Optoelectronic properties of encapsulated 2d-semiconductors

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Abstract

Two-dimensional semiconductors provide fascinating prospects for optoelectronics, because they combine charge transport with high mobility and tuneable optical gaps. Many of those materials are, however, sensitive to air and other environmental influences. Examples of such materials are InSe, GaSe, and black phosphorus (BP). Therefore, it is essential to encapsulate these materials in order to stabilise their properties for extended times. We have shown that the materials mentioned above are stable when encapsulated with thin layers of hexagonal boron nitride (hBN), and can, at the same time, be electrically contacted using via contacts created through the hBN-layers by dry etching. We show how the optical [1] and optoelectronic [2] properties of the semiconductor are affected by the presence or absence of the encapsulating material. We also demonstrate that we can operate the resulting structure as field-effect transistor (FET). FETs with BP as semiconducting material are ambipolar, making them candidates for reconfigurable transistors with high mobility.

References

- [1] T. Venanzi, H. Arora, A. Erbe, A. Pashkin, S. Winnerl, M. Helm, and H. Schneider, Exciton Localization in MoSe2 Monolayers Induced by Adsorbed Gas Molecules, Appl.~Phys.~Lett. **114**, 172106 (2019).
- [2] H. Arora, Y. Jung, T. Venanzi, K. Watanabe, T. Taniguchi, R. Hübner, H. Schneider, M. Helm, J. C. Hone, and A. Erbe, Effective Hexagonal Boron Nitride Passivation of Few-Layered InSe and GaSe to Enhance Their Electronic and Optical Properties, ACS Appl. Mater. Interfaces, **11** 43480 (2019).

Figures



Figure 1BP flake contacted by via contacts in Hall-bar geometry