Multi-terminal transport measurements of MoS$_2$ using a van der Waals heterostructure device platform - DTU Orbit (17/06/2017)

Multi-terminal transport measurements of MoS$_2$ using a van der Waals heterostructure device platform

Atomically thin two-dimensional semiconductors such as MoS$_2$ hold great promise for electrical, optical and mechanical devices and display novel physical phenomena. However, the electron mobility of mono-and few-layer MoS$_2$ has so far been substantially below theoretically predicted limits, which has hampered efforts to observe its intrinsic quantum transport behaviours. Potential sources of disorder and scattering include defects such as sulphur vacancies in the MoS$_2$ itself as well as extrinsic sources such as charged impurities and remote optical phonons from oxide dielectrics. To reduce extrinsic scattering, we have developed here a van der Waals heterostructure device platform where MoS$_2$ layers are fully encapsulated within hexagonal boron nitride and electrically contacted in a multi-terminal geometry using gate-tunable graphene electrodes. Magneto-transport measurements show dramatic improvements in performance, including a record-high Hall mobility reaching 34,000 cm$^2$ V$^{-1}$ s$^{-1}$ for six-layer MoS$_2$ at low temperature, confirming that low-temperature performance in previous studies was limited by extrinsic interfacial impurities rather than bulk defects in the MoS$_2$. We also observed Shubnikov-de Haas oscillations in high-mobility monolayer and few-layer MoS$_2$. Modelling of potential scattering sources and quantum lifetime analysis indicate that a combination of short-range and long-range interfacial scattering limits the low-temperature mobility of MoS$_2$.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanocarbon, Center for Nanostructured Graphene, Columbia University, Yonsei University, Cornell University
Authors: Cui, X. (Ekstern), Lee, G. (Ekstern), Kim, Y. D. (Ekstern), Arefe, G. (Ekstern), Huang, P. Y. (Ekstern), Lee, C. (Ekstern), Chenet, D. A. (Ekstern), Zhang, X. (Ekstern), Wang, L. (Ekstern), Ye, F. (Ekstern), Pizzocchero, F. (Intern), Jessen, B. S. (Intern)
Pages: 534-540
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: Nature Nanotechnology
Volume: 10
Issue number: 6
ISSN (Print): 1748-3387
Ratings:
BFI (2017): BFI-level 2
BFI (2016): BFI-level 2
BFI (2015): BFI-level 2
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 17.683 SNIP 8.303
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 16.857 SNIP 8.013
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 11.936 SNIP 7.96
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 8.629 SNIP 4.821
Scopus rating (2007): SJR 8.317
Original language: English
DOIs: 10.1038/NNANO.2015.70