Supporting Information

The Mechanism of Modulation of Electronic Anisotropy in Two-dimensional ReS_2

Renyan Wang,[a] Xiang Xu,[a] Yiwei Yu,[b] Meng Ran,[a] Qingfu Zhang,[a] Aoju Li,[a] Fuwei Zhuge,[a] Huiqiao Li,[a] Lin Gan,[*a,c] and Tianyou Zhai[*a]

[a] State Key Laboratory of Material Processing and Die & Mould Technology, School of Material Science and Engineering, Huazhong University of Science and Technology, Wuhan, 430074, P. R. China. E-mail: zhaity@hust.edu.cn

[b] Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan, 430074, P. R. China.

[c] Shenzhen R&D Center of Huazhong University of Science and Technology, Shenzhen 518000, P. R. China. E-mail: ganlinust@hust.edu.cn

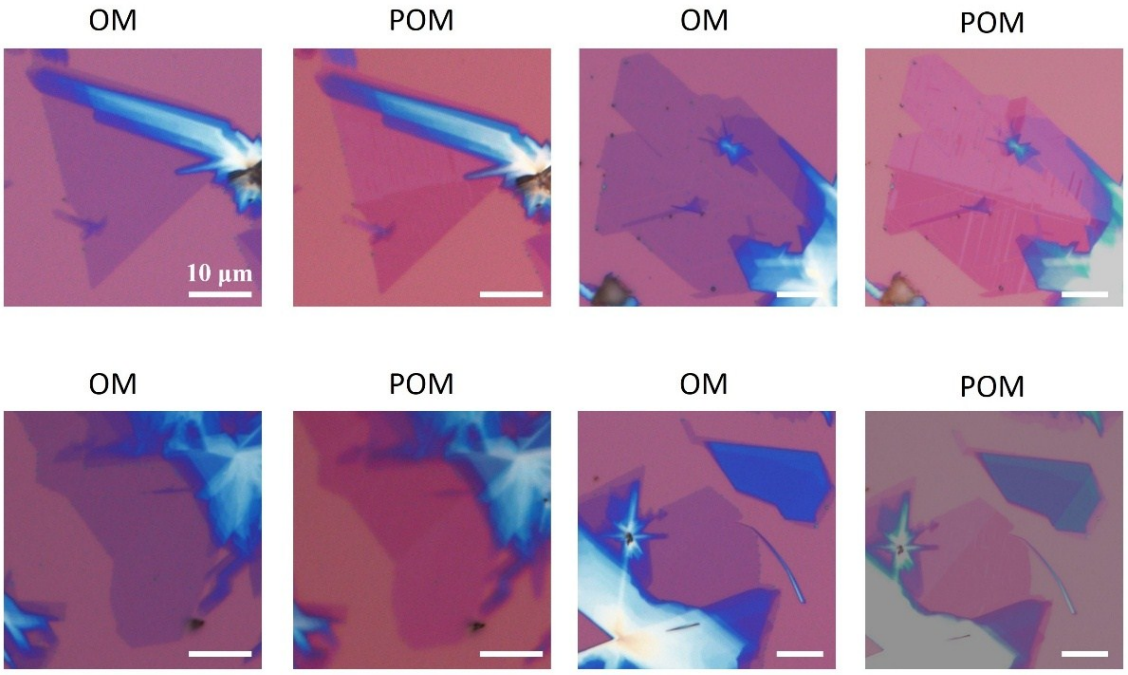


Figure S1. The optical images and polarized optical images of as-synthesized ReS_2, scale bar is 10 μm.

