Spin and Valley Relaxation in Single-Electron Graphene Quantum Dots

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The relaxation time of single-electron states in a quantum dot (QD) is an important parameter for solid-state spin and valley qubits, as it directly limits the lifetime of the encoded information. Thanks to the low spin-orbit interaction and low hyperfine coupling, graphene and bilayer graphene (BLG) have long been considered promising platforms for spin qubits. Only recently, it has become possible to control single-electrons in BLG QDs and to understand their spin-valley texture [1], while the relaxation dynamics have remained mostly unexplored [2]. Here, we present spin and valley relaxation times (T_1) of single-electron states in BLG QDs. Using pulsed-gate spectroscopy, we extract spin relaxation times T_{1s} exceeding 200 µs at a magnetic field of B = 1.9 T [3] and valley relaxation times T_{1v} of around 6 µs at B = 0.1 T. The strong dependence of T_{1s} on the spin splitting, promises even longer T_{1s} at smaller B, where our measurements are limited by the signal-to-noise ratio. The spin relaxation times are more than two orders of magnitude larger than those previously reported for carbon-based QDs, further suggesting that graphene is a promising host material for scalable spin qubits.

References

[1] L. Banszerus, S. Möller, C. Steiner, E. Icking, S. Trellenkamp, F. Lentz, K. Watanabe, T. Taniguchi, C. Volk, and C. Stampfer, Nat. Commun.12, 5250 (2021).
[2] 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).
[3] L. Banszerus, K. Hecker, S. Möller, E. Icking, K. Watanabe, T. Taniguchi, C. Volk, and C. Stampfer, arXiv:2110.13051 (2021).

Figures

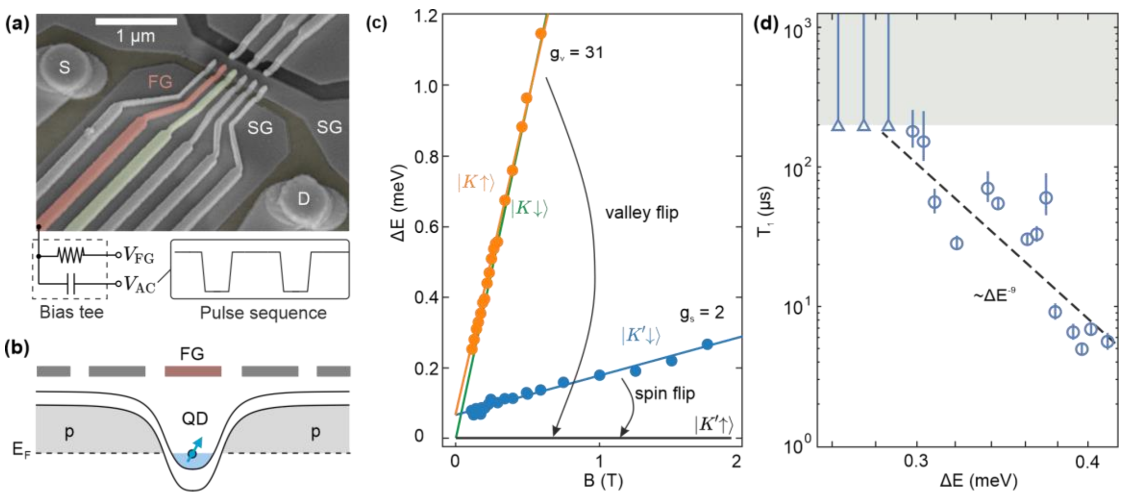

Figure 1: (a) Scanning electron micrograph of the device. AC and DC voltages are applied to the finger gate (FG). (b) Band edge diagram along the p-type channel, illustrating the formation of a QD. (c) Measured energy splitting of the states. (d) Spin relaxation time T_1 as a function of the energy splitting.