1548 CD
DOI: 10.1017/S1431927606065159
Microsc Microanal 12(Supp 2), 2006

High Resolution STEM Tomography of Nanomaterials

I. Arslan,* J.R. Tong,** D. Medlin,* and P.A. Midgley**

* Sandia National Laboratories, 7011 East Avenue, Livermore, CA 94550, USA.
** Department of Materials Science and Metallurgy, University of Cambridge, Pembroke St., Cambridge, CB2 3QZ, UK.

Advances in nanotechnology have led to the demand and fabrication of smaller and smaller inorganic materials structures. One of the keys to successful device functionality is the ability to finely control the size, shape and electronic properties of the nanostructures. This requirement has prompted high resolution characterization using transmission electron microscopes (TEM), and most recently, to the development of three-dimensional tomographic imaging on the nanoscale using Z-contrast imaging in the scanning transmission electron microscope (STEM) [1].

Here we present high resolution single and dual axis STEM tomography of quantum dots and tetrapods. The results from Sn quantum dots in a Si matrix illustrate the ability to identify the size, shape and distribution of embedded dots in a layer in three dimensions. Furthermore, we are able to identify how the quantum dots are actually formed by observing a dot that has formed outside of the embedded layer. These results indicate 1nm resolution in all three dimensions using single axis tomography [2].

Dual axis tomography is demonstrated using CdTe tetrapods. Tetrapods are the perfect test specimen for dual axis tomography as they have long thin arms in a tetrahedral geometry, meaning at least one of the arms may be pointing in the direction of the missing wedge during acquisition of the data, and hence missing from the reconstruction. For the dual axis tomography, two tilt series are taken at 90° to each other. This can be seen in Fig. 1, which shows two 0° projection Z-contrast images, one from each tilt orientation. The second image has been rotated clockwise with respect to the first, with the arrows indicating the position of the same tetrapods in each image. Each tilt series is reconstructed on its own first, and these reconstructions can be seen if Figs. 2 (a) and (b). The arrows indicate some of the legs of the tetrapods that are missing because they point in the direction of the missing wedge, perpendicular to the tilt axis. If the information in these two tilt series is combined, then all of the legs in the tetrapods can be reconstructed, as can be seen in Fig. 2 (c) [3]. A comparison of the single and dual axis reconstructions will be shown and implications for resolution will be discussed. Other recent applications to nanostructures that will be presented are Fischer-Tropsch catalyst systems and GaN nanowires [4].

References

[1] P.A. Midgley and M. Weyland, *Ultramicroscopy* 96 (2003) 413.
[2] I. Arslan, T.J.V. Yates, N.D. Browning, and P.A. Midgley, *Science* 309 (2005) 2195.
[3] I. Arslan, J.R. Tong, and P.A. Midgley, *Ultramicroscopy* in press.
[4] This research was supported by the Royal Society and the NSF in the form of Fellowships. The authors would like to acknowledge N.D. Browning and T.J.V. Yates for helpful discussions and collaborations, and A. P. Alivisatos for the tetrapod samples.

