Silicene and the X-enes for a new nanotechnology platform

Carlo Grazianetti

CNR-IMM, unit of Agrate Brianza, via C. Olivetti 2, 20864, Agrate Brianza (MB), Italy

The advent of two-dimensional (2D) materials inspired new paradigms in the research and technology directions. The recent discovery of silicene brings to the forefront the class of the X-enes with X currently including elements of columns III-VI of the periodic table. Unlike graphene, X-enes do not exist in Nature, but they are stabilized via epitaxy on substrate, herein including the deposition on substrate, segregation from a substrate or recently reported intercalation [1]. X-enes can appear as metals, semimetals, semiconductors, and topological insulators thus allowing for a broad range of applications in nanotechnology. Not only the wealth of electronic states makes X-enes suitable as electronic and photonic materials, but also the non-trivial topological character of heavier X-enes paves the way to a new paradigm of topological devices. In this perspective and in the molecular beam epitaxy framework, the route and challenges for X-enes to be integrated in nanoelectronic devices by taking silicene as flagship case (with focus on the silicene stabilization and then on single- and multi-layer silicene transistors fabrication [2,3]) will be discussed. The two main device integration paths for the case of silicene, *i.e.* delamination from a cleavable substrate and substrate engineering, will be extended to either other X-enes or other potential applications for silicene. Within the former option is the emerging case of the epitaxial phosphorene that will be also proposed as promising example of scalable 2D X-ene retracing the silicene thread [4]. A case in point for the latter option is the growth of silicene on sapphire where by means of optical absorption spectroscopy a Dirac-like electrodynamics was observed thus paving the way to unprecedented routes for silicene exploitation even in photonics [5].

[1] Molle *et al.*, Chem. Soc. Rev. **47**, 7370 (2018)

[2] Tao *et al.*, Nature Nanotech. **10**, 227 (2015)

[3] Grazianetti *et al.*, ACS Nano **11**, 3376 (2017)

[4] Grazianetti *et al.*, submitted

[5] Grazianetti *et al.*, Nano Lett. **18**, 7124 (2018)