Tunable few-electron single and double quantum dots in bilayer graphene

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Bilayer graphene (BLG) is an attractive host material for spin based quantum information processing, as BLG has very little spin-orbit interaction and low hyperfine coupling and thus promises long spin coherence times. Furthermore, BLG offers the unique opportunity to open up a band gap and tune the band curvature and band topology using an external electric field. Through the use of a graphitic back gate and metal split and finger gates, we electrostatically confine charge carriers in single quantum dots (QD) with a dot diameter of around 70nm. We are able to control the QD occupation from a single electron up to more than twelve electrons. In the single QD, we observe a shell filling sequence of spin and valley states with a pronounced spin valley gap on the order of 500μeV for the first three shells.
Next, we focus on a BLG double QD, where we are able to control the number of charge carriers on two gate-defined quantum dot independently between zero and five.
The high tunability of the device meets requirements to make such a device a suitable building block for spin-qubits. In the single electron regime, we determine interdot tunnel rates on the order of 2 GHz. Both, the interdot tunnel coupling, as well as the capacitive interdot coupling increase with dot occupation, leading to the transition to a single quantum dot. Finite bias magneto-spectroscopy measurements allow to resolve the excited state spectra of the first electrons in the double quantum dot; being in agreement with spin and valley conserving interdot tunnelling processes.

References

[1] L. Banszerus, S. Möller, E. Icking, K. Watanabe, T. Taniguchi, C. Volk, and C. Stampfer, arXiv: 1912.11373

Figures

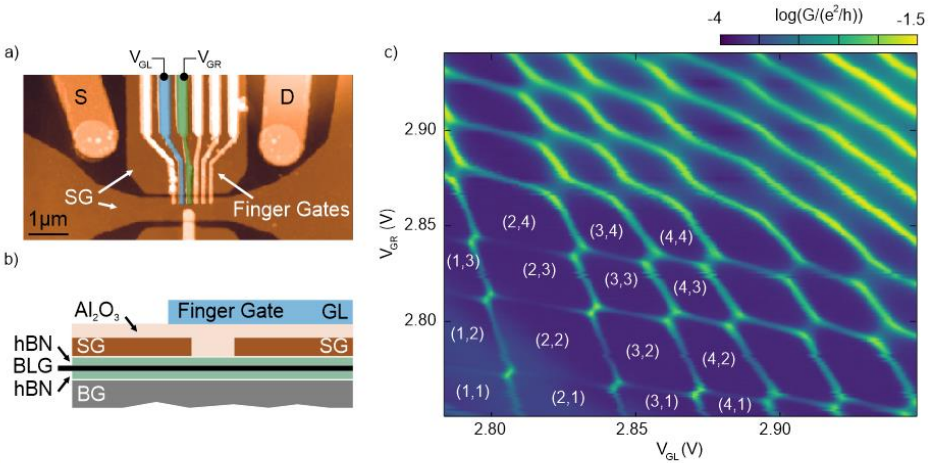

Figure 1: a) Atomic force microscopy image of the bilayer graphene quantum dot device b) Schematic cross section of the van-der-Waals heterostructure with metal gates on top. C) Charge stability diagram of the bilayer graphene double quantum dot.