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XAFS investigations of local structural changes in (Ga,Mn)As thin layers at low temperature postgrowth annealing

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One of the most pressing problems of spintronics is to find new materials with properties combining both ferromagnets and semiconductors. Such magnetic semiconductors can be produced by deliberate doping of a given semiconductor with atoms of a magnetic material, such as Mn. The most studied material among these dilute magnetic semiconductors (DMS) is (Ga, Mn) As, and with the optimized MBE growth and post-growth annealing procedures nowadays (Ga, Mn) As layers have T_C as high as about 200 K. This is remarkably high as for DMS, but still too low in view of potential application in spintronics devices. Theoretically, up to now there is no universal model which adequately describes in details the processes of ferromagnetic ordering in the DMS. The most common theory is Ruderman-Kittel-Kasuya-Yosida (RKKY) model, in which the ferromagnetic ordering of the localized spins occurs through the exchange interaction with the gas of free carriers (valence-band holes in the case of (Ga, Mn) As), has its own limitations predicting not always experimentally observed increase of the Curie temperature (T_C) with increasing concentration of impurities. Further studies **not only** of the influence of microstructure and its inhomogeneities upon material's properties **but also** of *dynamical processes* (as well as formation and migration of point defects) taken place in microstructure evolution of (Ga, Mn) As during growth and postgrowth annealing should lead to an improved understanding of the whole picture and could potentially lead to further progress in T_C increasing of (Ga, Mn) As.

The project's goal was to check the effectiveness of EXAFS (extended x-ray absorption fine structure) as a probe of *local dynamics* and thermally activated decomposition of DMS, namely, (Ga, Mn) As after post growth annealing (up to about 600 ^{o}C). In order to determine the local atomic structure around Mn atoms we analyzed the XAFS (X-ray absorption fine structure) spectra at the K-edges of Mn for investigated samples. The samples devoted for the XAFS measurements were grown at MAXLab MBE system, by Dr Janusz Sadowski. After growth the samples were subsequently annealed at the temperatures 200, 300, 400, 500 and 600°C, respectively. The measurements were done at the I811 beamline of MaxLab II. The x-ray beam was monochromatized by two parallel silicon crystals with flat reflecting (111) faces, detuned to reduce the harmonics influence. The beam intensity was measured before the sample by argon-filled ionization chamber. Total fluorescence signal from the sample was gathered by Vortex silicon-drift detector. The measurements were done at liquid nitrogen (LN) to reduce thermal vibration of atoms.

Obtained X-ray absorption fine structure (XAFS) data along with X-ray diffraction (XRD) and Energy-dispersive X-ray spectroscopy (EDX) results will be presented and discussed in details.

[1] J.Sadowski and J. Z. Domagala, chapter 2 in *Advanced Functional Materials: A perspective from theory to experiment.* Edited by B. Sanyal and O. Eriksson. (Elsevier, 2012)