MATEriaux : Ingénierie et Science

CNRS UMR 5510

Campus LyonTech la Doua
INSA de Lyon
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PhD position: Liquid-phase 3D electron microscopy for materials science

A PhD position is available at MATEIS laboratory at INSA-Lyon in the frame work of the project Liquid3DSTEM that is in cooperation with the Institute for New Materials, Saarbrücken and is funded by the French Research National Agency (ANR) and the Deutsche Forschungsgemeinschaft (DFG).

Context

Electron microscopy has traditionally been associated with the study of thin solid samples in vacuum. However, during the last decade, a few groups were able to pioneer systems that are enabling nanometer resolution in the analysis of specimens suspended in liquid. The broad applicability of liquid phase electron microscopy has driven a wave of interest as it has opened exciting possibilities for solving grand challenges in materials science, chemistry, biology and other fields and has opened the route for *operando* studies. Whatever the application field, a three-dimensional (3D) representation of the sample in liquid is often required for understanding its morphology and chemical distribution. The primary method for obtaining insight into the 3D morphology at the nanometer scale of unique samples from biology and materials science is tilt-series transmission electron tomography. The goal of the project Liquid3DSTEM is to establish liquid-phase scanning transmission electron tomography as new 3D microscopy modality, presenting unique way for nanoscale characterization of samples in liquid from both materials science and biology.

The “microscopy team” at INSA have used environmental scanning electron microscopy (ESEM) to study specimens in gaseous environments or in liquids since two decades. Such electron microscope, is able to work in transmission scanning mode with by setting a STEM detector below a thin sample that allows the analysis of suspensions in liquid. During Juan Xiao’s PhD, aqueous latex nanoparticles and their surfactants were characterized in 3D while they were suspended in liquid. However, artifacts due to irradiation damage have been identified. Therefore, the aim of the present PhD is to go further and optimize the set-up in order to minimize irradiation damage enabling to follow 3D morphological modifications of the studied samples, for instance during dehydration/hydration of liquid suspensions.

PhD work

The PhD will be trained on a latest generation ESEM and will be able in the shortest time to perform experiments in full independence. He/she will handle the home-made tomography stage and will develop a code for the “fast” acquisition of tilted image series in STEM mode.

Once recorded, the images tilt series will be aligned and the volume of the analyzed sample reconstructed by using dedicated algorithms. The volumes will be then segmented following the gray levels of the components in order to extract quantitative 3D data that are representative of the suspension. The results will be compared with those obtained using other characterization methods developed within the ANR project (liquid-phase in

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TEM using a dedicated sample holder, or using graphene encapsulation of the sample). The spatial resolution in 3D will be estimated on the reconstructed volumes and compared with simulation results performed at INM.

Model suspensions, such as gold nanoparticles in water, will be used to develop "fast" STEM tomography in liquids and to measure the spatial resolution reached in 3D. The technique will also be applied to aqueous suspensions of latex particles, surfactants, and aerogels. As they are more electron-sensitive the electron dose received by the sample will have to be estimated and controlled. Such samples are currently developed in the laboratory for super-insulation applications in building renovation. The interface between aerogels and latex particles are the key step for the design of efficient super-insulating materials (low thermal conductivity associated with high mechanical resistance). The evolution of several morphological parameters will be studied from the wet to the dry state. In particular, migration of the surfactant molecules during latex firm formation will be monitored. Samples will also be provided by the team at INM to study in 3D the intracellular fate of gold nanoparticles within biological cells (macrophage cells).

The PhD student will work in MATEIS, INSA Lyon and will be co-supervised by Prof. Karine Masenelli-Varlot and Dr. Lucian Roiban. He/she will interact with the team at INM. Frequent meetings will be organized between both teams within the framework of this project. The 3-year PhD can start in February, 2021. The gross salary is € 3,083/ month.

Profile

The applicant should have a Master's degree in Materials Science or in Physics, ideally (but not necessarily) with experience in electron microscopy. He/she should have a strong interest for experimental work and subsequent data analysis. He/she should be open-minded, thorough in his/her work, and able to work very carefully. He/she should also be able to work in team. Programming skills in Python or Matlab would be a plus.

How to apply

Applications have to be sent by email to Karine.Masenelli-Varlot@insa-lyon.fr and Lucian.Roiban@insa-lyon.fr. Applications should include a CV, a short statement on the applicant motivation and a reference contact.

About MATEIS

MATEIS is a Materials Science laboratory that encompasses different fields, namely, chemistry, physics and mechanics. The MATEIS laboratory studies three classes of materials (metals, ceramics and polymers), and their composites, incorporating their characteristics by volume and surface and their interfaces. Within MATEIS, the aim of the microscopy group (SNMS) is to develop *in situ* or *operando* tools and analyze the multiscale structure of materials, in order to better understanding the relations between their properties of use and structural aspects.

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