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Electron tomography – 3D atomic, elemental and field mapping

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Electron tomography is a powerful technique for 3D materials characterization at the nanoscale using a (scanning) transmission electron microscope (S/TEM). Recent developments focus on the one hand on pushing 3D resolution to the atomic level, on the other hand on extracting a wide range of 3D information, such as chemical composition or material properties. In this presentation, we will address both topics.

First, we will show direct 3D atomic imaging of a Au-Ag nanocluster grown in superfluid helium nanodroplets. Reconstruction of both the atomic structure and the 3D composition allows to understand the formation and deposition of nanoclusters, which leads to a (multi-)core/shell morphology with a highly symmetric multiply twinned structure (Fig. 1a) [1].

A combination of electron tomography with spectroscopic techniques – electron energy-loss spectroscopy (EELS) and energy-dispersive X-ray spectroscopy (EDXS) – allows mapping of chemical variations and gradients, approaching the goal of full 3D elemental quantification. As an example for a simultaneous EELS and EDXS tomography and 3D mapping experiment, we demonstrate the reconstruction of different phases in Al-alloys (Fig. 1b). In addition, we recover spectral EDXS and EELS data, by reconstructing each spectral channel, providing four-dimensional datasets with spectra available separately for each voxel [2].

Finally, we will also discuss the power of EELS tomography for the extraction of optical material properties in the form of 3D surface plasmon fields around metallic nanostructures. Plasmons allow confining light to the nanoscale and are of significant interest for sensing, optical computing or medical applications. Formulating EELS tomography as an inverse problem, we reconstruct the full photonic local density of states (LDOS) around metallic nanoparticles, describing nanoscale light-matter interactions (Fig. 1c) [3].

The presentation attempts to give insight into the current status of electron tomography with a focus on combination with spectroscopy, showing its potential and current limitations.

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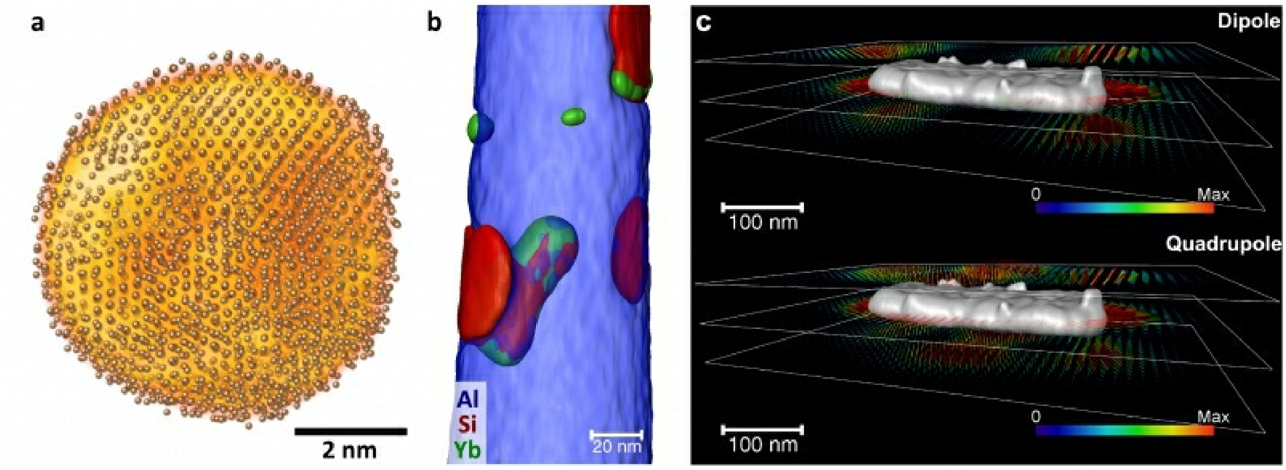

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