Exploring Quasi-One-Dimensional Systems for Advanced Electronic Applications

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Abstract

In condensed matter physics, one-dimensional (1D) systems display electronic properties distinct from higher-dimensional materials. Confining electron motion to a single dimension enhances electron-electron interactions and introduces size quantization effects, yielding discrete energy levels. These quantization effects, combined with strong correlations, enable phenomena such as the Kondo effect in quasi-1D carbon nanotubes (CNTs), where a localized magnetic impurity couples with conduction electrons. The Kondo effect manifests as a characteristic increase in conductance below the Kondo temperature, $T_K \sim e^{(-1/(J\rho))}$, where J is the exchange coupling and ρ is the density of states. We also examine quasi-1D tellurium (Te) nanowires, which form nanoscale van der Waals (vdW) diodes with nanosized depletion regions, enhancing charge control for efficient rectification. Additionally, hybrid 1D-2D vdW heterostructures are explored for CMOS applications, leveraging 1D directional transport and 2D material flexibility, suggesting a pathway to next-generation CMOS technology through miniaturization and enhanced quantum control.

Reference:

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[2] Datta *et al.* ACS Nano **2019** 13 (9), 10029-10035.
[3] Das *et al.* Applied Physics Letters **2023** 122 (26).