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Schottky Barrier Diode's as Enablers of Scalable Quantum Computing Hardware

ANJALI SAHU[1], PRAVASH RANJAN TRIPATHY[2] and S. P. PATI[3]

[1, 2]Gandhi Engineering College Bhubaneswar
[3]Former Professor, Sambalpur University
E. Mail: anjali.sahu@gec.edu.in, pravashrt76@yahoo.co.in, prof_sppati@yahoo.co.in

Abstract: Scalable quantum computing hardware necessitates electronic components that integrate ultra-fast switching, minimal leakage, and energy-efficient performance at Nano scale dimensions. This study examines Schottky barrier diodes (SBDs) as pivotal devices for scalable quantum computing hardware through quantum-aware device simulations utilizing Indium Phosphide (InP) as the semiconductor platform. Quantum transport mechanisms, such as WKB-based tunneling and quasi-ballistic carrier transport, are included to accurately represent device behavior beyond the classical thermionic emission regime. Simulation findings indicate that the modulation of engineered barrier height decreases the Schottky barrier from 0.65 eV to 0.45 eV, resulting in a 54% decrease in switching delay from 1.2 ps to 0.55 ps. The forward current density rises from 1.8×10^4 A/cm^2 to 6.2×10^4 A/cm^2 at an operating bias of 0.25 V, whereas the reverse leakage current density is reduced by nearly in order of magnitude at -.05 V. These findings illustrate that InP-based Schottky barrier diodes provide high-speed, low-power operation and consistent performance, positioning them as promising elements for quantum control, readout circuitry, and scalable hybrid quantum-classical computing architectures.