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- fill in a separate form for each project or series of measurements.
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- 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.
- bear in mind that the double-page report will be reduced to 71% of its original size, A4 format. A type-face such as ”Times” or ”Arial” , 14 points, with a 1.5 line spacing between lines for the text produces a report which can be read easily.

Note that requests for further beam time must always be accompanied by a report on previous measurements.

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ROBL-CRG	**Experiment title:** "HRXRD characterization of MOCVD-grown GaN layers on 4H, 6H 001 SiC substrates with AlGaN/GaN heterostructures as a buffer layer".	**Experiment number**: HS 3850
Beamline: BM 20	**Date of experiment**: from: 10 July 2009 to: 14 July 2009	**Date of report**: 03-02-2010
Shifts: 12	**Local contact(s)**: Dr. Nicole M. Jeutter	*Received at ROBL:*
Names and affiliations of applicants (* indicates experimentalists): Jarosław Gaca, Marek Wojcik, Krystyna Mazur Institute of Electronic Materials Technology, Warsaw, Poland		

Report:

The properties of SiC applied as a substrate for III-N compound epitaxy allow to utilize it for high-power devices, working in high-temperature and resistant to the action of the electromagnetic field. This is the source of great interest in an epitaxial growth of Al(Ga)N/GaN/In(Ga)N heterostructures on both 4H and 6H SiC substrates. The problem consists in finding the appropriate buffer layers to grown good quality Al(Ga)N/GaN/In(Ga)N heterostructures. The objective of the project was to work out the undestructive method of characterization of the above mentioned buffer layers and heterostructures based on X-ray diffraction. To this end the measured rocking and reflectometric curves were compared to the ones simulated by means of a computer program based on a Darwin version of X-ray diffraction theory [1]. Because of the small volume of the investigated III-N layers the synchrotron radiation proved to be necessary to properly determine the chemical composition and interplanar spacing profiles especially in the interface region of succeeding layers.

At the first stage of the experiment the rocking curves were collected at the vicinity of the 002 GaN reflection for Al(Ga)N/GaN heterostructures grown on 4H and 6H 001 SiC substrates by MOCVD technique [2]. The sample of such experimental and simulated rocking curves for heterostructure deposited on 6H SiC substrate are presented in Fig. 1. The investigated heterostructures have been designed so that to enable the assessment of the influence of the substrate and buffer type, thickness of AlN layer and the level of the doping of the AlGaN layer on the their crystalline quality.

At the second stage of the experiment the strain was induced in 1μm thick GaN layer by means of the Ar ion implantation. It was found that strained layer was created within the GaN one, with lattice constant greater then that for GaN, and that the relative lattice misfit $\Delta a/a$ between these two layers, measured in the growth direction as a function of implanted dose of Ar ions proved to be linear for doses less then 1.0E+15, Fig. 2. The increase of the implanted dose beyond that value does not bring about the increase of the lattice deformation in the growth direction. These results may be employed to accomplish the postgrowth engineering of the interface profiles in AlN/GaN/AlGaN hetrostrructures.

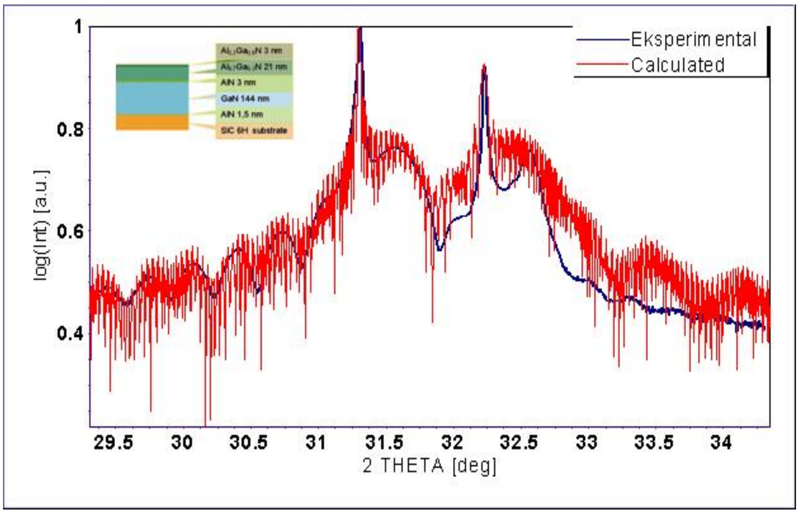

Fig. I. Experimental and simulated rocking curves for the heterostructure presented in the inset. The experimental data were collected at the ESRF BM 20 with wavelength λ=0.139997nm

