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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

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.