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Optimizing Performance in GaN HEMTs Through Doping, Layer Thickness, and Polarization

GaN High Electron Mobility Transistors (HEMTs) are essential for high-power and high-frequency applications due to their superior performance characteristics. Understanding the effects of doping concentration, buffer layer thickness, and polarization is crucial for optimizing these devices. This study explores the impact of doping concentration, buffer layer thickness, and polarization effects on the performance of GaN High Electron Mobility Transistors (HEMTs) with p-gate structures using TCAD software Silvaco. It has been found that variations in doping concentration in the AlGaIn buffer layer significantly influence the 2DEG density and device characteristics, with moderate doping levels ($1 \times 10^{17} \text{ cm}^{-3}$) providing optimal performance. The thickness of the AlGaIn layer affects piezoelectric polarization and 2DEG confinement, enhancing device performance up to a point before introducing potential issues. Spontaneous and piezoelectric polarization effects improve input characteristics as their values increase, though the combined effect must be carefully managed. Temperature variations impact device performance by altering polarization fields and 2DEG density, with higher temperatures leading to increased gate leakage and reduced transconductance. Optimizing these parameters is crucial for achieving balanced device performance.

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