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Microssistemas e Nanotecnologias

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TÉCNICO LISBOA

Thin Film Deposition: Layer by Layer until the Sensor

2nd Cycle Integrated Project

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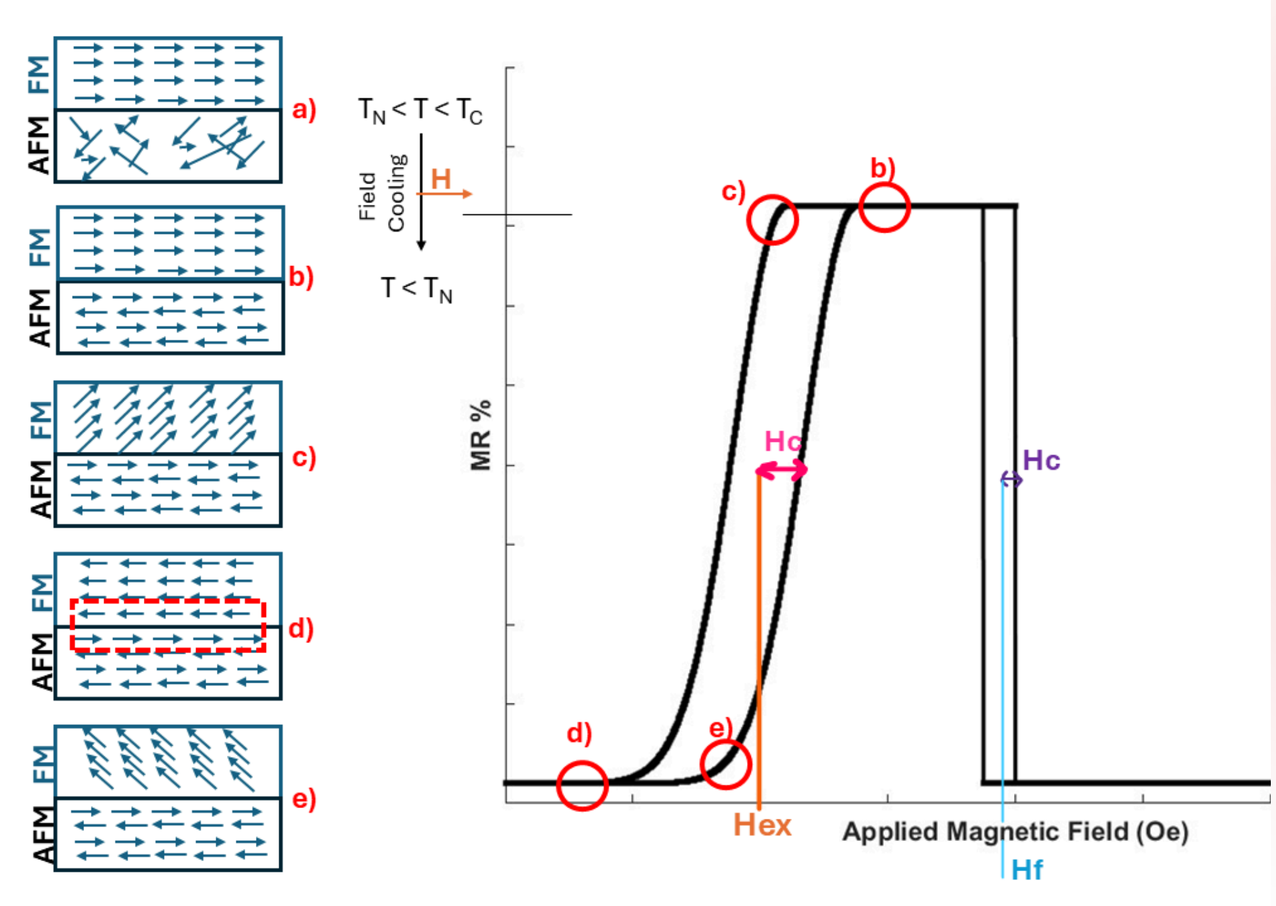
From the video...



