ROBL-CRG	**Experiment title:** **Investigation of Fe-rich phases in (Ga,Fe)N:Mg by x-ray diffraction**	**Experiment number**: HS-4246
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Report:

(Ga,Fe)N is a nanocomposite material system, in which the existence of nanoscale regions or crystals containing a large density of magnetic cations exhibiting high Curie temperature, account for its ferromagnetic behaviour. The aggregation of these magnetic cations depends strongly on the fabrication conditions and also on co-doping with shallow impurities. While the influence of co-doping with donors (e.g. Si) has been already studied, the influence of co-doping with acceptors (e.g. Mg) is yet not clear. In order to obtain a conclusive picture on the orientation, composition, and structure of the different observed nanocrystals, annealing experiments and a set of reciprocal space mapping (RSM) measurements were performed.

For this purpose 4 samples fabricated at different growth temperatures and containing different Fe_xN nanocrystals were carefully studied using coplanar diffraction at different annealing temperatures (from 100 to 800°C) in a N_2 atmosphere at 800 mbar. RSM of each sample prior and after annealing were acquired at different sample orientations to obtain information on the topotaxial relationship of the nanocrystals to the host matrix.

In figure1 we show the effect of annealing on the Fe-rich phases. The phases observed in the as-grown sample (peaks 2 and 3) are ε-Fe_3N (002) and (111), respectively. After annealing this phase is reoriented as (110) along the growth direction (peak 1). Peak 4 is identifed as GaN(003), peak 5 probably belongs to a Fe_3C alloy and peak 6 is identified as $Fe_{0.7}Ga_{0.3}$.

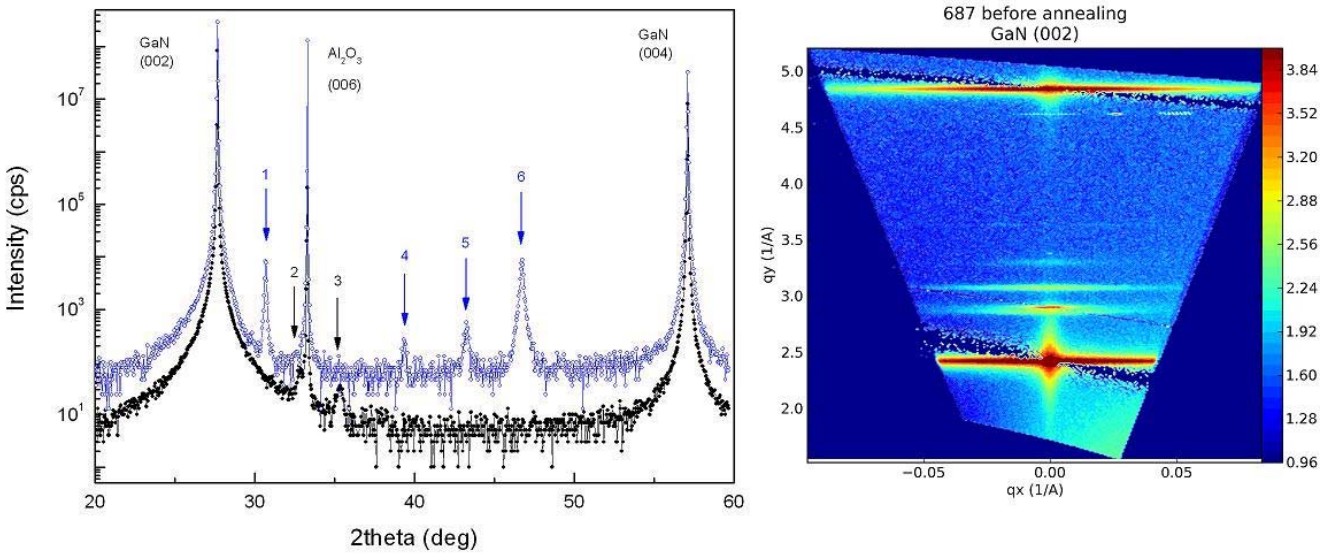

Fig 1. (left) SXRD spectra of the sample grown at 850°C prior (black) and after annealing (blue). The numbers indicate the phases present and described in the text. **(right)** RSM of the as-grown sample.

On the right side of figure 1 the RSM of the as-grown sample is shown. One can clearly distinguish the GaN (002) and (004) peaks, the Al_2O_3 (006) peak and the two ε-Fe_3N nanocrystal peaks close to the substrate diffraction. RSM at asymmetric directions were acquiered to find their orientation along the in-plane direction of GaN. From this we found that the annealed ε-Fe_3N nanocrystals orient in GaN as follows: $[110]_{Fe3N}$ll$[001]_{GaN}$ and $[221]_{Fe3N}$II$[101]_{GaN}$, and that the $Fe_{0.7}Ga_{0.3}$ nanocrystals, observed also after annealing, lie with $[102]_{FeGa}$ll$[001]_{GaN}$ and $[201]_{FeGa}$II$[101]_{GaN}$ and have an hexagonal lattice structure with a six-fold symmetry. Unfortunately most of the GaN and substrate asymmetric diffractions lie along the expected asymmetric diffractions of the nanocrystals, screening the contribution these last. Therefore, only some of the asymmetric diffractions could be observed. The same procedure was applied to all samples, gathering a full set of data which is currently still under analysis. The measurements during this beamtime will be very helpful to know the orientation of these Fe-rich nanocrystals in GaN, which might be related to the magnetic properties of the layers. The results obtained during this beamtime will be submitted for publication.

References: [1] A. Bonanni et al., *Phys. Rev. Lett*. **101** (2008).

[2] M. Rovezzi et al., *Phys. Rev. B* **79** 195209 (2009)