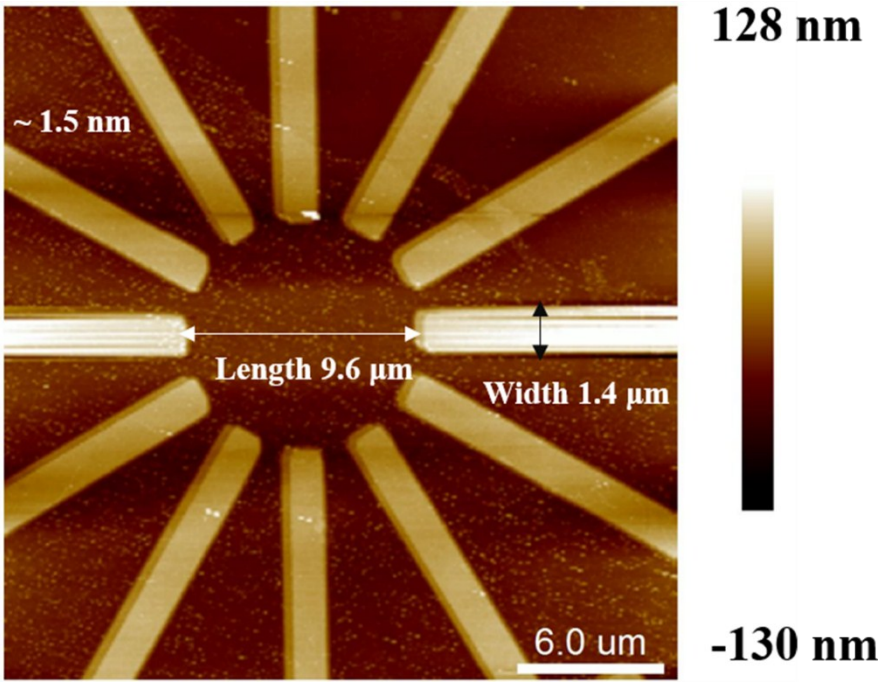


Figure S2. The atomic force microscope image of ReS_2 device.

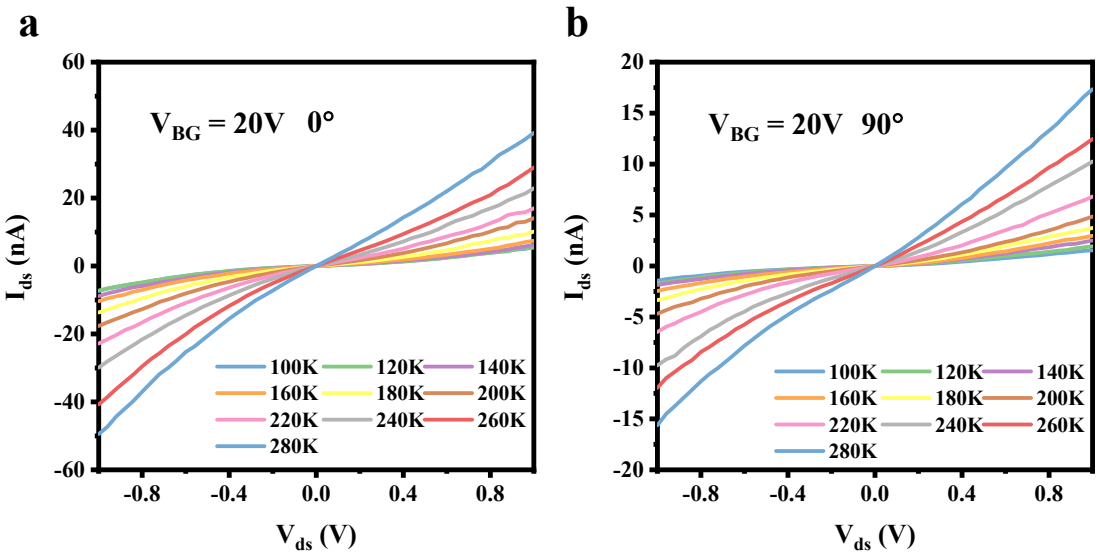


Figure S3. Temperature dependent I-V curves at 0˚ and 90˚ directions at V_g of 20 V, respectively.

