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Fabrication of Thermoelectric Field-Effect Transistors Using Few-Layer MoS_2 for Exploration of Optimum Thermopower

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ABSTRACT

High-efficiency MoS_2 field-effect transistor devices will be facing huge waste heat. Thus, studying the material properties over a wide temperature range and utilizing superior thermopower for energy harvesting is inevitable. The electrical and thermoelectric properties of MoS_2 flakes across a wide thickness range from 1 to 39 layers over a broad temperature range are extensively explored. At 600 K, the maximum thermoelectric power factor of ~10 mW/m K² is achievable for MoS_2 with thicknesses of 1-5 layers, and the maximum Seebeck coefficient of ~1 mV/K is reachable for MoS_2 with thicknesses of 15-20 layers. The carrier concentration behavior of the Seebeck coefficient is analyzed and fitted to obtain the k_B/e of -9.09×10^{-5} V/K, within 5% error close to the ideal value of -8.62×10^{-5} V/K, and the effective electron mass of 0.733 m_0 for monolayer MoS_2. Here, the simplest method for measuring the effective mass of carriers in the 2D semiconductor channel has been discovered. Notably, the release of trapped charges from the SiO_2 dielectric above 450 K is probed, which significantly modulates electrical and thermoelectric properties of the 2D MoS_2 channel.

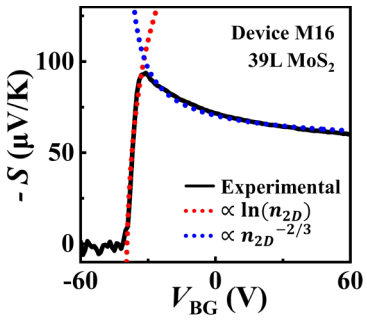

Fig. 1 Seebeck coefficient as a function of back-gating voltage.

REFERENCES

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