Thesis title: “Real-time tracking of the catalytic reactivity of nanoalloys through environmental electron microscopy and nanoplasmonic measurements”

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Source of the grant: Allocation doctorale de recherche de la région Rhône-Alpes, ARC 4 Énergie montant équivalent à une allocation MENRT

Desired profile: The student should possess a Master 2 degree in materials science, solid-state physics, physical chemistry, nanosciences, or equivalent.

Skills: Interest in experimental science, dynamism, autonomy, ability to work in a team, good level in English.

Documents to provide: full CV, Master 1 and 2 transcripts, with student and class averages

PhD subject

Nanoalloys are nanoparticles obtained by a mixture of two or more metallic species. Employed as model catalysts, their structure is prone to variations in shape and chemical composition as a function of the catalytic environment (atmosphere, pressure and temperature). Hence, their catalytic properties may be altered during the reaction. The aim of the proposal is to quantify these structural changes (morphology, chemical configuration, reactivity) by physical and chemical approaches, gathering the abilities of our three research groups.

The first experiments will deal with Ni-Ag and Fe-Ag nanoparticles, synthesized at the cluster beam source PLYRA by laser vaporization. In a second step, nanoparticles of identical composition but synthesized by chemical route will be studied under operating reaction conditions. The catalytic test-reaction will be the steam reforming of methane (CH_4 + H_2O) into syngas (H_2 + CO).

One of the main research axes of the thesis will be to implement advanced characterization techniques such as Corrected Environmental Transmission Electron Microscopy ($C_s$corr-ETEM) and nanoplasmonics to understand the structural evolution of the nanoparticles and to identify the adsorbed chemical species at the surface of the nanoparticles under variable temperature and reactive atmosphere. Regarding optics, it is already known that the evolution kinetics of the surface plasmon resonance can be extremely sensitive to the shape, the chemical composition and the dielectric environment of the nanoparticles. These optical studies will be carried out in a cell working under controlled environment, and specially developed to combine optical measurements and chemical reactions.

At the end of this PhD thesis, the transition mechanisms of the nanoparticles from one structural configuration to the other should be clearly identified at the atomic scale. We also hope that significant progress will be achieved in the use of nanoplasmonics as an indirect probe of the catalyst structure and the reaction mechanisms.

Our aim is to drive the recruited PhD student to a high scientific level through this project. Experimental developments have already been engaged by the three laboratories collaborating within this project. Interactions between the laboratories will be eased by their proximity, all being located on the same campus of La Doua. This multidisciplinary approach will also bring to the student a very broad scientific experience.