Electron Tomography For Nanomaterials: Colouring Atoms in 3 Dimensions

Sara Bals*, Bart Goris, Annick De Backer, Sandra Van Aert and Gustaaf Van Tendeloo.

EMAT-University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium

*E-mail: Sara.Bals@uantwerpen.be

Electron tomography has evolved into a powerful tool to investigate a broad variety of nanomaterials. Most of these results have been obtained with a resolution at the nanometer scale but different approaches have recently pushed the resolution to the atomic level.

One possibilitiy to perform electron tomography with atomic resolution is by applying reconstruction algorithms based on compressive sensing [1,2]. The methodology was applied to HAADF-STEM images acquired from defect-free Au nanorods [1]. Going further is the aim to determine the type of individual atoms in hetero-nanoparticles. Using the same approach, we were able to distinguish individual Ag from Au atoms at the interface in core-shell Au@Agnanorods [2].

Another challenge is to measure lattice strain in 3D. A well-known example of strained nanoparticles arenanodecahedra. Such particles consist of five segments bound by {111} twin boundaries, yielding a crystallographic forbidden morphology. We aimed at comparing strain investigations using 2D projection images with 3D measurements based on high resolution electron tomography reconstructions [3]. Therefore, a continuous tilt series of 2D projection images was acquired using HAADF-STEM and a dedicated alignment procedure was applied. These projection images are then used as an input for a model based tomography reconstruction algorithm. The final reconstruction is presented in Figure 1. Since the coordinates of the atoms are a direct outcome of the reconstruction, it becomes straightforward to calculate the 3D displacement map.

Also the ability to determine the crystal structure of more complex nanomaterials will be discussed.

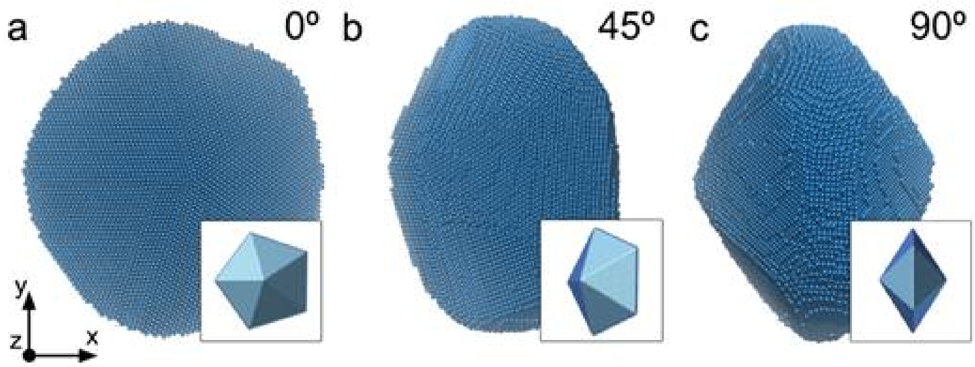

Figure 1: 3D visualizations of the reconstruction showing the atomic lattice of a Au nanodecahedron..

[1] B. Goris, S. Bals, W. Van den Broek, E. Carbo-Argibay, S. Gomez-Grana, L. M. Liz-Marzan, G. Van Tendeloo, Nature Mater. 11 (2012) 930

[2] B. Goris, A. De Backer, S. Van Aert, S. Gómez-Graña, L. M. Liz-Marzán, G. Van Tendeloo, S. Bals, Nano Lett. 13 (2013) 4236

[3] B. Goris, J. De Beenhouwer, A. De Backer, D. Zanaga, K. J. Batenburg, A. Sánchez-Iglesias, L.M. Liz-Marzán, S. Van Aert, S. Bals, J. Sijbers, G. Van Tendeloo Nano Lett. 15 (2015) 6996-7001