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Double Negative Differential Resistance Features in Series AIN/GaN Double-Barrier Resonant Tunneling Diodes Vertically Integrated by Plasma-Assisted Molecular Beam Epitaxy

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Abstract : This study reports on the epitaxial growth of a GaN-based resonant tunneling diode (RTD) structure with stable and repeatable double negative differential resistance (NDR) characteristics at room temperature on a c-plane GaN-on-sapphire template using plasma-assisted molecular beam epitaxy (PA-MBE) technology. In this structure, two independent AlN/GaN RTDs are epitaxially connected in series in the vertical growth direction through a silicon-doped GaN layer. As the collector electrode bias voltage increases, the two RTDs respectively align the ground state energy level in the quantum well with the 2DEG energy level in the emitter accumulation well to achieve quantum resonant tunneling and then reach the negative differential resistance (NDR) region. The two NDR regions exhibit similar peak current densities and peak-to-valley current ratios, which are 230 kA/cm² and 249 kA/cm², 1.33 and 1.38, respectively, for a device with a collector electrode mesa diameter of 1 μm. The consistency of the NDR is much higher than the results of on-chip discrete RTD device interconnection, resulting from the smaller chip area, fewer interconnect parasitic parameters, and less process complexity. The methods and results presented in this paper show the brilliant prospects of GaN RTDs in the development of multi-value logic digital circuits.

Keywords : MBE, AlN/GaN, RTDs, double NDR
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