PhD Topic: **Development of Nanostructured Thin Films for Advanced Photoelectrodes via ALD and Template-Based Processes**

Research Unit : CIMAP - NIMPH Team (Integrated Nanostructures for Microelectronics and Photonics)

Location: CIMAP Laboratory, ENSICAEN, Caen, France/LCS Lab, ENSICAEN, Caen, France,

Context and Objectives: The energy sector is rapidly evolving, with an increasing demand for renewable and sustainable solutions. The production of hydrogen through water splitting using solar energy is a promising pathway toward clean energy, providing a decarbonized fuel source. In this context, photoelectrodes play a crucial role, and optimizing materials and their nanostructures can significantly enhance performance. This PhD project aims to develop innovative photoelectrodes using thin films deposited by Atomic Layer Deposition (ALD), combined with advanced nanostructuring techniques to improve the efficiency of solar hydrogen production.

Project Description: This project will integrate two complementary research themes:

1. **Nanostructuring via Templates:**
   - Develop new nanostructuring processes using anodized aluminum oxide (AAO) templates to control the properties of materials deposited by ALD. This includes the fabrication and optimization of AAO templates, characterized by their uniform nanopore arrays, serving as guides for the growth of nanomaterials.
   - Use these templates to create networks of nanostructured films, allowing better control of optical, electrical, and catalytic properties essential for advanced electronic and optoelectronic devices.
2. **Spinel Oxide Films via ALD for Photoelectrodes:**
   - Synthesize thin films of spinel oxides via ALD for use in photoelectrodes. These materials are recognized for their stability and suitable electronic properties, making them excellent candidates for solar water splitting.
   - Optimize stoichiometry and deposition parameters to enhance optical absorption, electrical conductivity, and chemical stability of the films. The project will build on recent advancements, such as the use of Nb−TiO_2 [10.1016/j.jacomc.2024.100018] as a complementary material to form effective heterojunctions.
   - Develop planar and 3D photoelectrode architectures to maximize surface area and improve light absorption and charge transport.

The thesis will focus on:

- Fabrication and Optimization of Nanostructured Templates: Synthesize AAO templates and adjust their properties (pore size, uniformity) to create well-defined structures for ALD.
- Thin Film Synthesis via ALD: Develop deposition processes to obtain spinel oxide films with precise stoichiometric control and optimized crystalline quality.
- Characterization: Use advanced techniques (X-ray diffraction, spectroscopic ellipsometry, secondary ion mass spectrometry) to analyze the structural, optical, and electrical properties of the films.
- Integration and Performance Testing: Integrate nanostructured films into functional photoelectrodes and evaluate their performance for solar water splitting, focusing on stability, efficiency, and scalability.

Skills Required:

- Fabrication and Optimization of Nanostructured Templates: Synthesize AAO templates and adjust their properties (pore size, uniformity) to create well-defined structures for ALD.
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This PhD project aims to::

- Fabrication and Optimization of Nanostructured Templates: Synthesize AAO templates and adjust their properties (pore size, uniformity) to create well-defined structures for ALD.
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- Characterization: Use advanced techniques (X-ray diffraction, spectroscopic ellipsometry, secondary ion mass spectrometry) to analyze the structural, optical, and electrical properties of the films.
- Integration and Performance Testing: Integrate nanostructured films into functional photoelectrodes and evaluate their performance for solar water splitting, focusing on stability, efficiency, and scalability.

Collaborative Framework: This PhD project, conducted within the NIMPH team, is supported by the LABEX EMC3 projects (SUNTOH and MARIE), dedicated to developing energy conversion technologies. The PhD student will have access to state-of-the-art facilities at CIMAP and will benefit from collaborations with Dr. Mohamad El-Roz from the LCS laboratory, whose expertise in catalytic characterization of materials and heterojunctions made from the same materials will provide essential complementary support to the project.

For any information or application, please contact:

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Additional Information:

Start: September-October 2025 (36-month contract)

Location: Caen, CIMAP-ENSICAEN Laboratory