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A General and Modular Approach to Solid-State Integration of Zero-Dimensional Quantum Systems

Zero-dimensional quantum systems, such as molecules, defects, and quantum dots, are promising building blocks for scalable quantum technologies; however, their practical deployment is often limited by challenges associated with device integration and reliable readout. We present an all-electrical readout mechanism for quasi-0D quantum states (0D-QS), such as point defects, adatoms, and molecules, that is modular and general, providing an approach that is amenable to scaling and integration with other solid-state quantum technologies. Our approach relies on the creation of high-quality tunnel junctions via the mechanical exfoliation and stacking of multilayer graphene (MLG) and hexagonal boron nitride (hBN) to encapsulate the target system in an MLG/hBN/0D-QS/hBN/MLG heterostructure. This structure allows for all-electronic spectroscopy and readout of candidate systems through a combination of coulomb and spin-blockade. To validate this, we demonstrated Scanning tunneling microscopy (STM) measurements of the molecular spin qubit vanadyl phthalocyanine (VOPc) deposited on hBN that reveal well-ordered bilayer films and the difference between direct tunneling and tunneling through the quantum states with differential conductance spectra. Our approach demonstrates a new pathway for the incorporation of molecules and atomic defects into solid-state quantum devices and circuits.

Academic or Professional Status

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