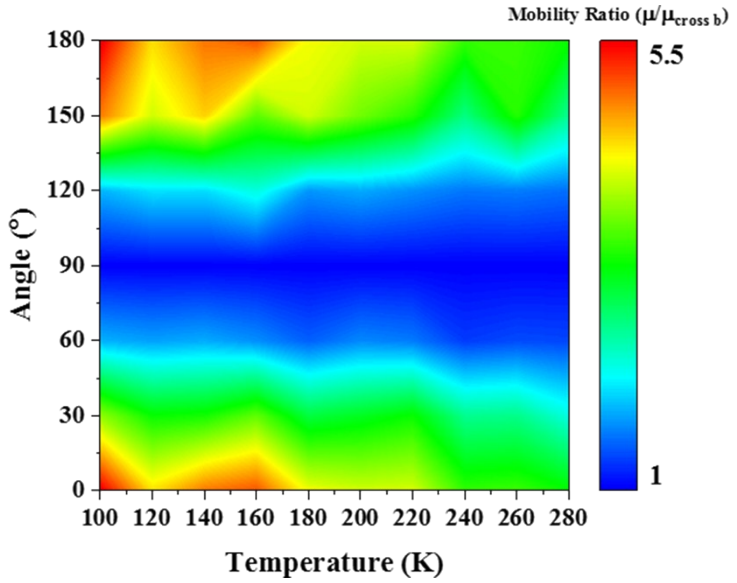


Figure S4. Angle dependent mobility ratio mapping of ReS_2.

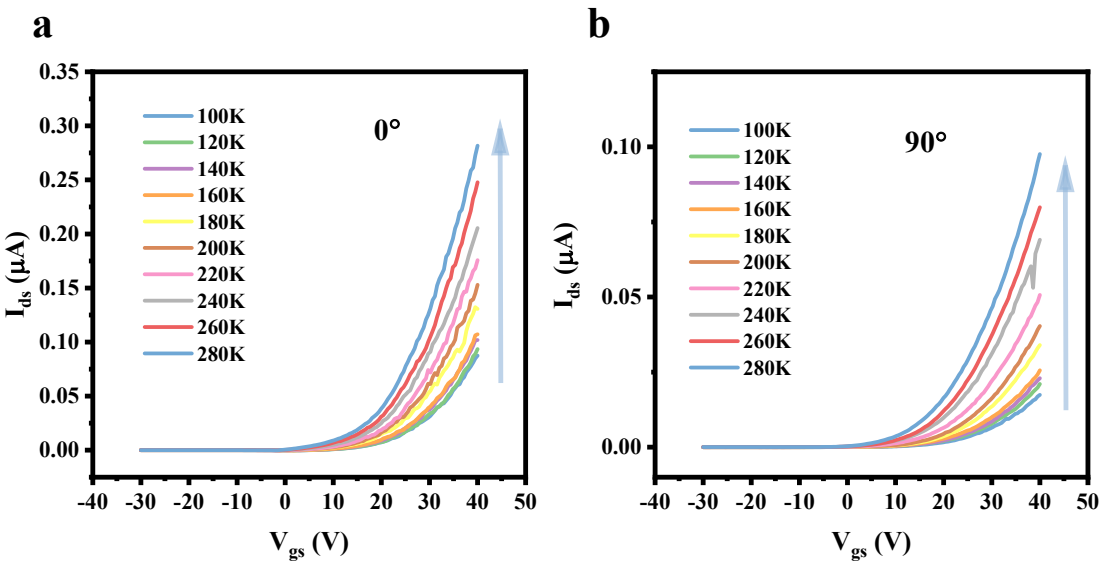


Figure S5. Temperature dependent transfer characteristic curves at 0˚ and 90˚ directions, respectively.

