EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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 using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now 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:** Study of the diffusion of Ga in the interface ZnO	**Experiment number**: MA-904
Beamline:	**Date of experiment**: from: 28/10/2009 to: 03/11/2009	**Date of report**:
Shifts:	**Local contact(s)**: Jakub Szlachetko	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

The principal aim of this experiment was to study the incorporation of III-element cations coming from the substrate or a GaN buffer layer into ZnO thin films.To this end, the samples studied were nominally undoped 5 μm thick (0001) ZnO layer grown on a 1 μm (0001) GaN buffer layer deposited by metal organic vapor phase epitaxy on sapphire at different temperatures. Moreover, a 20mm thick ZnO layer was deposited directly on a sapphire substrate at high temperature to validate the origin of the incorporation (Al or Ga). The growth time and temperature were varied to change the quantity of III-element cations incorporated into ZnO film. Further information about the growth parameters and optical, electrical and structural properties were published on Ref. 1.
Involuntary doping of samples can introduce undesired results in the manufacture of thin films-based optoelectronic devices. Indeed, the incorporation of Al into ZnO coming from sapphire substrate has recently triggered the attention of several studies [2,3]. Cathodoluminescence measurements along the interfaces of ZnO-GaN-Al2O3 showed a redshift of the photoluminescence peak as the excitation area approaches the ZnO/GaN interface [1]. Their origin could be clarified scanning the chemical composition along the interface. The wavelength dispersive spectrometer of the ID21 beamline employs the polycapillary x-ray optic for efficient x-ray collection and is operated in the flat-crystal geometry. In the present experiment, the x-ray fluorescence delivered by the polycapillary was diffracted on the TlAP(001) (2d=25.9 Å) crystal and recorded with the gas proportional

counter. The achieved overall spectral resolution was about 20eV in the energy range between 1keV to 1.5keV. The high-resolution of detection was necessary in order to resolve unequivocally the overlapping x-ray fluorescence lines of Zn, Ga and Al. Piezoelectric sample stage was used to scan the chemical distribution along the interfaces.

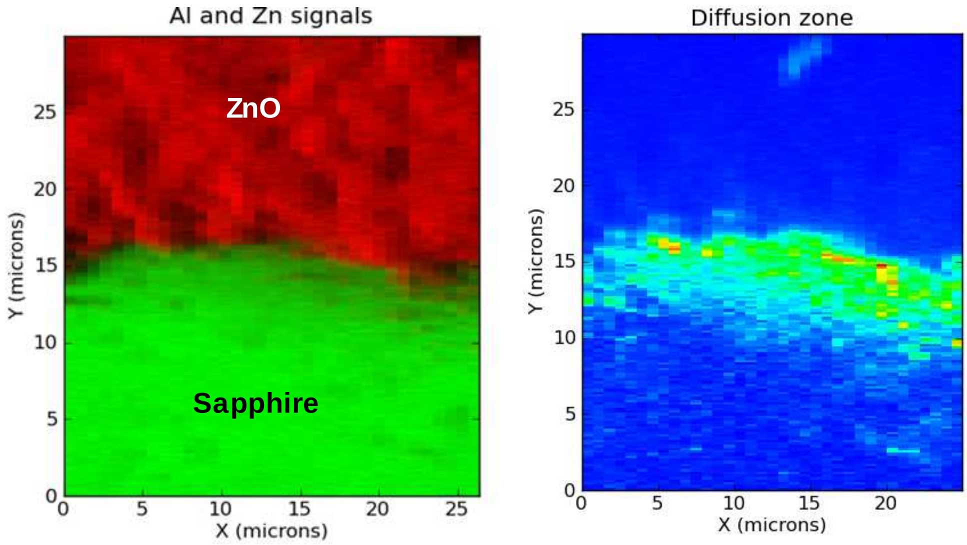

Figure 1. a) Spatial distribution of fluorescence signals of Zn (red) and Al (green) around the interface. b) Map of Zn×Al signals

Al diffusion was considered responsible for the changes in the structural and optical properties close to the interface and it was demonstrated the effect of the growth temperature on the amount of Al diffused. In the sample grown without buffer layer, it is possible to observe the formation of an intermediate zone where there is a mix of the signals coming from the Zn and Al (figure 1). The complete XRF spectrum at different zones of the sample (figure 2) allows concluding that the diffusion of Al dominates in these samples.

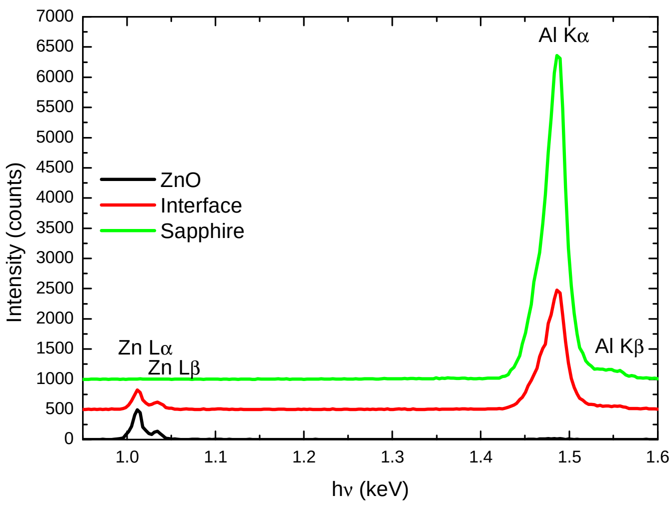

Figure 2. XRF spectra taken in the ZnO, around the interface and into the sapphire.

The inclusion of GaN buffer layer was used not only to reduce the lattice mismatch between the substrate and ZnO, but also to try to avoid the Al diffusion. Nevertheless, the results

obtained showed that Al is diffused along the buffer layer achieving the ZnO layer. In this case, the effect of the temperature on the amount of Al incorporated is a crucial parameter. Indeed, for samples grown at low temperature, it is possible to observe an overlaping of the signals, obtained by the multiplication amongst them, which reveals sharp edges around the interfaces ZnO/GaN and GaN/Al_2O_3. This result indicates the Al diffusion is very low, although non-nenglegible. With the increase of the growth temperature, samples exhibited the creation of a diffusion zone corresponding to the way that Al is incorporated into the GaN buffer layer and into the ZnO.

In conclusion, the basic hypothesis of the proposal seems to be confirmed by the experiment.

Many spectra recorded during the experiment are still being interpreted. Nevertheless, further investigations around the way that Al incorporates to the GaN and ZnO (interstitial, substitutional, forming a new crystalline phase…etc) is required to understand this fact.