Crystalline structure of nanostructured materials and physical measurements by using in situ real-time transmission electron microscopy

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Electron-matter interaction leads into multiple types of radiations that can be registered to analyze chemical and physical properties of materials. The progress of transmission electron microscopy (TEM) has taken a big step forward after achieving ultra-high spatial resolution by using correctors of higher order aberrations and more recently the dynamic measuring of physicochemical properties inside the electron column by using *in situ* TEM. However, two important limitations remain, the *multiple scattering in electron diffraction* and the *phase retrieval in high resolution imaging*.

Electron diffraction has been used for several decades to identify crystalline structures, group symmetries, and structural defects. However, the multiple scattering results in spurious reflections and non-proportional intensities of the electron diffraction patterns, which cannot be supported by the kinematical framework. In order to address this issue, precession electron diffraction (PED) gives an alternative to overcome this problem. In the present talk, the advantages of PED in the study of thiolated metallic clusters and grain boundaries will be covered.

In TEM image observation mode a big cornerstone is imaging the phase of the electron wave, since only the amplitude can be detected. **Electron holography** provides the most direct and reliable access for dealing the problem phase in electron microscopy, but its requirements related to the coherence of the electrons are strict, and the optimized conditions due to the changes in magnification remains a significant instrumental limitation. In this talk, a variety of in-situ TEM experiments performed under external stimuli and the method to recover the phase image in real time will be exposed such as the analysis of magnetic properties of materials and electric potentials in metallic nanowires.

Live electron holography registers the modulation of the electron wave in its phase due to the intrinsic properties of the samples or due to the external stimuli at **in-situ TEM** set ups. The understanding of the behavior of functional materials exposed to external stimuli will be presneted. Physical and chemical measurements in situ TEM at individual nanostructures include mechanical (stress vs strain curves), electrical (I-V curves), phase transformations (cooling/heating), magnetization, and chemical reaction in liquid cells. In this talk a broad view of the new developments of these stages in dynamical electron microscopy will be explained.