Single phase of germanene on Al (111) single crystals: a compelling photoemission study

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Germanene, with Ge atoms packed in a honeycomb lattice, like graphene and silicene, is expected to be a promising material with significant theoretical and practical repercussions. Simulations show that Ge monoatomic sheets have as graphene semi-metallic electronic structure character by a linear dispersion around the Dirac point and charge carriers behaving like massless Dirac fermions. Moreover, its large spin–orbit gap, can make experimentally accessible germanene-derived materials with exotic electronic quantum materials. Moreover, the obvious compatibility of germanene with a mature silicon-based nanotechnology makes this material particularly interesting for nano/microelectronics applications. We have grown an atom-thin, ordered, two-dimensional single-phase film in situ through germanium molecular beam epitaxy using an aluminium (111) surface as a substrate. Its growth is similar to the formation of silicene layers on silver (111) templates [1]. The obtained films were characterized by using scanning tunneling microscopy, showing a nearly flat 1H structure, i.e. a network with one Ge atom per unit cell shifted upward with respect to the others [2]. Thanks to a deep high energy resolution synchrotron photoemission study, recording core-level spectroscopy measurements and angle resolved photoemission, (ARPES), we have identified spectroscopic and electronic features characteristics of the (3 × 3) phase of Ge on Al(111) supercell, presenting compelling evidence of the synthesis of the germanene on aluminium [3][4].

References

[1] P. Vogt et al., J. Phys. Rev. Lett., 108 (2012) 155501.
[2] R. Stephan et al., J. Phys. Chem. Lett., 8 (2017) 4587−4593.
[3] R. Stephan et al., J. Phys. Chem. C, 120 (3) (2016) 1580-1585.
[4] W. Wang and R.I.G. Uhrberg, Beilstein J. Nanotechnol., 8 (2017) 1946–1951.

Figures

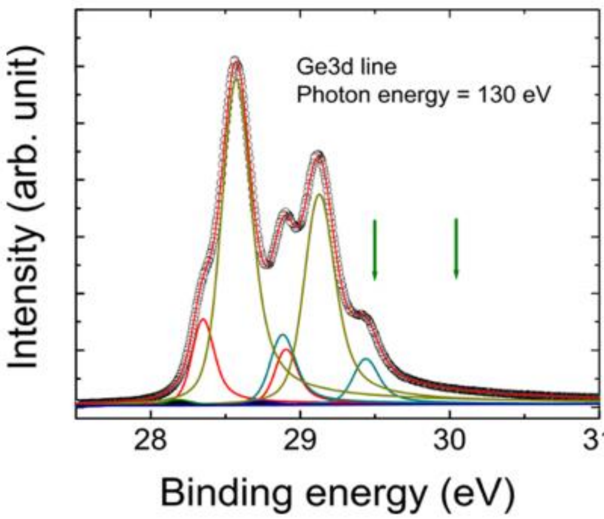

Figure 1: Core level Ge 3d line measured on germanene-covered Al(111) taken at a photon energy of 130 eV. This spectrum was recorded at normal photoelectron detection. This spectrum is decomposed into Ge $3d_{5/2}$ and $3d_{3/2}$ doublets. Also indicated by the green arrows are the Ge 3d doublets binding energy for bulk Ge (111) crystal.