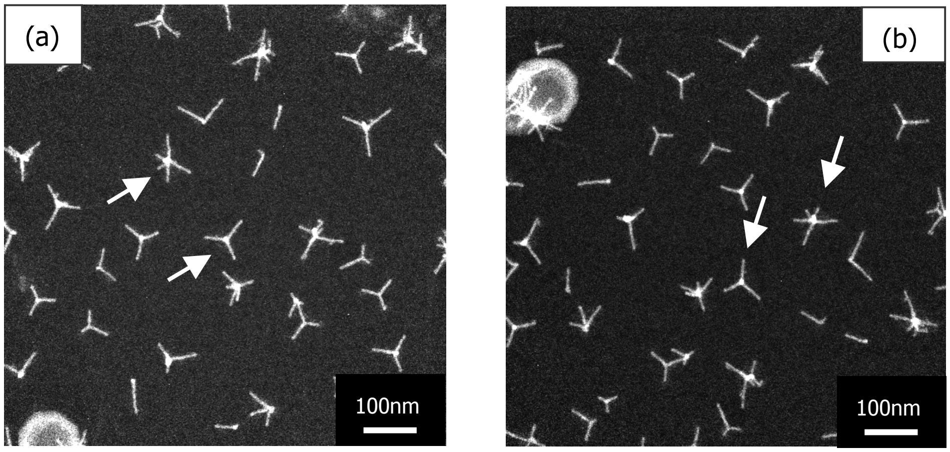

FIG. 1. Z-contrast projection images at 0° tilt, one from each tilt orientation. The second image has been rotated clockwise with respect to the first. The arrows indicate the position of the same tetrapods in each image.

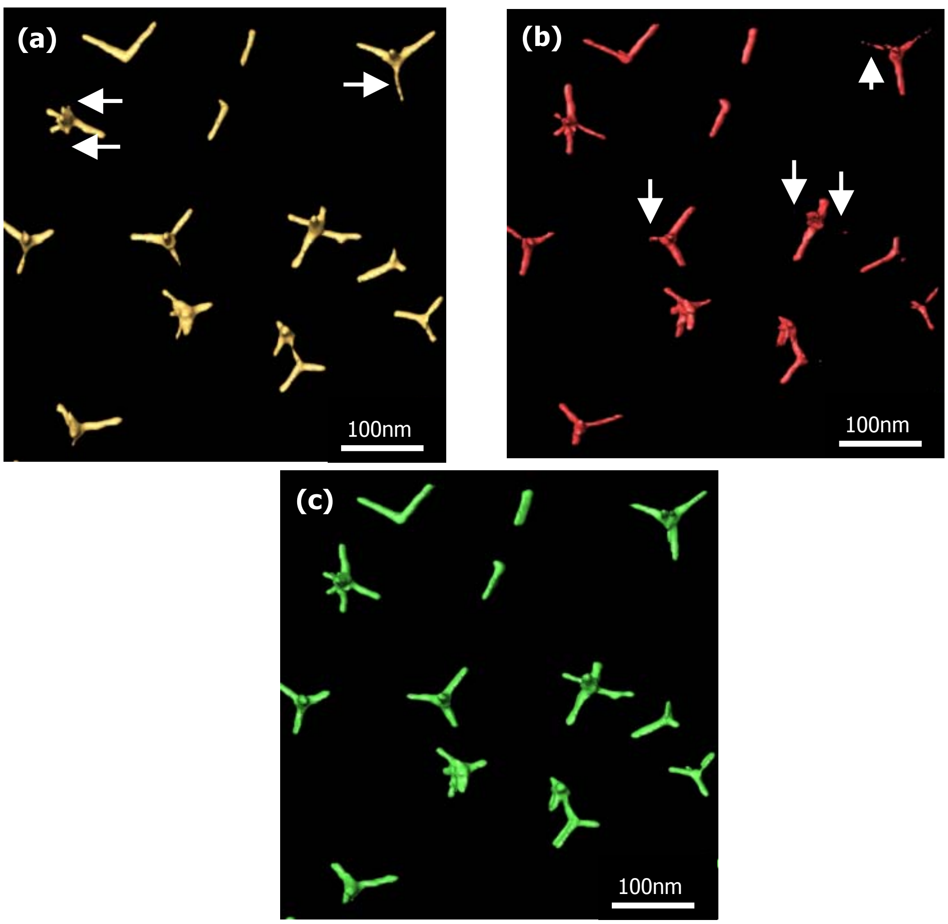

FIG. 2. Reconstructions of dual axis data. (a) and (b) are each single axis reconstructions, and the arrows indicate missing legs due to the missing wedge. (c) shows that dual axis tomography recovers information from all legs in all directions.

https://doi.org/10.1017/S1431927606065159 Published online by Cambridge University Press