Interfaces engineering strategies for 2D semiconductor field-effect transistors

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Two-dimensional (2D) transition metal dichalcogenides (TMDCs) have emerged as promising materials for next-generation electronics due to their exceptional electronic and optical properties and compatibility with complementary metal–oxide–semiconductor (CMOS) technology. However, practical implementation remains limited by the lack of reliable strategies for precise performance control and optimization. Here, we present a comprehensive interface engineering framework that chemically functionalizes multiple interfaces within TMDC-based field-effect transistors (FETs), enabling systematic regulation of charge injection and charge transport. At the electrode–semiconductor interface, molecular functionalization tailors the electrode work function, significantly enhancing carrier injection and improving the rectification ratio of Schottky diodes. At the semiconductor–environment interface, defect engineering vis chemical healing and molecular doping reduce surface vacancy density and enhance electrical performance. Beyond performance optimization, functional molecules introduce new device functionalities, including isomer recognition and non-volatile memory behavior. Furthermore, functionalization of grain boundaries heals crystalline defects and promotes carrier transport, advancing the development of 2D semiconductor electronic inks toward scalable manufacturing. Through multi-interface chemical modulation, we achieve multidimensional control over the optical and electrical properties of TMDC devices. This work establishes a versatile platform for engineering high-performance 2D semiconductor electronics and represents a significant step toward their practical integration in future digital systems.

References

[1] B. Han, P. Samorì*. Acc. Chem. Res. 57(2024), 2532–2545.
[2] B. Han,# C. Ma,# … P. Samorì*. J. Am. Chem. Soc., 147(2025), 24162–24170
[3] B. Han, Y.M. Gali, S. Dai, D. Beljonne, P. Samorì*. ACS Nano 17(2023), 17956−17965.
[4] B. Han, Y. Zhao, C. Ma, … W. Hu, P. Samorì*. Adv. Mater. 34(2022), 2109445.
[5] B. Han, Y. Li, ... X. Yu*, W. Hu*. J. Am. Chem. Soc. 21(2020), 142, 9708-9717

Figures

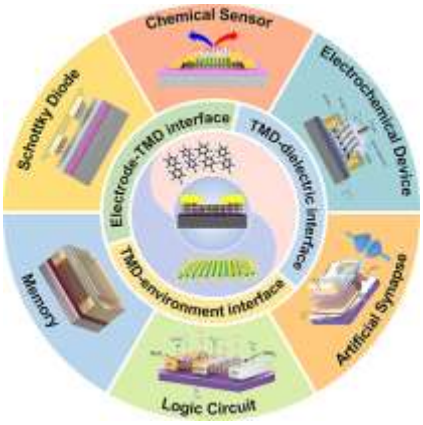

Figure 1: Engineering the Interfacing of Molecules with 2D Transition Metal Dichalcogenides.