ESRF	**Experiment title:** Spin depth profile of Pt on the antiskyrmionic Heusler compound PtMnSn investigated by x-ray resonant magnetic reflectivity	**Experiment number**: HC-3757
Beamline: BM28	**Date of experiment**: from:11 April 2018 to:17 April 2018	**Date of report**: April 06, 2020
Shifts: 18	**Local contact(s)**: Laurence Bouchenoire	*Received at ESRF:*

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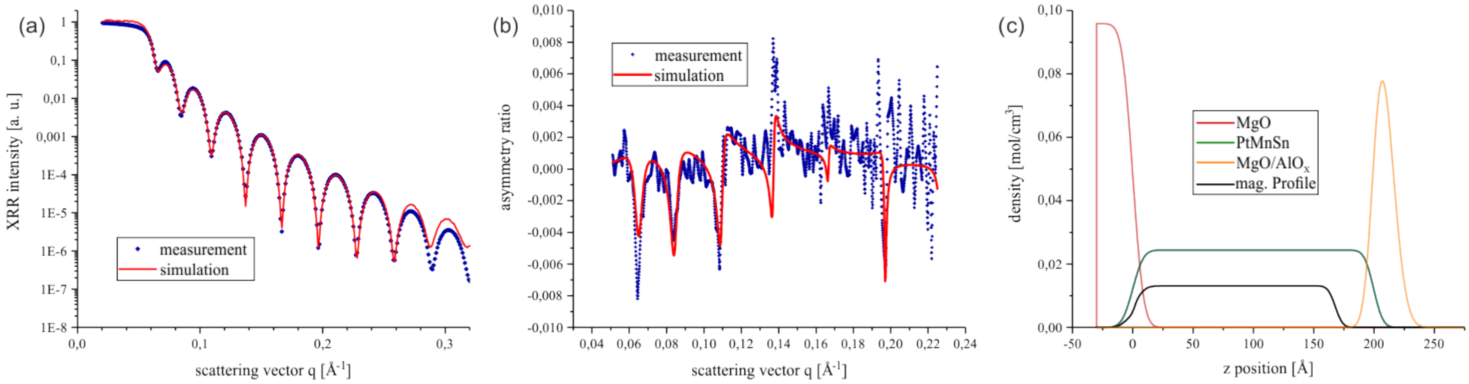
Report:

In our prior beamtime (HC-2861), we investigated the Pt magnetic depth profiles of the half Heusler compound PtMnSb by x-ray resonant magnetic reflectivity (XRMR) at BM28 [1-4] and found Pt magnetic dead layers when the Heusler is capped by an oxide material (MgO/AlO_x). The beamtime now (HC-3757) was dedicated to the investigation of the tetragonal Heusler compound PtMnSn, which is important for the creation of antiskyrmions, especially when being off-stoichiometric and doped with Pd [5].

We studied sputter-deposited PtMnSn thin films with oxide capping layer by XRMR at the Pt L_3 absorption edge (11.567keV) [6-10]. We obtained the Pt spin depth profiles and compared the results with the prior outcomes of PtMnSb thin films [4]. In both cases, we found indications of Pt magnetic dead layers if the films are capped by the oxide material.

Figure 1 presents the data set of a 20 nm PtMnSn film with a MgO/ AlO_x capping. The x-ray reflectivity (XRR) curve I in Fig. 1(a) has distinct interference oscillations (Kiessig fringes) which can be simulated by the recursive Parratt algorithm [12] obtaining thicknesses and roughnesses of the layer stack by, e.g., the element mode of the analysis program ReMagX [6]. The asymmetry ratio $\Delta I=(I_+-I_-)/(I_++I_-)$ in Fig. 1(b) with I_+ and I_- being the intensity for positive and negative magnetic field direction can be modelled using the depth profiles of the material's density together with the depth profile of the Pt magnetic change in absorption (cf. Fig. 1(c)).

Since the asymmetry ratio data of PtMnSn is much noisier compared to our PtMnSb asymmetry ratios, the results are not that distinct as for the analysis of our prior beamtime. The Pt magnetic dead layer in not the only reasonable magnetic depth profile describing the asymmetry ratio data reasonably well. Other possibilities such as a Pt magnetic dead layer at the substrate interface is also describing the asymmetry ratio data in a decent way. Here, we have to further improve our XRMR analysis and apply a technique of mapping the goodness of fit to analyse the parameter space and its nominal global and local minima in great detail. This analysis and comparison is still in progress and will be published in another manuscript [13].



Figur 1: (a) XRR intensity I of 20nm of PtMnSn with MgO/AlO_x capping layer (Pt L_3 edge at 11.567keV). (b) Asymmetry ratio ΔI and the corresponding simulation generated with the element mode of ReMagX. (c) Density depth profile of MgO, PtMnSn ad the capping material MgO/AlO_x. In addition, the magnetic depth profile of Pt is displayed.

Next steps will include the analysis of PtMnSn/Pt bilayers, since the magnetic depth profile of PtMnSb/Pt has no Pt magnetic dead layer, but instead provides magnetic Pt up to the interface of the Heusler and the Pt layer. First experiments in this direction with PtMnSn/Pt has been performed during the beamtime. However, the asymmetry ratios are even lower than for PtMnSn/MgO/AlO_x which makes it hard to get any reasonable result from the fittings.

In addition, we will study the magnetic depth profile of Mn in these samples and compare it to the magnetic Pt depth profile to discuss the influence of oxidation and magnetic dead layer of Mn on the magnetic depth profile of Pt. Therfore, we have already performed XRMR at soft x-ray energies at BL 4.0.2, ALS, and are currently in progress of processing and fitting the data.

Finally, we plan to apply for more beamtime at the tender x-ray range to study Pd magnetic depth profile effects in Pd based Heusler compounds (single proposal, Pd L_3 absorption edge at 3.173keV) and the general magnetism of Ru (long term proposal, Ru L_3 absorption edge at 2.838 keV)).

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