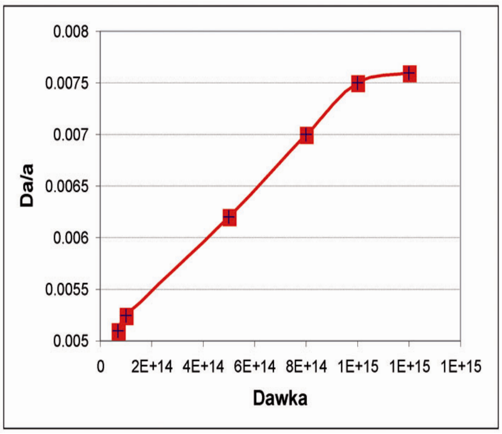

Fig. 2. The lattice misfit Δa/a between the ion-implantation damaged and non-damaged layers as a function of the implanted dose of Ar ions.

At the third stage of the experiment the study of the degree of crystalline and chemical perfection of AlN/GaN heterostructures consisting of ultra-thin GaN quantum wells (QWs) separated by AlN barriers, grown on the top of AlN buffer layers with thickness ranging from 100 nm to 220 nm have been investigated.

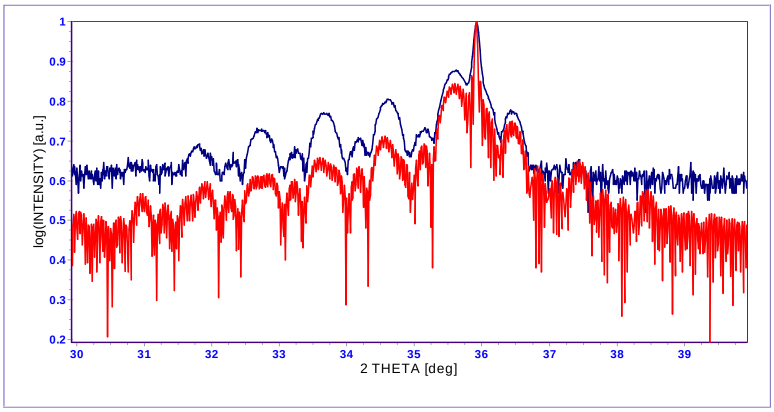

Fig 3. The experimental and simulated HRXRD diffraction 002 profiles for AlN/GaN heterostructures obtained by means of synchrotron radiation ESRF Grenoble, (logaritmic scale θ/2θ scan mode)

It has been found, that in the volume of GaN well, no relaxation occurred i.e. both AlN and GaN layers have the same in-plane lattice parameter as the underlying buffer layer. It means that GaN QWs are compressed to match the lattice constant of AlN. This means that applied buffer layers actually are effective substrates for the two-dimensional growth. The structure quality of AlN/GaN heterostructures have been confirmed by the satisfactory match between the measured and simulated diffraction and reflectometric profiles. The values of correlation length of columnar crystallites and the strain normal to the surface has been determined by applying the pseudo-Voit fit of 002 AlN and heterostructure reflections. The strain plotted versus correlation length normal to the surface turned out to be a monotonically decreasing function.

References

[1] A. Jasik, A. Wnuk, J. Gaca, M. Wójcik, A. Wójcik-Jedlińska, J. Muszalski, W. Strupiński, J. of Cryst. Growth 311 (2009) 4423– 4432

[2] P. Caban, K. Kosciewicz, W. Strupinski, J. Szmidt K. Pagowska, R. Ratajczak, M. Wojcik, J. Gaca, A. Turos, Materials Science Forum Vols. 615-617 (2009) pp 939-942