Exchange Bias (Hex): This is the field that arises due to the coupling at the interface between a ferromagnetic (FM) layer and an antiferromagnetic (AFM) layer.

Ferromagnetic Coupling (Hf): This represents a shift in the sensor's response curve caused by the coupling between the free layer and the fixed layer, even though they are separated by a non-magnetic spacer.

Objetives

Optimize a spin valve structure to maximize the MR signal, changing only the thickness of each layer.

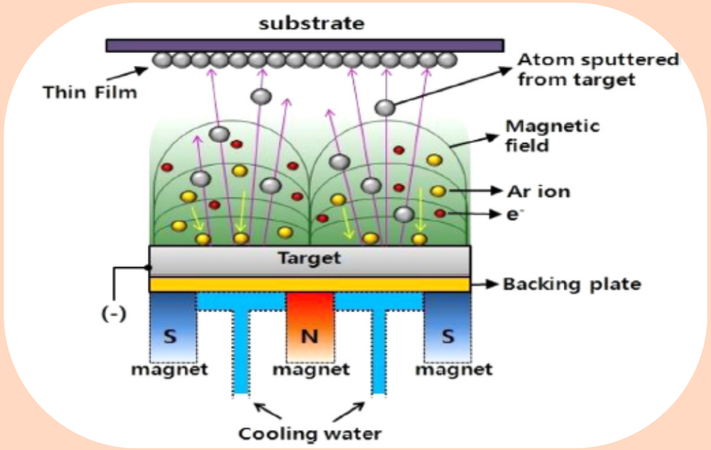
Final Goals

Hex > 400 Oe

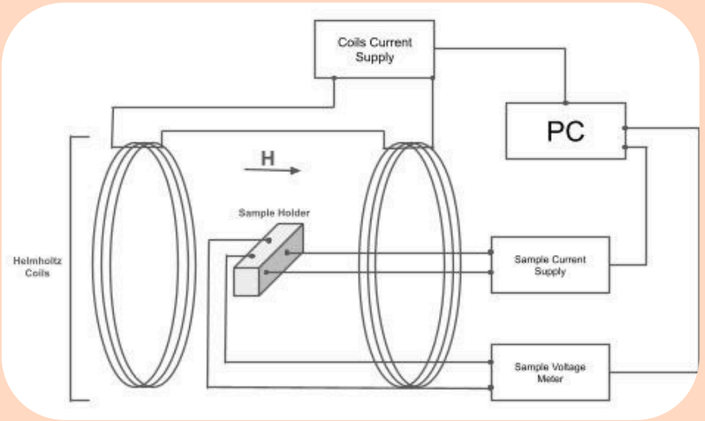
MR=10%

Hf < 10 Oe

Methodolody



Deposition:
Magnetron Sputtering using Nordiko 2000



Measurements:
Measure the resistance (R) as a function of the field (H) using the 400 Oe Setup

