Experimental verification of shielding effect in coplanar waveguide VNA-FMR experiments

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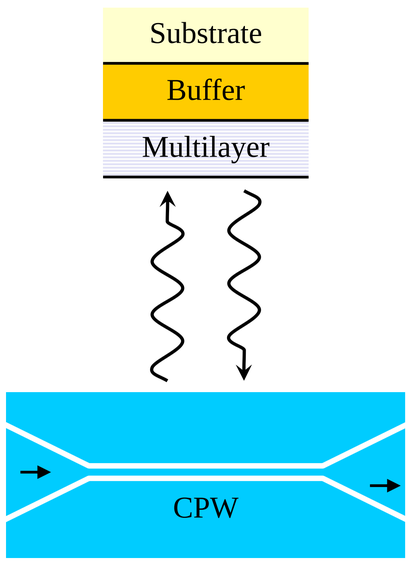
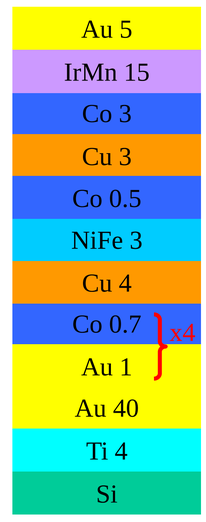
Introduction

Ferromagnetic resonance (FMR) based on VNA and CPW has become a common experimental tool for studying magnetization dynamic of magnetic films and nanostructures. Here we present a new effect of enhancement of the FMR absorption due to a conducting buffer layer, which acts as a shield for microwaves.



Experimental details

- The multilayer films were deposited in a Prevac sputtering system .
- FMR was measured with a Vector Network Analyzer (VNA) on a coplanar waveguide (CPW). Measurements were done at constant microwave frequency.
- The scattering matrix parameter $S_{21}$was measured in a field-sweep mode.



Results

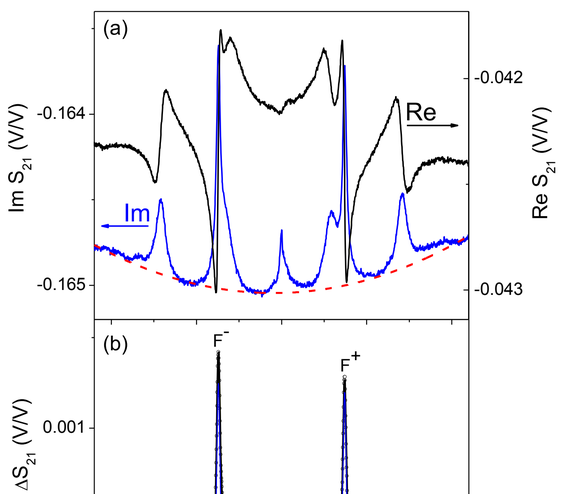
- S_{21} can be seperated into magnetic and nonmagnetic contributions assuming that a reflection of microwave power is weak in our VNA-FMR set-up [4].

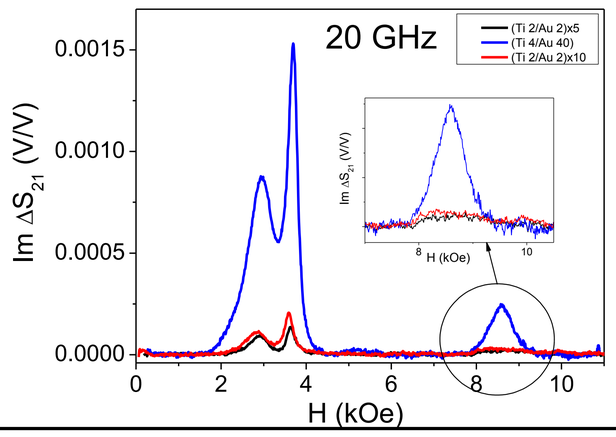
- The multilayer thin films comprise a [Au/Co]×4 perpendicular **polarizer**, an in-plane magnetized [Py/Co] **free layer** with Permalloy (Py), and an in-plane Co **analyzer** in contact with IrMn antiferromagnetic layer.

