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Contact resistance of two dimensional materials

Two dimensional (2D) materials are recently being investigated very intensively, with some of them holding great promise as semiconducting materials for future nano-electronics, beyond current semiconductor technology which faces hard limitation in performance enhancement due to excessive power dissipation during high frequency operation, as they present ultra-thin body with efficient electrostatic control. These properties, combined with mechanical flexibility, enable 2D materials to be very promising candidates that can meet major requirements for electronic and photonic devices operated in emerging future mobile and IoT environment. However, formation of proper electrical contacts to nanoscale 2D materials (e.g. transition metal dichalcogenides: TMDs) is becoming a major challenge in realizing the performance of the 2D material-based devices. According to recent studies, the observed two-terminal mobility in single-layer TMD devices is unexpectedly low [1], due to high contact resistance (Rc) induced between metal contact and TMDs. It is known that many 2D crystals are subjected to strong Fermi level pinning when they are in contact with metals. That is, the pinning is responsible for the observed high Schottky barrier height and high Rc. In this work, we report contact resistances and Schottky barrier heights at the interfaces [2] formed between molybdenum dichalcogenides and various metals, by obtaining I – V characteristics for various temperatures. According to our results, the pinned energy level was found to locate near the conduction band edge for MoS2 whereas it was near the intrinsic level for MoTe2. Furthermore, we experimentally demonstrate one-dimensional (1D) electrical contact to MoS2 formed by using controllable plasma etching. Interestingly, we were able to demonstrate Mo/MoS2 FET (n-type), and Pd/MoS2 FET (ambipolar), realizing efficient polarity control via depinning of Fermi level at the metallic contact interface.

Acknowledgments

This work was supported by the Global Research Laboratory (GRL) Program (2016K1A1A2912707) and Global Frontier R&D Program (2013M3A6B1078873), both funded by the Ministry of Science, ICT&Future Planning via the National Research Foundation of Korea (NRF).

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