Chemistry of 2D graphene analogues – silicene and germanene

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Monoelemental two-dimensional (2D) materials are at the forefront of current material research. Beyond graphene, the large family of unexplored materials remain unexplored. The development of these materials starts rapidly in last few years. In the carbon or so called tetrel group are beyond carbon silicon, germanium and tin. These elements are capable to form a layered allotrope, however the synthesis methods are not so straightforward as for the graphite. All these materials are non-zero band-gap semiconductors with huge application potential in electronic and optoelectronic devices. This property opens new application possibilities in electronic and optoelectronic devices. Also, the research in the field of energy storage and conversion, as well as sensors and other fields, is rapidly growing. The properties strongly correlate with chemical modifications and functionalization. Compare to graphene, the chemistry of its heavier counterparts remains significantly less explored.[1] The main rote for top-down methods of synthesis is based on exfoliation and functionalization of Zintl phases with general formula AB_2 consisting from hexagonally arranged Si/Ge layers separated by alkaline earth atoms, typically calcium. The exfoliation procedure is typically based on reaction with acid at ow temperature forming hydrogen terminated surface. In this contribution will be demonstrated novel methods and strategies in synthesis and functionalization of silicene and germanene monolayers. The methods providing controlled functionalization surfaces are based on formation of negatively charged silicene/germanene and subsequent reactions with halogenderivatives, formation of reactive halogenated intermediates or direct reactions of Zintl phases with bromine or iodine derivatives. The developed methods were used for introduction of various alkyl and aryl derivatives in order to control transport and optical properties of functionalized materials. The functionalized germanium derivatives exhibit strong photoluminescence, which maxima can be tuned by substitution with various alkyl and aryl derivatives. For newly developed materials were utilized various applications including gas sensors, hybrid organic-inorganic OLED devices and photocatalytic water splitting.

References

[1] T. Hartman, Z. Sofer, ACS Nano, 13 (2019) 8566.