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THE SHAPE ANISOTROPY OF THE MnSb INCLUSIONS FORMED IN GaSb MATRIX AS PROBED BY XMCD

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The formation of the inclusions inside of the matrix leads to the breaking of the symmetry and bonding at the interface between the matrix and inclusions. Magnetized grains produce magnetic charges or poles at the surface. This surface charge distribution, is itself another source of a magnetic field, which acts in opposition to the magnetization and is called the demagnetizing field. The resulted magnetization depends on the inclusions shape and exhibits the shape anisotropy. *E.g.* in the case of inclusions with the shape of a long thin needle the demagnetizing field is smaller if the magnetization is along the long axis than if it is along one of the short axes. This can produce an easy axis of magnetization along the long axis. A sphere, on the other hand, has no shape anisotropy. For the grain, smaller than about 20 microns, shape anisotropy is the dominant form of magnetic anisotropy. In larger sized particles, shape anisotropy is less important than magnetocrystalline anisotropy which is an intrinsic property of a ferrimagnet and is independent of grain size and shape. The anisotropy effects can be studied by X-ray magnetic circular dichroism (XMCD) technique [1]. The XMCD possess several advantages over the traditional magnetic techniques. The most important is the element specific, quantitative separation and determination of spin and orbital magnetic moment. Moreover, in the well oriented samples by changing the angle between magnetic field, circularly polarized X-ray and sample the anisotropy of spin and orbital magnetic moments can be studied. This possibility was first suggested by Bruno [2] in the case of transition metal thin films.

Usually it is implicitly assumed that the dichroism intensities do not depend on the sample orientation relative to the X-ray wave vector or polarization. This is rather good approximation for material which have high symmetry lattices (fcc, bcc or hcp) and hence the bonding and charge distribution is rather isotropic. Nevertheless, this assumption does not hold for the thin l ayers or nanostructures with the different dimensions in the in-plane and out-of-plane axis.

In the presented paper we demonstrate the first attempt to measure the anisotropy effects in the samples with MnSb hexagonal inclusions formed inside the GaSb matrix and in MnSb thick layers grown on GaAs substrates oriented into two crystallographic directions (111)B and (100).

The samples were characterized by several methods. The morphology of surface was studied by AFM and MFM and it was shown that inclusions ferromagnetic at the room temperature with in plain dimensions from 200 to 500 nm and height up to 70 nm were formed. The example of the surface morphology in the studied samples is shown in Fig. 1. The SQUID measurement showed the ferromagnetic behavior of the investigated samples starting from the helium temperatures till the RT, see Fig. 2.

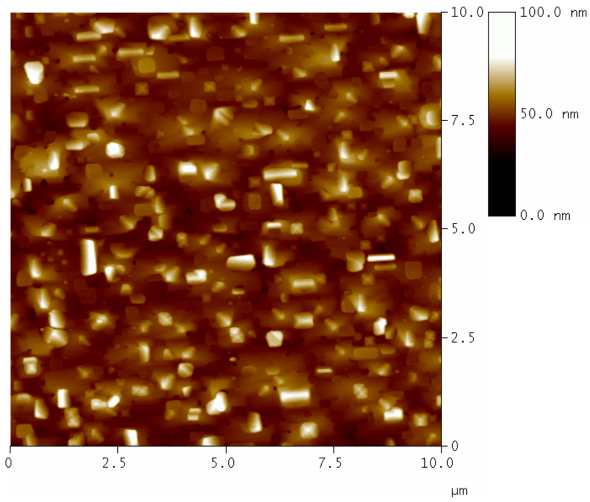

Figure 1. The example of surface morphology measured by AFM for HT5 sample.

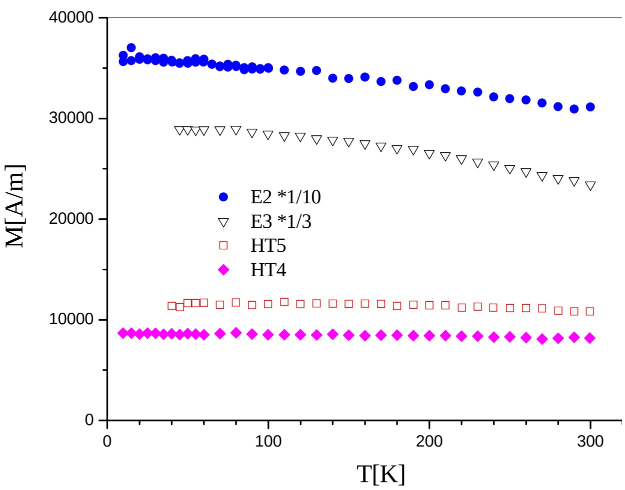

Figure 2. The temperature dependence of the magnetisation in the samples E2 and E3 grown on the GaAs(111) substrate and HT4 and HT5 grown on GaSb substrate. The magnetic field was in plane of samples. E2, E3 and HT4 were measured under the field of 0.33 T and HT5 under 0.05 T.

The EXAFS studies confirmed that all Mn atoms in these samples are located in the MnSb hexagonal inclusions. The XMCD of the samples was measured at the MAXLAB, Lund University at the D1011 and I1011 stations. The XMCD spectra were recorded in remanence after pulse magnetization by 0.035 T external magnetic field, oriented parallel to the X-ray propagation in the total electron yield mode and at liquid nitrogen temperature.

The measurements were performed at several angles with respect to the surface normal of the sample. The example of the XMCD signal for thick MnSb layer as measured at 45 and 10 degree in respect to the sample surface is shown in Fig. 3.

The XMCD was strongly dependent on the angle of measurement in thick MnSb layers as well as in the case of MnSb inclusions. Moreover, it depends on the morphology of formed inclusions which in turn depends on the substrate and growth conditions.

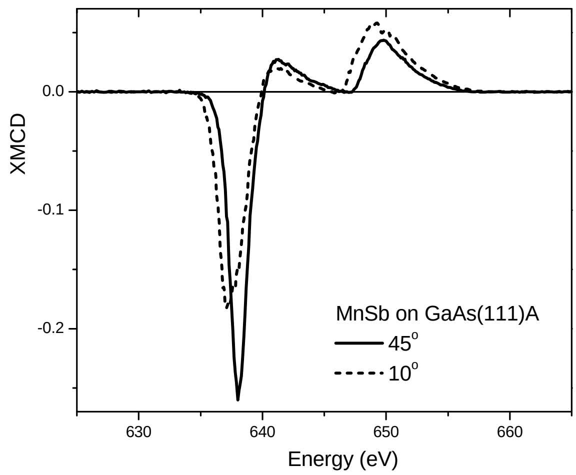

Figure 3. The XMCD signal for MnSb thick layer measured at LN for 45 and 10 degree in respect to the sample surface.

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