Experimental report

03/04/2025

Proposal: 5-72-24 **Council:** 10/2023

Title: Spin depth profile and interlayer quality influence on the All-Optical Switching phenomena performance in Co/Pt multilayer thin films

Research area: Physics

This proposal is a new proposal

Main proposer: Aritz VILLAR

Experimental team: Daniel DOMENECH AZORIN
Aritz VILLAR

Local contacts: Alexei VOROBIEV
Anton DEVISHVILI

Samples: SiO2/Ta/Pt/Co/Pt/Co/Pt

Instrument	Requested days	Allocated days	From	To
D17	6	0		
SUPERADAM	0	8	25/03/2024	02/04/2024

Abstract:

The interaction between light and magnetism in magnetic metamaterials with ultrafast optical response could lead to novel magnetic memory devices. One of the promising candidates with such characteristics are Co/Pt multilayer thin films with perpendicular magnetic anisotropy (PMA) that exhibit an emerging phenomenon called All-Optical Switching (AOS). The AOS consists in the inversion of the magnetization induced by ultrafast laser pulses, where circularly polarized femtosecond laser pulses deterministically reverse the magnetic domains of magnetic thin films driven by the AOS phenomenon. The AOS behaviour is critically dependent on the growth conditions of the multilayers, as well as on and subtle variations in layer thickness, roughness and magnetic depth-profile, alongside with possible interlayer atomic diffusion events. Here we propose to carry out a polarized neutron reflectometry experiment to shed light on the widely discussed mechanism under AOS and optimizing the sample¿s parameters towards its usefulness in future technological devices.

EXPERIMENT: 5-72-24 **INSTRUMENTS:** SuperAdam

DATES OF EXPERIMENT: 25/03/2024 – 03/04/2024

TITLE: Influence of the spin depth profile and interlayer quality on the All-Optical Switching phenomena performance observed in Co/Pt multilayer thin films

REPORT: 01/04/2025

All-Optical Switching (AOS) is the deterministic reversal of magnetic domains by circularly polarized femtosecond laser pulses. Among the materials where this phenomenon can be observed we studied Co/Pt multilayer systems with perpendicular magnetic anisotropy. The magnetic properties, and therefore the final behaviour of this phenomenon, depends on various parameters of the system: stack repetition, thicknesses of the Co and Pt layers, layer roughness and possible interdiffusion events between layers.

In this work we aimed to study how those parameters impact the magnetic depth profile and understand the relation between the magnetic properties and the AOS phenomenon.

The samples characterized were Co/Pt multilayers with different Co and Pt thicknesses (from 0.5 nm to 2nm), different buffer layers (with and without tantalum buffer layer) and different repetition stack numbers (2 and 3 different repetitions). The total number of samples characterized was 11, all of them with perpendicular magnetic anisotropy.

The procedure for the characterization consisted in polarized neutron reflectometry applying two in-plane magnetic fields: low magnetic field for full polarized neutron reflectometry and high magnetic field for half polarized neutron reflectometry measurements. The field values for the low field was 50 Oe and 7000 Oe for the high field. At low field we perform full polarized neutron reflectometry to measure the in-plane magnetization and if there was spin-flipping signal in any of the samples measured. At high fields the external field strength is enough to pull all the magnetic moments parallel to the external field. This was necessary to measure the magnetic depth profile of magnetization which is out-of-plane at zero field, but also will vanish any spin-flipping signal, therefore it was not necessary to perform full polarization.

The program used for the analysis of the polarized neutron reflectometry data was BoToFit. We can obtain on the one hand the structural SLD of the samples, and on the other hand the magnetic SLD of the samples from measurements. In addition, we can compare the magnetic depth profile between low and high fields. As an example, in Fig. 1 we can observe the structural and magnetic SLD at high field of the sample Ta[5]/Pt[5]/Co[1]/Pt[2]/Co[1]/Pt[2], also known as TaCo1Pt2. The profiles show that the magnetization is strong around Co layers and the Pt layers next to them are partially magnetized.

The analysis of all the samples is quite challenging, and the work on the fittings is still ongoing.

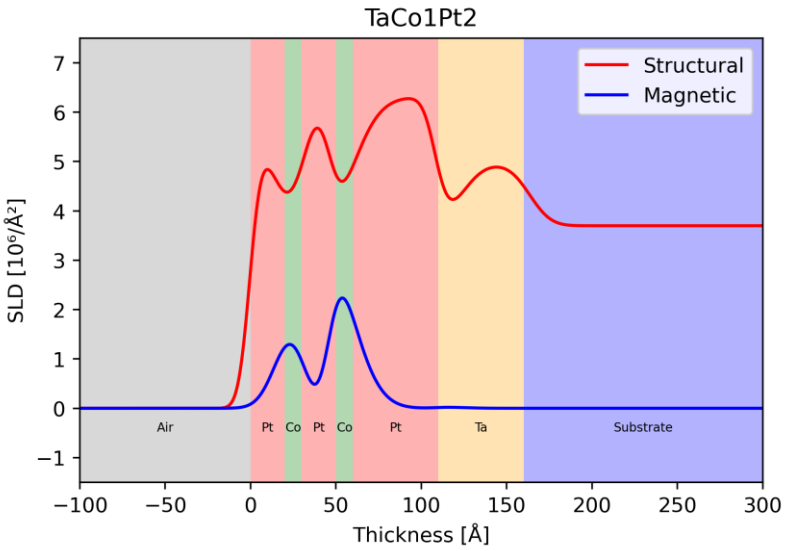

Fig. 1: SLD and mSLD profile of sample TaCo1Pt2.