PremC
Conferences, Events & Workshops
ANNIC 2019
Applied Nanotechnology and Nanoscience International Conference
Nov 18-20, 2019
Paris

3D Structure of Nanomaterials under Realistic Conditions

Prof. Sara Bals
Dr. Wiebke Albrecht, Dr. Eva Bladt et al.
EMAT, University of Antwerp, Belgium

Electron tomography has evolved into a powerful tool to investigate a broad variety of nanomaterials, also at the atomic scale. However, 3D characterisation by transmission electron microscopy (TEM) is conventionally performed in ultra-high vacuum and at room temperature. To fully understand the connection between the 3D structure and properties under realistic conditions, innovative methodologies are required to track the fast 3D changes of nanomaterials that occur in different thermal and gaseous environments.

For example, to investigate the thermal stability of metallic nanoparticles, a combination of a tomographic heating holder with fast tilt series acquisition has been used. First, we investigated the morphological evolution of a Au nanostars at elevated temperatures and quantified local volume changes [1]. Figure 1 shows the original structures in bue with the final structures after heating in red. Moreover, using the same approach, we showed that Au/Pd octopods displayed an improved thermal stability in comparison to pure Au octopods, preserving their complete morphology up to 450 ◦C when heated in vacuum, see figure 2 [2]. Next, we performed an accurate 3D compositional quantification based on fast tomography. We hereby measured the 3D elemental redistribution dynamics of individual bimetallic nanoparticles upon heating. We conclude that for a given composition, the shape of the nanoparticle does not influence the alloying process significantly. Based on our analysis, it is clear that interdiffusion of metals at the nanoscale is more complex than predicted by simple Fickian diffusion and that other factors such as surface diffusion need to be taken into account [3].

To quantify nanoparticle shape dynamics in a gaseous environment in 3D, HAADFSTEM images served as an input for atom counting procedures followed by 3D relaxation of the structure. In this manner, we characterized shape changes of a Pt nanoparticle in a gaseous environment (Figure 3). The conditions have been varied from vacuum (Figure 3.a) to a 1 bar H2 flow (Figure 3.b), followed by a 1 bar O2 environment (Figure 3.c). To investigate the behaviour during cycling, we repeated the experiment several times using the same particle (Figure 3.d&e). We clearly observe morphology changes and we were even able to quantify the occurrence of the different surface facets [4].

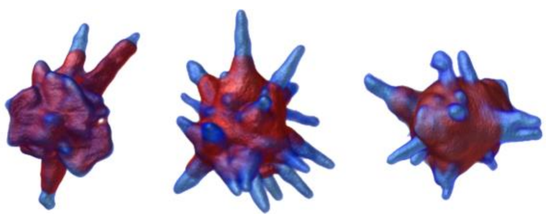

Figure 1

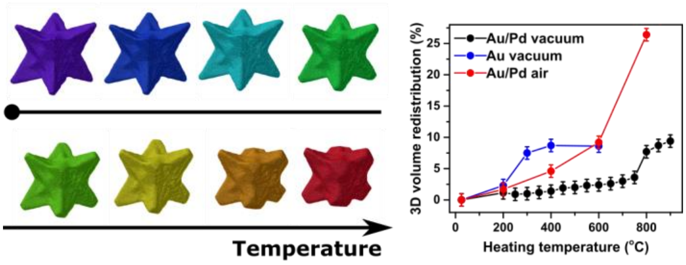

Figure 2

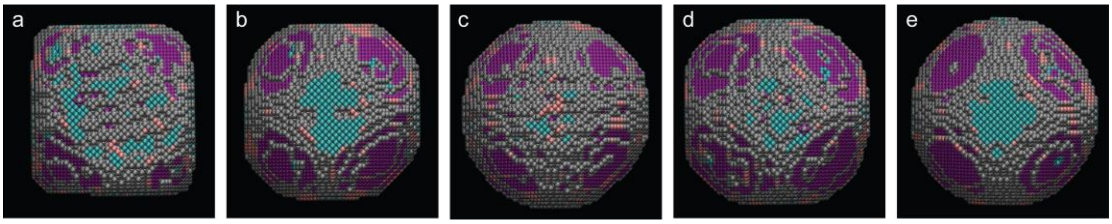

Figure 3

References:

1. H. Vanrompay, E. Bladt, W. Albrecht, A. Béché, M. Zakhozheva, A. Sánchez-Iglesias, L. M. Liz-Marzán, S. Bals, Nanoscale 10 (2018) 22792
2. A. Skorikov, W. Albrecht, E. Bladt, X. Xie, J. E. S. van der Hoeven, A. van Blaaderen, S. Van Aert, S. Bals ACS Nano accepted
3. W. Albrecht, E. Bladt, H. Vanrompay, J.D. Smith, S.E. Skrabalak, S. Bals, ACS Nano 13 6522 (2019)
4. T. Altantzis, I. Lobato, A. De Backer, A. Béché, Y. Zhang, S. Basak, M. Porcu, Q. Xu, A. Sánchez-Iglesias, L. M. Liz-Marzán, G. Van Tendeloo, S. Van Aert, S.Bals, Nano Letters 19 (2019) 477