Pulsed-Gate Spectroscopy of Single-Electron Spin States in Bilayer Graphene Quantum Dots

Christian Volk[1,2]
L. Banszerus[1,2], K. Hecker[1,2], E. Icking[1,2], K. Watanabe[3], T. Taniguchi[4], and C. Stampfer[1,2]
[1]*JARA-FIT and 2nd Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany*
[2]*Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany*
[3]*Research Center for Functional Materials, NIMS, 1-1 Namiki, Tsukuba 305-0044, Japan*
[4]*International Center for Materials Nanoarchitectonics, NIMS, 1-1 Namiki, Tsukuba305-0044, Japan*
volk@physik.rwth-aachen.de

Bilayer graphene (BLG) is an attractive host material for spin qubits due to its small spin-orbit and hyper-fine interaction, as well as the possibility to open a gate voltage controllable band gap. The development of gate-defined quantum dots (QDs) in ultra-clean BLG-based van der Waals heterostructures has led to a boost in device quality. Although the electrostatic confinement of single electrons in BLG QDs has been demonstrated, and their spin and valley texture of the single particle spectrum has been studied in detail, their relaxation dynamics remains still unexplored. We present high-frequency, transient-current spectroscopy on a single-electron QD in BLG. When applying a MHz square pulse to the gate defining the QD, we observe transient currents through single-electron excited states with opposite spin than the ground state. Measuring the current as a function of the pulse width, we extract characteristic blocking times, after which transient currents are suppressed. The extracted value of 0.5 μs serves as a lower bound to the spin lifetime of excited states in single-electron BLG QDs [1]. This result represents an important step towards the investigation of spin coherence times in graphene-based QDs and the implementation of spin-qubits.

References

[1] L. Banszerus, K. Hecker, E. Icking, S. Trellenkamp, F. Lentz, D. Neumaier, K. Watanabe, T. Taniguchi, C. Volk, and C. Stampfer, Phys. Rev. B **103**, L081404 (2021).

Figures

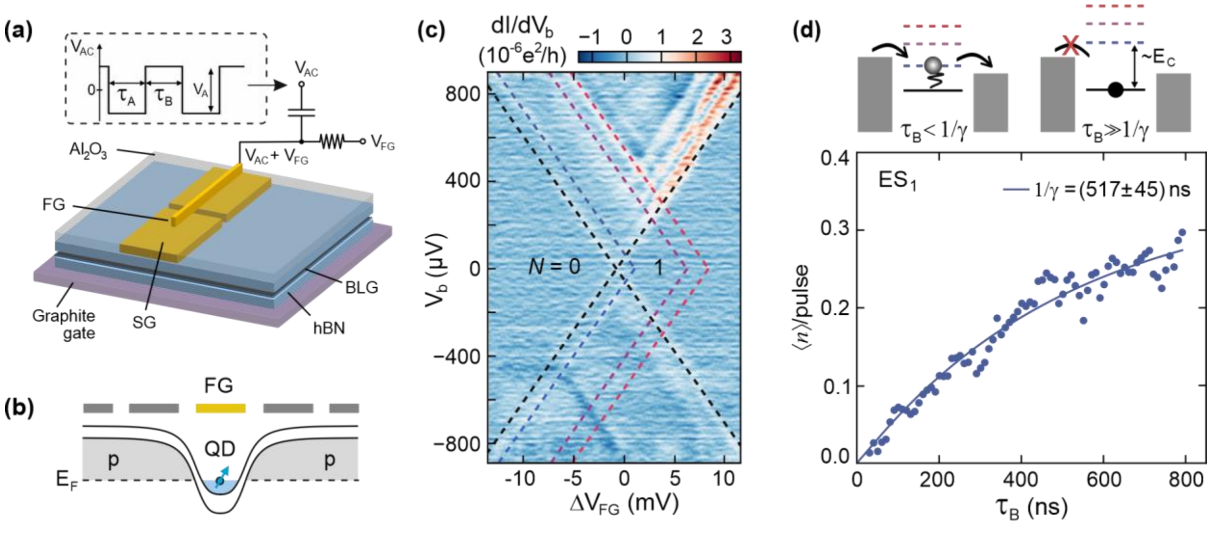

Figure 1: (a) Schematic of the device. AC and DC voltages are applied to the finger gate (FG). Inset: Pulse sequence with pulse widths τ_A, τ_B. (b) Band edge diagram along the p-type channel, illustrating the formation of a QD. (c) Finite bias spectroscopy at the transition from 0 to 1 electrons highlighting excited state transitions. (d) Average number of electrons passing through the QD via the first excited state as function of τ_B, which allows determining the characteristic blocking time $1/\gamma$.