Magnetic Annealing:
Stabilize the performance of a spin valve

Preliminary Results

Initial Structure : MR=1.6%

Final Structure: MR=3.732%

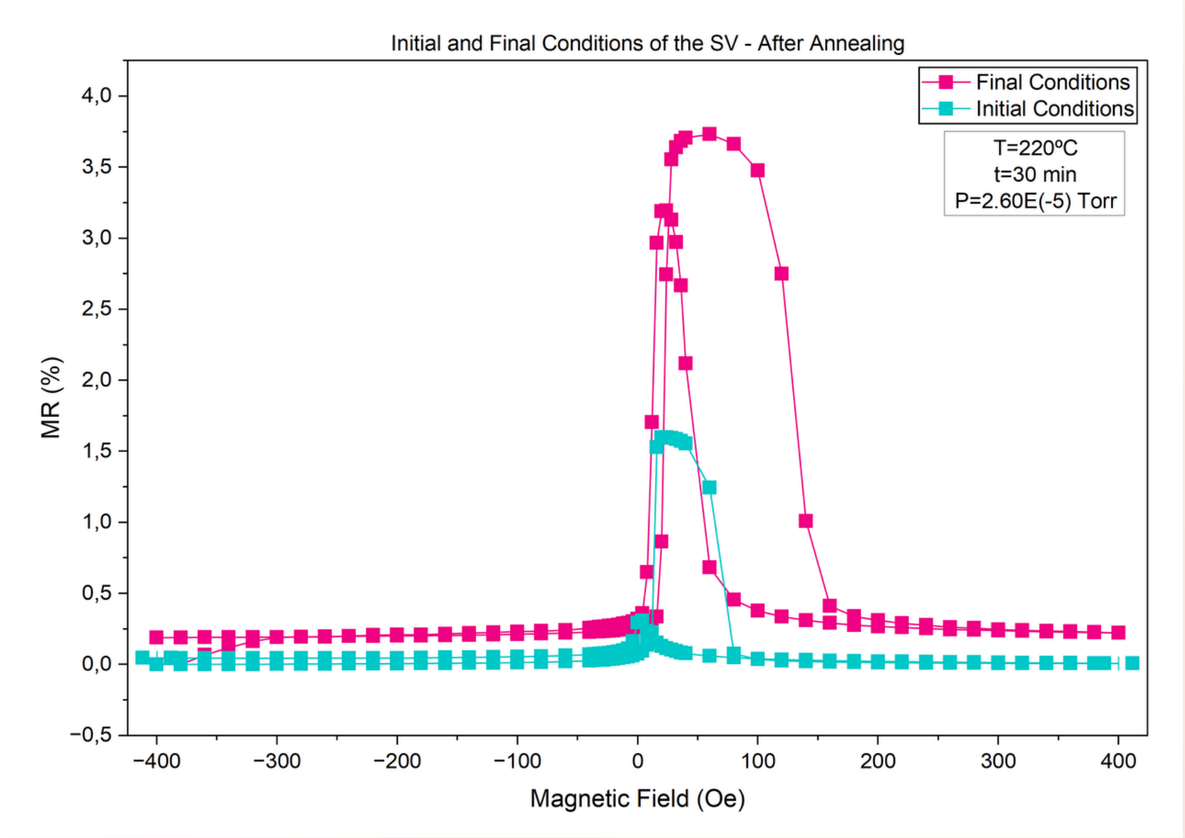
Hex=86.82 Oe

Hc (FL)=43.32 Oe

Hf=17.32 Oe

Hc (PL)=4.81 Oe

The MR signal doubled after optimizing each layer, demonstrating that this approach is a powerful tool for enhancing sensor performance.



Conclusions & Future Work

Conclusions

- Through systematic layer-by-layer optimization, the Magnetoresistance (MR) signal was increased from an initial 1.6% to a maximum of 3.732%.

- While progress was made, the results remained below the ideal goals (MR > 10% and Hex > 400 Oe), highlighting the challenges of achieving high-performance sensors under current conditions.

Future Work

- Intervention in the Nordiko 2000 to fix vacuum leaks, aiming for base decrease pressures to prevent material oxidation.

- Clean deposition slots and the chamber to eliminate contaminants that degrade thin-film interfaces.