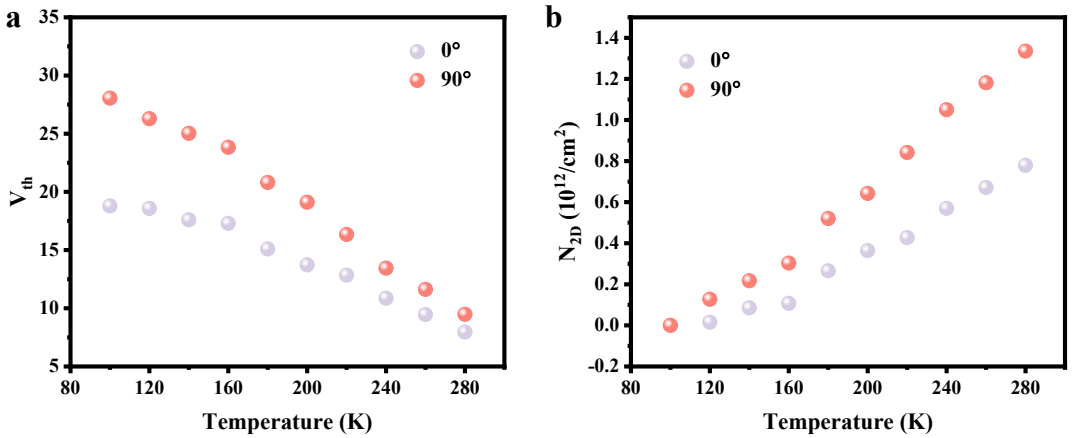
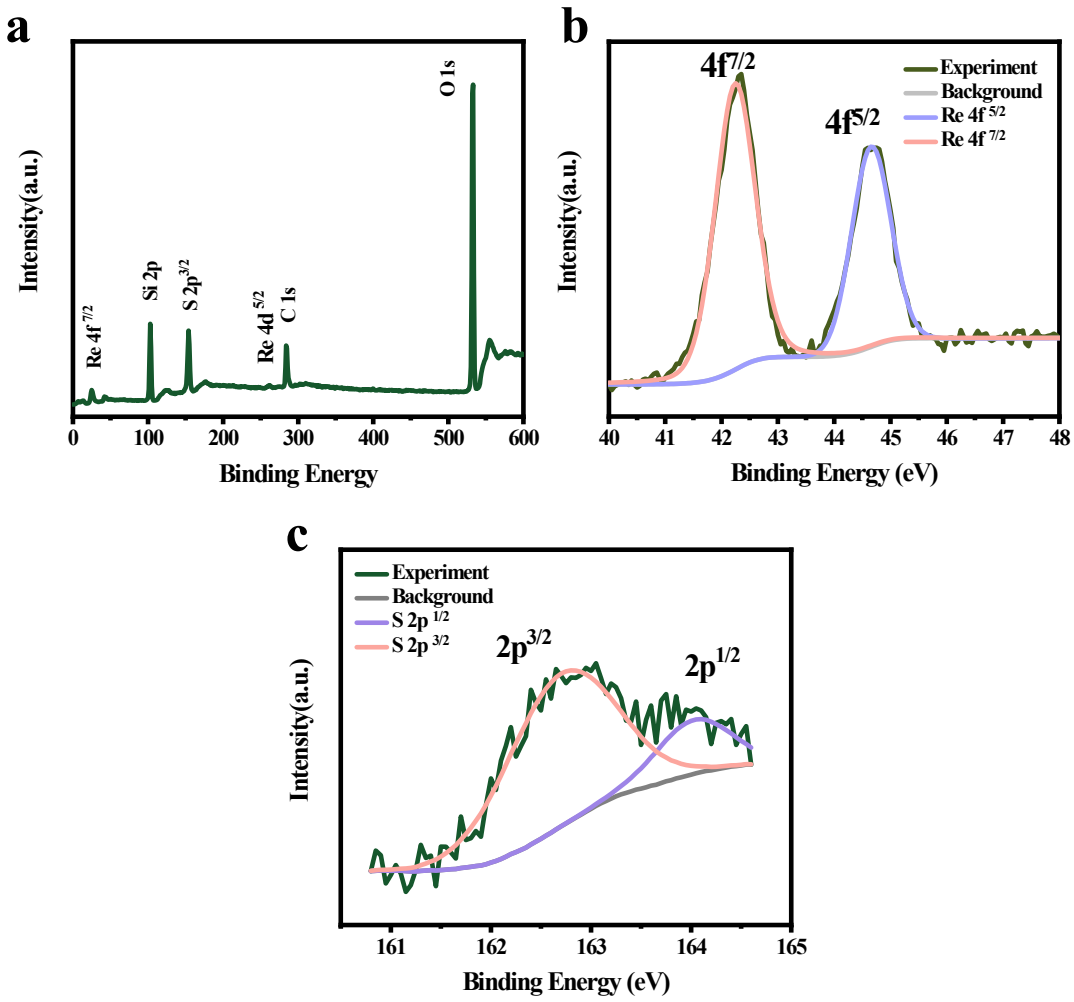


