GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

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Account of the diversity of tunneling spectra at the germanene/Al(1 1 1) interface

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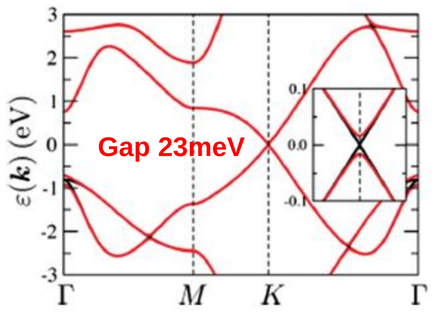
A new two dimensional crystal: germanene

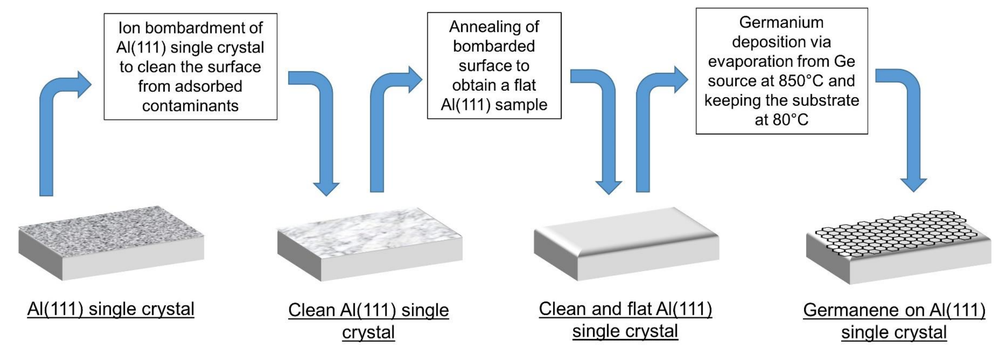


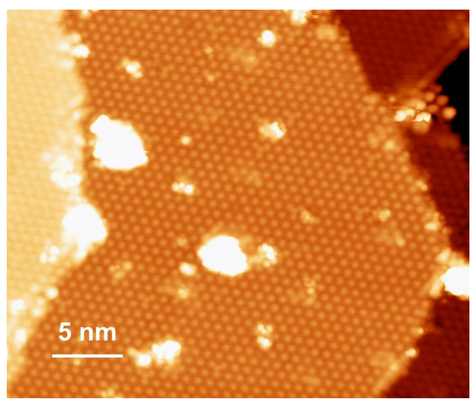
Germanene is the promising **germanium analogue of graphene [1]**. The predicted properties differ from those of graphene due to the presence of **buckling** (uplifted atoms in the honeycomb structure), **larger lattice constant** and stronger **spin orbit coupling**. It is expected to present **Dirac cones** with a **small bandgap**.

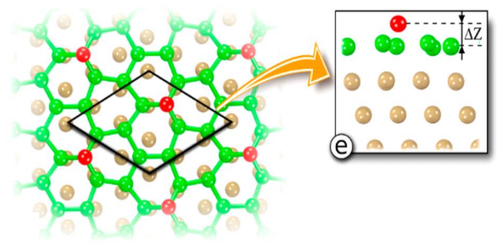
There's no germanite analogue of graphite in nature to exfoliate. Germanene requires **epitaxial deposition** to suppress vibrations that promote its preferential **sp^3** configuration.

The growth requires **weak interactions** between the 2D atomic crystal and the substrate. The candidates are:

- **Other inert 2D materials**, to minimize the interaction: until this moment only growth on MoS_2 has been claimed, while growth on HOPG has been disproved;
- **Weakly interacting metals** with a small electronic corrugation at the surface (for example Platinum or **Aluminium**), to have an homogeneous and weak interaction;

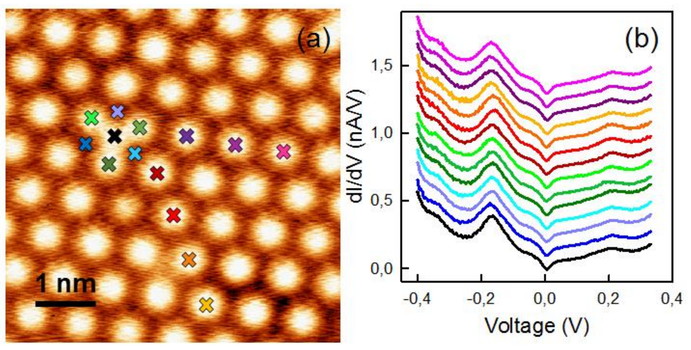




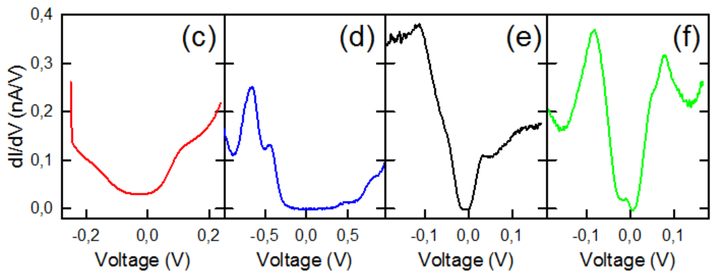


3x3 reconstruction of germanene on Al(111) [2], with only one atom buckled and probed in STM images

Scanning Tunneling Spectroscopy on monolayer



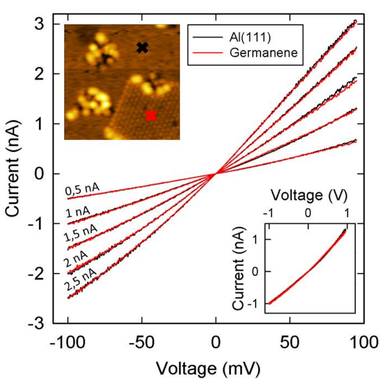
- Spatial delocalization of electronic states;
- No dependence from defects (adatoms, vacancies, exc);



