Electronic and Structural Properties of the Germanene Buffer Layer on Ge_2Pt

Ugur Basci
Ali Sakr, Dennis J. Klaassen, Esra D. van't Westende, Kevin Vonk, Harold J. W. Zandvliet, Pantelis Bampoulis
University of Twente, Drienerlolaan 5, 7522 NB, Enschede, Netherland
u.basci@utwente.nl

Germanene, the germanium counterpart of graphene, has a relatively large spin-orbit coupling, enabling the observation of the Quantum Spin Hall (QSH) effect at temperatures achievable in typical experimental conditions[1,2]. In this work, we have synthesized germanene layers on a Ge_2Pt crystal. We find that the first germanene layer on Ge_2Pt is electronically coupled to the substrate and is thus referred to as the buffer layer[2,3]. While the properties of the following germanene layers have been widely studied and the QSH effect has been confirmed experimentally [2,4], electronic and structural characteristics of the buffer germanene layer remain largely unexplored. In this research, we employed Scanning Tunnelling Microscopy and spectroscopy at 4 K to investigate the structural and electronic properties of the germanene buffer layer. We identify two distinct structural stackings: one in which the buffer layer is aligned with the underlying Ge_2Pt lattice and one in which it is rotated by approximately 4°. For the non-rotated case, we establish a commensurate $2 \times \sqrt{3}$ periodic unit cell and propose a structural model that quantitatively reproduces the observed real-space symmetries and Fourier components. In contrast, the rotated configuration exhibits additional signatures, including a moiré superlattice and a strong energy-dependent modulation of the local density of states. We find that, a pronounced state localized at the edge, consistent with the topological edge state, emerges at the rotated flakes, while the bulk exhibits strong energy-dependent modulations that appear to be imposed by the underlying substrate. This highlights the critical role of the Ge_2Pt substrate not only in stabilizing germanene, but also in driving symmetry breaking and electronic renormalization in the buffer layer.

References

[1] Bampoulis, P. et al., J. Phys.: Condens. Matter, 26 (2014), 442001.
[2] Bampoulis, P. et al., Phys. Rev. Lett., 130 (2023), 196401.
[3] R. van Bremen et al., J. Appl. Phys., 124 (2018) 125301.
[4] H. J. W. Zandvliet, et al., Phys. Rev. B, 109 (2024) 115419.

Figures

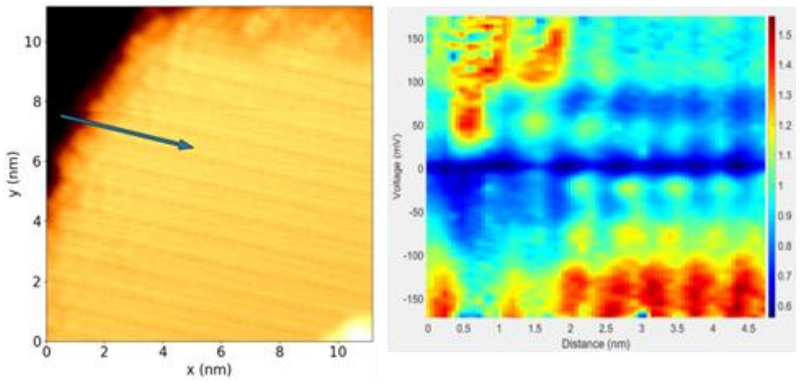

Figure 1: STM Line Spectrum Heat Map From Edge to Bulk