Multi-technique nanoscale structural analysis of III-nitrides

C. Bougerol[1,2*], J.P. Barnes[3], M. Beeler[1,4], E. Bellet-Amalric[1,4], B. Bonef[1,4], A. Grenier[3], P.H. Jouneau[1,4], M. Lopez-Haro[1,4], E. Monroy[1,4], E. Robin[1,4]

[1] *Université Grenoble Alpes, 38000 Grenoble, France*
[2] *Institut Néel-CNRS, 25 avenue des Martyrs, 38042 Grenoble, France*
[3] *CEA-Grenoble, LETI, 17 avenue des Martyrs, 38054 Grenoble, France*
[4] *CEA-Grenoble, INAC/SP2M, 17 avenue des Martyrs, 38054 Grenoble, France*

[*]catherine.bougerol@cea.fr; Téléphone : 0438782675;

1. INTRODUCTION

From the early studies of III-nitride semiconductors, numerous analyses have focused on the structural aspects, and especially the detailed investigations of extended defects. Nowadays, the development of nanostructured nitride-based materials in the domain of photonics or optoelectronics requires us to go a step further and to obtain quantitative information at the nanometerscale of the structure, strain state, and/or composition. This is particularly true when extended to ternary or quaternary systems and in that case a multi-technique approach is necessary.

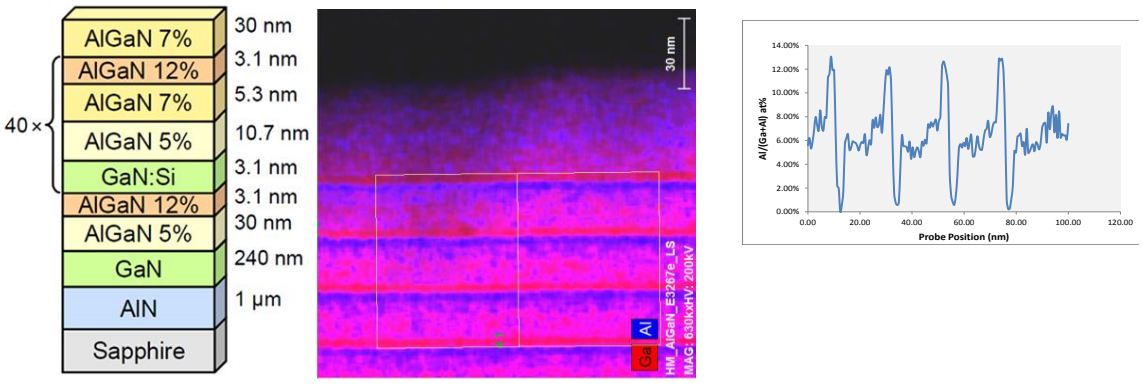
2. RESULTS

2.1 Experimental conditions

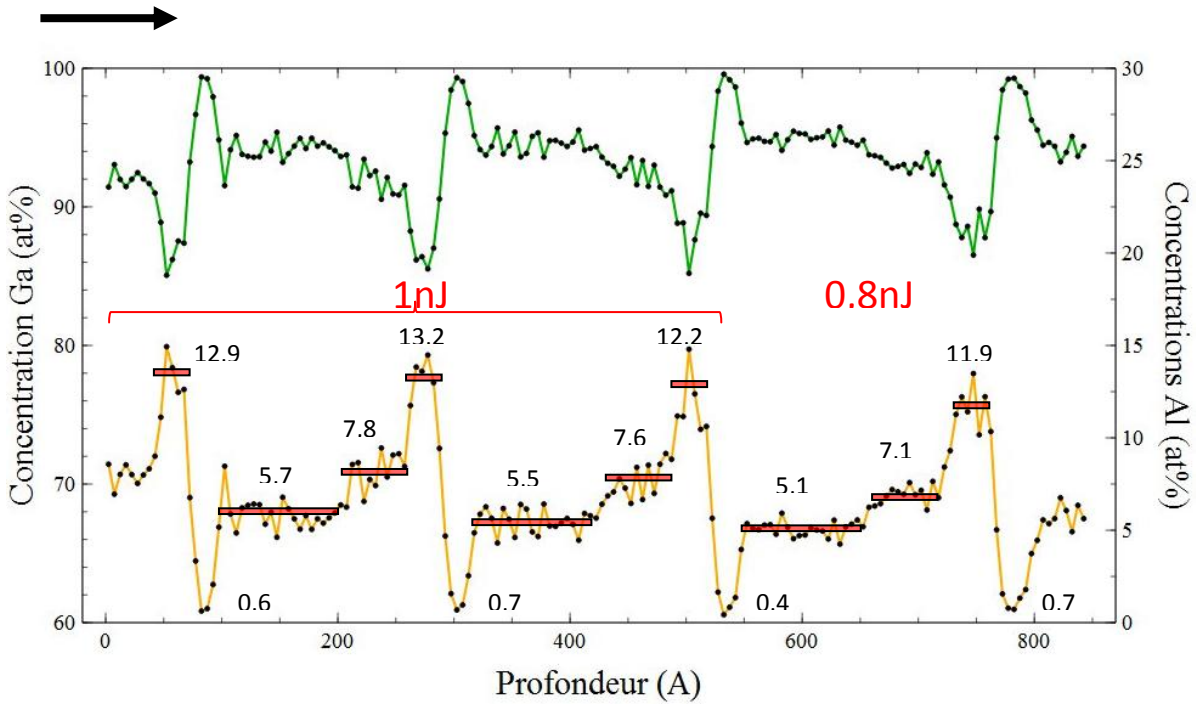
Recently, we have investigated nm-size AlGaN/GaN multilayers, used for THz intersubband (ISB) optoelectronics [1], which require a precise control of the alloy composition (down to 0.5%) and of the layers thicknesses. For that purpose, we have used a combination of Energy Dispersive X-ray Spectroscopy (EDX) coupled to Transmission Electron Microscopy (TEM) on a FEI-Osiris microscope equipped with 4 Bruker SDD detectors, Atom Probe Tomography (APT) on a Flextap Cameca equipment, Time of Flight Secondary Ion Mass Spectroscopy (ToF-SIMS) and X-ray diffraction in order to cover macroscopic as well as nanometer scale ranges.

2.2 Results

We have shown that it is possible to distinguish layers thinner than 3nm by EDX mapping. Furthermore, by performing analysis using the Z-factor method [2] which enables absorption correction, the composition has been obtained with a precision better than 0.5% for all the elements, including light ones (Al). The APT tomography experiment performed on the same sample gave very similar results in terms of both spatial and composition resolution. The knowledge of the precise composition of the layers has then enabled us to analyze the macroscopic data (X-ray diffraction and ToF'SIMS) in terms of strain and spatial homogeneity.



Scheme of the AlGaN/GaN superlattice; composition map from EDX and associated profile



Profile from APT data

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[2] Watanabe et al. J. Microscopy 221, **89**, (2001)