# Charge Transport in Split-gated Point Contact based on $MoS_2/WSe_2$ Heterostructure

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As advancements in quantum phenomena coincide with the ongoing miniaturization of nano-semiconductor transistors, the exploration of novel quantum structures beyond conventional types becomes essential [1]. This study delves into the investigation of electrostatically defined nanoscale devices within 2D semiconductor heterostructures, particularly focusing on van der Waals heterostructures, which offer notable advantages such as large-scale uniformity and flexibility [2,3]. The research presented here scrutinizes the charge transport characteristics within a split-gated point contact device of a $MoS_2/WSe_2$ heterostructure. It elucidates the step-like behavior observed under the influence of split-gate and middle-gate control, while also examining the confinement transport mechanisms governed by split-gate and back-gate configurations. Through meticulous electrostatic manipulation, the interplay between quantum confinement and gate control is explored, providing valuable insights into the engineering of nanoelectronic devices. The observed step-like current profile underscores the intricate relationship between quantum effects and gate voltage modulation, thereby shedding light on the underlying physics governing charge transport in two-dimensional semiconductor heterostructures. By systematically varying gate voltages and temperatures, this study reveals the temperature-dependent nature of charge scattering mechanisms and the pivotal role of gate potentials in manipulating carrier concentration and transport pathways. These findings significantly contribute to a deeper understanding of electrostatic effects in 2D transition metal dichalcogenide heterostructures, thus paving the way for the development of advanced electronic devices with tailored confinement for enhanced functionalities [4].

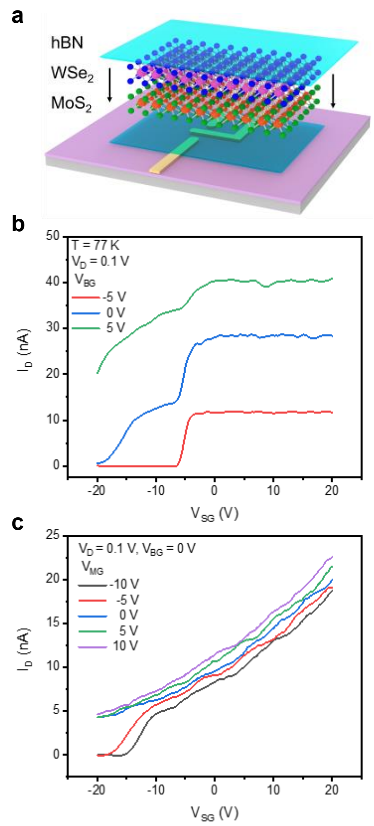


Fig.1. a) Schematic of the $WSe_2/MoS_2$ device. b) Confinement transport under split-gate and back-gate control. c) Step-like currents at 77 K for a series of $V_{SG}$ and $V_{MG}$.

References

[1] A. Jouan, et al., Nat. Electron. **3**, 201 (2020).

[2] K. Sakanashi, et al., Nano Lett. **21**, 7534 (2021).

[3] C. H. Sharma and M. Thalakulam, Sci. Rep. **7**, 735 (2017).

[4] G. Milano, et al., Adv. Mater. **34**, 2201248 (2022).