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Performance potential and limit in van der Waals $MoTe_2$ Transistors

Due to the versatile and tunable properties in nature, atomically thin transition-metal dichalcogenides (TMD) with the common formula MX_2, where M stands for a transition metal (Mo or W) and X is a chalcogen element (S, Se, Te), have garnered considerable attention for development of next-generation electronics from 2011. Among the TMD compounds, 2H-type molybdenum ditelluride ($MoTe_2$) has a smaller semiconducting gap in the range of 0.8 to 1.0 eV, which gives a high compatibility with modern Si thin-film processing. In this talk, I will present the synthesis, thickness identification of layered $MoTe_2$ materials as well as its electrical characterizations. In contrast to the unipolar features in widely studied MoS_2 transistors, van der Waals $MoTe_2$ transistors display the ambipolarity in charge transport, which is attributed to the existence of Schottky potential barriers between metals and conducting channel [1]. Through applying different controlled electric field, the modulation of such the potential barrier can be realized, allowing a low contact resistance for both n- and p-type channels, which will also be discussed. In addition, to deliberately explore the fluctuation mechanism of carrier trapping/de-trapping in such nanoscale electronics, I will demonstrate the origin of electric noise in van der Waals $MoTe_2$ transistors by means of the strategy of low-frequency noise measurements [2]. The experimental data clearly suggest that the dynamic processes at the channel surface such as gas absorptions/desorptions strongly affect its carrier transport. Eventually, using this feature of gas absorptions/desorptions, I will show a new doping concept, electrothermal doping [3]. The electrothermal doping adopted in obtaining p/n-type doping $MoTe_2$ transistors can provide an approach to create logic devices with desired performance.

References

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Figures

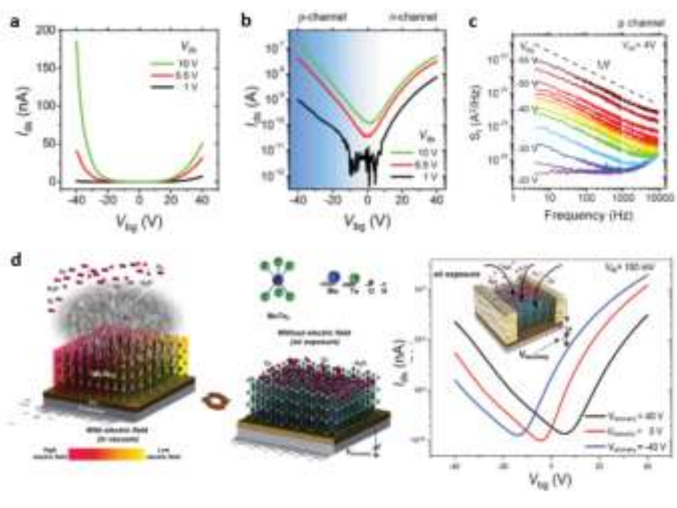

Figure 1: Room-temperature transfer characteristics of van der Waals $MoTe_2$ transistors under different V_{ds} values on a linear scale (a) and on a logarithmic scale (b). (c) Typical current fluctuations as a function of frequency under different V_{bg} values. (d) Schematic of a $MoTe_2$ channel processed by the electrothermal doping process and the corresponding transfer characteristics.