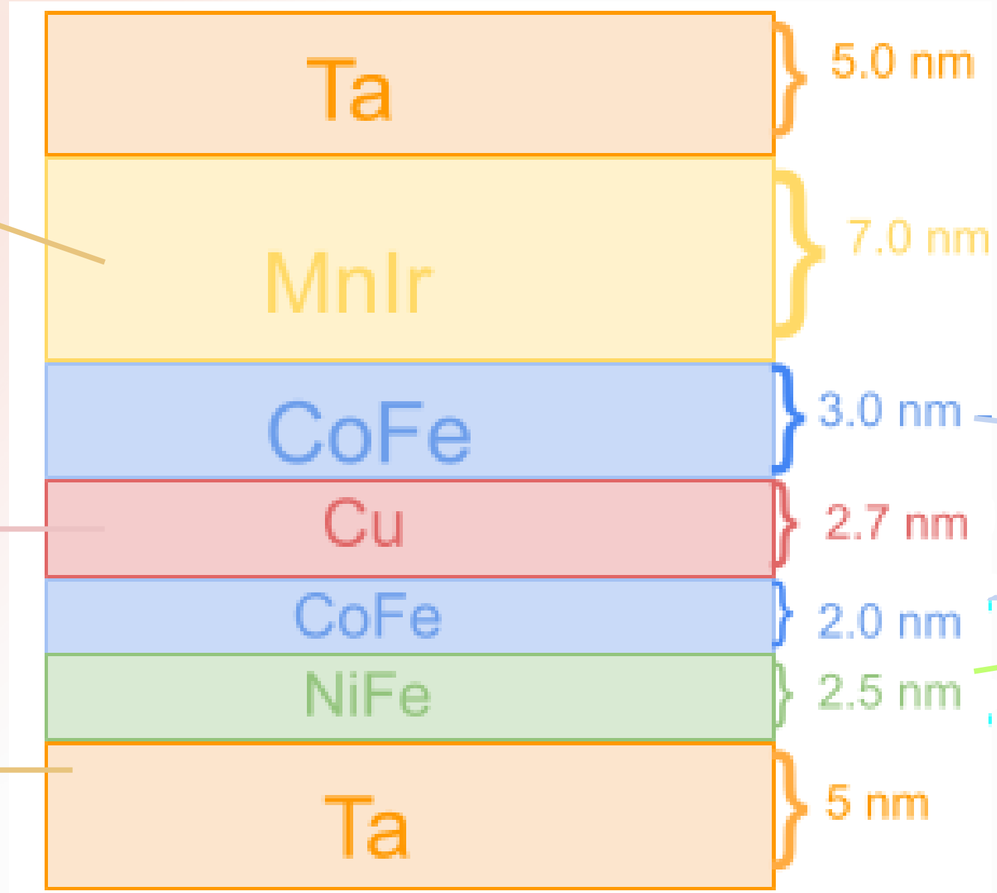
- Re-optimize the stack in a clean environment to reach the "Ideal Goal" of 10% MR and stable exchange bias (Hex > 400 Oe).

Thank You!

ANTIFERROMAGNETIC LAYER
It "pins" the magnetic orientation of the adjacent layer (Pinned Layer) through exchange coupling.

