



SENTINEL

European Training Network in Single-Entity NanoElectrochemistry

Early stage researcher opportunity based at the
Alternative Energies & Atomic Energy Commission (CEA)
Paris-Saclay Civil Research Centre

Project Description

ESR5: Nanoscale Electrocatalytic Activity at Individual Carbon Nanostructures

This post will be co-supervised by the Electrochemistry Group at the University of Warwick.

Objectives: The project involves electrochemical probe microscopy to map the electrocatalytic activity of individual catalysts particles, interpreted thanks to finite element method modelling. The focus will be on oxygen reduction reaction catalysis in acidic media of Pt-free nanomaterials.

Expected Results and methodology: Combining nanoscale electrochemistry and numerical simulation will provide access to the intrinsic electrocatalytic activity of functionalised nanotubes and graphene sheets, with identification of the origin of their activity (edges or defects) which is of huge benefit to our understanding of electrocatalysts.

For this purpose the PhD candidate will be in charge of (i) the substrate fabrication by metal evaporation on SiO₂ wafers, (ii) the nanomaterial deposition with various techniques and conditions in order to have well dispersed nanomaterials (iii) the multitechnique imaging of the sample: SEM, AFM, SECM and SECCM will be performed on the same zones, and (iv) Interpretation of the SECM results, through numerical simulations considering the exact geometry of the nano-objects as evaluated with SEM and AFM.

Planned Secondments:

- University of Warwick – nanoscale measurements. The ESR will gain hands on nanoscale SECM and SECCM measurements: probe fabrication and handling, noise managements, identification of the probe position on the substrate.
- Bio-Logic Science Instruments. This secondment will expose the ESR to state-of-the-art electrochemical imaging techniques to study of electrochemical interfaces with nanoscale resolution. Special emphasis will be put on the control of the nanometric displacement (step by step vs continuous displacements) and on the low current measurements (noise, amplification, etc).

- Aarhus University - surface charge mapping of single-cells. This secondment will expose the ESR to a recently developed technique capable of mapping surface charge density of living cells to understand neurological function. Its applicability to electrocatalytic activity mapping will be evaluated.

About the Employer

The CEA is a French national agency, employing about 15,000 people. Along with a number of other organisations CEA leads research related to sustainable energy storage and transportation. Its nanosciences department notably contributes to 2D materials and nanotubes functionalisation for fuel cells and batteries. Its work spans the analysis of individual objects through to their integration into multifunctional materials put into complete devices. There is access to state of the art facilities in electrochemical microscopy (3 commercial apparatus), substrate fabrication (gold evaporation on wafer, etc), and templated sample deposition (dropcast, spray, etc). The Nanosciences laboratory has a complete set of standard electrochemical characterisation facilities: rotating ring-disk electrodes, half cells and full cells; advanced spectroscopic characterisation apparatus (IR,Raman,XPS) and imaging (AFM,SEM-FEG). The laboratory has full access to the numerical simulation software COMSOL multiphysics. The modelling activity is fully integrated into the experimental investigations. Numerical simulations either support the interpretation of the measurements by extracting the relevant parameter from the measured quantity, or help predict the behaviour of a given device, by reproducing the multiphase processes (species transport and charge transfer) that are at play upon functioning. Material performance testing within devices (fuel cell, etc) using standardised protocols is also possible.

Enrolment to this post will be through the University of Paris-Saclay, which will provide the ESR with full access to all standard facilities and benefits in addition to those offered on site by CEA-Saclay.



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