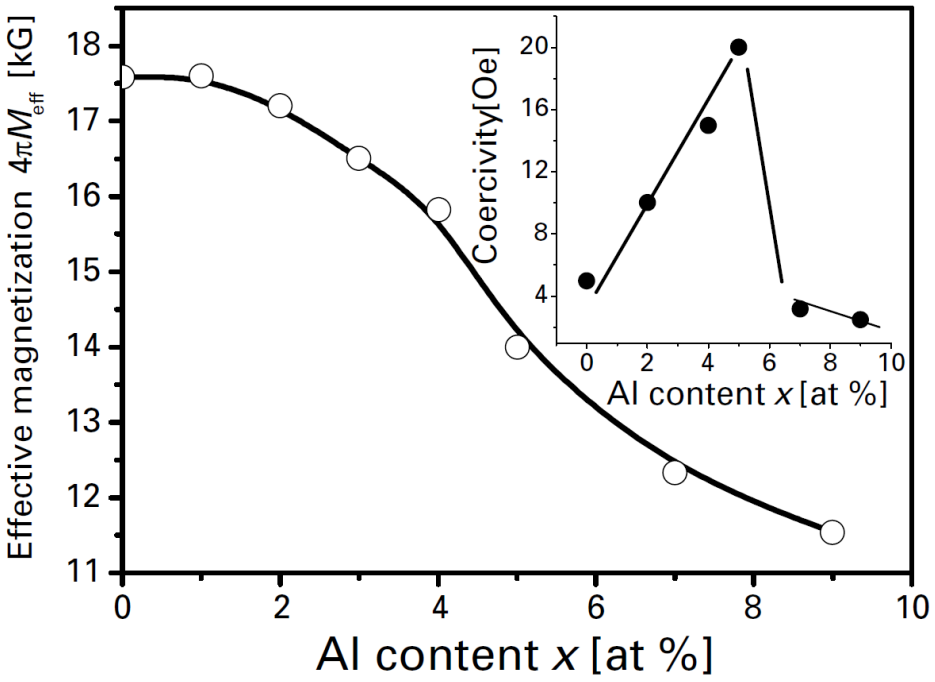
Nanocrystalline soft magnetic material Finemet, Hitachi Metals, Ltd.

