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New Analytical Current-Voltage Model for GaN-based Resonant Tunneling Diodes

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Abstract : In the field of GaN-based resonant tunneling diodes (RTDs) simulations, the traditional Tsu-Esaki formalism failed to predict the values of peak currents and peak voltages in the simulated current-voltage(J-V) characteristics. The main reason is that due to the strong internal polarization fields, two-dimensional electron gas(2DEG) accumulates at emitters, resulting in 2D-2D resonant tunneling currents, which become the dominant parts of the total J-V characteristics. By comparison, based on the 3D-2D resonant tunneling mechanism, the traditional Tsu-Esaki formalism cannot predict the J-V characteristics correctly. To overcome this shortcoming, we develop a new analytical model for the 2D-2D resonant tunneling currents generated in GaN-based RTDs. Compared with Tsu-Esaki formalism, the new model has made the following modifications: Firstly, considering the Heisenberg uncertainty, the new model corrects the expression of the density of states around the 2DEG eigenenergy levels at emitters so that it could predict the half width at half-maximum(HWHM) of resonant tunneling currents; Secondly, taking into account the effect of bias on wave vectors on the collectors, the new model modifies the expression of the transmission coefficients which could help to get the values of peak currents closer to the experiment data compared with Tsu-Esaki formalism. The new analytical model successfully predicts the J-V characteristics of GaN-based RTDs, and it also reveals more detailed mechanisms of resonant tunneling happened in GaN-based RTDs, which helps to design and fabricate high-performance GaN RTDs.

Keywords : GaN-based resonant tunneling diodes, tsu-esaki formalism, 2D-2D resonant tunneling, heisenberg uncertainty
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