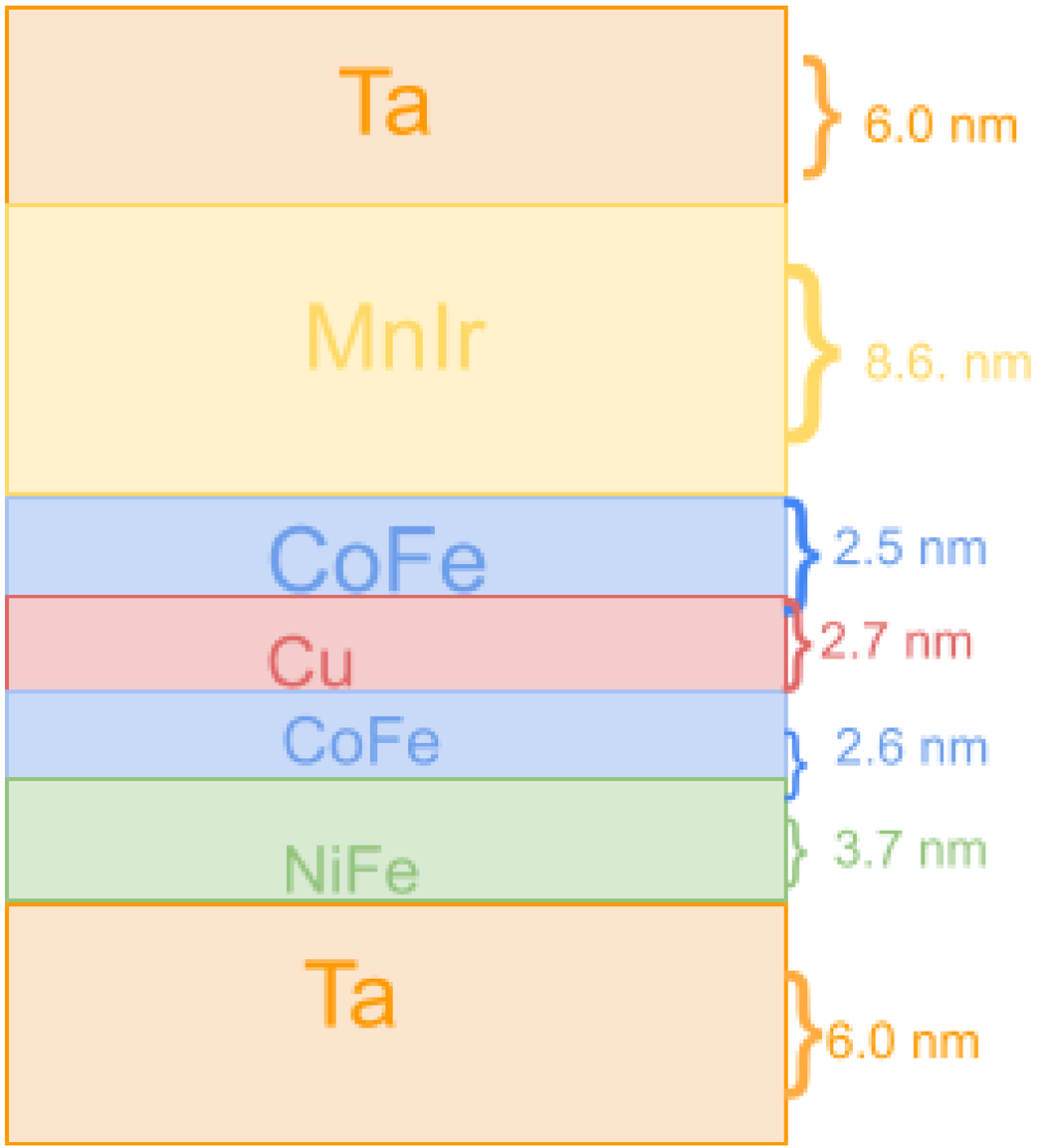
SPACER
A non-magnetic layer that magnetically decouples the fixed layer from the free layer, allowing their magnetizations to be controlled independently.

BUFFER
Prepare and stabilize the substrate surface



PINNED LAYER
Its magnetization has a fixed orientation, serving as a stable reference..

FREE LAYER
Its magnetization rotates freely in response to an external magnetic field.


Ta
6.0 nm
MnIr
8.6. nm
CoFe
2.5 nm
Cu
2.7 nm
CoFe
2.6 nm
NiFe
3.7 nm
Ta
6.0 nm

Future Work

Equipment Maintenance

Intervention in the NORDIKO 2000 vacuum system to reach lower pressures (< 1.5 E-6 Torr), cleaning of sample holders, and replacement of targets (CoFe, NiFe) to reduce contamination.

Process Optimization

Studying the impact of deposition conditions. Such as Argon flow, pressure, and applied potential to minimize interfacial roughness.

Structural Innovation

Exploring the addition of a Nano-Oxide Layer (NOL) to reflect conduction electrons and increase spin-dependent scattering, further boosting the MR signal.

Additional Studies

Evaluating the effect of the target-substrate distance and the application of a magnetic field during deposition to optimize anisotropy. Repeating the study for other magnetron sputtering machines or for other deposition methods.