Atomic manipulation and morphology engineering in two-dimensional materials: from buckled Xenes to anisotropic MoS_2

Alessandro Molle

CNR-IMM, Laboratorio MDM, via C. Olivetti 2, I-20864 Agrate Brianza, Italy (www.mdm.imm.cnr.it)
alessandro.molle@mdm.imm.cnr.it

Making adjustable two-dimenasional (2D) materials is an emerging route to reach a superior control of new functinal properties at the 2D level. Consideration will be given here to two distinct cases in this respect. On one hand is the case of the epitaxial Xenes, an emerging class of 2D monoelemental lattice; on the other hand is the artificial synthesis of MoS_2 nanosheets with an anisotropic fashion. By close analogy with graphene, epitaxial Xenes are comprised of monoelemental atoms arranged in a honeycomb lattice; unlike graphene, Xenes are epitaxially grown on substrates and exhibit a varying degrees of buckling and/or puckering in the lattice structure.[1] Examples in this respect are silicene, germanene, stanene, borophene, epitaxial phosphorene. Buckling in Xenes can be taken as a leverage to tune the electronic and quantum properties (see the pictorial sketch of a buckled Xenes with topologically protected edge states in Figure 1). Indeed, the electronic state of epitaxial Xenes can range from topological insulators to trivial insulators, semiconductors, and semimetals, depending on the configurational details (e.g. buckling, substrate, chemical functionalization, and strain); and topological transitions among these electronic states can be tuned by means of a buckling dependent elecrical field applied to the Xenes. An overview of the state-of-the-art on the epitaxial Xenes and of their potential in nanoelectronics will be here given.
A second case of anisotropy is based on the chemical vaour deposition of MoS_2 nanosheets on one-directional substrates. The highly conformal character of the growth allows for the achievement of an anisotropically modulated MoS_2 nanosheet (see the sketch and the related TEM image in Figure 2) where the phonon and electronic properties are observed to be strongly morphology dependent. The so-induced anisotropy in the MoS_2 nanosheet (that are isotropic in chatacter) results in a light polarization dependent Raman spectrum and periodic charge fluctuations.[2] Implications on the band-gap and strain engineering will be discussed.

References

[1] A. Molle, J. Goldberger, M. Houssa, Y. Xu, S.-C. Zhang, and D. Akinande, *Nat. Mater.* DOI: 10.1038/NMAT4802
[2] C. Martella, et al., under consideration of *Advanced Materials*.

Figures

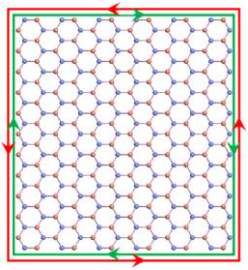

Figure 1: Pictorial sketch of an epitaxial Xene lattice with topologically protected edges states.

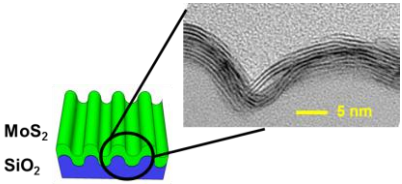

Figure 2: Sketch of an anisotropic MoS2 nanosheet and corresponding TEM image.