Coherent x-ray diffraction of a semiregular Pt nanodot array

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ABSTRACT

Structural insight into nano-objects down to the atomic scale is one of the most important prerequisites to understand the properties of functional materials and will ultimately permit one to relate the size and shape of nanoparticles to their catalytic activity. We elucidate the potential of extracting structural information about an electron-beam lithography prepared, small ensemble of nanoparticles that are semiregularly arranged on a periodic array from coherent x-ray Bragg diffraction. The observed fringe pattern in the Pt(111) Bragg peak obviously originates from the mutual interference of the Bragg scattered wave field from individual nanoparticles in the nanoarray. Despite the absence of a symmetry center in the Bragg peak of the nanoarray, we identify the most prominent in-plane spatial frequencies of the latter by applying a Patterson map analysis to the Bragg peak superstructure. Integration along the in-plane reciprocal space direction over the relevant in-plane regions of interest results in Laue oscillations that arise from nanoparticle sets of similar heights in real space. A one-to-one comparison with real-space microscopic information obtained from scanning electron microscopy and atomic force microscopy suggests potential nanoparticle subsets as the origin for the x-ray intensity in these regions of interest by the good agreement in their height and direction-dependent in-plane interparticle distances, as also further supported by simulations. Nanoparticle arrays with well-defined tunable sizes and lateral distances may serve in the future to track structural changes in, e.g., sizes, relative positions, and tilts of smallest' catalysis-relevant nanoparticles during operando heterogeneous catalysis experiments in the 10-nm-size regime.

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