EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Minority sites of Mn impurities in ZnO and GaN	**Experiment number**: 26-01 959
Beamline: BM26A	**Date of experiment**: from: 30 April 2013 to: 04 May 2013	**Date of report**: 23 Aug. 2014
Shifts: 12	**Local contact(s)**: Dipanjan Banerjee, Sergey Nikitenko	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

*Dr. Lino miguel da Costa Pereira (KU Leuven)
Dr. Sebastien Couet (KU Leuven)
Dr. Claudia Fleischmann (KU Leuven)
Dr. Stefan Decoster (KU Leuven)
Prof. dr. Kristiaan Temst (KU Leuven)
Prof. André Vantomme (KU Leuven)
Prof. dr. Margriet Van bael (KU Leuven)
* Kelly Houben (KU Leuven) – experimentalist, not applicant
* Sergio Miranda (KU Leuven) – experimentalist, not applicant
* Ligia Amorim (KU Leuven) – experimentalist, not applicant

Goal:

These experiments were aimed to study the effect of local structure on the ferromagnetic behavior of model dilute magnetic semiconductors, and how it all depends on thermal annealing temperature.

Samples:

The samples consisted of Mn-doped GaAs thin films grown by molecular beam epitaxy (MBE) with different Mn concentrations (1% and 5% Mn). The 1% Mn samples consisted of a (Ga,Mn)As film with a thickness of 1500 nm grown on a GaAs substrate. The 5% samples consisted of a (Ga,Mn)As film with a thickness of 200 nm, grown on a 200 nm AlAs buffer layer, grown on a GaAs substrate. For each concentration we kept one as-grown sample and subjected three others to thermal annealing at 200°C and 300°C for 100 hours in air, and at 600°C for 10 minutes in vacuum.

Results:

Figures 1 and 2 compile the results of the EXAFS measurements performed within this experiment. Figures 3 and 4 show selected data of complementary SR-XRD measurements performed at the BM20 (ROBL) beam line at ESRF. Combining these two sets of data, as well as extensive magnetic characterization (not shown) we were able to correlate different magnetic regimes with the respective local structure originating them: low and high T_C ferromagnetism in the dilute Mn regime (with varying concentration of self-compensating interstitial Mn), non-magnetic states for disordered Mn-rich precipitates at intermediate annealing temperatures, and superparamagnetic MnAs nanoclusters at high annealing temperatures. A manuscript is currently in prepration for submission to Physical Reviw B.

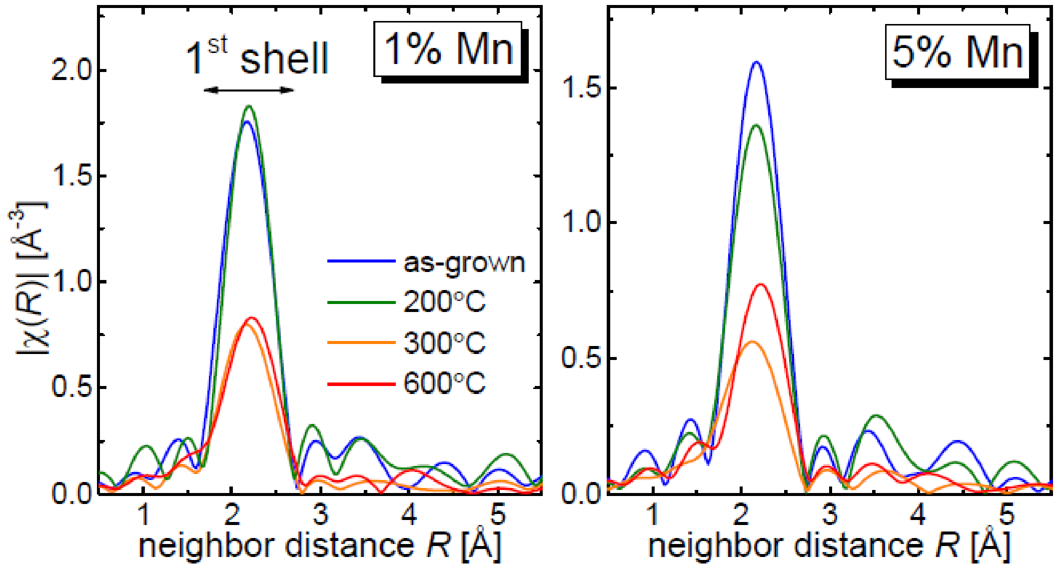

Figure 1. Magnitude of the Fourier transform as a function of non-phase corrected radial distance for Mn atoms in (Ga,Mn)As (1% and 5% Mn), as-grown and after the different annealing steps.

