Growth and structural study of equilibrium and out-of-equilibrium AuAg nanoparticles

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Owing to their multifunctional character, bimetallic nanoparticles (NPs) are being used in an increasing number of applications. Not only do they offer the combined properties of the two metals they are made of, but they can also develop completely new properties through alloying effects. The fields of application of these nanoscale objects are therefore numerous and include catalysis, optics, magnetic recording, drug delivery, hyperthermia, bactericidal actions, etc.

For these applications the development of scalable nanomaterial fabrication techniques allowing the synthesis of nanoparticles with controllable size, composition and morphology is of utmost importance. In addition, to be able to dissociate the properties of NPs from the environment effects, it is essential to obtain extremely pure NPs, i.e., free from any ligand or surfactant. In this regard, physical deposition approaches are ideally suited as they allow NPs deposition under high-vacuum conditions, resulting in high chemical purity due to the absence of organic solvents.

During this experimental thesis work, we will focus on the AuAg system, which presents a great interest in many domains as optics [1], sensing [2], water splitting [3], catalysis [4], and constitute a good model system for studying e.g. the elementary mechanisms modifying the chemical order under environment.

Two complementary ultra-high vacuum physical vapor deposition methods will be used to synthesize NPs with controlled sizes and compositions: i) high-temperature magnetron-sputtering, which will allow the 3D growth of nanoparticles at **thermodynamic equilibrium** and ii) room temperature inert-gas condensation synthesis, which will allow the **out-of-equilibrium** synthesis of NPs with well-defined size, chemical composition, crystalline structure and morphology [5].

The objective here is to explore the effects of deposition conditions on the AuAg nanoparticles population (size and density), chemical distribution and morphology and understand their growth mechanisms. The effect of the substrates used for optical and electrocatalytic applications on nanocrystals growth mechanisms will also be studied.

The morphological and structural properties of the NPs will be studied through advanced TEM based techniques (HREM, STEM-HAADF, STEM-EDX) down to the atomic scale. The optical and catalytic properties will be studied in collaboration with other research teams.

Candidates should have a background in condensed matter physics, physical chemistry and a genuine interest in experimental physics. Experience in the synthesis of metallic NPs by physical methods will be highly appreciated.

Keywords: bi-metallic nanoparticles, magnetron-sputtering, gas-phase synthesis, electron microscopy

References:

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