

## Influence of the structure and morphology of plasmonic photoanodes based on the titanium oxide on their photoactivity in the solar water splitting

Nowadays fossil fuels resources are dwindling rapidly and the environment is polluted by increasing industrial emission. In this point of view very important are the environment-friendly energy sources and the hydrogen occupies along them a special place. Hydrogen is a natural carrier of renewable energy, the use of which allows the production of clean energy, free of greenhouse gases and other pollution. What is more, during hydrogen combustion only the safety water is produced as by-product, and it can be reused in hydrogen production (for example in water splitting). When the hydrogen will be sourced from fully renewable energy sources (as solar or wind energy) then the low-carbon society will come true. During solar water splitting the hydrogen and oxygen are formed. This method of hydrogen production is considered as a potential means of clean, large-scale fuel production. In solar systems the semiconductors (like a TiO<sub>2</sub>) are typically used as a photocatalyst. However, using of the TiO<sub>2</sub> is limited to UV radiation. Moreover, it is well known that loading of nanoparticulate cocatalysts onto a photocatalyst significantly improves the water splitting rate, so the modification of semiconductor by for example Cr<sub>2</sub>O<sub>3</sub>, Mn<sub>3</sub>O<sub>4</sub> or noble metals are often performed. This is also a method to extend the response of photoanode.

The main aim of the proposed project is to determine the impact of structure and morphology of photoanode, composed of Anodic Titanium Oxide (ATO) and plasmonic metallic nanostructures (M). We hope to achieve enhancement of TiO<sub>2</sub>/M anode photoactivity in water splitting process occurring under sunlight radiation utilizing excitations of plasmons in metallic nanostructures.

Photoanodes based on TiO<sub>2</sub>, covered by plasmonic nanostructures can be successfully used as a high efficiency solar cell – there are the first papers on the possibility of hydrogen production by plasmonic enhanced photocatalytic solar water splitting. A well-known phenomenon is also the relationship between materials structures and their physicochemical properties. However the structure impact is not unique and each investigated system required basic research and detailed analysis in order to optimize its best work parameters. Based on detailed literature review it can be concluded that independently of large number of papers about the topic of proposed project, there are no systematic studies regarding TiO<sub>2</sub>/M composites morphology and structures impact on their photocatalytic activity. Properly selected structure of the TiO<sub>2</sub>/M composite component will allow to increase the photoactivity of tested photoanodes. It is worth to know that from the point of view of materials science the detailed study of the structure and morphology of TiO<sub>2</sub>/M composites photoanode on their photoactivity in sunlight assisted hydrogen production is extremely interesting scientific problem.

Under the proposed project will be carried out a systematic study of the impact of structure and morphology of TiO<sub>2</sub>/M composites photoanode on their photoactivity in hydrogen production during solar water splitting. According to the available knowledge for the first time will be made the trial of anodizing the TiO<sub>2</sub> layers with variable resistivity (resulting from different oxygen content), which should directly lead to produce ATO with TiO<sub>2</sub> particles placed in its structure. According to the literature ATO structure coated by TiO<sub>2</sub> particles used as anodes in 3rd generation of solar cells shows a significantly higher activity than the electrode containing only ATO. The structural and morphological characterization of continuous and structured TiO<sub>2</sub> layers as well as plasmonic nanostructures will be performed. The fully controlled change of the structure of titanium oxide (amorphous, anatase, rutile or mixture of it) will be made. The semiconductor crystal structure effect on the photocatalytic properties of tested photoanodes will be investigated. Moreover, for the most promising solar cell system, the TiO<sub>2</sub> surface modification attempt by electrochemical incorporation of various ions (for example Al<sup>3+</sup> or Ag<sup>-</sup>) in its matrix will be made.