The world of science and industry has been fascinated by two-dimensional materials from their first observation thanks to K. Novosolev and A. Geim, who in 2004 published their work on graphene - a two-dimensional graphite layer with a thickness of one carbon atom. The observation was even more interesting because they received it in a banal way - as a result of mechanical exfoliation of graphite, which can actually be achieved by peeling off the graphite layer (from a pencil) with adhesive tape. The development of newer / more efficient / more controllable methods of graphene fabrication allowed to reveal its fundamental properties, and thus to assess the application potential.

Since then, new 2D materials have been discovered that now form a large family of so called post-graphene materials. These include, among others: transition metal dichalcogenides (TMDs), phosphorene, boron nitride, germanene, silicene, stanene. Among them, borophene, which was first obtained and studied in 2015. Already then, it gained great interest of scientists, mainly due to its unique metallic and mechanical properties and the presence of many active sites, which may be key in many energy applications, e.g. as electrode materials in supercapacitors, batteries (not only lithium-ion) or in electrocatalytic generation of hydrogen and oxygen during water splitting. Currently, however, most work is limited to theoretical research. This is mainly due to the very limited work on the development of processes for obtaining borophene on a scale that allows conducting experiments. This is also due to the fact that the mechanism of their creation has not yet been fully explored.
For this reason, the Applicant with the research team under the proposed project aims to:
- development of a controlled process for the fabrication of borophene, oxidized borophene, and reduced borophene oxide;
- study of electrocatalytic efficiency in hydrogen/oxygen evolution reactions (HER / OER) during water splitting as energy conversion. In the strategy, the strategy of borophene and its oxidized derivatives will be designed in two systems: (i) a new high yield combined strategy of sonochemical exfoliation and chemical oxidation/reduction – it is assumed that their combination will offer material with defined flake size, flakes thickness and oxygen functional groups content, (ii) chemical vapor deposition (CVD). In addition, the research will help to describe the mechanism of formation of this new class of material. Finally, we will have opportunity to perform pioneering research which will allow to experimentally verify the electrocatalytic performance of borophene and borophene derivatives (oxide with a specific concentration of oxygen groups) in HER / OER reactions. So far, in the state of the art there is only theoretical research in this area. Shematically, research tasks are following: