Master thesis proposal

In situ and real time characterization of nanomaterials by plasma spectroscopy

Keywords : Nanomaterials, Flame Spray Pyrolysis, physical chemistry, atomic spectroscopy, laser, aerodynamic lens

SCIENTIFIC DESCRIPTION :

The proposed work is part of a national effort to accelerate the discovery of innovative materials through the PEPR “Diadem”. The aim is to provide the scientific community with an experimental device for synthesising specific nanoparticles in the gas phase, with an online, real-time analysis instrument to monitor the quality of the synthesis. This instrument provides immediate feedback on synthesis parameters, enabling faster convergence towards a targeted composition. More specifically, our objective is to perform in situ and real time elemental analysis of NanoParticles (NP) during their synthesis by Flame Spray Pyrolysis (FSP). Laser-Induced Breakdown Spectroscopy (LIBS) will be used to identify the different elements present and, ultimately, their stoichiometry.

Preliminary experiments carried out at NIMBE have demonstrated the feasibility of such a project and in particular the acquisition of a LIBS spectrum of a single nanoparticle. Nevertheless, a new experimental set-up is currently being developed and improved in order to obtain a better signal-to-noise ratio and increase the detection limit.

During this internship, the student will acquire LIBS signal from specific nanoparticles under vacuum and study the evolution of the signal obtained as a function of the size, composition and structure of the NP. Once the various effects have been understood and according to the time remaining, an automatic identification algorithm will be developed, as well as another one for automatic quantification.

Techniques/methods in use :
In order to carry out this internship, several benchmark materials will be selected from those currently being studied at NIMBE (Fe_2O_3, Fe_3O_4, Fe_3C, FeN_x, TiO_2, Si, SiO_2, FeCN). Before installing the new LIBS analysis chamber on the FSP device, instrumental and scientific work is first required to improve the current instrument. Thus, initially, a simple nanoparticle generator will be used to inject them into the LIBS chamber. The following improvements and studies will be carried out:

- Optimization of the optical collection system
- Optimization of the laser-nanoparticle interaction (laser focusing, pulse duration, energy per pulse, repetition rate)
- Study of the LIBS signal as a function of nanoparticle size (size-calibrated nanoparticles will be used)
- Development of complex nanoparticles analysis (multi-elements or core-shell NP)
- Determination of the detection limit
- Automatic identification and quantitative analysis of different elements

Budget description and use :
The grant will be used to supplement the budget allocated to the student’s salary and environment.

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Applicant skills :
Master of Science (M2 research) in physics, physical chemistry or materials. Knowledge of optics and at least one of the following areas is desirable: physical chemistry, nanomaterials, atomic spectroscopy. The lack of knowledge in several of these fields can be filled during the internship.

Internship supervisor(s) :
Marc Briant, marc.briant@cea.fr, 01-69-08-53-05

Internship location :
Commissariat à l'Energie atomique et aux Energies alternatives, CEA-Saclay, DRF/IRAMIS/NIMBE (UMR 3685)
NIMBE: Nanosciences et Innovation pour les Matériaux, la Biomédecine et l'Énergie

Possibility for a Doctoral thesis :
Yes, possibility to apply for funding from the 2MIB doctoral school (Paris-Saclay University) through a competitive application process.