ESRF	**Experiment title:** Electric field-induced changes in the magnetic properties studied with element selectivity in doped semiconductors with lack of inversion symmetry	**Experiment number**: HC-3266
Beamline: ID 12	**Date of experiment**: from: 17.11.20/12.2.21 to: 20.11.20/14.2.21	**Date of report**: 01.08.2022
Shifts: 18	**Local contact(s)**: F. Wilhelm	*Received at ESRF:*

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Report:

The aim of the proposal was to study the incorporation of Mn in a series of topological insulators of $Bi_{2-x}Sb_xMnTe_4$, (214 compounds) with x ranging from 0 to 2, by x-ray linear dichroism (XLD) and to determine the associated magnetic properties using x-ray magnetic circular dichroism (XMCD) up to high magnetic fields. The samples were grown on two different substrates, $BaF_2(111)$ and $SrF_2(111)$, respectively. The latter did significantly reduce the background fluorescence mostly stemming from the Ba. Therefore, XMCD measurements were only possible and restricted to the Bi_2MnTe_4 and Sb_2MnTe_4 grown on $SrF_2(111)$. Figure 1 shows the concentration series of the 214 compound on $BaF_2(111)$ (top) and the comparison to a dilute sample (bottom) only highlighting subtle changes in the spectral shapes of XANES and XLD pointing towards a similar Mn incorporation in either sample. Only the Sb-214 compound shows an altered XLD.

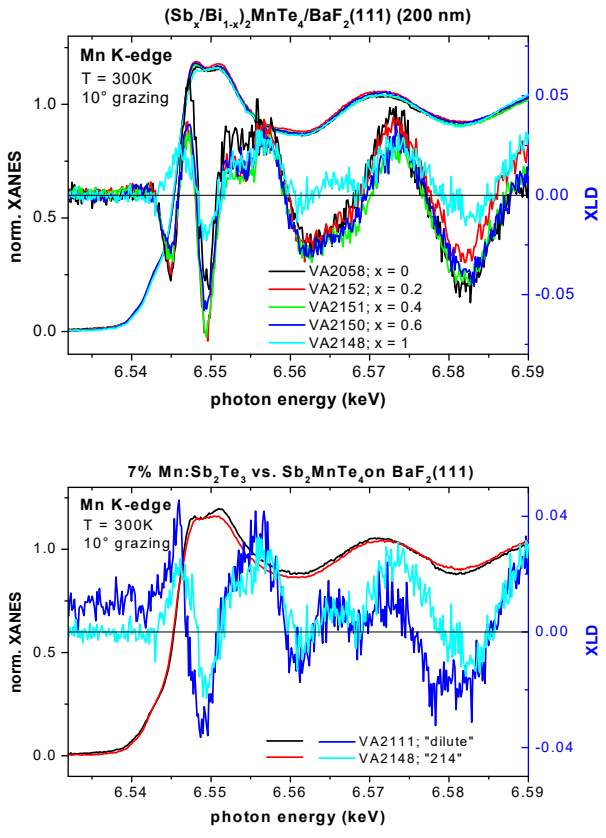

Figure 1: XANES/XLD at the Mn K-edge for the concentration series on BaF_2 (top). Comparison between 7% Mn in Sb_2Te_3 versus the 214 compound (bottom)s.

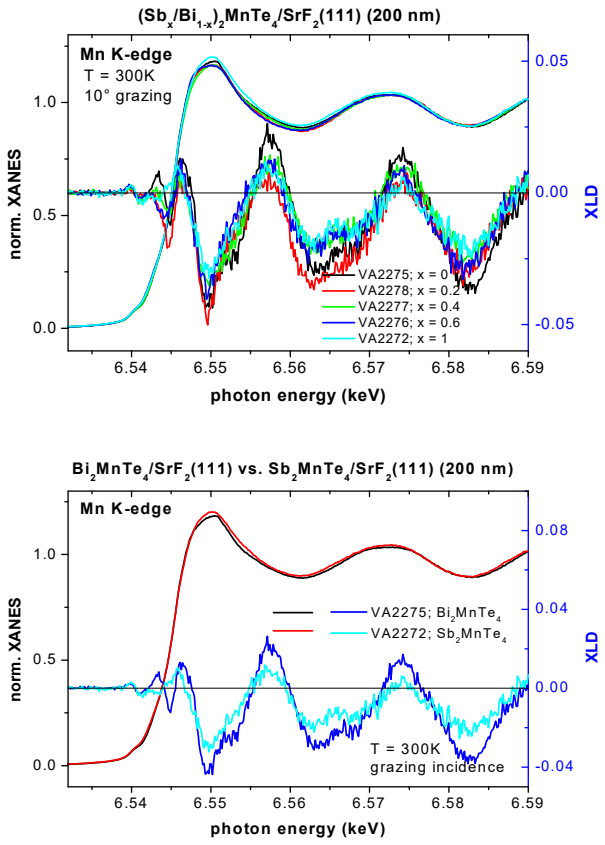

Figure 2: XANES/XLD at the Mn K-edge for the concentration series on SrF_2 (top). Comparison of the two 214 compounds on the two substrates.

Figure 2 shows the concentrations series of the 214 compound grown on $SrF_2(111)$ (top) and the comparison between Sb_2MnTe_4 grown on $BaF_2(111)$ and $SrF_2(111)$, respectively. The apparent difference between the two substrates is the loss of the double peak structure at the Mn K-edge XANES while the changes in the XLD are rather minor (with the exception of the Sb_2MnTe_4). Unfortunately, the beamtime was carries out remotely in two parts and the XANES and XLD was done in the second step. Therefore, the samples selected for the XMCD were the ones with the most obvious changes in the XANES/XLD. It is thus difficult to say, whethere these observations are general to the concentration series or a speciality of the two end-components of the 214 concentration series.

