Quantum transport in nanostructures based on semiconducting van der Waals heterostructures

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In the 21st century advances in materials and device manufacture have enabled controlled fabrication of nanostructured materials. Our aim is to investigate novel quantum phenomena due to the spin-valley coupling in atomically thin two-dimensional (2D) transition metal dichalcogenides (TMDCs) such as MoS_2, an emerging class of materials with promise for quantum technologies using a new quantum degree of freedom, the valley pseudo-spin. Notably, due to a sizable band gap and the strong spin-orbit coupling, TMDCs are expected to have good condition to form a quantum bit. Furthermore, the pure thinness of these materials in combination with 2D insulators such as boron nitride pave the way for ultra-small strongly coupled gate-defined quantum devices.

To achieve high mobility TMDC devices, we fabricate MoS_2-based van der Waals heterostructures, as shown in fig 1 [1]. Furthermore, we realize a split gate geometry which results in a tunable tunnelling barrier, the starting point for any electronic quantum device.

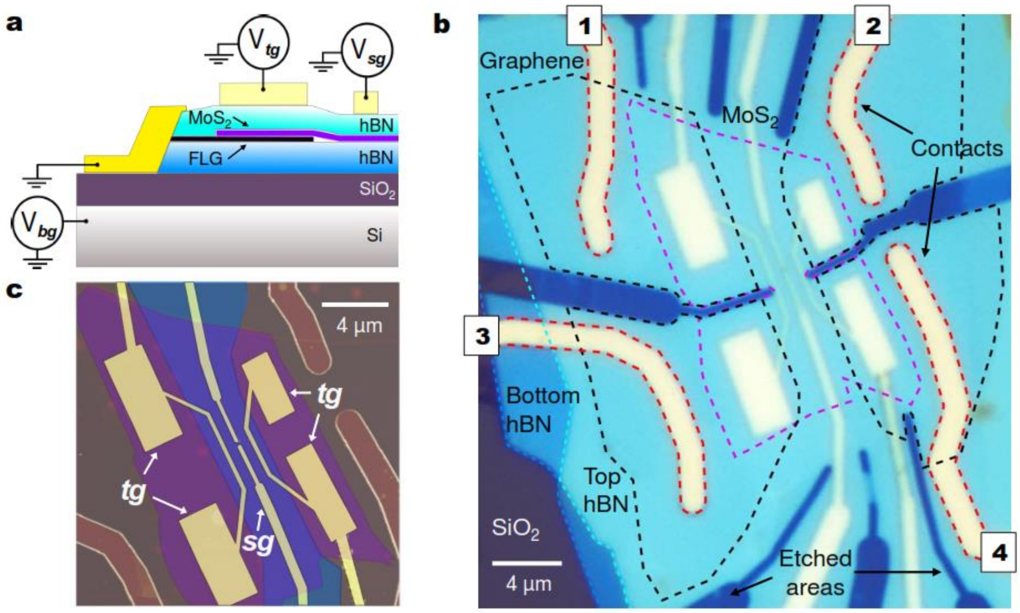

Figure 1.(a) Cross-sectional schematic of the MoS_2 -based field-effect device. (b) Optical micrograph of the device. An encapsulated trilayer MoS_2 (purple dashed lines) is connected to two graphene flakes (black dashed lines). Au/Cr 1-dimensional edge contacts (numbered 1-4) to the graphene flakes are fabricated. The dark blue regions outline the etched areas that define the final device geometry. (c) False-color AFM image of the device before the last etching process. Four rectangular gates have been deposited on top of the contact areas between graphene and MoS_2 in order to reduce the contact resistance without affecting the low carrier density in the MoS_2channel. A split gate, defining a nanoconstriction, has been placed on top of a bubble-free region.

Our ultimate goal is to realize a double quantum dots in TMDCs which have the potential application towards quantum computing.

[1] R. Pisoni et al., Quantized conductance and broken symmetry states in MoS_2 van der Waals heterostructures. *arXiv:1701.08619*