Intrinsic Carrier Mobility of Multi-Layered MoS_2 Field-Effect Transistors on SiO_2

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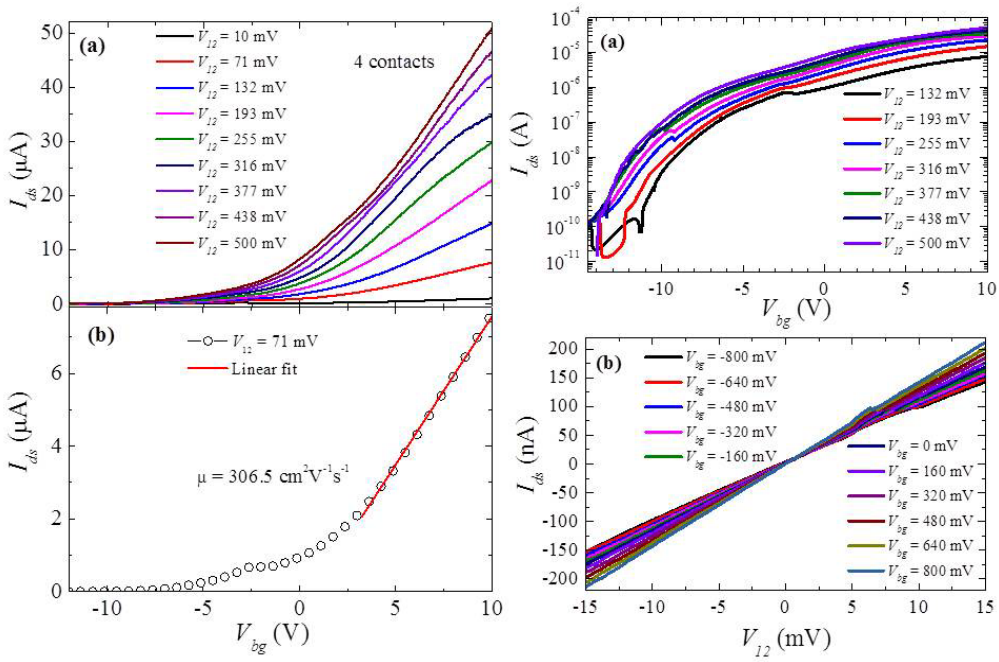
Introduction

Transition metal dichalcogenides are layered materials characterized by strong in-plane covalent bonding and weak inter-planar van der Waals coupling. Similarly to graphene, these weak interactions allow the exfoliation of these materials into two-dimensional layers with just a few or even a single layer thickness. These compounds have been studied for decades, but recent advances in nanoscale characterization and device fabrication have opened up the potential for applications of thin, two-dimensional layers of dichalcogenides in nanoelectronics and in optoelectronics.

Experimental

We used the ACS nano-fabrication facility, coupled to the NHMFL e-beam evaporator system to produce field-effect transistors of exfoliated MoS_2 flakes.



Left panel: (a) Electrical current I_{ds} flowing through the current leads as a function of the back-gate voltage V_{bg} for several constant values of the voltage across the voltage leads. (b) From the slope of Ids as a function of V_{bg} acquired under a constant value V = 71 mV, one extracts a carrier mobility μ = 306:5 cm^2 /Vs. Right Panel: (a) I_{ds} in a logarithmic scale as a function of the back-gate voltage V_{bg} for several constant values of V. Notice how I_{ds} increases by 6 orders of magnitude when V_{bg} is swept from -14 to 10 V. (b) Current I_{ds} as a function of the voltage V for several values of constant back-gate voltage V_{bg}. Notice the nearly linear or Ohmic-like behavior. The four-terminal resistance of the flake ~ 87.7 kΩ can be extracted from the inverse of the slope of the V_{bg} = 0 V curve.

Conclusions

Carrier mobility in field-effect transistors based on few-layered transition-metal dichalcogenides, as reported by a number of groups, is strongly limited by non-Ohmic contacts, a problem that has yet to be circumvented. However, and as the present work indicates, a systematic comparison between 4- and 2-terminal configurations for a variety of metals, combinations of thereof, and treatments should lead to a solution to this important issue. Notice, nevertheless, that previous studies on similar MoS_2 devices also using a four-terminal configuration for revealed considerably smaller mobilities than the ones reported here.

Acknowledgements

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