Electronic Supplementary Material

Barrier inhomogeneities at vertically stacked graphene-based heterostructures

Yen-Fu Lin[1](✉), Wenwu Li[1], Song-Lin Li[2], Yong Xu[1], Alex Aparecido-Ferreira[1], Katsuyoshi Komatsu[1], Huabin Sun[1], Shu Nakaharai[1], and Kazuhito Tsukagoshi[1](✉)

[1] WPI Center for Materials Nanoarchitectonics (WPI-MANA), National Institute for Materials Science (NIMS), Tsukuba, Ibaraki 305-0044, Japan.

[2] International Center for Young Scientist (ICYS), National Institute for Materials Science (NIMS), Tsukuba, Ibaraki 305-0044, Japan.

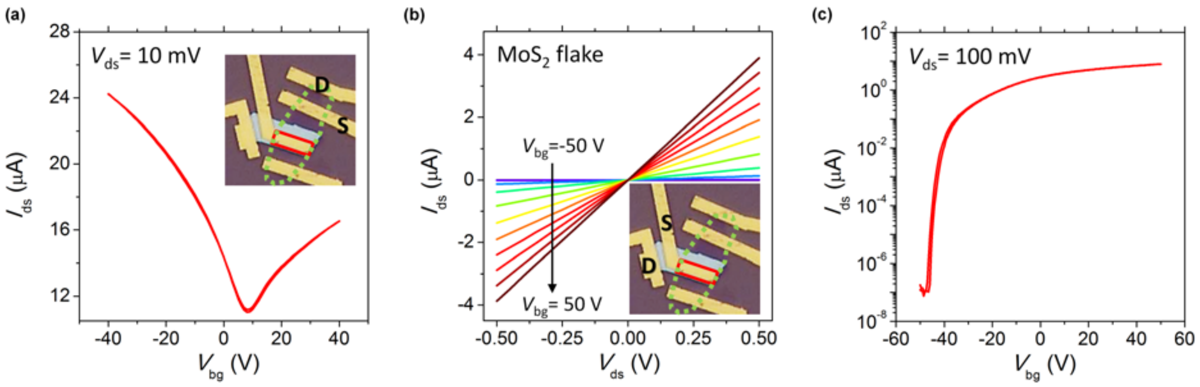

Figure S1: (a) Transfer characteristics of a graphene transistor (at 300 K). (b) and (c) display output and transfer characteristics of a thick MoS_2 transistor (at 300 K), respectively. The corresponding positions of both drain (D) and source (S) electrodes are marked in the optical microscope image, shown in the inset. The graphene mobility in (a) was estimated to be about 5×10^3 cm^2 V^{-1} s^{-1}, which is comparable with previous report [1]. In addition, the symmetrical and linear relationship of I_{ds}-V_{ds} demonstrates the formation of Ohmic contact between Ti and a think MoS_2 flake. The carrier mobility of a thick MoS_2 flake was derived to be 10^1 cm^2 V^{-1} s^{-1} in high consistent with the literature [2,3]. Though making the multiple-electrode configuration on the graphene-based heterostructures, it guarantees that the charge transport mechanism is dominated mainly by the vertically stacked heterostructure interface.

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Address correspondence to Yen-Fu Lin, yflin1981@gmail.com; Kazuhito Tsukagoshi, TSUKAGOSHI.Kazuhito@nims.go.jp

