Measurement of atom mobility of gold nanorods via coarse-sampling in quantitative 4D-STEM

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Metal nanoparticles have attracted significant interest due to their distinctive properties which show significant potential in applications including drug delivery, chemical sensing, and biological imaging. A common method for synthesizing such nanoparticles is wet chemical synthesis; however, despite decades of development in synthetic methodologies, the precise mechanisms governing symmetry breaking and shape modification of these particles remains ambiguous and subject to debate. It is widely recognized that the introduction of different surfactants affects nanoparticle morphology.

In this work, we aim to study the influence of surfactants on the surface energies of nanoparticle facets. Our approach uses quantitative scanning transmission electron microscopy (STEM) to obtain a measure of surface mobility — as a proxy to estimate surface stability and hence energy [3]. We investigate the optimum set of parameters, including course sampling, for acquisition of a four-dimensional STEM dataset, such that the location and number of atoms in each atom column can be accurately determined while minimizing the electron dose. We quantify dose versus accuracy across these different parameter sets.

We apply these parameters to investigate the relationship between dose and atom mobility on a gold nanoparticle, with the use of double aberration-corrected microscopes (FEI Titan3 80-300 FEG TEM and a newly installed Thermo Fisher Scientific Spectra ϕ FEG TEM) (see Fig.1). We further apply this to measure surface mobilities on different gold nanoparticle morphologies.

This approach aims to offer insights into the fundamental processes underlying nanoparticle synthesis and shape evolution, paving the way for tailored nanoparticle design and optimization in various applications.

Graphic:

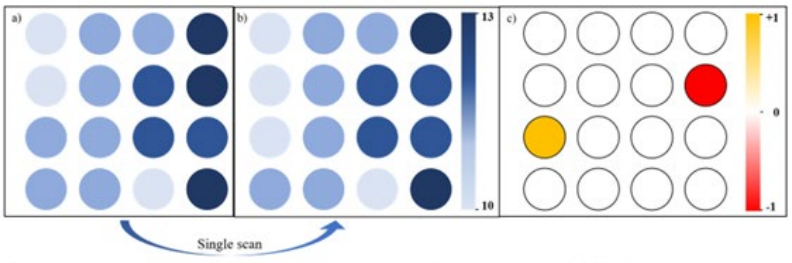

Figure 1. ***Schematics for the determination of facet mobility****. a) and b) two consecutive 4D-STEM scans with known electron doses, and c) difference in number of atoms in each atom column. The mobility of the atoms on this facet can be measured as the energy of one scan under which one atom movement can be detected.*

Keywords:

4D-STEM, nanoparticles, surface mobility

Reference:

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