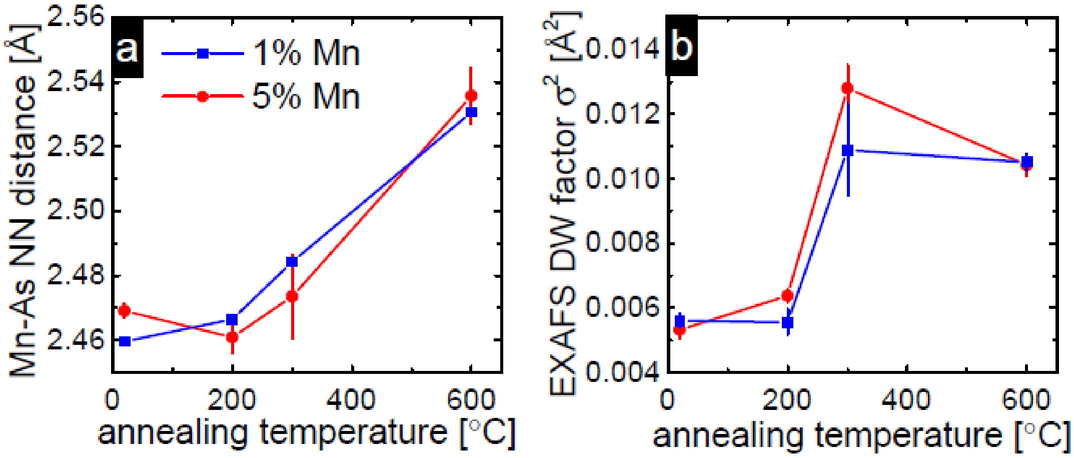

Figure 2. Outcome of the first-shell analysis (using the Iffefit software package) for as-grown (Ga,Mn)As and after after different annealing steps. a) Mn-As nearest neighbor distance. b) EXAFS Debye-Waller factors for the first single scattering path of Mn absorbers.