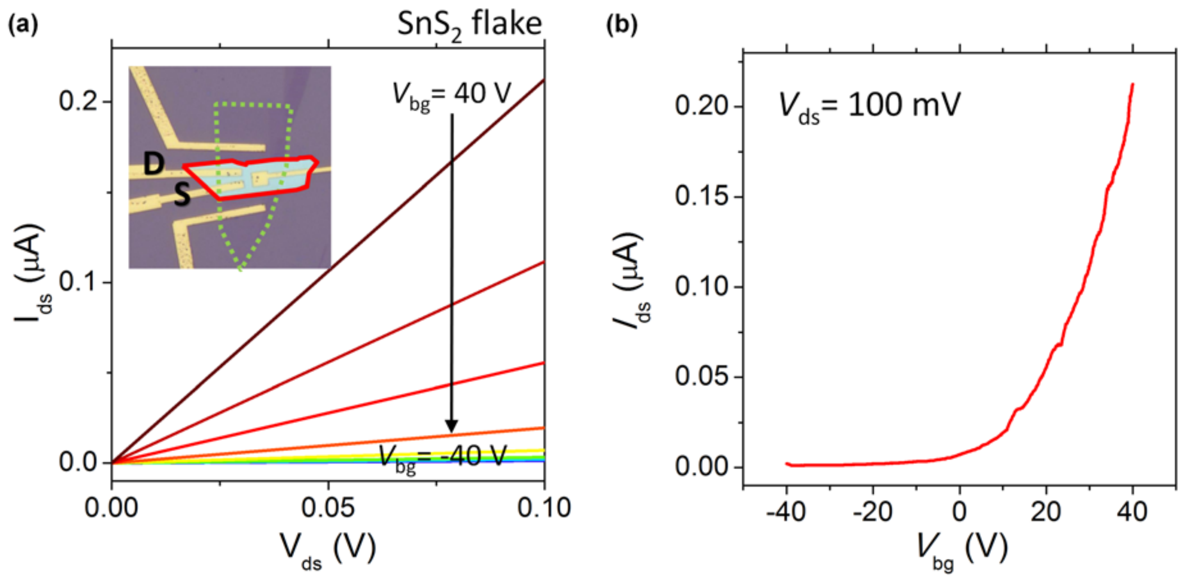

Figure S2: (a) and (b) display output and transfer characteristics of a thick SnS_2 transistor (at 300 K), respectively. The corresponding positions of both drain (D) and source (S) electrodes are marked in the optical microscope image, shown in the inset of (a). The linear dependence of I_{ds}-V_{ds} manifests negligible contribution of contact resistance in the Ti/SnS_2 interface. The estimated value of carrier mobility is about 3 $cm^2\ V^{-1}\ s^{-1}$, compared with the previous report [4].

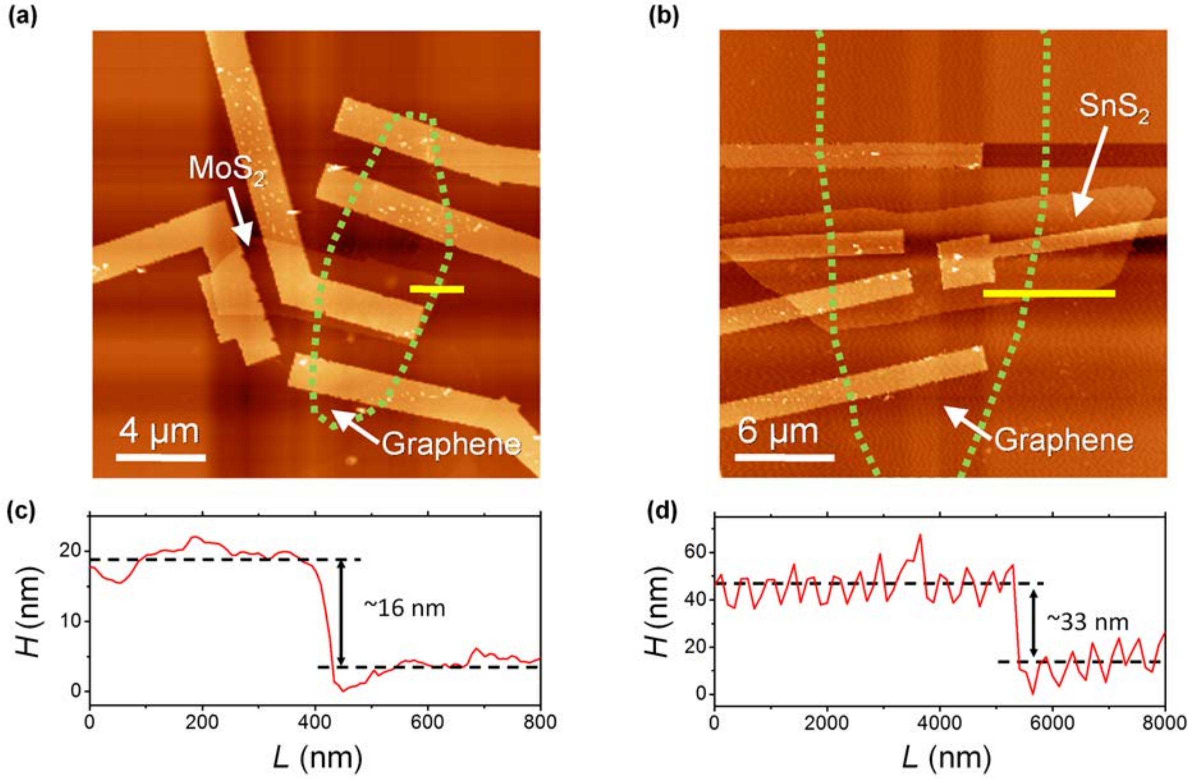

Figure S3: AFM images of graphene/MoS_2 (a) and graphene/SnS_2 (b) heterostructure transistors with corresponding line profiles in (c) and (d)

