Laboratoire des Solides Irradiés, UMR 7642

Habilitation à Diriger des Recherches

Evolution of metal-dielectric nanocomposites under sustained ion-irradiation in both nuclear and electronic stopping regimes

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Abstract: Most of my research activity has focused on the development of strategies to control the properties of metal-dielectric nanocomposites using ion beams in both nuclear and electronic energy loss regimes. In the nuclear stopping regime my interest mainly focused on compositional patterning of nanoparticles under sustained irradiation. This is, the evolution of a dissipative system - an open system that is evolving under far from thermodynamical equilibrium conditions, and exchanges energy (or matter) with an external environment -toward a steady-state configuration. The use of a model system composed of monodispersed metallic NPs sandwiched between two dielectric layers has demonstrated to be particularly effective for studying the kinetic evolution of a nanophase under irradiation. In this way, we showed that several processes occurring in parallel can be to some extend separated, for instance i) the dissolution, ii) nucleation and growth and iii) evolution of NPs toward a steady-state size. Finally, we are working on the extension of the existing analytical undirectional ballistic model to bridge the gap with the more complete full account of forced mixing models developed so far for driven alloys. In the electronic stopping regime, my interest mainly focused on the ion-shaping of metallic nanoparticles. We introduced a rational description of the deformation process based on the concept of size dependent indirect-heating mechanism. Firstly, we showed that the ion-shaping is not a linear process whereby all the NPs are transformed in the same way. It is rather a complicate function of initial NP size and irradiation fluence such that different morphologies can be obtained. Secondly, we introduced several major improvements to the existing (Thermal Spike) codes to get a better description of the thermal evolution of a nanocomposite containing NPs of arbitrary shapes. Recently, this work was extended to describe the ion-shaping of Au hollow NPs, i.e. a cavity surrounded by a metallic shell. Also, we performed optical characterization of second-harmonic generation from spatially oriented ion-shaped nanoantennas using vectorial microscopy. Finally, I contributed to the creation and I am leading the microscopy center of the Ecole Polytechnique, CimeX. I was the main coordinator of several projets developed so far: Jeol, Cryo-ultramicroscopy, national partnership with Leica instruments. I have also been involved in the EquipeX TEMPOS within the framework of the NanoMax projet and I'm the project leader for the development of the liquid phase microscopy.

Keywords: Irradiation, nanocomposites, transmission electron microscopy, ion-shaping, compositional patterning, nucleation and growth