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Quantum Point Contacts in Monolayer WSe_2

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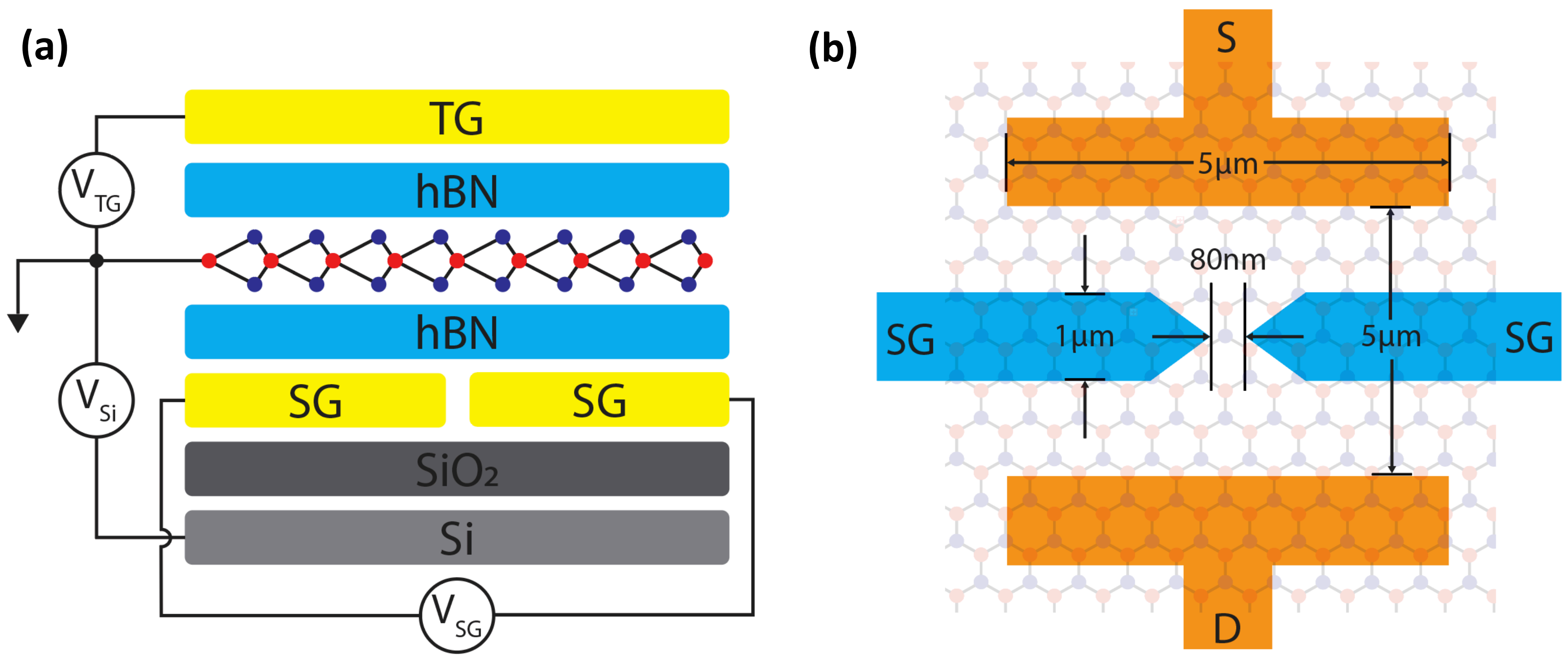
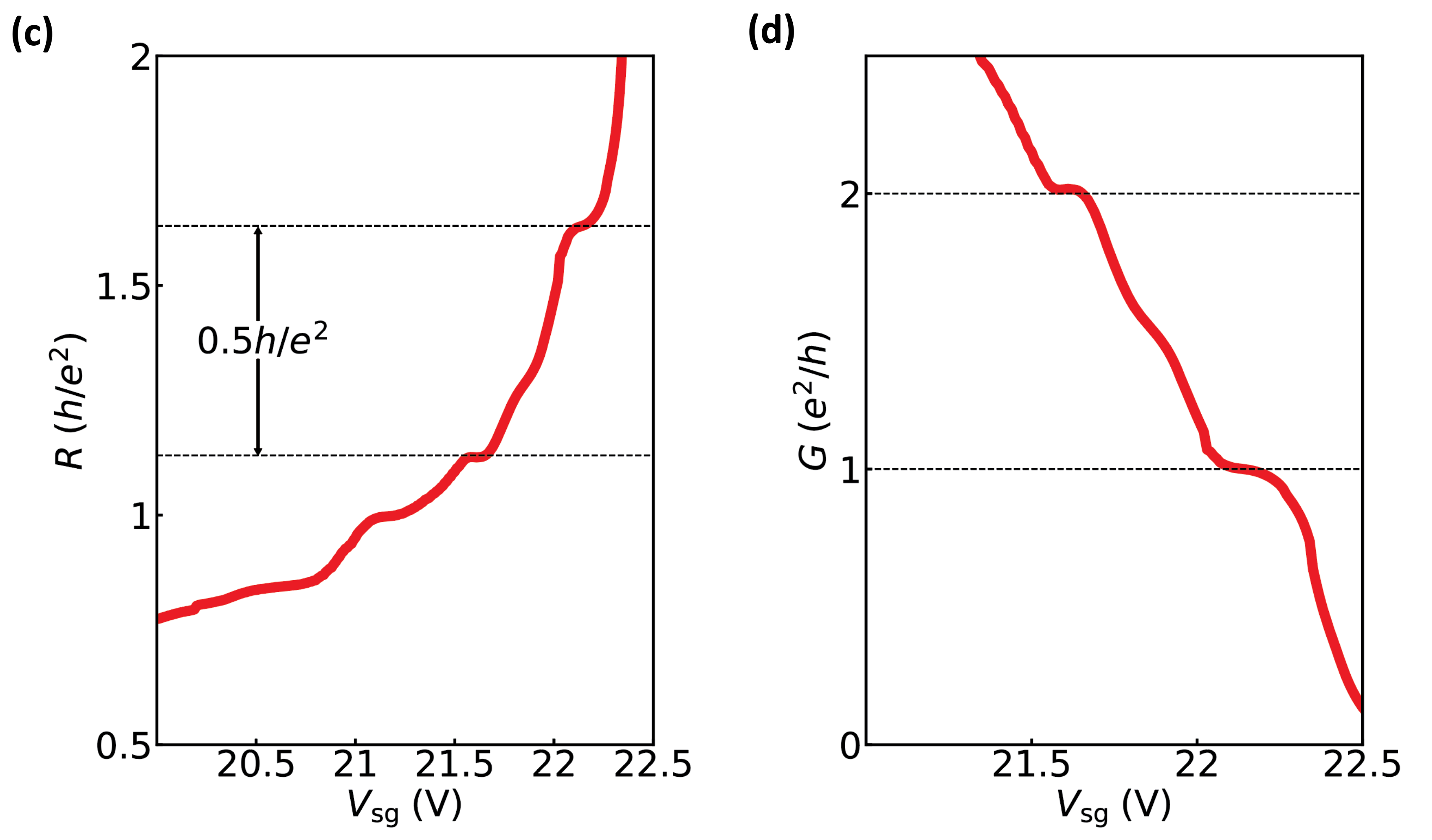
Abstract