Figure 3 shows the XMCD spectra of the Bi_2MnTe_4 grown on $SrF_2(111)$ recorded at 17 T under grazing and normal incidence (top) proving the latter to be the easy axis of magnetization in accordance with SQUID measutrements. The XMCD(H) could only be recorded under grazing incidence due to too many disturbancies because of the frequent injections of the new EBS. This also explains the extremely high noise level of the XMCD(H) curves which only indicate magnetic saturation starting from ~5T. Figure 4 shows the XMCD spectra of the Sb_2MnTe_4 grown on $SrF_2(111)$ recorded at 5 T and 17 T under grazing incidence (top). XMCD under normal incidence was too noisy to be meaningful (not shown). The XMCD(H) curve under grazing incidence (bottom) shows the onset of a spin-flop transition at around 15-16 T which is corroborated by the two different amplitudes of the XMCD at 17 T and 5 T, respectively. However, since not more than 17 T could be reached, it is difficult to compare these findings with the known spinflop transition of bulk samples because it cannot be seen from the data if the spinflop transition is fully completed at 17 T or if it would extent to even higher fields.

In summary, this beamtime under remote access conditions was not very successful since the magnetic properties could not reveal new insights beyond what was already known. The noise level was rather high, and in particular the new operation mode with the frequent injections render a proper measurement of XMCD(H) curves virtually impossible. Obviously the beamposition in the ring is not stable so that mostly distorted curves are recorded. Unfortunately, also the concentration series of the 214 compound did not reveal any significant changes of the Mn incorporation by means of XANES/XLD on either substrate with the exception of the Sb_2MnTe_4 where it however remains unclear, whether this is a sample issue or system or a specificity of this 214 end compound.

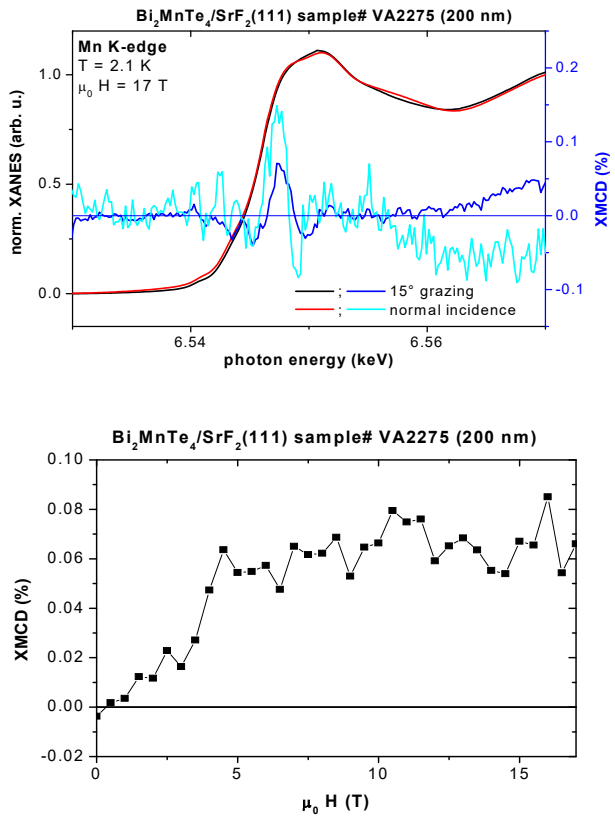

Figure 3: XANES, XMCD of the Bi_2MnTe_4 grown on SrF2(111)at 2K and 17T and 5 T (top) and the XMCD(H) curve recorded at the main-edge under grazing incidence (bottom).

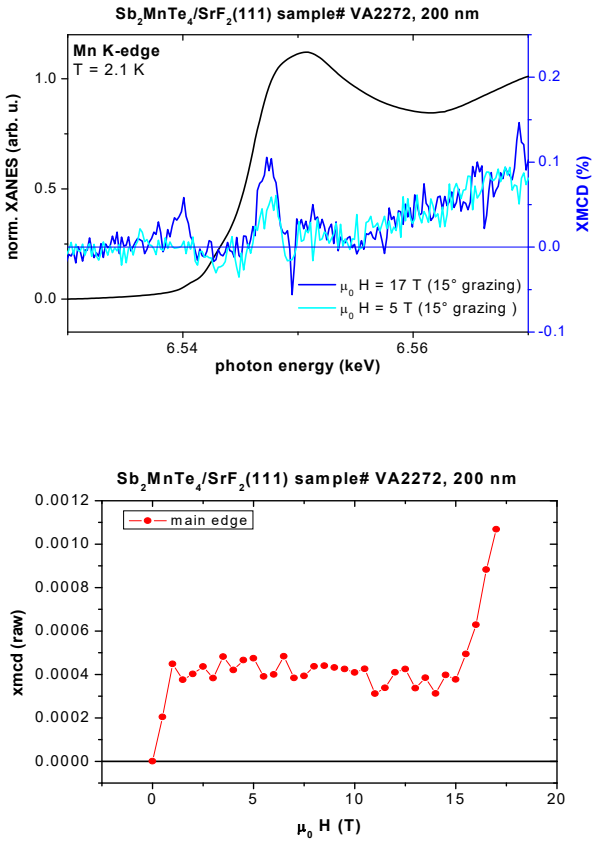

Figure 4: XANES, XMCD of the Sb_2MnTe_4 grown on SrF2(111)at 2K and 17T and 5 T (top) and the XMCD(H) curve recorded at the main-edge (bottom).