Figure S6. (a) the V_{th} value under different temperatures at both directions. (b) Temperature-induced doping concentration at both directions. Temperature-induced doping concentration can also be extracted by the parallel-plate capacitor model where ΔV is change of V_{th} induced by temperature. Taken 100 K as initial point, thus the temperature-induced doping concentration is: $P_{2D}=(C_{ox}\Delta V_{th})/e$, Where $\Delta V_{th} = |V_{th}(T) - V_{th}(100K)|$.



Atom	Peak Area (Re4f 7/2)	Peak Area (Re4f 5/2)	Peak Area Sum (Re)	Peak Area (S2p 3/2)	Peak Area (S2p 1/2)	Peak Area Sum (S)	Sensitivity Factor (Al)	Atom component
Re	1473.947	936.713	2410.66				1.89	0.5
S				587.836	129.209	717.04	0.49	0.89

Figure S7. X-ray photoelectron spectroscopy of as-grown ReS_2 on silicon substrate. (a) XPS full spectrum and (b) the high-resolution XPS Re 4f, (c) S 2p spectra.

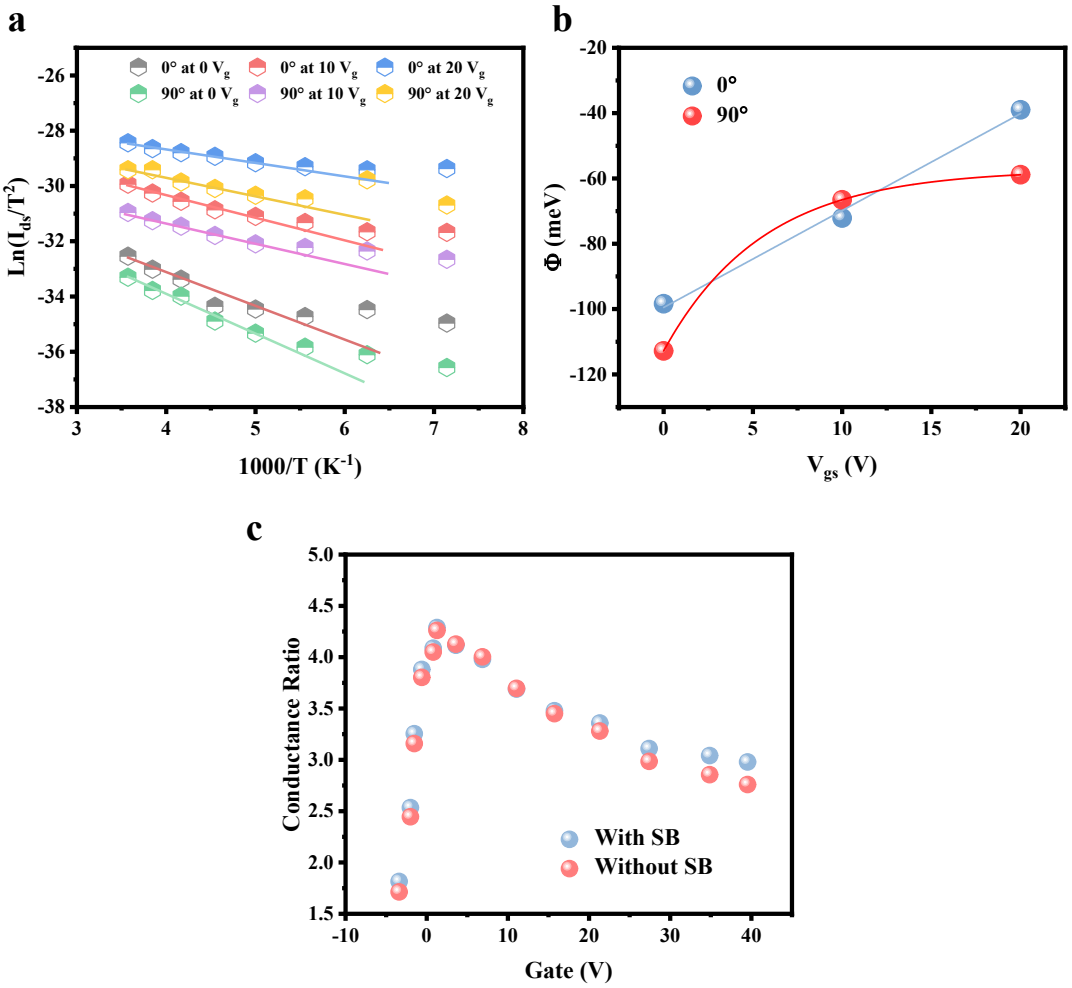


Figure S8. (a) The Arrhenius plots for temperature-varied conductivity curves under different gate voltages at 0˚ and 90˚ directions. (b) The Schottky barrier heights at different gate voltages. (c) Conductance Ratio under different gate voltages with and without Schottky barriers estimated from b.

The Schottky barriers are induced and investigated according to thermionic I-V relationship given as below:[1]

$$I_{ds} = AA^{*}T^{2}exp\left(\frac{q\Phi}{k_B T}\right)\left[1 - exp\left(-\frac{qV_{ds}}{k_B T}\right)\right]$$

