# ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

**Title : Localized Photo-ElectroChemical measurements: Rapid optimization of photoelectrode materials for $H_2$ production**

**Internship supervisor**

| | |
|---|---|
| Name, first name | Cottineau Thomas |
| E-mail, Telephone | cottineau@unistra.fr / 03 68 85 28 14 |
| Laboratory | ICPEES |
| Collaboration with a HiFunMat member (*please indicate their name*) | ☒ No ☐ Yes : |

**Student profile looked for**

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

**Internship description**

The large amount of energy brought to Earth each year by sunlight, and its availability across the planet, makes it an attractive source of energy for future use. In addition to the conversion of photons into electricity in photovoltaic panels, new applications using semiconductor materials (SC) to convert light energy into chemical energy have emerged rapidly in recent times. These photoelectrochemical (PEC) approaches utilize thin-film electrodes to convert solar energy into storable chemical energy (solar fuel, e.g., $H_2$) or to degrade pollutants in air or water. While different research teams have obtained promising results, it appears that a single material cannot combine all the required properties in terms of light harvesting, charge carrier mobility ($e^-/h^+$ pairs), stability in water, and catalysis of redox reactions. It is therefore necessary to create composite electrodes combining different materials to ensure the various functions of the reaction. However, due to the complexity of these composite systems, optimization in terms of composition and morphology to achieve high performances requires a significant time investment.

Our team recently developed an original photoelectrochemical tool to accelerate the discovery of optimized structures of composite photoelectrodes. This method uses a small light spot as a probe to analyze the PEC efficiency of electrodes having variable properties along their surface (Fig. 1). This approach allows us to map the photoelectrode efficiency since the PEC reaction is only triggered under the illuminated area. Our team has already demonstrated promising results to optimize the light absorption in the case of $TiO_2$ nanotubes film with variable thickness (F. Gelb et al. *Sustain. Energy & Fuels*, 4, **2020**, 1099). Furthermore, we demonstrate how this method can be used to determine some properties of the SC electrode *operando* in PEC conditions by modeling the numerous data obtained by mapping (S. Vergne et al. *Solar RRL*, 8, **2024**, 2400156).

Based on these promising initial results, the main objective of the internship will be to utilize this approach for composite electrodes. The study will focus on the influence of the concentration of CoO nanoparticles, deposited on the surface of $TiO_2$, as a co-catalyst to accelerate the water-splitting reaction. The first task will be to synthesize photoelectrodes with a variable $TiO_2$ film thickness and a variable cocatalyst loading using methods developed in our laboratory. Subsequently, the local PEC properties will be investigated to determine the structure and composition providing the best PEC performance. The photocurrent mapping results will be fitted using a physical model of the reaction to determine the charge carrier transport properties and the efficiency of the charge transfer kinetic at the semiconductor/electrolyte interface.

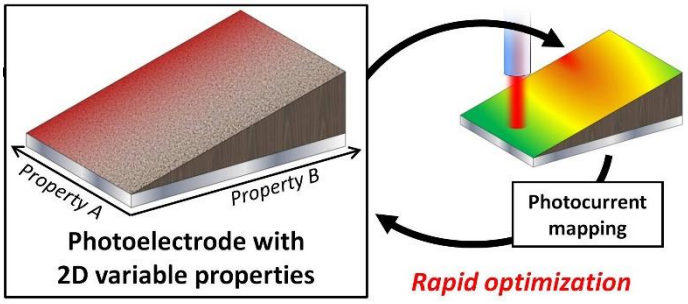


***Figure 1:*** *Schematic principle of the method for rapid measurement of functional properties of photoelectrode*

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 work on the multidisciplinary aspects of the project such as materials synthesis, electrochemistry, data treatment, optic, *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's internship.

For more information and to apply please send a **CV and a motivation letter to Thomas Cottineau (cottineau@unistra.fr ; 03 68 85 28 14)**