Optical properties of GaN grown on Ga- and N-polar substrates by PAMBE

P. Tatarczak[1], **E. Łacińska**[1], **A. Wysmołek**[1], **C. Skierbiszewski**[2] **and H. Turski**[2]

[1] *Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*
[2] *Institute of High Pressure Physics PAS, ul. Sokołowska 29/37, 01-142 Warsaw, Poland*

Gallium nitride grows spontaneously as a polar crystal, which offers built-in polarization fields that can be exploited in device design and lead to better performance. However most commercially available devices are obtained using Ga-polar substrates with almost no exceptions for N-polar ones. Epitaxy of nitrides along N-polar direction is known to suffer from higher oxygen incorporation (leading to high unintentional n-type doping) and hillock formation. Recently, huge improvement in the growth of N-polar structures by metal-organic vapor phase epitaxy was reported by the used of high miscut angle sapphire substrates through lowering the background doping [1]. In plasma-assisted molecular beam epitaxy (PAMBE), where metal-rich growth conditions are used, near to ideal p-n junction obtained on N-polar GaN substrate was recently also presented [2].

Our recent finding that both metal- and Nitrogen-excess growth conditions can result in smooth growth of N-polar GaN [3] in PAMBE opens unique possibility. Smooth GaN layers obtained under the excess of group-III and group-V elements (with other growth parameters the same) can be compared.

In present study we compare optical properties of 1 μm thick GaN layers grown on N- and Ga-polar high quality bulk Ammono-GaN substrates. Low temperature photoluminescence (PL) study confirmed high quality of GaN layers obtained on N-polar substrates. As an example sharp excitonic emission peaks obtained for Ga-polar and N-polar substrates at 4.2 K are shown in Fig. 1 (a) and (b), respectively. Free excitonic emission (FE) for N-polar GaN layer is higher than donor bound exciton (DBE) emission observed for this sample (Fig 1(b)). For reference Ga-polar sample, grown in the same growth process, PL exhibits regular behavior where FE is weaker than DBE (Fig. 1(a)). Obtained results show very high quality of N-polar GaN layers. Higher than 1 FE to DBE intensity ratio was never reported for GaN and suggests extremely low defect/impurity concentration, which results in high mobility in grown material.

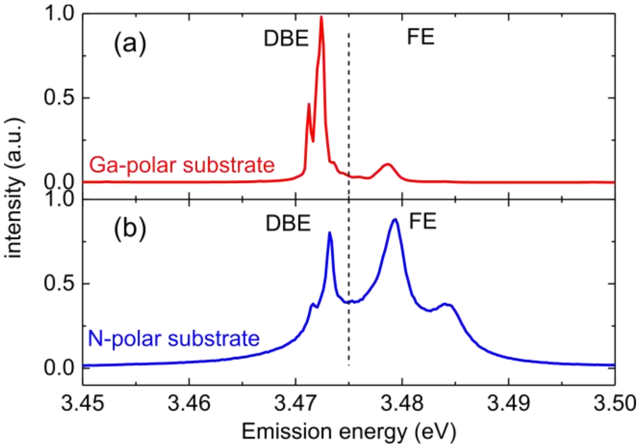

Fig. 1. Near band edge photoluminescence spectra obtained at 4.2 K for (a) Ga- and (b) N-polar GaN layers grown at Gallium-rich conditions in a single growth

Performed measurements can be used to indicate which growth conditions are appropriate for a given substrate orientation to fabricate nitride structures such as high electron mobility transistors or light emitting diodes.

[1] C. Lund, et al., Journal of Crystal Growth 464, 127 (2017).
[2] Y. Cho, et al., Applied Physics Letters 110 (2017).
[3] H. Turski et al., Journal of Crystal Growth 512, 208 (2019).

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