ITI HiFunMat Master Internship Proposal

☐ M 1 X M 2

Title : Localized Photo-ElectroChemical: Rapid optimization of photoelectrode materials for Hydrogen production

Internship supervisor

Name, first name	Cottineau Thomas
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Laboratory	ICPEES UMR7515
Collaboration with a HiFunMat member (*please indicate their name*)	X No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked)*	X Material science and engineering X Chemistry X Physics
Other indications if necessary	

Internship description

Solar energy has a great potential to meet the challenges that our societies face thanks to the large amount of energy brought annually to Earth by sunlight and its availability in almost all regions of the planet. Besides, the conversion of photon into electricity in photovoltaic panels, new applications using semiconductor (SC) material to convert light energy into chemical energy are emerging. These so photoelectrochemical (PEC) approaches uses thin-film electrodes and can convert solar energy into storable chemical energy (solar fuel, e.g.: H_2) or be used for degradation of pollutant in air or in water. If promising results were obtained by different teams around the world, it appears that a single material cannot gather all the required properties in terms of light collection, charge carriers mobility (e^-/h^+ pairs), stability in water and catalysis of the redox reactions. It is then required to create and optimize complex composite electrodes which will associate different materials that will ensure different functions. Furthermore, some of the mechanisms leading to high efficiency photo-electrochemical conversion still must be understood.

In this project we aim to develop a unique photoelectrochemical tool that can be used to determine some properties of the SC electrode *operando* in PEC conditions and that could turn into a powerful tool to rapidly optimize the structure of photoelectrodes. This method uses a small light spot as a probe to analyze the PEC efficiency of electrodes that present variable properties along their surface. In this way during the mapping of the electrode, the PEC reaction is only triggered under the illuminated area. First promising results were already obtained in our group on TiO_2 nanotubes film with variable thickness to optimize light absorption and charge transport in the photoelectrode for water splitting reaction (F. Gelb et al. *Sustain. Energy & Fuels*, 4, **2020**, 1099). Here the main objectives will be: (1) use this approach for composite electrode by studying the influence of the loading in CoO nanoparticles deposited as co-catalyst on the surface of TiO_2 to accelerate the water splitting reaction. (T. Favet et al. *Mater. Today Energy*, 37, **2023**, 101376) (2) To use Photoelectrochemical impedance spectroscopy method (IMPS) combined with local illumination to determine photogenerated charge carrier transport properties locally on the surface of the electrode with variable properties. (T. Cottineau et al. *Phys. Chem. Chem. Phys.*, 19, **2017**, 31469)

This project is for a master 2 student in the field of Chemistry, Physico-Chemistry or Material Science. It requires a strong motivation for experimental work and an ability to understand the multidisciplinary aspects

of the project such as electrochemistry, materials synthesis etc. The work will be done at the ICPEES on the campus of Cronenbourg (ZRR) and a PhD on the same topics can potentially follow this master internship.

The daily work, will include electrochemical synthesis and characterization, design of opto-electrochemical measurements, material characterizations (XRD, XPS SEM…) and the associated data analysis.

For more information and to apply please send a **CV and a motivation letter to Thomas Cottineau (cottineau@unistra.fr ; 03 68 85 27 33 ; ICPEES)**