Al substituted Finemet

Flash evaporation





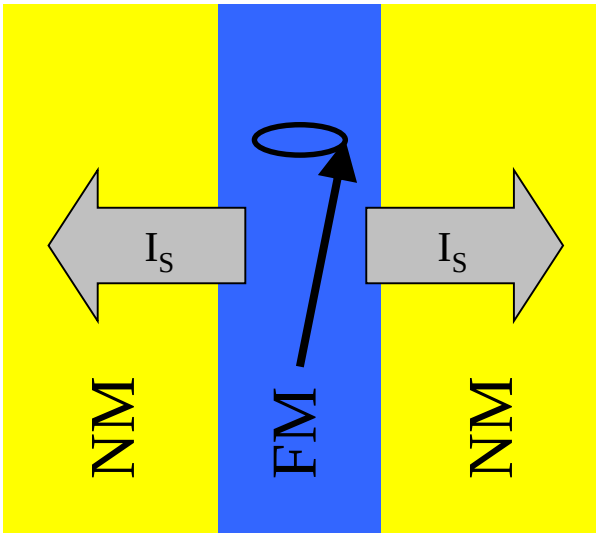


Al substitution:
- decrease magnetization
- decrease linewidth

I. Gościańska et al. / Journal of Magnetism and Magnetic Materials 242–245 (2002) 177–179

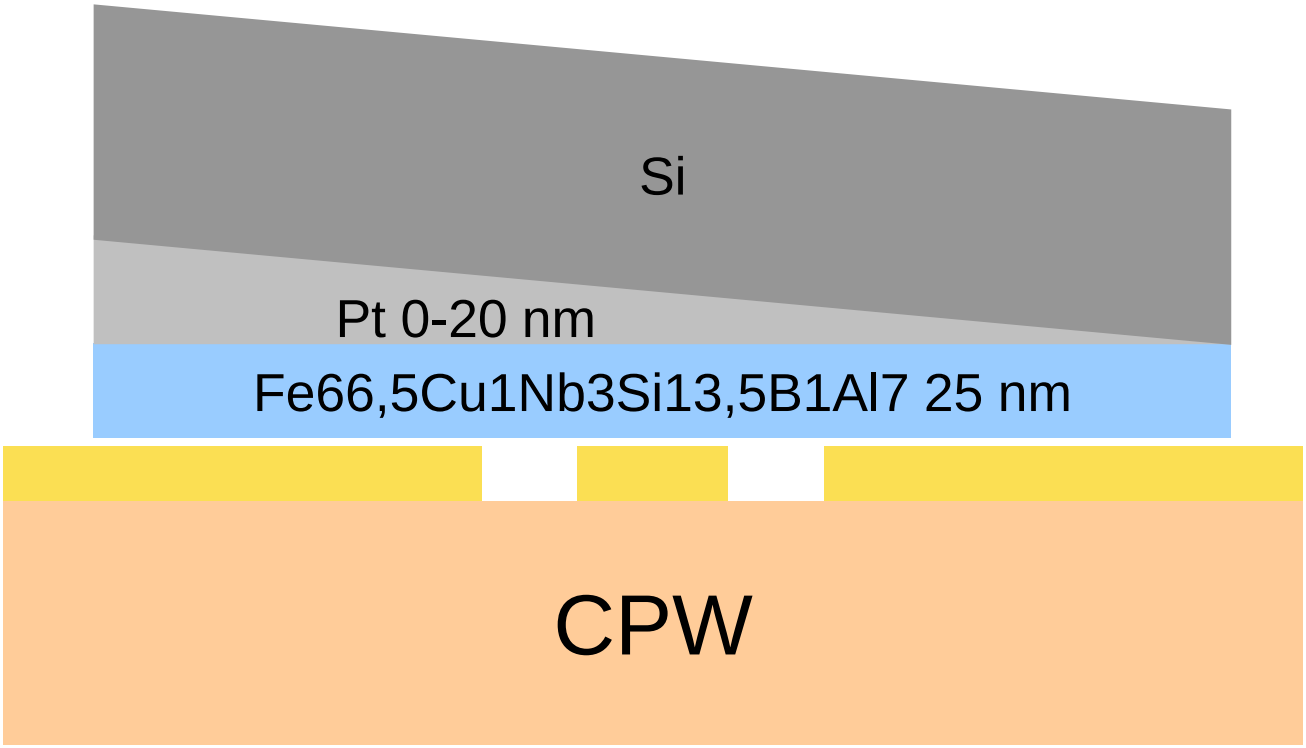
Spin pumping

- During precession ferromagnetic layer looses angular momentum due to spin pumping to adjacent nonmagnetic layer
- Spin pumping can be observed as increase in FMR linewidth

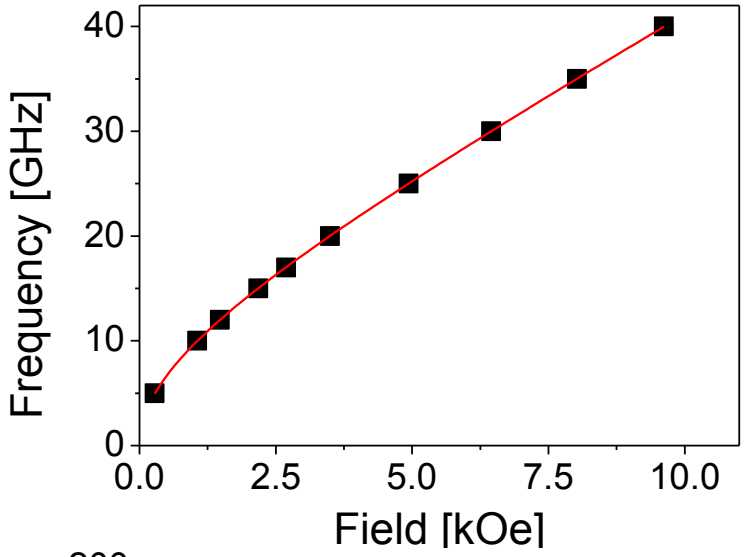


Yaroslav Tserkovnyak et al., Phys. Rev. Lett. **88**, 117601 (2002)

