Carriers mobility of 2DEG of AlGaN/GaN structure on bulk ammonothermal GaN substrate

Kruszewski P[1,2], Prystawko P[1,2] , Kasalynas I[3], Plesiewicz J[2], Dwiliński R[4], Zając M[4], Kucharski R[4], Leszczyński M [1,2]
[1] Institute of High Pressure Physics UNIPRESS, Warsaw, Poland
[2] TopGaN Sp.z o.o., Warsaw, Poland
[3] Center for Physical Science and Technology, Vilnius, Lithuania
[4]Ammono SA, Warsaw, Poland

Keywords: AlGaN/GaN HEMT structure, Ammonothermal method, MOVPE technique

It is rather well established that the performance of GaN-based High Electron Mobility Transistors (HEMT) is directly correlated with the type and quality of the substrate used for further epitaxial growth. Unwanted impurities, defects and high density of dislocations present in the HEMT structure can be a source of undesirable effects as parallel conduction or existence of effective scattering centers which can limit electron mobility in the channel of HEMT transistor. All of these parasitic effects can be significantly reduced when high quality, defect free and low dislocation density bulk GaN substrates for epitaxial growth are used.

In this study, we report on theoretical and experimental results obtained from electrical characterization of 2DEG (Two Dimensional Electron Gas) of AlGaN/GaN HEMT on bulk GaN substrate produced by ammonothermal method [1]. Such GaN substrate is characterized by an ultra high purity and dislocation density as low as 10^4 cm^{-2} [2]. The AlGaN layers grown by MOVPE (Metalorganic Chemical Vapour Phase Epitaxy) method reproduce this low dislocation density ensuring simultaneously high uniformity and smoothness of AlGaN/GaN interface such essential for high electron mobilities in the HEMT`s channel.

For our detail analysis, complementary Hall effect studies in the Van der Pauw configuration have been planned and successfully performed. A temperature dependent Hall effect measurements taken for different positions of the same epi-wafer have clearly shown that no parallel conduction in analyzed HEMT structure exists. Additionally, a slightly increase of the carrier concentration at liquid nitrogen has been observed suggesting stronger electron confinement in the quantum well in comparison with room temperature. These results have been also confirmed by Capacitance-Voltage measurements where no carriers freezing at low temperatures have been observed.

Finally, mobilities and concentrations of 2DEG obtained from Hall experiments are in range of 1500 cm^2/Vs (300K) , 8000 cm^2/Vs (77K) and $8x10^{12}$ cm^{-2} (for both, 77K and 300K), respectively and agree quite well with theoretical predictions calculated using one dimensional Poisson solver [3]. It is also worth to underline that Hall effect results were entirely independent on the position of analyzed sample clearly confirming high homogeneity and quality of grown HEMT structure.

Acknowledgements:

This work was supported by the PolHEMT Project under the Applied Research Programme of the National Centre for Research and Development, Contract no. PBS1/A3/9/2012 and NANOTEC Project “Nanostructured materials and RF-MEMS RFIC/MMIC technologies for highly adaptive and reliable RF systems”, Contract no. 288531.

References:

[1] Dwilinski et al., J. Crystal Growth 310, 3911 (2008).
[2] R. Kucharski et al., Semicond. Sci. Technology 27, 024007 (2012).
[3] 1D Poisson solver website: www3.nd.edu/~gsnider/