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Silicene, germanene and stanene: emerging artificial 2D nanomaterials beyond graphene

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"Silicene growth and properties" is number 4 among the 10 Hot Research Fronts in Physics identified by Thomson Reuters for the years 2011-2014, after "Observation of Higgs boson", "Globalneutrino data analysis" and "Nonlinear massive gravity" [1].

Born in 2012, silicene is a novel two-dimensional (2D) silicon based nano/electronic material, an artificially created honeycomb allotrope of Si [2]. Germanene and stanene, his germanium and tin analogues, recently synthesized, are also attracting considerable interest, especially because of the 2D Topological Insulator character resulting from the large Spin Orbit Coupling, and, indeed because of the direct compatibility with the Si advanced electronic technologies [3,4].

These elemental synthetic group IV materials are artificially created, since, at variance with graphene, which descents from graphite, they have no parent crystal in nature. They appear as emerging electronic materials and are considered as promising candidates for ultimate scaling of nanoelectronic devices. Indeed, the recent fabrication of the first silicene field effect transistors operating at room temperature demonstrates their potential [5].

In this invited talk, I will first present the perfectly aligned Si nanoribbons initially formed on the Ag(110) surface [6], next the archetype 3x3 2D silicene phase formed on a silver (111) substrate [2], its sister phases, its functionalization with hydrogen, and the growth and properties of multi layer silicene, which hosts Dirac fermions and which is stable in ambient air, protected by its ultra-thin native oxide, which is highly beneficial for device realization beyond the 5 nm node [7].

The recent synthesis of single and multi layer germanene on gold (111) templates, will be addressed next [3,8], along with first results on stanene synthesis on Ag(111) [4].

These outstanding novel 2D materials constitute highly promising nano-platforms, typically for realization of nano-ribbons hosting the quantum spin Hall effect, possibly at room temperature and above, which would be a crucial step toward dissipation-less spintronics applications.

1. C. Day, Physics Today, 25 September 2015.
2. P. Vogt et al., Phys. Rev. Lett., 108, 155501 (2012).
3. M.E. Davila et al., New J. Phys., 16, 095002 (2014).
4. Y. Fujii , J. Yuhara , K. Soda , M. Nakatake, L. Xian, Angel Rubio and G. Le Lay, to be published.
5. Tao et al., Nature Nanotechnol., 10, 227 (2015)
6. M. E. Davila et al., Nanotechnology 23, 385703 (2012).
7. P. De Padova et al., 2D Mater., 1, 021003 (2014).
8. M. E. Davila and G. Le Lay, Sci. Rep., 6, 20714 (2016).