VNA-FMR measurements of Al substituted Finemet

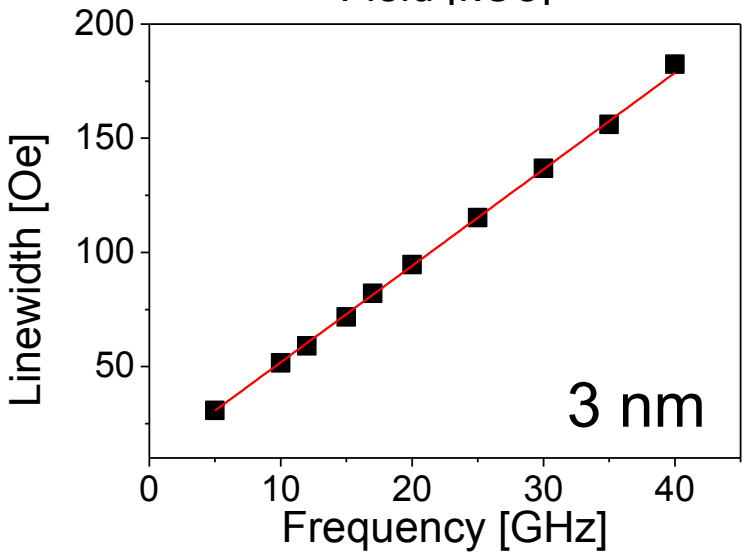


VNA-FMR measurements of Al substituted Finemet



$$\left(\frac{\omega}{\gamma}\right)^2 = H_{FMR}\left(H_{FMR} + 4\pi M_{eff}\right)$$