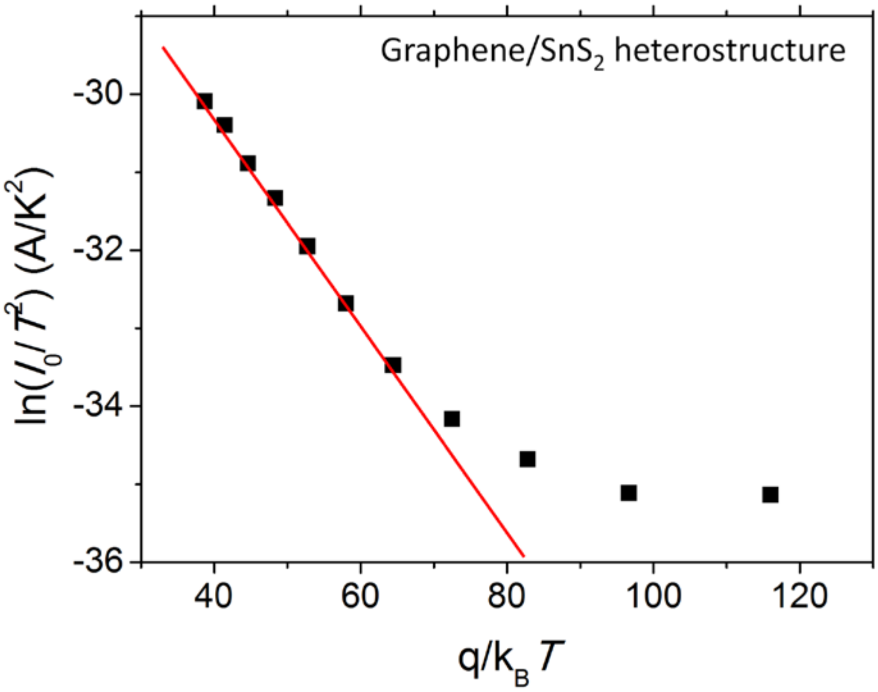

Figure S4: $\ln(I_0/T^2)$ versus qk_B/T plot for the graphene/SnS_2 heterostructure transistor. The solid line in red is guide to eyes. A temperature independence of Schottky barrier height cannot be derived from the plot.

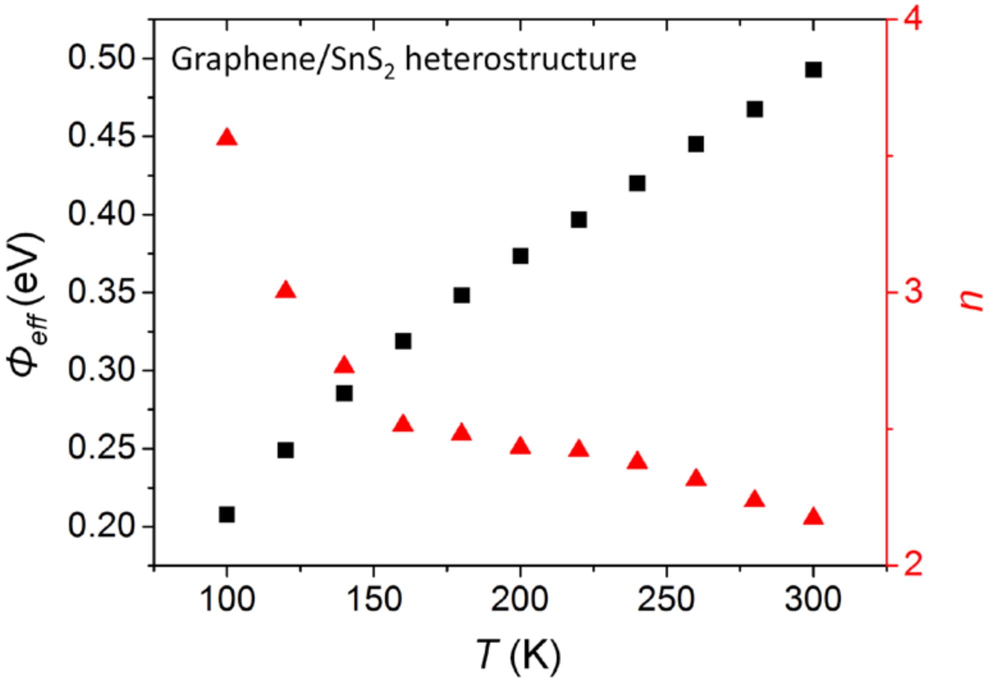

Figure S5: Effective Schottky barrier height and ideality factor as a function of temperature for the graphene/SnS_2 heterostructure transistor. Clearly, the plot shows a strong temperature dependence of both fitting parameters. With decreasing temperature, the effective barrier varies from 0.49 down to 0.21 eV, while the ideality factor increases from 2.17 to 3.56.

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