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Strained Channel Aluminum Nitride/Gallium Nitride Heterostructures Homoepitaxially Grown on Aluminum Nitride-On-Sapphire Template by Plasma-Assisted Molecular Beam Epitaxy

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Abstract : Due to its outstanding material properties like high thermal conductivity and ultra-wide bandgap, Aluminum nitride (AlN) has the promising potential to provide high breakdown voltage and high output power among III-nitrides for various applications in electronics and optoelectronics. This work presents material growth and characterization of strained channel Aluminum nitride/Gallium nitride (AlN/GaN) heterostructures grown by plasma-assisted molecular beam epitaxy (PA-MBE) on AlN-on-sapphire templates. To improve the crystal quality and manifest the ability of the PA-MBE approach, a thick AlN buffer with a thickness of 180 nm is first grown on AlN template, which acts as a back-barrier to enhance the breakdown characteristic and isolates the leakage path existing in the interface between AlN epilayer and AlN template, as well as improve the heat dissipation. The grown AlN buffer features a root-mean-square roughness of 0.2 nm over a scanned area of 2×2 µm2 measured by atomic force microscopy (AFM), and exhibits full-width at half-maximum of 95 and 407 arcsec for the (002) and (102) plane the X-ray rocking curve, respectively, tested by high resolution x-ray diffraction (HR-XRD). With a thin and strained GaN channel, the electron mobility of 294 cm2 /Vs. with a carrier concentration of 2.82×1013 cm-2 at room temperature is achieved in AlN/GaN double-channel heterostructures, and the depletion capacitance is as low as 14 pF resolved by the capacitance-voltage, which indicates the promising opportunities for future applications in next-generation high temperature, high-frequency and high-power electronics with a further increased electron mobility by optimization of heterointerface quality.

Keywords : AlN/GaN, HEMT, MBE, homoepitaxy
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