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XMCD studies of the shape anisotropy of the MnSb inclusions formed in GaSb matrix

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Despite of the intensive search for the proper semiconductor base materials for spintronics no appropriate material was proposed so far. In a single phase material, either ferromagnetism is observed below room temperature only [1] or there is no ferromagnetism at all (e.g. GaMnN). [2] On the other hand, it was demonstrated that during growth of the magnetic III-V semiconductors, precipitates are fairly easily produced, yielding multiphase ferromagnetic materials (often at room temperature). [2] Recently the increase of interest in producing ferromagnetic precipitates can be observed. [3, 4] It seems that magnetic properties of MnSb are more suitable for spintronic applications, than these of MnAs, since T_C of bulk MnSb is much higher - above 300°C.

The investigated GaSb:MnSb layers were grown on the GaSb(100) and GaAs(111)A substrates using the MBE technology. The layers on both substrates were grown in the same process in order to investigate how the type of substrate influences the dots' formation. First, the GaSb buffer of 40-45 nm was grown and then the GaMnSb layer. The samples were grown at 450°C with different nominal Mn content, here we focus on the samples with 3% of Mn. The MnSb hexagonal inclusions were formed directly during the epitaxial growth procedure without the post growth annealing. The detailed analysis of the structure of the dots by means of EXAFS and SEM is provided in reference 5.

The X-ray Magnetic Circular Dichroism (XMCD) experiment was performed at the beamline ID08. X-ray absorption spectra were collected in the Total Electron Yield (TEY) and Total Fluorescence Yield (TFY) modes simultaneously. The measurements were conducted at temperatures of 3 and 300 K, on the remanently magnetized samples as well as on the samples under the magnetic field of 5 T. The magnetic field used to magnetize samples was oriented along the X-ray path, the angle between the sample surface and the X-ray beam was being changed from grazing (70°) to normal (10°).

Let's focus on the spectra gathered at room temperature. While the X-ray absorption spectra look quite similar for both detection modes, the XMCD signals differ very significantly. In case of the samples measured under the field, the TFY XMCD signal is considerably stronger than the TEY XMCD one (see Figure 1). What's more the TEY XMCD signal shows structure which is not repeated in the TFY signal. In case of the measurements carried out in remanence the TEY XMCD signal cannot be detected.

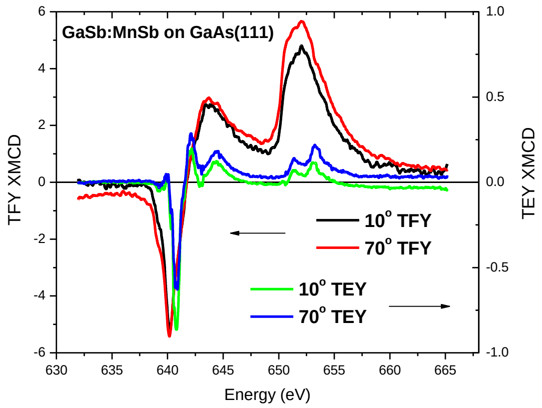

Figure 1: The XMCD signals on the Mn $L_{3,2}$ edges measured on the GaSb:MnSb/GaAs(111) sample under the magnetic field of 5 T. The signal was gathered at room temperature in TFY and TEY modes with X-ray beam at 10° and 70°.

The investigation on the TFY XMCD signal for the remanently magnetized samples revealed that the strength of that signal shows the angular dependence which is presented in Figures 2 and 3. Moreover, the tendency is opposite for both substrates suggesting the presence of the differences in the direction of the easy magnetization axis. This is in agreement with the behavior observed in the previous investigations. [6]

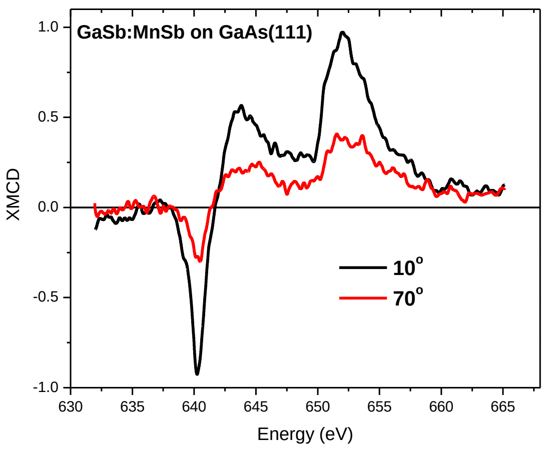

Figure 2: The XMCD signals on the Mn $L_{3,2}$ edges measured on the GaSb:MnSb/GaAs(111) sample. The signal was gathered at room temperature in TFY mode with X-ray beam at 10° and 70°.

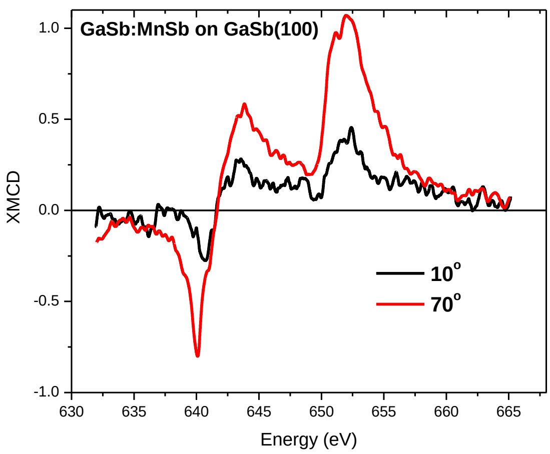

Figure 3: The XMCD signals on the Mn $L_{3,2}$ edges measured on the GaSb:MnSb/GaSb(100) sample. The signal was gathered at room temperature in TFY mode with X-ray beam at 10° and 70°.

In summary, the GaSb:MnSb layers grown on the GaSb(100) and GaAs(111)A substrates exhibit the dichroic signal at room temperature which shows the angular dependence opposite for both substrates. It appears that the direction of the easy axis can be controled by proper choice of the substrate and growth conditions. The dependence of the orbital and spin magnetic moment on the magnetic field and size of the inclusion was also studied and is under analysis.

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