Ultrafast Transmission Electron Microscopy of Phase Transformations in Nanoparticles

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A new type of electron microscope will be installed at the IPCMS (Strasbourg) in 2014. It is an instrument, funded by the national excellence program EQUIPEX, that is able to obtain microscopic images with microsecond to sub-picosecond resolution. This unique instrument is operated with extremely short electron pulses, induced by pulsed laser beams. Thus, it allows the imaging of dynamic processes in materials with both high spatial and high temporal resolution and will be used to explore a variety of new fields in materials research. Among other projects, the new instrument will be applied to study ultrafast transformations in nanoparticles that have not been accessible by other techniques until now.

The PhD candidate will study phase transformations in nanoparticles that occur upon changing the temperature. The particles will be heated by an intense infrared laser pulse that is guided into the specimen chamber of the electron microscope. The heating pulse is followed, after an adjustable time, by an electron pulse that is used for imaging. Of particular interest are phase transformations that lead first to the kinetically favoured phase which, then, relaxes to the energetically most stable phase. These step-wise relaxations occur at very short time scales and have hardly been observable with the necessary spatial resolution until now.

The work of the candidate will start with the synthesis of different types of nanoparticles. A detailed structural characterization with conventional electron microscopy will follow. In-situ heating experiments will identify the systems. Finally, experiments by ultrafast electron microscopy will be carried out to study the dynamic evolution of the nanoparticles. It is known that both reversible and irreversible phase transformations occur in nanoparticles (irreversible transformations end up in metastable states); therefore experiments in different directions will be carried out, reducing the risk of the project. The experiments will be followed by an extended analysis of the data in collaboration with theory groups.

The candidate should hold a Master degree in physics, chemistry, or materials science. He/she should be competent to work in a highly demanding field of nanocharacterization.

The project will be a collaboration with partners in Strasbourg, in France, and in other European countries. Since it is part of “Investissement d’avenir”, it is of high importance for the scientific excellence in the Region.