PhD THESIS. SUMMARY

Influence of External Hydrostatic Pressure and Epitaxial Strain on Magnetic and Transport Properties of Thin GaMnAs Films

(Ga,Mn)As is a diluted magnetic semiconductor, which is considered as material for possible spintronics applications. However, in spite of many experimental and theoretical papers, there are still a lot of open questions. Its why new experimental data are necessarily.

In this PhD thesis study of series of $Ga_{1-x}Mn_xAs$ samples with manganese content $x \approx$ 6-7 % was performed. Samples, grown by low-temperature Molecular Beam Epitaxy, were prepared on GaAs or on $Ga_{1-y}In_yAs$ buffer with different indium content (y = 12 – 30%). Magnetic and magnetotransport properties like anisotropy and paramagnetic-ferromagnetic phase transition temperature (T_C) were investigated.

The results of the measurements of resistivity and magnetization as a function of external magnetic field are presented. The analysis of the data allowed to find the anisotropy parameters (in-plane and out-of-plane one) and their changes as a function of temperature. Experimental data were analyzed theoretically by means of the upgraded Stoner-Wolfarth model.

Results obtained for samples with high epitaxial strain (grown on $Ga_{0.7}In_{0.3}As$ buffer with very high indium content) are especially interesting. The buffer provided a 2% lattice mismatch, which is an important extension to mismatch ranges studied up to now. The resulting anisotropy fields is very high in this case and reaches 2 T.

For GaMnAs sample without buffer nonmonotonic relation between anisotropy field and temperature was observed.

The main part of the thesis consists of magnetotransport investigation of GaMnAs under hydrostatic pressure. Two samples with GaInAs buffer were studied in details. For both an increase of critical temperature (T_C) of about 2 K per 1 GPa was observed. Moreover, there is trend that the higher the T_C under normal condition, the bigger increase of T_C triggered by pressure. In order to determine T_C four different methods were used. The comparison of the results obtained by all is performed, leading to a conclusion that a method basing on derivative of resistivity versus temperature is not universal.

The in-plane and out-of-plane anisotropy parameters were determined as a function of hydrostatic pressure for two samples with different epitaxial strain: one with magnetic easy axis perpendicular to the sample plane and the other with easy axis parallel to the plane. Application of external hydrostatic pressure increased anisotropy parameters by about 10% ±5% per 1 GPa for both samples. The anisotropy investigations of GaMnAs under hydrostatic pressure have never been done before.

Measurements of resistance as a function of magnetic field revealed anomalies with a complex magnetic field dependence, for example a narrow maximum accompanied by side minima or several maxima. As shown by means of computer simulations of a current flow and potential distribution in the sample, those anomalies can be ascribed to magnetization switching. Finite elements method was used assuming a complex magnetic domain structure. The specific shape of the domain structure, allows to obtain a correct description of the complex shape of the anomalies. The implemented algorithm can be used to numerically address problems of magnetotransport properties of inhomogenous samples.

To sum up, new, experimental data were obtained. T_C and magnetic anisotropy investigations under pressure is an original contribution to the current experimental knowledge of the GaMnAs layers. Possibly, it will help to understand diluted magnetic semiconductor properties and to verify the underlying theories.

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