Radio-Frequency Charge Detection on Gate-Defined Bilayer Graphene Quantum Dots

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Quantum dots (QDs) in bilayer graphene (BLG) are promising hosts for spin or valley qubits. The small, voltage controllable band gap in BLG allows the realization of electron-hole double quantum dots (DQDs) that exhibit near-perfect particle-hole symmetry. The particle-hole symmetric spin and valley texture leads to a protected single-particle spin-valley blockade which can be exploited for spin-to-charge and valley-to-charge conversion [1]. This promises a high-fidelity readout scheme for spin and valley states, which is essential for qubit operations. This blockade mechanism has so far only been studied by DC transport.

Here, we present high-bandwidth charge detection of an electron-hole DQD using a capacitively coupled quantum point contact (QPC). An optimized device design reduces screening effects and increases the sensitivity of the charge detector. The QPC has been arranged to maximize the readout contrast between the two QDs. The use of radio-frequency (RF) reflectometry techniques allows for a distinction of the charge states with a signal-to-noise ratio (SNR) of up to 160 and a bandwidth of up to 7 MHz. Finally, we demonstrate time-resolved detection of individual tunneling events across the (0h,0e) - (1h,1e) charge transition. These findings mark an important step in realizing a qubit in the electron-hole BLG QD system.

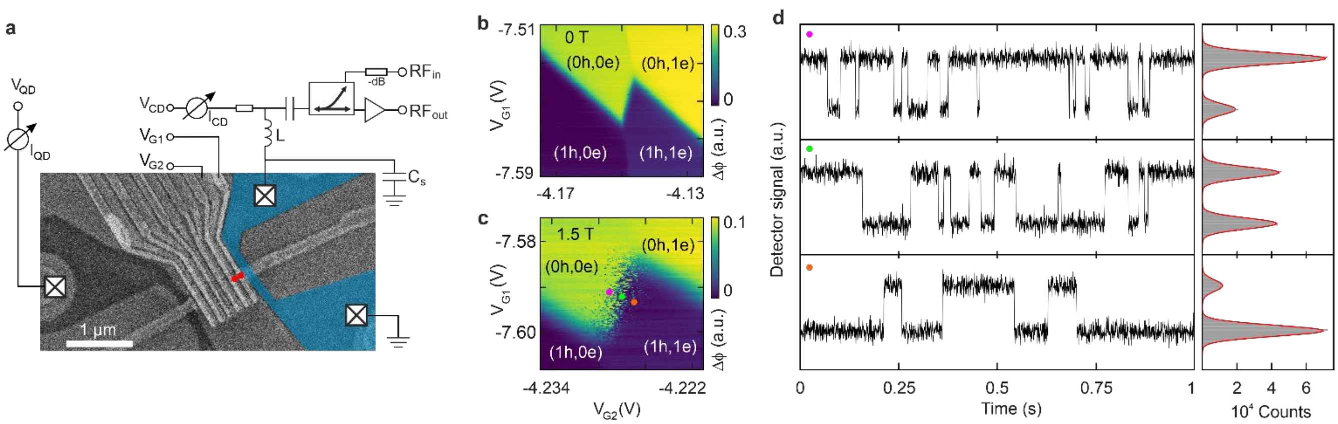

Fig. 1. (a) Scanning electron microscope image of the device together with a schematic of the RF readout circuit. QDs are formed under the finger gates as indicated in red and couple capacitively to a QPC formed in the channel highlighted in blue. An LC resonant circuit is connected to that channel and the reflected RF signal is measured. (b, c) Charge stability diagrams of the DQD in the single-electron single-hole regime measured at $B = 0$ T and at $B = 1.5$ T. (d) Time-resolved detection of (0h,0e) - (1h,1e) charge transitions together with their histograms. Data taken at three different points in gate space as indicated in by the colored dots in panel (c).

References

[1] L. Banszerus et al., Nature 618, 51 (2023).