

ABSTRACT:

Competition Between Interband Tunneling and Defect-Assisted Transport in Interband Tunnel Diodes Under Radiation and Microwave Stress

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Reliability of semiconductor devices under radiation and electromagnetic stress is a critical issue for advanced electronics, particularly for harsh environments and space applications that have greatly increased their activity levels. Tunnel diodes, especially interband tunnel diodes, have demonstrated great resilience to harsh environments.¹⁻²

In this work, we develop a physical model to describe the evolution of current transport in interband tunnel diodes subjected to radiation and microwave fields. Rather than considering the excess current as an independent empirical contribution, we interpret it as a consequence of competition between different carrier transport pathways. Radiation-induced defects introduce localized states within the bandgap, creating additional defect-assisted transport channels, while the microwave electric field modifies the carrier transition probability through these states.

The proposed model incorporates carrier conservation by considering the redistribution of carriers between interband tunneling, defect-assisted transport, and diffusion-related processes. This approach provides a unified physical interpretation of radiation- and microwave-induced changes in current-voltage characteristics and device degradation. The results may provide insight into reliability mechanisms of tunnel-based semiconductor devices operating in extreme environments and contribute to the development of more robust space electronic components.

[1] BD Weaver, PE Thompson, N Jin, SY Chung, AT Rice, PR Berger, Radiation tolerance of Si/Si_{0.6}Ge_{0.4} resonant interband tunneling diodes, Journal of Applied Physics, 95 (11), 6406-6408 (2004). DOI: <https://doi.org/10.1063/1.1710719>

[2] PR Berger, G Gulyamov, MG Dadamirzaev, MK Uktamova, SR Boidedaev, Influence of microwave and magnetic fields on the electrophysical parameters of a tunnel diode, Romanian journal of physics, 69, 609 (2024). DOI: <https://doi.org/10.59277/RomJPhys.2024.69.609>