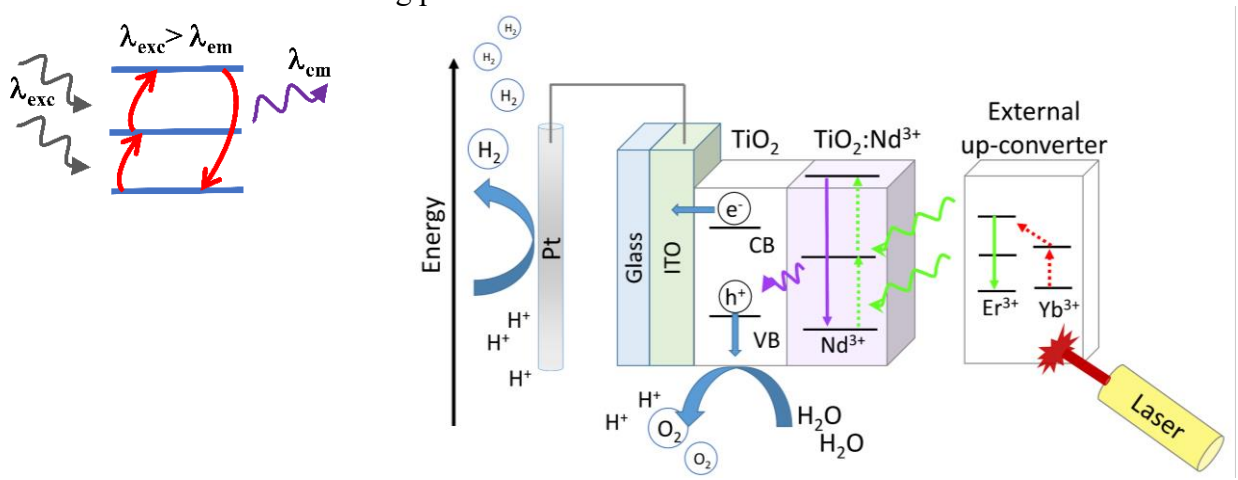
M.Radecka: Photoelectrochemical reactors supported by the "up-conversion" process

Among many methods widely employed for hydrogen production, water photoelectrolysis upon solar irradiation is considered as the most attractive from the point of view of ecological safety. True renewable, sustainable and pollution free energy sources require the use of water and natural light, only, for their fabrication and operation. However, to become practically viable the process of water splitting has to attain at least 10% of conversion efficiency. At the moment, this aim is far from being reached in simple systems. The reason for this failure lies mostly in poor adaptation of the available metal oxide semiconductors acting as auxiliary light absorbers, i.e., photoelectrodes, to the solar spectrum. Therefore, the concept of light harvesting becomes essential for successful realization of efficient solar-hydrogen photoelectrochemical reactors.

Light absorption as a first step of transformation of solar-to-chemical energy needs to be improved in order to increase the efficiency of hydrogen generation. Modification of the photoanode material by periodic texturing, structuring, doping or/and sensitization has been proposed. However, the most interesting is the reverse approach based on manipulation of incident electromagnetic radiation in order to adapt it to the spectral characteristics of the semiconducting photoanode via a wavelength-shift operation. Up-conversion non-linear process converting two or more photons of lower frequency to one photon of higher frequency is this innovative strategy. The processes taking place in the photoelectrochemical reactor containing Nd^{3+} doped TiO_2 photoanode combined with an external Yb^{3+}/Er^{3+} up-converter are demonstrated in figure below.

In this project we intend to undertake the studies of both: (1) optimization of the host structure, composition and architecture, as well as (2) selection and implementation of the up-converting activators in the semiconducting photoanode.



The ultimate aim of the project is to test the new strategy of the light management and to answer, until now unresolved, question: Is it possible to increase the efficiency of hydrogen generation in the photoelectrochemical reactor by means of up-conversion?