The influence of native oxides on physicochemical properties of p-type GaN(0001) and N-rich GaNAs(0001) surface

D. Majchrzak [1,2], M. Grodzicki [1,3], P. Ciechanowicz [1,3], E. Piskorska-Hommel [1,2], J. -G. Rousset [1] and D. Hommel [1,3]

[1] *PORT Polish Center for Technology Development Sp. z o.o., Stabłowicka 147, 54-066 Wrocław, Poland*
[2] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Okólna 2, 50-422 Wrocław, Poland*
[3] *Institute of Experimental Physics, University of Wrocław, Maksa Borna 9, 50-204 Wrocław, Poland*

The GaN-based semiconductors attract much attention in the electronic industry because of wide, direct energy band gap (3.4 eV) and good thermal conductivity [1]. These materials have a huge potential to fabricate short-wavelength optoelectronics as well as high-power and -frequency devices [2]. Moreover, GaN-based materials attract great interests due to possibility of bands structure modification by replacing one of its components. For example, substituting the nitrogen with an arsenic atom leads to a decrease of the band gap [3]. Optical measurements show that the band gap of GaNAs alloys is reduced with increase of the As content [4], which was also well explained by the band anticrossing model (BAC) [3].

A native oxide layer and other contaminants which appear after air exposure of the sample, acts as a barrier at the metal/GaN interface [5] and can reduce a potential device performance. To remove oxide and carbon coverage different surface treatments need to be introduced. Our studies show change of physicochemical properties of p-GaN(0001) and $GaN_{0.996}As_{0.004}$ (0001) after air exposure and different surface treatments (HCl treatment, UHV annealing, Ar^+ bombardment). The investigated samples were grown by molecular beam epitaxy (MBE) and studied under ultrahigh vacuum (UHV) by means of X-ray photoelectron spectroscopy (XPS). The experiment shows that applied cleaning techniques allow to obtain the surface with a trace amount of oxygen and carbon. Our research indicates that air exposure shifts valence band maximum (VBM) to 2.7 eV for p-GaN(0001) and to 2.6 eV for $GaN_{0.996}As_{0.004}$ (0001), which greatly corresponds with the theoretical study by Segev and Van de Walle [6]. Our research indicates that the VBM lies at positions of 1.6 eV and 2.1 eV below the Fermi level (E_F) for cleaned p-GaN and GaN(As) samples, respectively. This shows that small amount of As atoms incorporated into the GaN matrix leads to the VBM shift by 0.6 eV towards the E_F which is in line with the BAC model [3].

[1] T. Yao and S.-K. Hong, *Oxide and Nitride Semiconductors: Processing, Properties, and Applications*, Springer-Verlag, Berlin Heidelberg 2009.
[2] S. Nakamura, T. Mukai, and M. Senoh, *Appl. Phys. Lett.* **64**, 1687–1689 (1994).
[3] J. Wu, *et al.*, *Phys. Rev. B* **70**, 115214 (2004).
[4] S.V. Novikov, *et al.*, *J. Cryst. Growth* **311**, 3417–3422 (2009).
[5] S. Tripathy, *et al.*, *J. Appl. Phys.* **91**, 3398–3407 (2002).
[6] C.G. Van de Walle and D. Segev, *J. Appl. Phys.* **101**, 081704 (2007).