$$4\pi M_{eff} = 4\pi M - 2K_{perp}/M$$



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

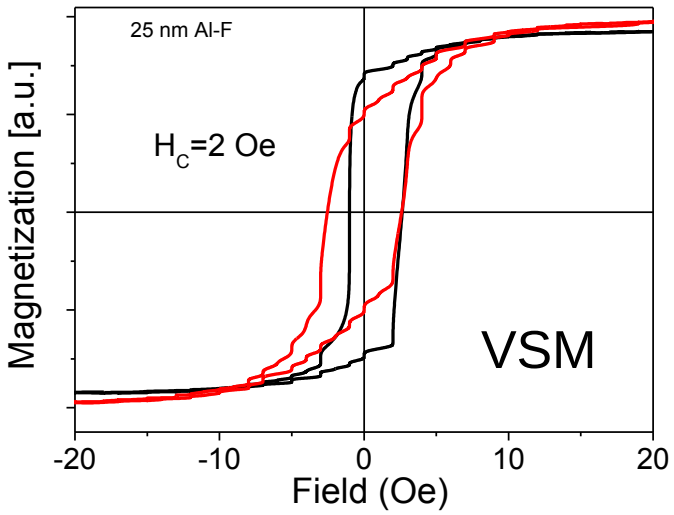
Al substituted Finemet

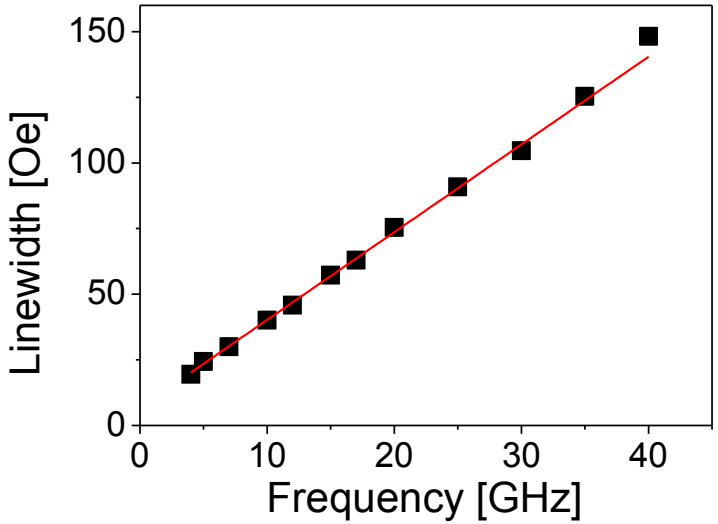