Quantum point contacts (QPCs) have been realized in III-IV semiconductor heterostructures, and more recently in bilayer graphene and trilayer WSe_2 [1, 2]. These QPCs are fabricated in these two-dimensional systems using electrostatic gates, and require ballistic transport from source to drain contact to observe conductance quantization. In this work, we show that it is possible to achieve high-quality QPCs on monolayer WSe_2 due to improvements in materials synthesis and contact quality. Measurements down to millikelvin temperatures show clear conductance quantization over micron-sized source-drain length scales. In WSe_2, at zero field, a two-fold degeneracy is expected at the top of the valence band due to the presence of strong spin-orbit interactions. Surprisingly, we find that the observed conductance plateaus are quantized in units of e^2/h, indicating that the spin-valley degeneracy is lifted even without the application of magnetic fields. Further, the first plateau has a systematic dependence on charge carrier density and on applied magnetic field, in a manner similar to the "0.7-anomaly" reported in previous experiments on III-V semiconductors [3].

Method

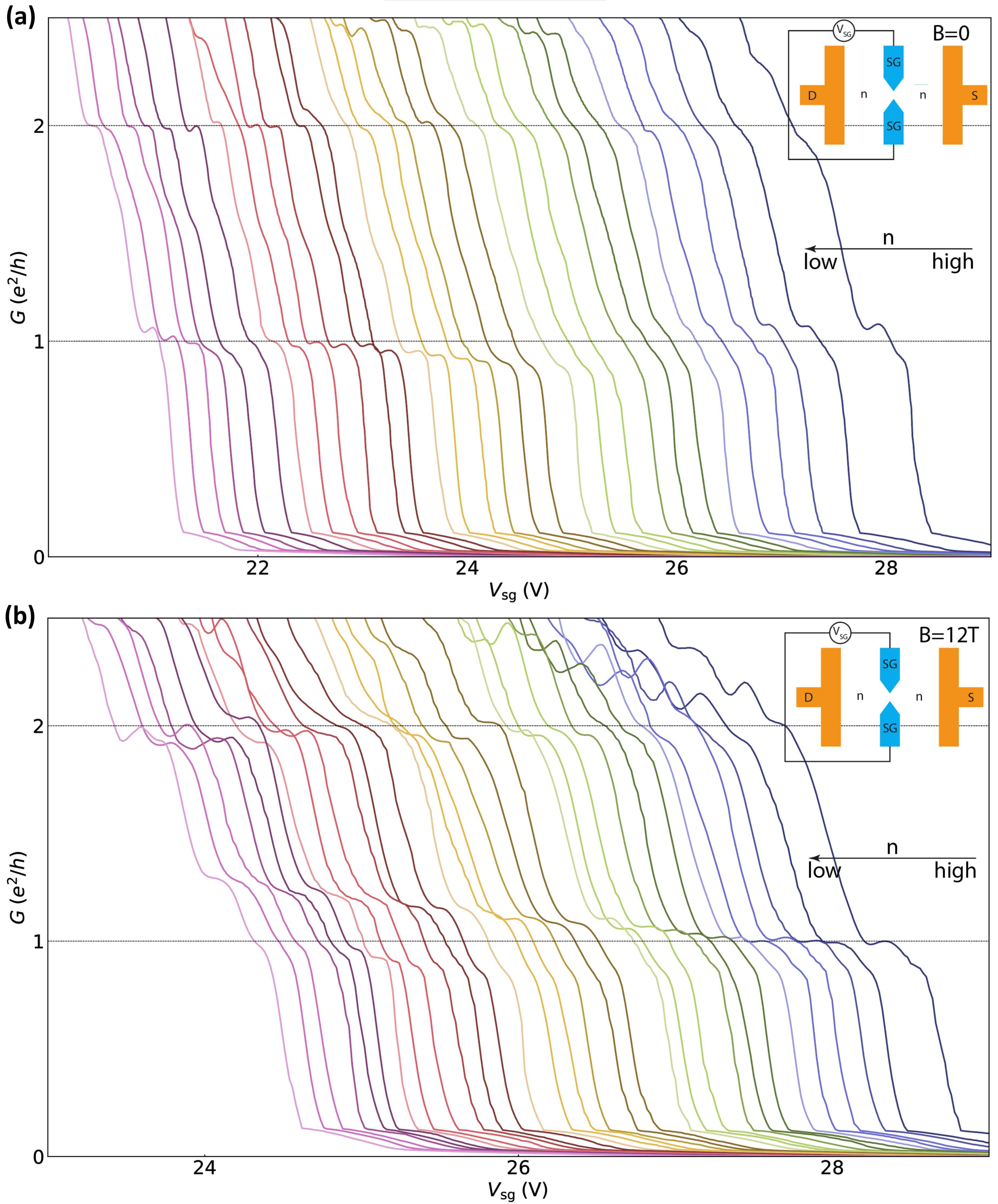


(a-b). Schematic drawings of our device geometry. A pair of metal split-gate (SG) with an 80nm gap is first deposited on the SiO_2/Si substrate, covered by a layer of hBN (~50nm thick) with Pt/Cr pre-pattern contacts on top. Then the hBN/WSe_2 stack is dropped onto the contacts and eventually covered by a global metal top-gate (TG).



(c-d). Method for subtracting the two-probe contact resistance. A $0.5h/e^2$ separation is found in the resistance steps (c) to locate the corresponding first two plateaus (i.e., $1e^2/h$ and $2e^2/h$) in the conductance (d).

Results



Conductance as a function of split-gate (V_{SG}) at zero field **(a)** and B=12T **(b)**. Curves from right to left correspond to lowering the carrier density outside the channel.

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