1. The aim of the project

The aim of the project is connected with the synthesis of Ni-Cu, Cu-Fe and Ni-Cu-Fe alloys and enhancing their electrocatalytic properties by the samples' active surface area multiplication. In order to develop these surfaces, the conically-shaped materials will be synthesized from the electrolytes containing the crystal modifier. This component influences the nucleation and growth mechanism of the deposited coating. The behavior of the hydrogen bubbles during the water-splitting reaction will be checked as well. It can be significantly modified due to the superhydrophobic properties of the sharp tips of the cones.

2. The project methodology

Coatings characterized by well-ordered conical morphology will be electrolytically deposited from electrolytes containing the addition of crystal modifiers. Firstly, materials will be synthesized from the electrolytes without crystal modifiers to determine the appropriate electrodeposition conditions for binary and ternary alloys. The produced alloy coatings should be compact and metallic. Then, based on the investigated synthesis parameters, various concentrations of the modifier will be added to the electrolytes, which will allow obtaining alloys with an analogous or very similar chemical composition, but in the form of well-ordered conical structures. The synthesized materials will be analyzed in order to confirm the increase of the electrocatalytic properties and explore the hydrogen bubbles' behavior in the water-splitting reaction. These analyzes will be performed using a number of electrochemical methods such as cyclic and linear voltammetry measurements. Moreover, the catalytic activity will be determined based on chrono- and potentiometric measurements in alkaline solutions. Besides electrochemical measurements, the in-situ observation by optical (microscopic, shadowgraph) method is also planned. The surface morphology will be check using Atomic Force Microscope (AFM) and Scanning Electron Microscope (SEM) methods. The phase and chemical compositions of sample surfaces will be analyzed using XRD, XRF, and EDS analyses. The optical techniques with a goniometer will be used to measure the wetting angle of superhydrophobic properties of cones.

3. Reasons for choosing the project topic

The project topic was chosen due to the fact that the need of using renewable energy sources is more and more important. One of the options is solar water splitting systems based on photocatalysts. Electrodeposition is commonly known as a simple process to obtain alloy coatings with defined compositions. This method allows obtaining alloys and composites, which can be successfully used as catalysts. Instead of searching for new material for application in the catalyst process, it is possible to enhance the electrocatalytic properties of a well-known one. This can be done by increasing the number of active centers on the sample surface without changing its geometric size. It is possible to obtain well-ordered materials with defined shapes without using any specific equipment or templates but using a simple one-step method. The conical shape of structures will ensure their mechanical stability during intensive hydrogen evolution in comparison with nanowires, which tend to bend or fall. This stability is connected with a higher value of the base’s diameter. The main novelty of this project is the synthesis of conical structures of two- and three metals from the electrolyte containing the crystal modifier during the single electrodeposition process. This method of obtaining ordered structured materials is a fast and “ecologically friendly” as well as a simple one. The sharp tip of cones enhances the superhydrophobic properties of samples.

4. Expected results

The expected results are connected with the synthesis of multi-functional Ni-Cu, Cu-Fe, and Ni-Cu-Fe conical structures by the simple and fast method. The multi-functional character means the possible application of these materials as catalysts and superhydrophobic materials. However, the most important issue is connected with enhancing the active surface area and therefore the electrocatalytic properties of the materials in HER due to the production of mechanically stable conical structures.