VNA-FMR measurements of Al-Finemet

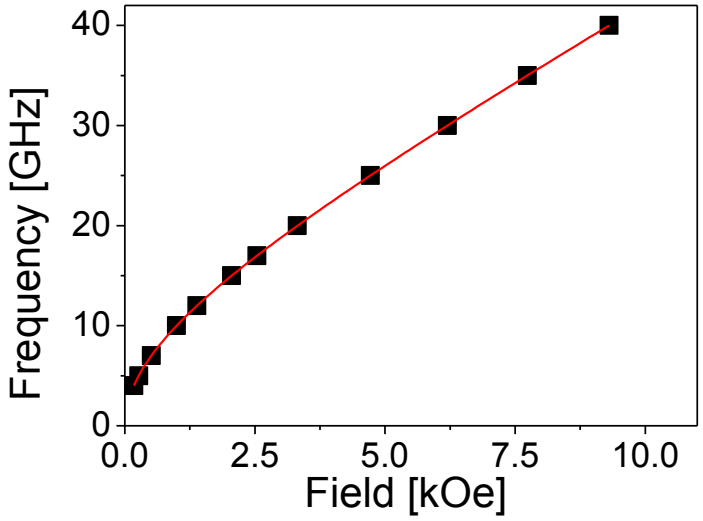
$g = 2.094$

$4\pi M_{eff} = 10.6$ kG

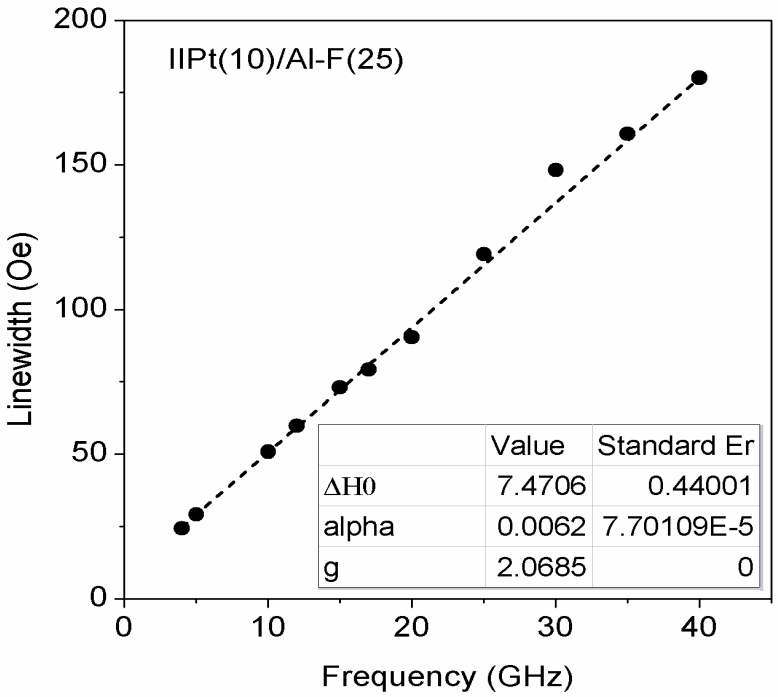
$\alpha = 0.0049$

