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Title:Overshoot mechanism in transient excitation of THz and Gunn oscillations in wide-bandgap semiconductors
Authors:Momox, Ernesto (1); Zakhleniuk, Nick (1); Balkan, Naci (1)
Author affiliation:(1) School of Computer Science and Electronic Engineering, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, United Kingdom
Corresponding author:Zakhleniuk, N.(naz@essex.ac.uk)
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Abstract:A detailed study of high-field transient and direct-current (DC) transport in GaN-based Gunn diode oscillators is carried out using the commercial simulator Sentaurus Device. Applicability of drift-diffusion (DD) and hydrodynamic (HD) models to high-speed, highfrequency devices is discussed in depth, and the results of the simulations from these models are compared. It is shown, for a highly homogeneous device based on a short (2 μm) supercritically doped (10¹⁷ cm⁻³) GaN specimen, that the DD model is unable to correctly take into account some essential physical effects which determine the operation mode of the device. At the same time, the HD model is ideally suited to solve such problems due to its ability to incorporate non-local effects. We show that the velocity overshoot near the device contacts and space charge injection and extraction play a crucial role in defining the operation mode of highly homogeneous short diodes in both the transient regime and the voltagecontrolled oscillation regime. The transient conduction current responses are fundamentally different in the DD and HD models. The DD current simply repeats the velocity-field (v-F) characteristics, and the sample remains in a completely homogeneous state. In the HD model, the transient current pulse with a full width at half maximum of approximately 0.2 ps is increased about twofold due to the carrier injection (extraction) into (from) the active region and the velocity overshoot. The electron gas is characterized by highly inhomogeneous distributions of the carrier density, the electric field and the electron temperature. The simulation of the DC steady states of the diodes also shows very different results for the two models. The HD model shows the trapped stable anodic domain in the device, while the DD model completely retains all features of the v-F characteristics in a homogeneous gas. Simulation of the voltage-controlled oscillator shows that it operates in the accumulation layer mode generating microwave signals at 0.3 to 0.7 THz. In spite of the fact that the known criterion of a Gunn domain mode n<inf>0</inf>L > (n<inf>0</inf>L)<inf>0</inf> was satisfied, no Gunn domains were observed. The explanation of this phenomenon is given. © 2012 Momox et al.
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Uncontrolled terms:Accumulation layers - Active regions - Carrier injection - Commercial simulators - Device simulations - Direct-current - Drift diffusion - Gunn domains - Gunn oscillations - High frequency devices - High-field - Homogeneous state - Inhomogeneous distribution - Microwave signals - Non-local effect - Operation mode - Physical effects - Steady state - THz - Transient conduction - Transient current - Transient excitation - Transient regime - Velocity field - Velocity overshoot - Voltage-controlled - Wide-band-gap semiconductor
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