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标题: Impact of Effective Mass on the Scaling Behavior of the f(T) and f(max) of III-V High-Electron-Mobility Transistors

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摘要: Among the contenders for applications at terahertz frequencies are III-V high-electron-mobility transistors (HEMTs). In this paper, we report on a tendency for III-V devices with low effective-mass channel materials to exhibit a saturation in their unity-current-gain and unity-power-gain cutoff frequencies (f(T) and f(max)) with a downscaling of gate length. We focus on InGaAs and GaN HEMTs and examine gate lengths from 50 nm down to 10 nm. A self-consistent, quantum-mechanical solver based on the method of nonequilibrium Green's functions is used to quasistatically extract the f(T) for intrinsic III-V devices. This model is then combined with the series resistances of the heterostructure stack and the parasitic resistances and capacitances of the metal contacts to develop a complete extrinsic model, and to extract the extrinsic f(T) and f(max). It is shown that the f(T) and f(max) of III-V devices will saturate, i.e., attain a maximum value that ceases to increase as the gate length is scaled down, and that the saturation is caused by the low effective mass of III-V materials. It is also shown that the InGaAs HEMTs have faster f(T) at long gate lengths, but as a consequence of their lower effective mass, they experience a more rapid f(T) saturation than the GaN HEMTs, such that the two devices have a comparable f(T) at very short gate lengths (similar to 10 nm). On the other hand, due to favorable parasitics, it is shown that the InGaAs HEMTs have a higher f(max) at all the gate lengths considered in this paper.

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