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Electrical Properties of Polarization-Induced Aluminum Nitride/Gallium Nitride Heterostructures Homoepitaxially Grown on Aluminum Nitride Sapphire Template by Molecular Beam Epitaxy

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Abstract : Owing to the excellent thermal conductivity and ultra-wide bandgap, Aluminum nitride (AlN)/Gallium nitride (GaN) is a highly promising material to achieve high breakdown voltage and output power devices among III-nitrides. In this study, we explore the growth and characterization of polarization-induced AlN/GaN heterostructures using plasma-assisted molecular beam epitaxy (PA-MBE) on AlN-on-sapphire templates. To improve the crystal quality and demonstrate the effectiveness of the PA-MBE approach, a thick AlN buffer of 180 nm was first grown on the AlN-on sapphire template. This buffer acts as a back-barrier to enhance the breakdown characteristic and isolate leakage paths that exist in the interface between the AlN epilayer and the AlN template. A root-mean-square roughness of 0.2 nm over a scanned area of 2×2 μm2 was measured by atomic force microscopy (AFM), and the full-width at half-maximum of (002) and (102) planes on the X-ray rocking curve was 101 and 206 arcsec, respectively, using by high-resolution X-ray diffraction (HR-XRD). The electron mobility of 443 cm2/Vs with a carrier concentration of 2.50×1013 cm-2 at room temperature was achieved in the AlN/GaN heterostructures by using a polarization-induced GaN channel. The low depletion capacitance of 15 pF is resolved by the capacitance-voltage. These results indicate that the polarization-induced AlN/GaN heterostructures have great potential for next-generation high-temperature, high-frequency, and high-power electronics.

Keywords : AlN, GaN, MBE, heterostructures
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