Doctoral School 352
Physics and Science of Matter

PhD Offer in Material Chemistry

Title : **Atomic Layer Deposition of Thin Protective Film on Epitaxial III-V Semiconductor Layers used as Photoelectrodes for Water Splitting.**

Laboratory : Centre Interdisciplinaire de Nanoscience de Marseille, CINaM (UMR 7325 CNRS – Aix-Marseille Univ.)

Advisor : Dr. Lionel SANTINACCI

Subject : In the context of global warming, the direct conversion of solar energy to H_2 by water photosplitting has attracted a great deal of interest in recent years. From an environmental point of view, this near-ideal solution combines the advantages of renewable solar energy production with zero CO_2 emission utilization. In addition to the many ways of producing H_2, solar-fuel conversion is a highly promising sustainable option. As part of the PEPR Decarbonated H_2 national program [1], the NAUTILUS project brings together 5 academic partners (Institut FOTON and Institut des Sciences Chimiques de Rennes, Institut Européen des Membranes in Montpellier, Centre de Nanosciences et de Nanotechnologies in Saclay and Centre Interdisciplinaire de Nanoscience de Marseille, CINaM) is proposing a solution to develop a photoelectrochemical (PEC) cell technology combining the low cost and technological maturity of Si and the high yields achievable with III-V semiconductors, which could be implemented for practical solar H_2 production applications. The overall aim of the project is to demonstrate a robust (long-life), self-sufficient (operating without applied voltage), high-efficiency (STH >10%) PEC cell based on direct-gap III-V thin films deposited on Si (a low-cost substrate).

III-V semiconductors tend to corrode under polarization in acidic and/or alkaline solutions. The stability of III-V/Si electrodes requires the deposition of a chemically stable thin films that do not hinder photoelectrochemical performance. This is CINaM's mission within the Nautilus project. TiO_2 has demonstrated its ability to effectively protect various semiconductors. The strategy is therefore to apply this approach to the III-V/Si electrodes manufactured by the Institut FOTON. The CINaM is equipped with both a commercial and a home-made ALD reactors, which have already been successfully used to protect Si-structured photoelectrodes [2]. As previously observed on this system, particular attention will be paid to (i) surface preparation prior to deposition, (ii) the influence of ALD conditions and (iii) post-treatments on final electrode properties. The electronic structure of the interface between the III/V semiconductor and the protective layer will be deeply investigated since it drives the charge transfer between the photoelectrode and the electrolyte. The main objective is to grow layers with the best thickness/protection ratio. Other protective films may also be studied. Nitride thin films such as TiN or TaN_x are also being considered, as they are stable and offer semiconductor properties close to those of TiO_2, but with different band positioning.

[1] https://www.cnrs.fr/en/pepr/pepr-dacceleration-hydrogene-decarbone
[2] L. Santinacci et al., **ACS Appl. Mater. Interfaces** (2016) 8, 24810

About the group: The hosting group in CINaM has a long-lasting experience within thin film deposition. Since 2011, a specific activity on Atomic Layer Deposition (ALD) dedicated to functional thin films has been initiated. Numerous materials have thus been grown by various ALD approaches along the 10 past years. Combining the expertise on materials science and (photo-)corrosion has led to focus notably on the protection of immersed surfaces under illumination. Several recent reports in the field of oxide protecting layers for various applications such as PEC cells or plasmonic devices illustrate those achievements. The group counts 4 permanent researchers and 6-7 non-permanent researchers in the field of materials chemistry for energy or photonic applications. They have a wide expertise in ALD, electrochemical, colloids and sol-gel synthesis as well as numerous material characterization using various techniques (SEM, TEM, optical methods, XRD, XPS…).

Qualifications: The candidates should hold a Master Degree with honours in Chemistry, Physics or Materials science with a preferential background in thin film deposition and/or electrochemistry. We are looking for an outstanding experimental physicist or chemist or engineer, passionate about nanoscience, motivated by interdisciplinary research and with a strong drive to excel in a competitive international environment. *Soft skills:* Analytical and critical thinking, motivation, flexibility.

Gross salary: 2135 €/month (hosting institution: CNRS)

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