Poliškumo Inversija GaN Sluoksniuose panaudojant ALD-Al_2O_3 Tarpinį Sluoksnį

Growth and Investigation of Polarity Inversed GaN Layers on ALD-Al_2O_3

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Gallium nitride (GaN) as a direct bandgap semiconductor with a large transparency window and with a high second-order nonlinearity (10 pm/V [1]) serves as an interesting candidate for nonlinear optics. Moreover, GaN has a non-centrosymmetric configuration along the growth (*c*) direction. Due to this property, there is a non-compensated spontaneous polarization along the *c* direction and can be referred to as polarity of the layer [2]. +*c* direction GaN is called Ga-face GaN and -*c* direction – N-face GaN. Fabricated as a waveguide, microring, or microdisc it provides high potential for frequency conversion applications [1,3]. However, efficient frequency conversion requires a phase-matching condition to compensate for material dispersion. Phase matching can be achieved by exploiting the birefringence exhibited in anisotropic crystals or artificial structures. A modal-dispersion phase matching (MDPM) has been achieved in a Ga-face GaN waveguide structure [1]. However, modeling results showed that conversion efficiency increases when fabricated GaN waveguide structures consist of two GaN faces.

In this work, growth parameter optimization of the N-face GaN on 2° offcut sapphire substrates and on ALD-Al_2O_3 layers, deposited on III-face GaN/AlGaN/AlN (waveguiding structure) in a PICOSUN® R-200 Advanced deposition tool (Picosun Oy, Finland), was performed using Aixtron Close-Coupled-Showerhead 3x2 MOCVD reactor. Figure 1 represents a schematic example of the grown samples. Before the N-face GaN growth nitridation process was followed. Main difference in these two cases was nitridation time and temperature. In the case of sapphire substrates, nitridation duration was about 7 minutes at 970°C. ALD-Al_2O_3 layers were nitrided much longer and at higher temperatures, for 40 minutes to 1 hour at 1100°C, respectively. This process for ALD-Al_2O_3 was required to impart crystallinity to the amorphous ALD-Al_2O_3 areas. Then N-face GaN growth was followed with first growing a GaN nucleation layer, then high-temperature annealing and high-temperature GaN growth processes. The polarity of GaN was determined by etching with KOH solution. The surface quality of each grown layer was controlled by AFM, the crystallinity of the layers was investigated with TEM and XRD. The most important result was made about ALD-Al_2O_3 interlayer which does not evaporate during nitridation and annealing processes at the beginning of the growth process. This was confirmed by the TEM and EDX. The thinner the nucleation GaN layer the smoother the surface of the resulting GaN layer. This was confirmed by AFM in two cases. After etching the samples in the KOH solution N-face GaN on the ALD-Al_2O_3 layers was confirmed in the samples with the thicker nucleation layers, while every GaN layer on the sapphire substrates exhibited N-polarity.

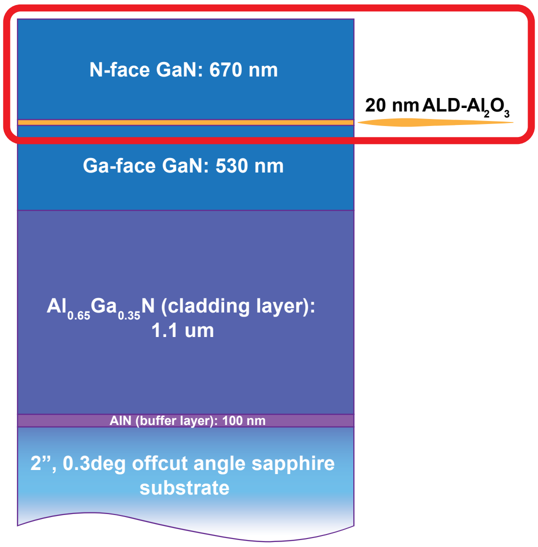

Figure 1. Schematics of N-face GaN grown on ALD-Al_2O_3 to form a waveguiding structure with polarity invesrion.

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Reikšminiai žodžiai: MOVPE, GaN, N-polinis GaN, oksidai.

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