Single element 2D materials and methods of their epitaxial synthesis

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Graphene-like allotrope modifications of single elements, such as borophene (B), silicene (Si), germanene (Ge), stanene (Sn), plumbene (Pb), phosporene (P), arsenene (As), antimonene (Sb), bismuthene (Bi) with two-dimensional honeycomb lattice are among the main goals of research for the last years due to their exotic electronic and optical properties caused by unique band structure, small effective masses, high electric and thermal conductivity and exceptional mechanical characteristics [1]. Progress in the epitaxial methods of synthesis of heterostructures with monoelemental 2D crystals makes it possible to create devices of new generation: topological transistors, high-sensitive sensors, energy-intensive power sources, supercapacitors, thermoelectric generators, quantum computers [2].

In this work we report on recent progress in the synthesis and implementation of monoelemental 2D materials. Peculiarities of epitaxial synthesis of single element two-dimensional materials, such as borophene, silicene, germanene, stanene, plumbene, arsenene, antimonene on various substrates are pointed out. Different stages of formation of two-dimensional layers with the thickness from one to several monolayers, including possible nucleation of two-dimensional and three-dimensional islands are described. Physics and mathematical model of thin film growth and islands nucleation in the considered systems is proposed. The possibilities of decreasing the surface roughness, suppressing the nucleation of islands and preventing the transition to undesirable three-dimensional growth are identified.

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