14:00 Oral

Influence of substrate on crystallographic quality of AlGaN/GaN HEMT structures grown by MBE

Aleksandra Wierzbicka, Zbigniew R. Zytkiewicz, Marta Sobanska, Kamil Klosek, Elżbieta Lusakowska

Polish Academy of Sciences, Institute of Physics, al. Lotników 32/46, Warszawa 02-668, Poland

e-mail: czyzak@ifpan.edu.pl

AlGaN/GaN high electron mobility transistor (HEMT) are promising devices for high frequency and high power applications. Since bulk GaN substrates are not readily available on an industrial scale, they are usually grown on alternative substrates as sapphire or silicon. It is known, however, that growth of lattice mismatched structures leads to formation of large strain and its eventual relaxation, that affect properties of devices.

Aim of this work was to study influence of substrate structure on crystallographic quality of AlGaN/GaN HEMTs grown by plasma-assisted molecular beam epitaxy (PAMBE). Figures 1a-1c show schematic drawings of the samples studied. As seen, all HEMT structures consist of undoped GaN layer, 20 nm thick AlGaN and 3 nm thick GaN cap. They differ in substrates used: the first HEMT was grown on commercially available 3 µm thick GaN/sapphire template grown by metalorganic vapor phase epitaxy (MOVPE). In the second one the same template was used but with additional 10 µm thick GaN layer grown by hydride vapor phase epitaxy (HVPE). The third HEMT structure was deposited on bulk GaN substrate that was grown by HVPE on MOVPE template and then separated from it (Fig. 1c). All samples were carefully studied with the use of high resolution X-ray diffraction (HRXRD), X-ray reflectivity (XRR) and atomic force microscopy (AFM) techniques to compare their properties.

Figures 1d-1f show high resolution XRD maps of the samples. As seen, diffracted signals from GaN layers overlap with those from substrate GaN, but widths of GaN diffraction peaks differ. Values of the full width at half maximum (FWHM) for asymmetrical -1-124 reflection equal to 0.056°, 0.043°, 0.024° for GaN and to 0.138°, 0.068°, 0.030° for AlGaN, for the first, second and third sample, respectively. This indicates significant improvement of structural quality of HEMTs when thickness of GaN template increases. Even larger improvement is obtained when bulk GaN substrate is used instead of the template. In all samples AlGaN layers are fully strained so their in-plane lattice constants are the same as in the underlying GaN.

Additionally, quality of the GaN/AlGaN interfaces in HEMTs structures were examined by XRR technique. This is very important parameter since enhanced interface roughness leads to scattering of charge carriers in two-dimension electron gas and to reduction of electron mobility. Finally, morphology of surface of the samples was studied by AFM. Results are shown in Figures 1g-1i. RMS values for 10x10 µm^2 surface AFM scans are 1.2 nm, 0.9 nm and 0.8 nm for samples 1-3, respectively.

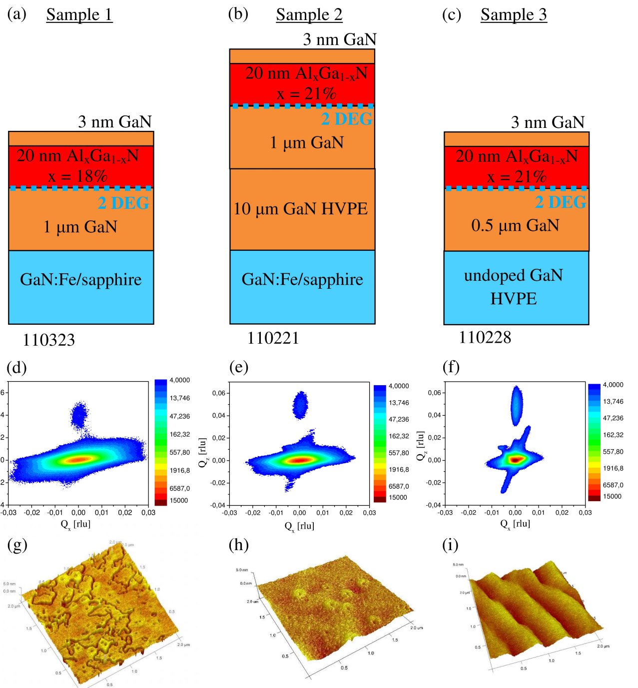

Figure 1. Schematic cross-section of the AlGaN/GaN HEMTs structures studied in this work (a-c), their HRXRD maps (d-f) and AFM images of their surfaces (g-i).

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