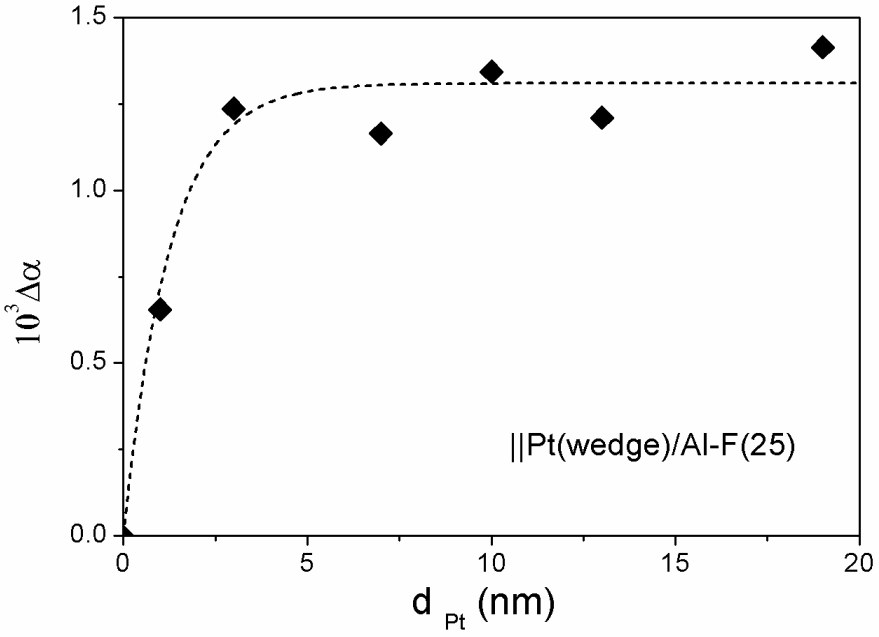






Spin pumping



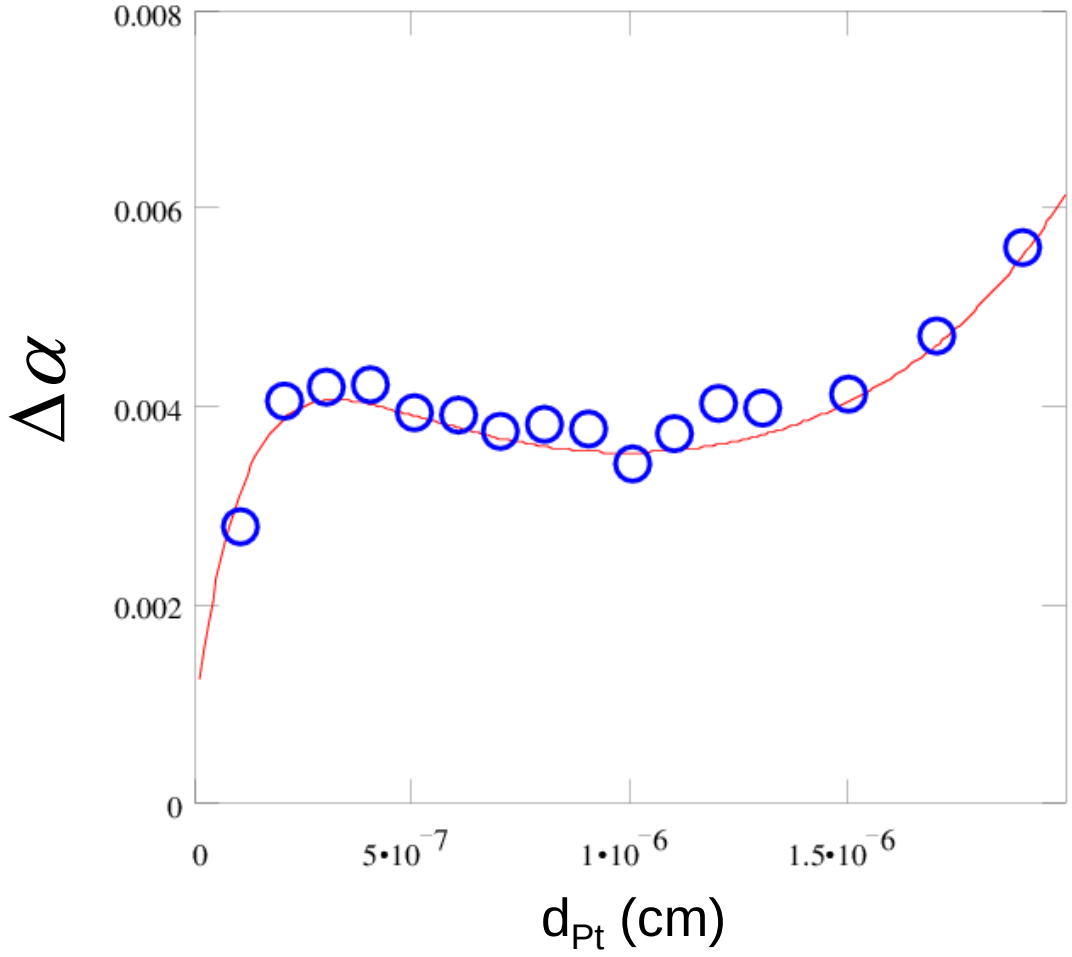


$$\Delta\alpha = g\mu_B \frac{g_{eff}^{\uparrow\downarrow}}{4\pi M_s t_{Al-F}} (1 - e^{\frac{-2t_{Pt}}{l_{sf}}})$$

