A two-dimensional Dirac material on a band gap substrate: Germanene on MoS_2

L. Zhang[1], P. Bampoulis[1], A.N. Rudenko[2], Q. Yao[1], A. van Houselt[1], B. Poelsema[1], M.I. Katsnelson[2] and H.J.W. Zandvliet[1]

1. Physics of Interfaces and Nanomaterials group, MESA+ Institute for Nanotechnology and University of Twente, P.O. Box 217, 7500AE Enschede, The Netherlands
2. Radboud University, Institute for Molecules and Materials, Heijendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

l.zhang@utwente.nl

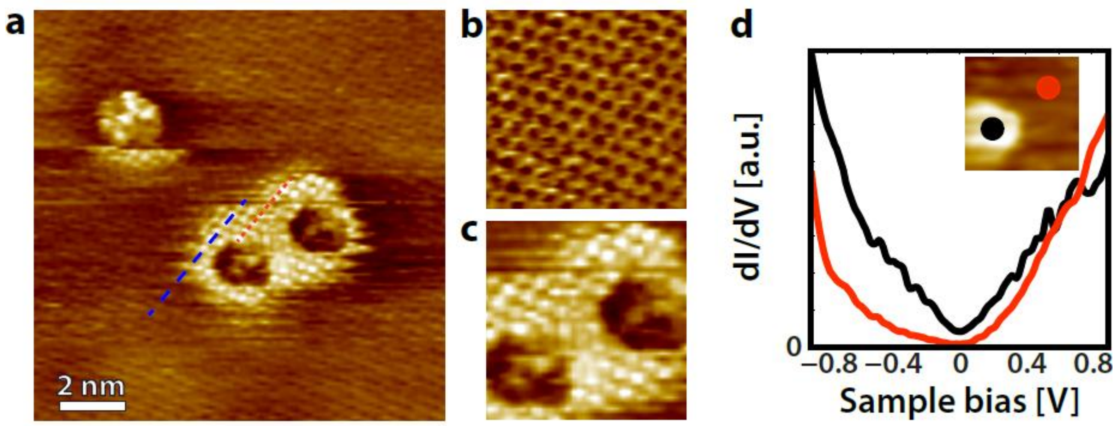
Abstract

To date germanene has only been synthesized on metallic substrates [1-3]. A metallic substrate is usually detrimental for the two-dimensional Dirac nature of germanene because the important electronic states near the Fermi level of germanene can hybridize with the electronic states of the metallic substrate. Here we report the successful synthesis of germanene on molybdenum disulfide (MoS_2), a band gap material. Pre-existing defects in the MoS_2 surface act as preferential nucleation sites for the germanene islands. The lattice constant of the germanene layer (3.8±0.2 Å) is about 20% larger than the lattice constant of the MoS_2 substrate (3.16 Å). Scanning tunneling spectroscopy measurements performed on the virtually continuous germanene layers reveal a V-shaped density of states, which is a clear hallmark of a two-dimensional Dirac material. These experimental results are in very good agreement with density functional theory calculations.

References

[1] P. Bampoulis, L. Zhang, A. Safaei, R. Van Gastel, B. Poelsema, H.J.W Zandvliet, J. Phys. Cond. Mat. **26** (2014) 442001.
[2] L. Zhang, P. Bampoulis, A. van Houselt, H.J.W Zandvliet, Appl. Phys. Lett. **107**(2015)111605.
[3] A. Acun, L. Zhang, P. Bampoulis, M. Farmanbar, A. van Houselt, A.N. Rudenko, M. Lingenfelder, G. Brocks, B. Poelsema, M.I. Katsnelson, H.J.W. Zandvliet, J. Phys. Cond. Mat. **27**(2015)443002

Figures



a). *Scanning tunneling microscopy image of the MoS_2/germanium substrate. The sample bias is 0.5 V and the tunneling current is 0.3 nA.* ***b).*** *A zoom-in on a bare MoS_2 area. The STM image reveals a honeycomb structure with a lattice constant of 3.15 ± 0.2 Å, which corresponds to the lattice constant of MoS_2. The sample bias and the tunneling current are the same as in (a)* ***c).*** *A zoom-in on the large germanene island of figure (**a**) reveals a hexagonal lattice with a lattice constant of 3.8 ± 0.2 Å. The sample bias and the tunneling current are the same as in (a)*