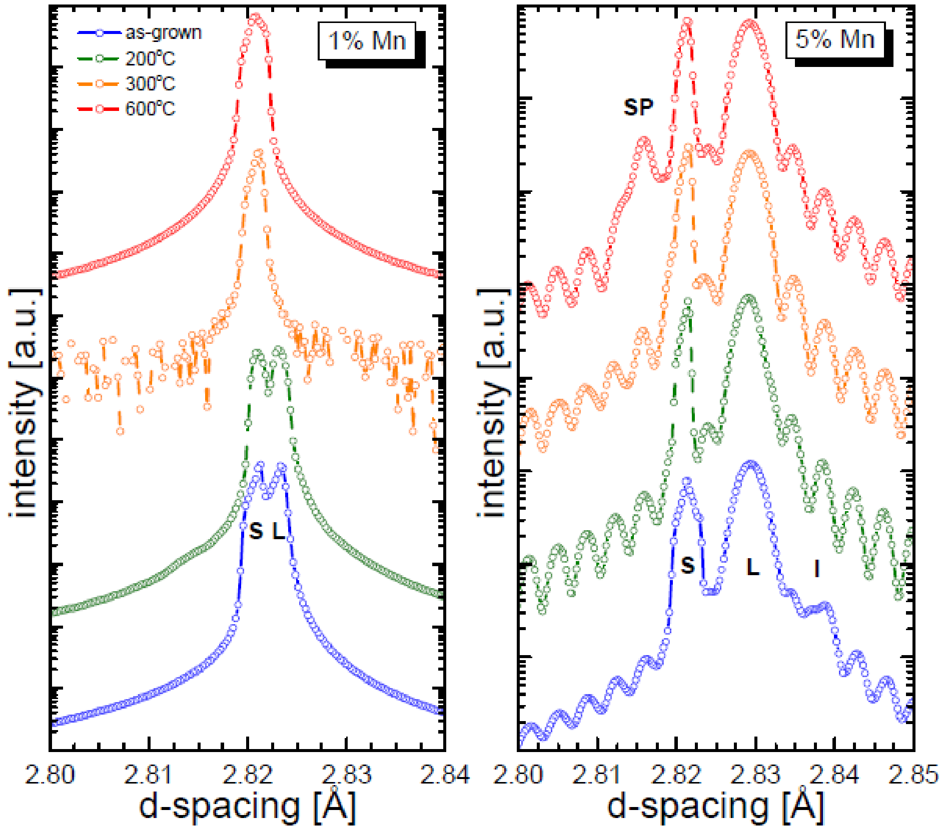

Figure 3. SR-HRXRD measurements around the <002> peak of GaAs on (Ga,Mn)As samples with 1% Mn and 5% Mn as-grown and annealed at 200°C, 300°C and 600°C. S, L, I and SP refer, respectively, to the substrate and the film peaks (the interstitial and the secondary phase peaks).

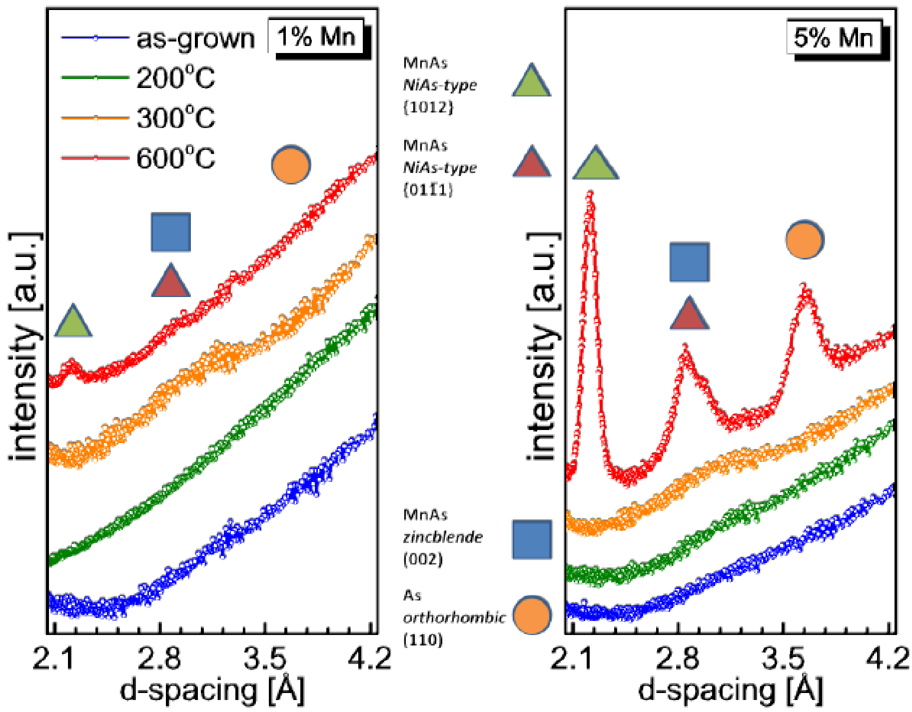

Figure 4. SR-GIXRD measurements (Ga,Mn)As samples with 1% Mn and 5% Mn as-grown and annealed at 200°C, 300°C and 600°C. The emergence of secondary-phases peaks is evident for the samples annealed at 600°C in the selected scan range and is represented by triangles for NiAs-type MnAs nanoclusters and by squares for zincblende MnAs nanoclusters. A peak corresponding to an orthorhombic As phase is also present and represented with a circle. Only the region of interest is displayed with no more peaks corresponding to secondary phases present in the remaining spectrum.