Charge density wave driven gate- and light-controlled negative differential resistor

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Abstract

1T-TaS_2 is a unique layered material that exhibits multiple temperature-dependent conductivity phases resulting from charge density waves (CDW) [1]. The non-commensurate (NC) to incommensurate (IC) phase transition of 1T-TaS_2 that occurs at 353 K can be driven at room temperature through an external electric field [2]. In this work, we demonstrate a negative differential resistor (NDR) in an asymmetric 1T-TaS_2/2H-MoS_2 T-junction using an electrically driven CDW phase transition. The device operational principle is regulated by majority carriers thus not limited by tunneling efficiency like in typical van der Waals heterojunctions. We obtain a peak current density in excess of 10^5 nAμm^{-2}, which is the highest peak current density reported to date in any layered material based NDR devices [3-4]. Additionally, the peak current density can be effectively tuned by an external gate voltage as well as photo-gating. The results are promising towards the implementation of active metal-based functionalities in electronic circuits.

References

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Figures

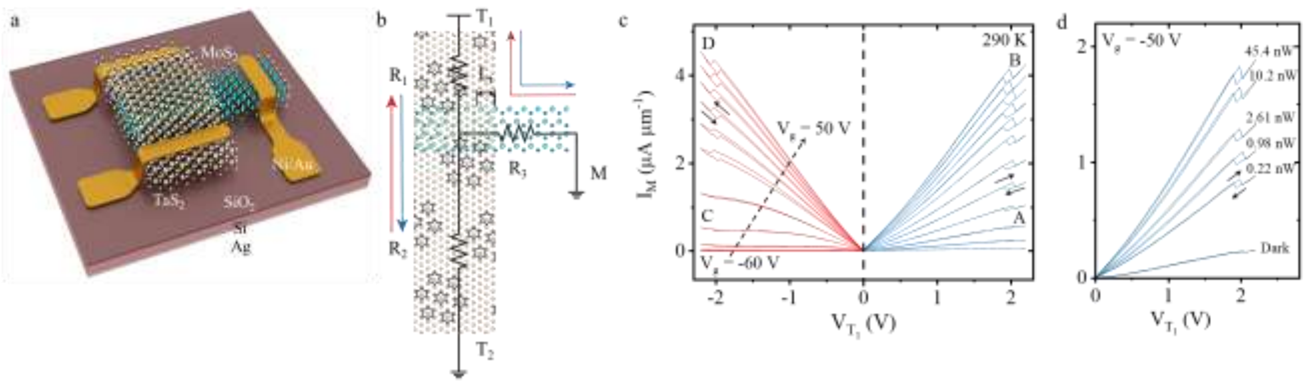

Figure 1: (a) Schematics of asymmetric 1T-TaS_2/2H-MoS_2 T-Junction. (b) Equivalent Circuit diagram of the device embedded with the crystal structure of 1T-TaS_2 in the non-commensurate (NC) phase. (c) MoS_2 current (I_M) versus V_{T1} depicting NDR as the function of gate voltage varied from -60 V to 50 V in steps of 10 V. (d) I_M versus V_{T1} as the function of 532 nm laser excitation power at V_g = -50 V depicting light-controlled NDR at 290 K.