Black Phosphorus-Based Metal-Insulator-Semiconductor Diode in 2D van der Waals Heterostructures

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In this project, we explore the potential of metal-insulator-semiconductor (MIS) diodes within 2D van-der-Waals (vdW) heterostructures, specifically focusing on a heterostructure comprising few-layer black phosphorus (BP), a thin hexagonal boron nitride (hBN) layer, and monolayer graphene (Gr). Such heterostructures have gained significant interest in their applications in multifunctional device designs for analogue and digital electronics [1,2]. Our investigation reveals that the tunnel diodes formed by BP/hBN/Gr exhibit intriguing rectifying behaviors and low ideality factors. We successfully assemble the MIS heterojunction structure through a novel fabrication approach involving vertical stacking of layered materials via a simple dry transfer method. Comparative analysis with metal-semiconductor diodes constructed from similar layered materials underscores the superior current rectification observed in the MIS diode. Notably, the current-voltage characteristic curve of the MIS diode indicates predominant current flow across interfaces, attributed to carrier tunneling phenomena. Furthermore, we thoroughly examine the performance metrics of the MIS diode, including rectification ratio, ideality factor, and tunneling barrier, across a temperature range from 77 to 300 K. Our findings shed light on the promising prospects of MIS diodes in ultrathin nanoelectronics, offering insights into their potential for future applications in advanced electronic devices [3,4].

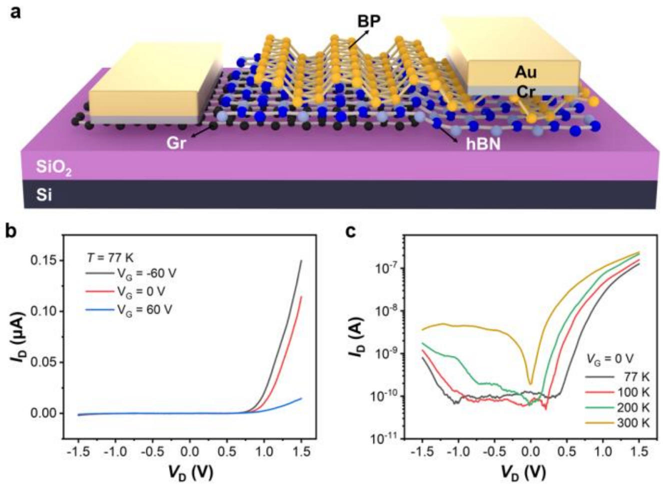

Fig.1. a) Schematic of the Gr/hBN/BP MIS diode. b) Diode behavior under different gate biases at 77 K. c) Temperature dependence of the MIS diode.

References

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