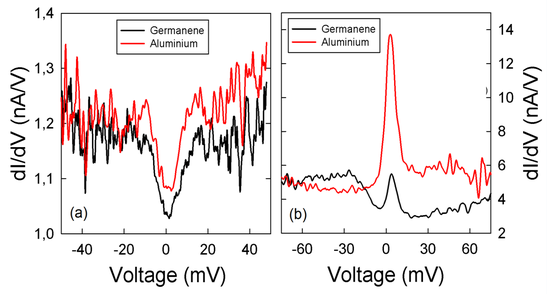
- Great variability of spectra between areas and/or different tips, not matched by a variation of topography;

Scanning Tunneling Spectroscopy on sub-monolayer

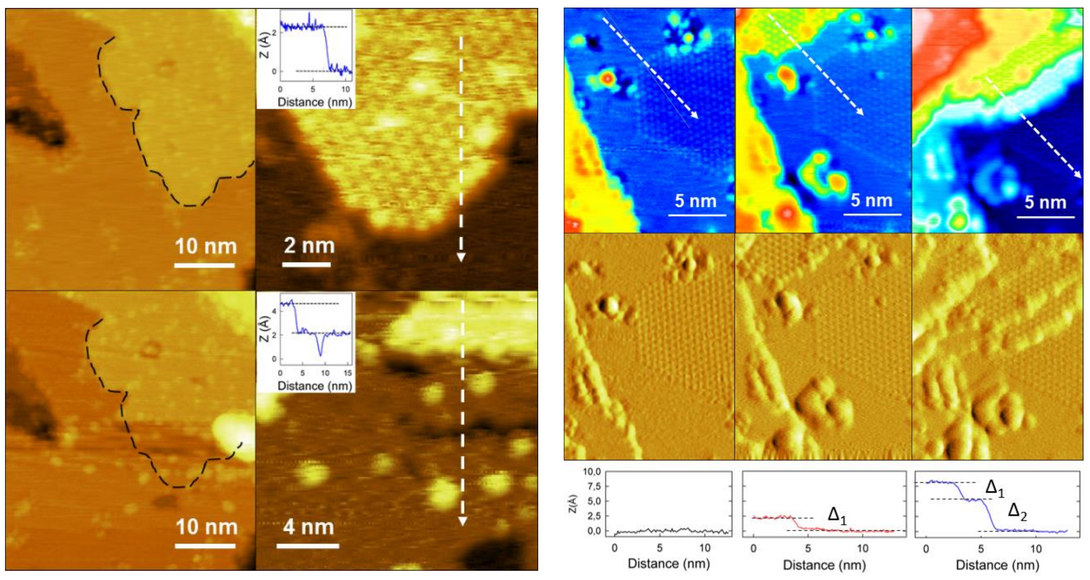
- Freshly prepared tip → metallic behaviour on both bare Al and germanene;
- No variation between higher and lower energies;
- No dependence on the current (i.e. sample/tip distance);
- **A significant electronic coupling** between adlayer and substrate can be deduced



Every deviation from metallic behaviour is also observed on bare Al next to germanene island → **STM tip is the most probable responsible of the variability** → how its properties are changed?

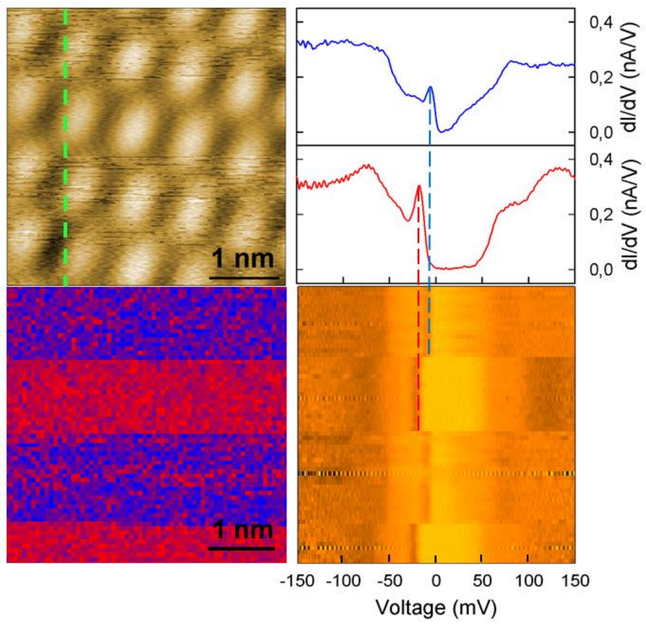


Mechanical coupling with the substrate



- Germanene islands have been detached (left panel) and moved (right panel) during the characterization of the surface;
- This easiness of manipulation proves a low mechanical coupling between germanene and aluminium substrate;
- Ge atoms or an Al-Ge alloy possibly gathered on the STM tip as a consequence of these processes;
- Quasiparticle effects and Coulomb repulsion in this kind of compound can account for previously reported non-metallic behaviours;

Tip influence on STS spectroscopy



Perfect interplay between morphology instability and Local Density of States, acquired together in a Current Imaging Tunneling Spectroscopy scan show how the tip itself can be the sole responsible of a band-gap opening without significant variation of morphology

Summary

- Germanene significatively electronically coupled to Al substrate;
- Germanene weakly mechanically coupled to Al substrate;
- The low mechanical coupling influences spectroscopy by modifying STM tip behaviour;

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REFERENCES

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2. *Nano letters*, **15**, 4, 2510-2516 (2015)

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