- Figure on the right shows microwave absorption for samples on different buffers, which have **different sheet resistance.**

$$S_{21}(H,t) \approx S_{21}^{0}(H,t) + \frac{\chi(H)}{\chi_0}$$

$$\chi(H) \approx \chi_0 \Delta S_{21}(H)$$



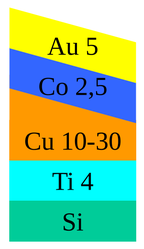


- Figure (a) shows the enhancement of the signal as a function of copper buffer.

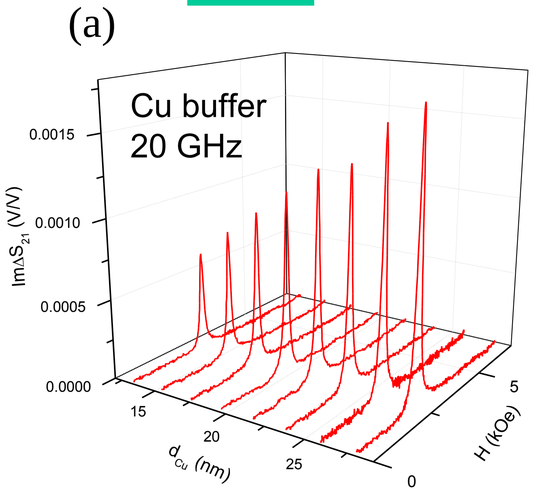
- Figure (b) shows the enhancement of the FMR absorption as a function of the thickness of Au buffer.

- Figure (c) shows that the FMR absorption intensity *I* is ∝exp(-1/buffer thickness) or ∝exp(-sheet resistance)

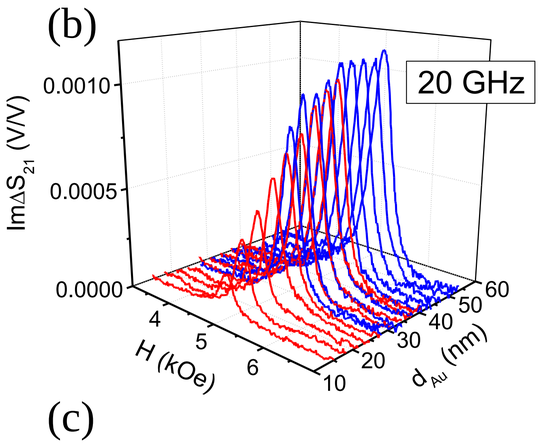
- S_{21} parameter can also be expressed as a function of thickness of conducting layer in proximity of CPW.



(a)



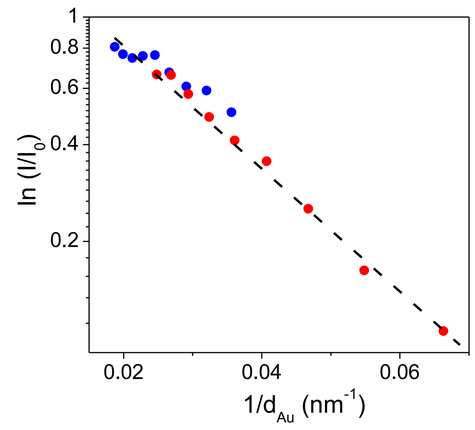
(b)

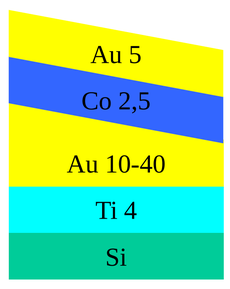


$$I \propto e^{-\frac{d_0}{d_{Au}}} = e^{-\frac{R}{R_0}}$$

$$\frac{S_{21}}{S_{21}^{0}} \propto \exp\left(-\frac{\frac{\gamma_0 \rho \delta^2}{2 Z_0 w}}{d}\right) \propto \exp\left(-\frac{d_0}{d}\right)$$

(c)





Summary

- We have shown that the intensity of FMR absorption in the single ultrathin Co layer measured with the use of coplanar waveguide (CPW) depends on the thickness *d* of the conducting Au buffer ∝exp($-d_0/d$) or, equivalently, on the buffer sheet resistance ∝exp($-R/R_0$).
- These findings are interpreted in terms of the microwave shielding effect by conducting films and an inhomogeneity of the dynamic magnetic field *h* related to the shielding [1-3]

References

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Acknowledgment

This work was supported by the Polish-Swiss Research Program NANOSPIN PSRP-045/2010