Highlights

Electronic and thermal transport from the nanoscale to the macroscale - 2019

Effect of Electron Irradiation on the Transport and Field Emission Properties of Few-Layer MoS2 Field-Effect Transistors

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THE JOURNAL OF PHYSYCAL CHEMISTRY C 123 (2019) 454

Molybdenum disulfide (MoS_2) is a two-dimensional (2D) layered material, one of the transition-metal dichalcogenides with layers that are weakly held together by van der Waals forces. Energy band gap in MoS_2 varies from 1.2 eV (indirect) in the bulk to 1.8 – 1.9 eV (direct) in monolayer. Electrical characterization of few-layer MoS_2-based field-effect transistors (FET) with Ti/Au electrodes is performed in the vacuum chamber of a scanning electron microscope in order to study the effects of electron-beam irradiation on the transport properties of the device. A negative threshold voltage shift and a carrier mobility enhancement are observed and explained in terms of positive charges trapped in the SiO_2 gate oxide, during the irradiation. The transistor channel current is increased up to 3 orders of magnitudes after the exposure to an irradiation dose of 100 e – /nm^2. Finally, a complete field emission (FE) characterization of the MoS_2 flake, achieving emission stability for several hours and a minimum turn-on field of ≈20 V/µm with a field enhancement factor of about 500 at an anode – cathode distance of ~1.5 µm, demonstrates the suitability of few-layer MoS_2 as a two-dimensional emitting surface for cold-cathode applications.

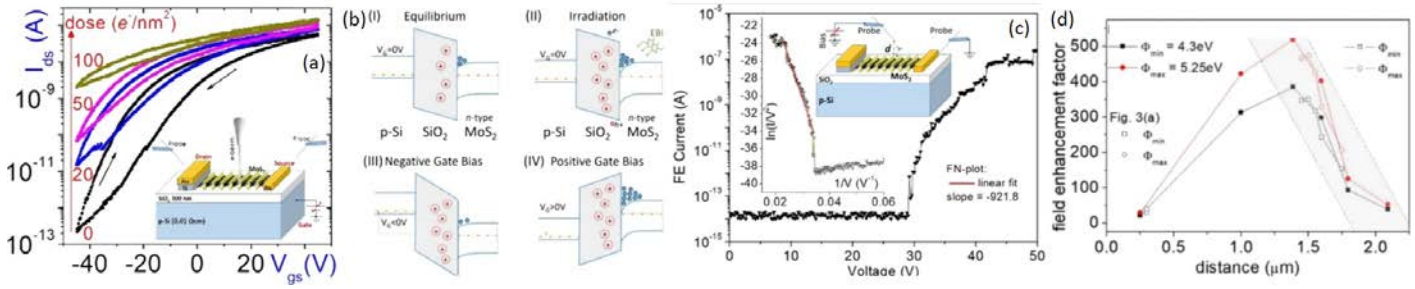

Fig. 1: (a) Transfer characteristics I_{ds} – V_{gs} measured before and after electron beam irradiation. Inset: Layout of the device. (b) Schematic band diagram for the n-type MoS_2/SiO_2/p-Si FET. (I) Unbiased initial state; (II) unbiased state after irradiation which favors the formation of additional positive charged traps; (III) band alignment for $V_{gs} < 0$ V with carrier depleted channel; (IV) band alignment for $V_{gs} > 0$ V with carrier accumulation. (c) Field emission I – V curve measured at d = 300 nm. Left inset: Fowler-Nordheim plot. Upper inset: Setup for field emission measurements. (d) Dependence of the field enhancement factor on the distance d.