Electrical properties of MoS_2/hBN field-effect transistors

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One of the challenges for future applications of transition metal dichalcogenides (TMDs) is to minimize the impact of environmental effects on the performance of TMD-based devices. TMDs are sensitive to ambient gases due to water and oxygen adsorption on the surface, which significantly degrades electrical properties of single-layer TMDs [1]. One way to improve the performance of devices is to use hexagonal boron nitride (hBN). hBN as a stable, doping-free and dangling bonds-free [2] insulator prevents adsorption of molecules by restricting the surface's exposure to air.

In this study, we fabricated field-effect transistors (FET) with MoS_2/hBN heterostructure. First, we prepared devices with CVD MoS_2 monolayer using e-beam lithography. Then mechanically exfoliated hBN flake was placed on top of the device channel using PDMS transfer method. We measured transfer and output characteristics investigating the electronic transport properties such as threshold voltage, carrier mobility and subthreshold swing. To present a comparative study of those electrical parameters, we calculated them using various methods.

Our measurements reveal improvement in the performance of devices after applying hBN layer due to the reduction of adsorbates. The results of this work contribute to a better understanding of the intrinsic transport properties of MoS_2.

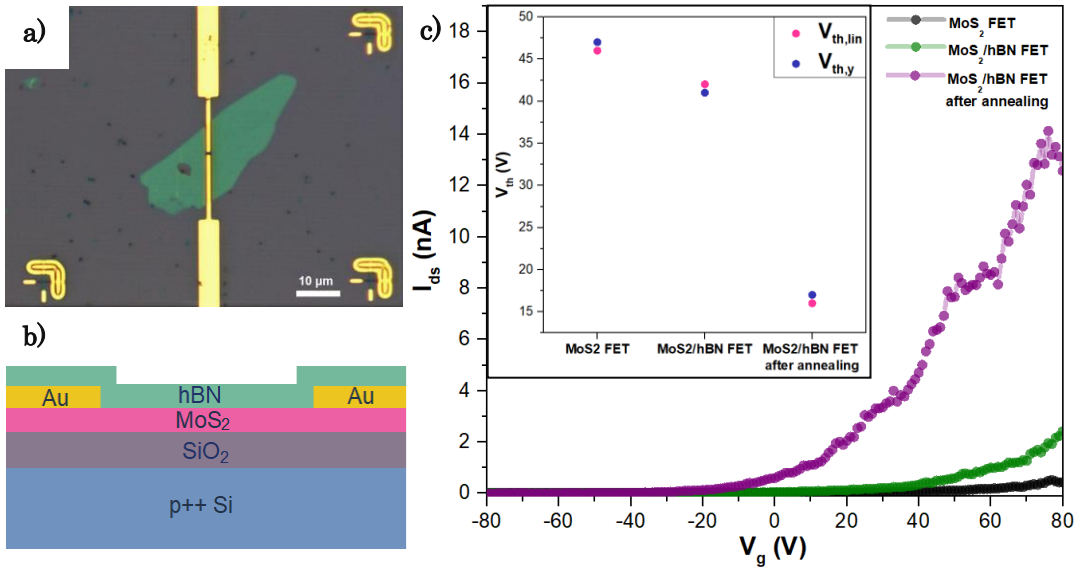

Figure 1. a) Optical microscope image of MoS_2/hBN FET, b)Schematic of the FET, c) Comparison of transfer characteristics of MoS_2 FET, MoS_2/hBN FET and MoS_2/hBN FET after vacuum annealing at 200 °C (measured in air at room temperature). The inset shows calculated threshold voltage with linear extrapolation ($V_{th,lin}$) and Y-function ($V_{th,y}$) [3].

[1] JH. Ahn, W. Parkin, C. Naylor, A. Johnson, M. Drndić, Scientific Reports **7**, 1-9 (2017)
[2] S. Ahn, G. Kim, P. Naya, S. Yoon, H. Lim, HJ. Shin, HS. Shin, ACS Nano **10**, 8973-8979 (2016)
[3] A. Sebastian, R. Pendurthi, T. Choudhury, J. Redwing, S. Das, Nature Communications **12**, 693 (2021)