Where A is junction area, A^{*} is the Richardson constant, q is the magnitude of the electron charge and Φ is the Schottky barrier. The Arrhenius plot of ReS_2 device measured at various gate voltages is shown in Figure S8a. When T > 180K, from the slope of ln (I_{ds}/T^2) vs. 1000/T,

we calculated the Schottky barrier height (SBH) under different gate voltages. With the voltage increased from 0 to 20 V, the SBH at both directions reduces ~ 60 meV owing to increasing density of states in Fermi level (Figure S8b). But we note that a near linear change of SBH in b axis occurs while in cross b direction SBH shows an exponent decrease mode.[2, 3] To eliminate influence of variable SBH during modulation process, the anisotropic mobility under different gate voltages without SBH can be extracted based on effective bias voltages ($V_{effective}=V_{load}$ - SBH). The anisotropic mobility ratio with and without SBH are shown in Figure S8c.

REFERENCES

1 B. Jiang, X. Zou, J. Su, J. Liang, J. Wang, H. Liu, L. Feng, C. Jiang, F. Wang, J. He and L. Liao, *Adv. Funct. Mater.* 2018, **28**, 1801398.

2 X. Zhang, J. Jiang, A. A. Suleiman, B. Jin, X. Hu, X. Zhou and T. Zhai, *Adv. Funct. Mater.* 2019, **29**, 1906585.

3 N. R. Pradhan, D. Rhodes, S. Feng, Y. Xin, S. Memaran, B.-H. Moon, H. Terrones, M. Terrones and L. Balicas, *ACS Nano* 2014, **8**, 5911-5920.