Nowadays, the dynamic development of civilization and technological progress contributes to a growing problem related to increased amounts of pollutants and energy deficiency. Therefore, one of the challenges faced by scientists is an attempt to develop new technological solutions that would contribute to the improvement of the cleanliness of the natural environment and the quality of life. Among the commonly proposed solutions, one of the most promising is photocatalysis, which allows to eliminate the harmful pollutants, and to produce valuable chemical fuels using solar energy. The photocatalyst plays a key role in the photocatalysis process. Many materials on the market are used as photocatalysts, and still, the aim is to obtain new systems that will be biologically inert, photostable, chemically resistant, relatively cheap, and most importantly, will be characterized by high photooxidative activity and spectral response. Among the well-known and widely available materials, semiconductors are the most popular. However, those materials have some limitations that can be overcame by selecting an appropriate method of their synthesis or modification. The main goal of these assumptions is to select the proper components which together with selected semiconductors, will build multifunctional materials, exhibiting increased photocatalytic or photovoltaic activity. The development of methods for obtaining modified forms of photoactive materials is very complex and requires many complicated experimental procedures for their proper implementation. One of such solutions is the formation of heterostructured systems, which are characterized by specific physicochemical and structural properties. An essential aspect in the synthesis of these materials seems to be skillful and conscious control of changes related to determining the impact of the synthesis method, type, and quantity of components used on their physicochemical and functional properties.

Research undertaken as part of the project is innovative and interdisciplinary and concerns current scientific and social problems, including the widely understood chemical engineering, materials science, and environmental protection. The proposed research topic is critical and undoubtedly constitutes the element of scientific novelty, as it attempts to answer how the conditions of hydro/solvothermal and microwave synthesis, as well as a selection of proper components, change the physicochemical and useful properties of heterostructured materials. ***Hence the planned research is based on the hypothesis that the application of hydro/solvothermal and microwave methods should allow to fabricate the heterostructured semiconductor materials with strictly defined morphology and structural properties. Moreover, considering specific properties of lanthanides, such as unique magnetic, optical, and redox properties, it is expected that their incorporation into the structure of synthetic semiconductors will translate into increased photocatalytic and photovoltaic activity.*** Quantum chemical calculations are planned to be used at the design stage to support the synthesis and modification optimization process. ***Their results can provide important information to understand and predict structural changes being the aftermath of synthesis and modification of a new generation of heterostructured materials.*** The functionality of the obtained materials will be verified firstly in photocatalytic tests concerning the degradation of selected organic (model and real) impurities. ***The key aspect will include evaluation whether commercially available light-emitting diodes (LEDs) as well as solar light can be an alternative to commonly used light sources for photocatalysis.*** The obtained materials will also be investigated as anode materials in dye-sensitized photovoltaic cells under simulated solar light and especially in ambient light conditions using low-energy LED sources. ***A detailed investigation of the production process of photovoltaic cells' working electrodes, its potential influence on the structural properties and morphology of the heterostructural semiconducting materials, and the parameters of photovoltaic devices will be crucial to the research.*** Such a comprehensive approach to the subject is uncommon in the available literature. ***Finding a correlation between the synthesis and modification of heterostructured materials, their structural changes, activity, and performance mechanism in photocatalytic as well as photovoltaic systems under specific process conditions is an ambitious and innovative approach of the project.*** In case of positive results, novel solutions for wastewater treatment and third-generation photovoltaic devices will be proposed, which will translate into reducing the amount of pollutants and solving the energy shortage problem.

The cooperation undertaken between the Faculty of Chemical Technology (Poznan University of Technology) - project leader, the Faculty of Chemistry (Adam Mickiewicz University, Poznan) and Faculty of Science and Technology (Jan Dlugosz University, Czestochowa) - the project partners, and the complementarity and experimental resources of those institutions, provide an undoubted guarantee that the research goals of the project will be completed to high practical and theoretical standards. A measurable result of the project will be the completion of interdisciplinary research leading to a significant expansion of knowledge and development of the scientific field in question, as well as highly ranked scientific publications indexed by *Thomson Reuters JCR*.