doi: 10.1017/S1431927609095920
Microsc Microanal 15(Suppl 2), 2009

Application of Electron Tomography on DRAM Structures

Shixin Wang, TEM laboratory, Micron Technology Inc., Boise, ID

As the semiconductor industry continues the trend to shrink device sizes, sample preparation for the related TEM work becomes increasingly difficult. When geometry variation occurs in the nanometer range, it is almost impossible to make the specimen thin enough for a clean cross-sectional view of a feature. Fig. 1 shows an example of DRAM capacitor cell arrays. The image blur is obvious, especially along the wavy HfOx dielectric layers. This 3D effect has become a major source of measurement error or misunderstanding in materials analysis of semiconductor devices.

Recent advancements of high resolution electron tomography in the materials science field has demonstrated that it will be a promising technique to overcome the 3D effect described [1,2]. The sample was prepared using focused ion beam. The imaging mode was Z-contrast HAADF STEM with a probe size of 0.5nm. The image series was manually collected in the tilt range of –75° to +66° with a step size of 1°. Tomography program package IMOD [3,4] was used on image alignment, tomogram reconstruction, and visualization.

Two orthogonal slices through the reconstructed tomogram are shown in Fig 2. In comparison with the original STEM image (Fig. 1), the tomogram slices show the capacitor structures with improved definition of individual layers. Because the tomogram contains 3D information, it is possible to select the slice orientation to view and to measure around small curvatures, as shown in Fig. 3. The measurements in Fig. 3 also indicate the possibility of sub-nanometer high-resolution 3D measurement.

References:

[1] M. Weyland, and P. A. Midgley, “3D electron microscopy in the physical sciences: the development of Z-contrast and EFTEM tomography”, Ultramicroscopy 96, (2003) 413 –431.
[2] C. Kübel, A. Voigt, R. Schoenmakers, M. Otten, D. Su, T. C. Lee, A. Carlsson, and J. Bradley, “Recent Advances in Electron Tomography: TEM and HAADF-STEM Tomography for Materials Science and Semiconductor Applications”, Microsc. Microanal. 11, (2005) 378–400.
[3] J.R. Kremer, D.N. Mastronarde, and J.R. McIntosh, “Computer visualization of three-dimensional image data using IMOD”. J. Struct. Biol. 116, (1996) 71 –76.
[4] D. N. Mastronarde, “Tomographic Reconstruction with the IMOD Software Package”, Microsc Microanal 12(Supp 2), 2006, 178–179.

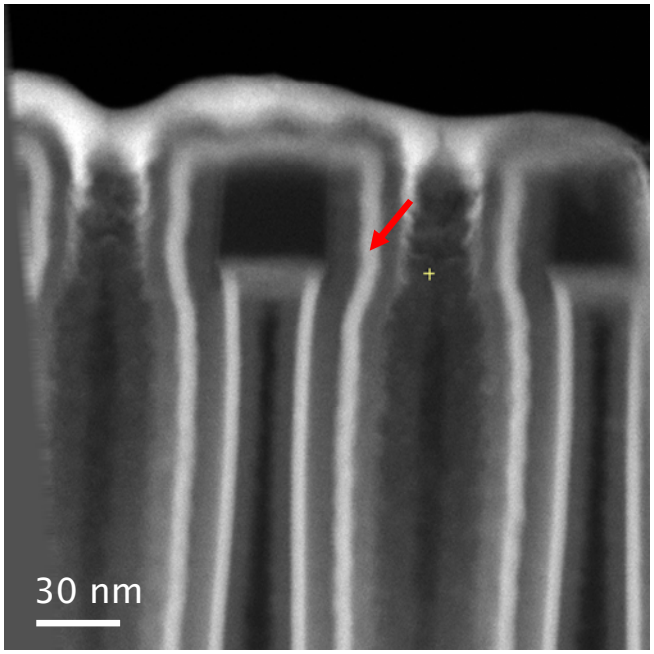

Fig. 1. HAADF STEM image showing part of DRAM capacitor cells. The arrow points to a wavy dielectric layer.

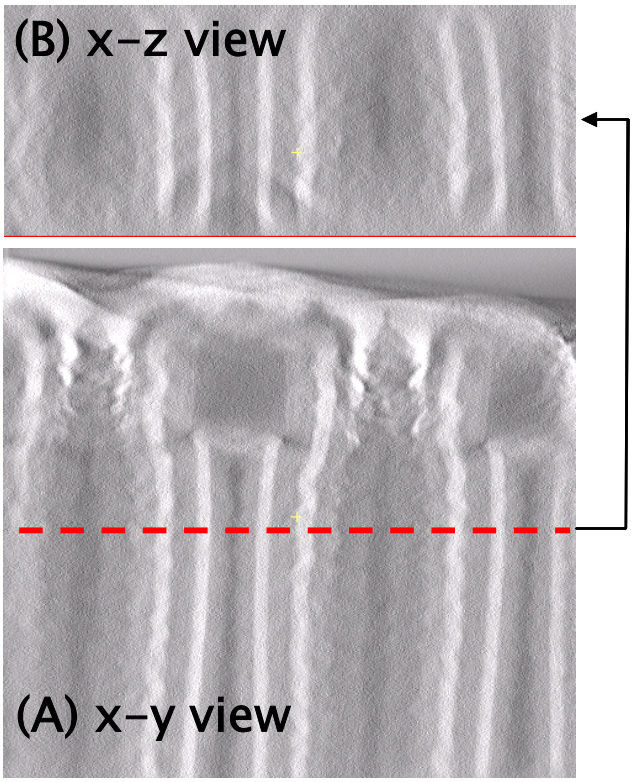

Fig. 2. Slices in reconstructed tomogram. (A) is the view parallel to the sample membrane. (B) is a view through sample thickness (z direction) as the slice cut at the location indicated by the dashed line.

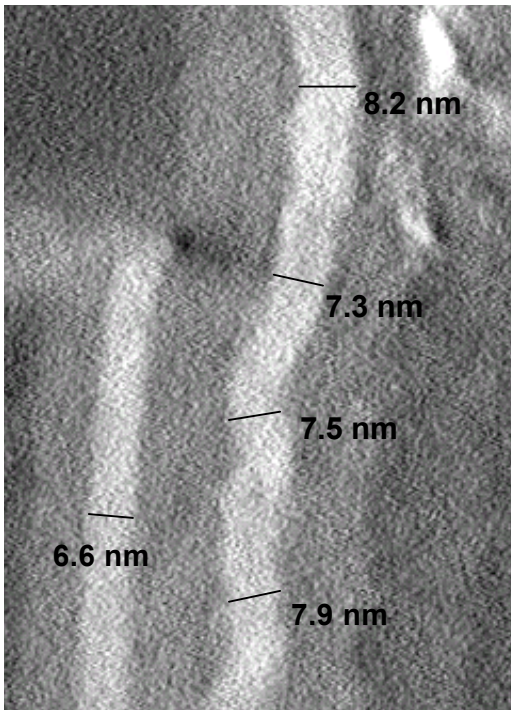

Fig. 3. Local measurement can be done unambiguously at selected slices at proper orientation.

https://doi.org/10.1017/S1431927609095920 Published online by Cambridge University Press