Exploring Coherent Transverse Coupling in 3D Semiconductor Nanowire Arrays for Quantum Applications

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The exploration of quantum coherence in nanostructures is as a critical field with vast implications for the advancement of quantum information, communication, and sensing [1]. Previous studies have predominantly focused on coherent tunneling processes within a limited number of stacked quantum nanostructures such as dots or rings, leading to the formation of delocalized molecular states characterized by robust electron and hole coupling [2]. These interconnected quantum dots and rings, similar to artificial molecules, demonstrate the potential for establishing quantum gates through coherent coupling, thereby laying the groundwork for essential components in quantum technologies [3]. In this talk, we present our latest theoretical findings on nanowire coupling [4-6]. Our focus is on the coherent transverse coupling in three-dimensional arrays of closely spaced, vertically stacked nanowires. These nanowires are characterized by their discontinuous charge distribution along the axial direction. This particular setup has enabled us to observe a widespread redistribution of carrier populations across various excited states within the nanowire array. Moving beyond theoretical models, we are currently engaged in the development of actual prototypes. This ongoing effort involves utilizing advanced epitaxial growth and nanowire self-assembly methods. While the fabrication of these prototypes is still in progress, it represents a crucial step towards validating our theoretical predictions in practical scenarios. Successfully developing these prototypes will not only enhance our understanding of quantum coherence in nanostructures but will also open new avenues in quantum computing and sensing technologies.

References

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