Thesis subject

Laboratory: CINaM (UMR CNRS-AMU 7325), *Surface Nanostructuring for Energy (SuNE)*
www.cinam.univ-mrs.fr/cinam/team/nanomateriaux/sune/

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Thesis title: Synthesis and characterization of new efficient catalysts for solar fuels generation

Subject:

The use of renewable energy sources are promising ways to decrease our detrimental impact on the planet. However, their use is limited by their intermittent nature. It becomes therefore critical to find a sustainable solution to convert those energies into storable and transportable fuels. Since the pioneering work of Fujishima and Honda[1] in the 1970's demonstrating the water photosplitting at TiO_2 photoelectrodes under solar illumination, this field has attracted a lot of interest but it still needs significant improvements to meet the demand at the grid scale. To reach such challenge, it is possible to optimize the photoelectrochemical cell architecture, to find cost-efficient materials (absorbers and co-catalysts), to perform electrode micro- or nanostructuring and, finally, to combine different materials. In previous works, the SuNE group has shown the positive impact of the electrode structuring using anodic processes and the interest of combining materials to preserve the efficiency of the electrodes[2,3].

Recently, a new class of promising cost-effective co-catalysts for water photooxidation has been evidenced[4]. The target of the present thesis is therefore to synthetize, characterize and probe the photoelectrochemical properties of different compositions of this new family of materials. Those catalysts will mainly be grown on plane Si-based electrodes using atomic layer deposition (ALD). Although the group has a long experience on this deposition process[5] the synthesis will not be limited to it and other approaches will be investigated through collaborations. During the PhD work, the student will learn how to deposit protective thin films (e.g. TiO_2, Fe_2O_3, NiO…). The deposition parameters will be optimized to control the chemical composition, crystalline structure and the morphology. The photoelectrochemical performances of these systems will be assessed and correlated with their physico-chemical properties as well as their electronic structure that will be calculated by DFT with specialists at CINaM. The catalysts will be studied using the various analytical techniques available in the institute. The morphology will be observed by electron microscopies (SEM, TEM), the crystalline structure by electron and x-ray diffractions and the chemical composition by XPS and FTIR. The electrodes performances will be tested using different (photo-)electrochemical setup of the group. Additional investigations will be performed in collaboration with the University of Rennes and possibly with University of Erlangen (Germany).

Duration: 3 years (01/10/21 – 30/09/2024)
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Gross salary: 1770 €/month (additional 210 €/month salary for teaching is possible)

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2. L. Santinacci, M.W. Diouf, M. Barr, Bruno Fabre, L. Joanny, F. Gouttefangeas, G. Loget, **ACS Appl. Mater. Interfaces** *8*, 24810 (2016)
3. S. Haschke, Y. Zhuo, S. Schlicht, M. Barr, R. Kloth, M. Dufond, L. Santinacci, J. Bachmann, **Adv. Mater. Interfaces** *6*, 1801432 (2019)
4. French patent application FR2012425 (30/11/20)
5. M. Dufond, M. Diouf, C. Badie, C. Laffon, P Parent, D. Ferry, D. Grosso, J. Kools, S. D. Elliott, L. Santinacci, **Chem. Mater.** *14*, (2020)