$g^{\uparrow\downarrow}_{\text{eff}} \approx 17.0\ \text{nm}^{-2}$

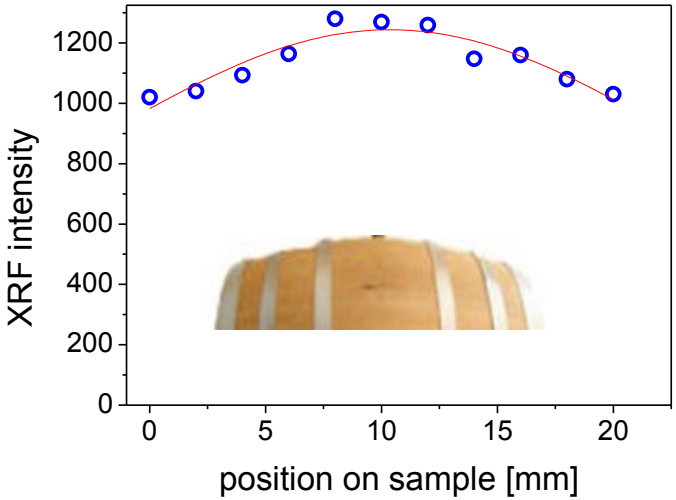
l_{sf} of 2.5 – 3.0 nm

After ion beam etching



$g^{\uparrow\downarrow}_{\text{eff}} = 1.7\times10^{15}\ \text{cm}^{-2}$

$l_{\text{sf}} = 3\ \text{nm}$

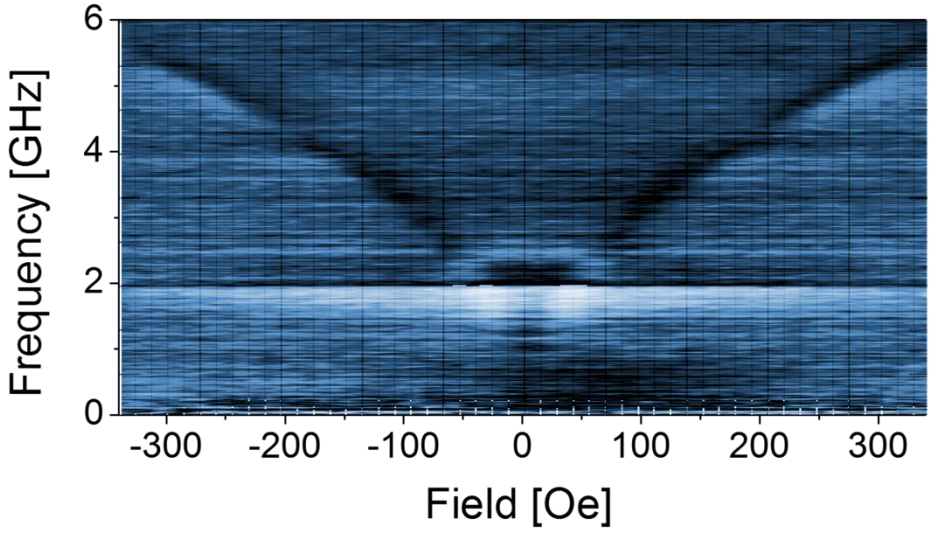


After ion etching sample's thickness is not homogenous

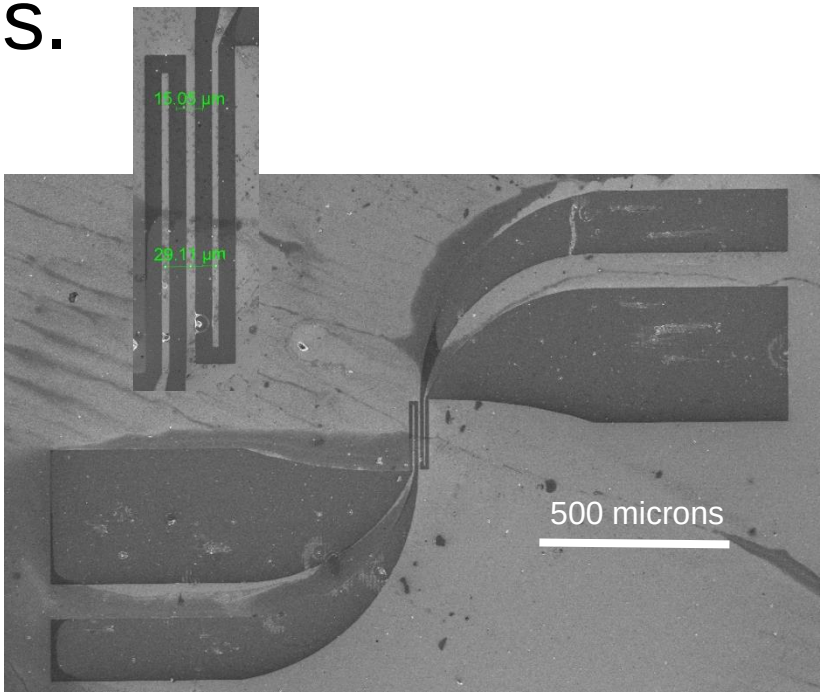
Propagation of magnons

- Magnon propagation in Al substituted Finemet is of 15 microns.

Measurement of S_{21}



VNA-FMR measurements



Summary

	Al-Finemet	CoFeB
α	0.0049	0.004
$4\pi M_{eff}$ [kG]	10	15
$g^{\uparrow\downarrow}_{\text{eff}}$ [cm^{-2}]	1.7×10^{15}	5.0×10^{15}
l_{sf} [nm]	2.5	3

- Ion beam etching doesn't change magnetic parameters of Al substituted Finemet
- Low damping allows magnon propagation in Al substituted Finemet for long distance in comparison to permalloy

D.-J. Kim et al. / Current Applied Physics 14 (2014) 1344, 1348

SWISS CONTRIBUTION

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Thank you for your attention!

AGH

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IFM PAN

This work has been carried out within Project No. NANOSPIN PSPB-045/2010 supported by a grant from Switzerland through the Swiss Contribution to the enlarged European Union.