High-resolution high-sensitivity characterization of nanoscale structures in a new combined SIMS-SPM instrument: Correction of topography artifacts

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Ever decreasing feature sizes necessitate improvements in techniques for imaging and characterization. Secondary ion mass spectrometry[1] (SIMS) is a powerful surface analysis technique capable of providing both 2D and 3D spatially resolved elemental information. Because of its high lateral resolution and high elemental sensitivity (ppm) the Cameca[2] NanoSIMS50 is an ideal tool for investigating nanoscale structures. However samples with significant surface topography present challenges for analysis. Artifacts arise from surface topography for two reasons: first the 3D reconstruction assumes that the initial sample surface is flat and the analyzed volume is cuboid, second significant field inhomogeneities arise as a result of distortion of the local electric field (necessary for extracting the secondary ions for SIMS). These perturb both the primary beam and the trajectories of secondary ions, resulting in a number of possible artifacts[3], including shifts in apparent pixel position and changes in intensity.

A novel approach for correcting such artifacts is currently under investigation. A scanning probe microscopy (SPM) head is being integrated into the analysis chamber of the NanoSIMS50 at the CRP-GL. This will allow correction of both artifacts described above. Topographical information gained from scanning probe measurements taken before, during and after SIMS analysis will be used, first to accurately reconstruct the actual 3D analyzed volume see Figure 1 and Figure 2, second to correct pixel shifts and intensity variations by using the topography to determine the actual electric field above the sample by modeling. This may then be used to determine the effects on the secondary ion trajectories and instrument transmission to produce correction maps see Figure 3.

This paper will present the combined SIMS-SPM approach in general and focus on the correction of artifacts induced by electric field inhomogeneities in particular.

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[1] P.C.Zalm,Vacuum 45 (1994) 753

[2] Cameca, Gennevilliers Cedex, France, www.cameca.com

[3] J.L.S. Lee, I.S. Gilmore, I.W. Fletcher and M.P. Seah, Appl. Surf. Sci. 255 (2008) 1560–1563

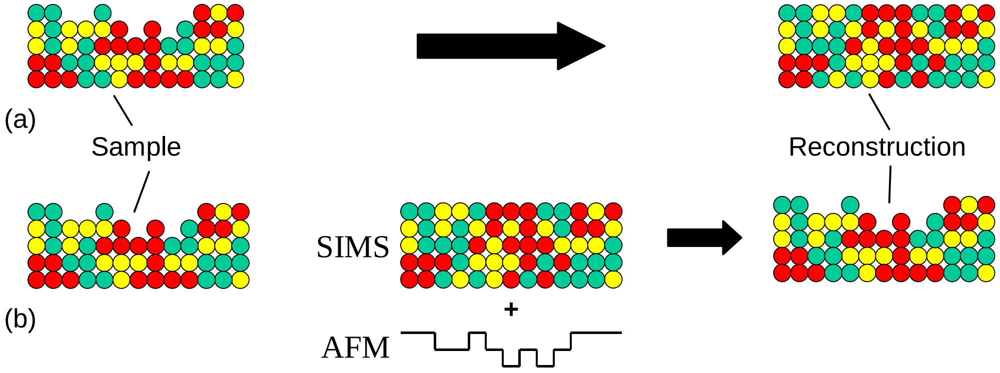

Figure 1: (a) Tradition reconstruction of the volume analyzed by SIMS. (b) Correction of SIMS 3D reconstruction using topographical data obtained from in-situ AFM measurements.

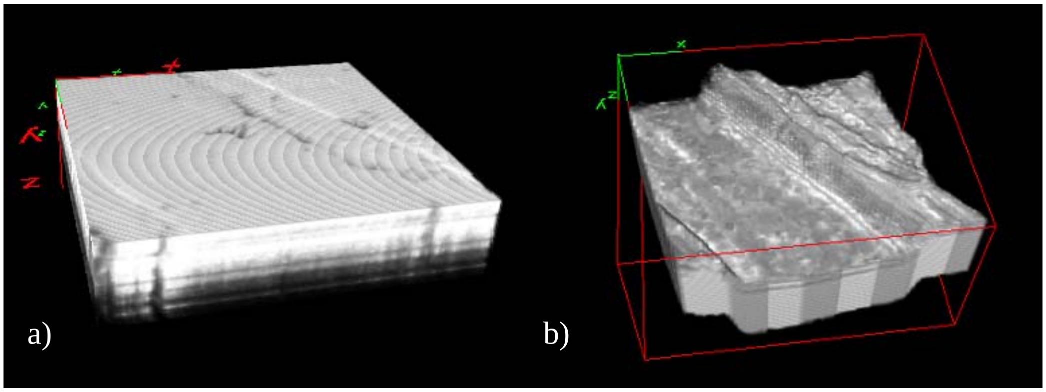

Figure 2: 3D reconstruction of copper line deposited on aluminum oxide substrate (a) traditional cuboid reconstruction. (b) reconstruction using AFM data.

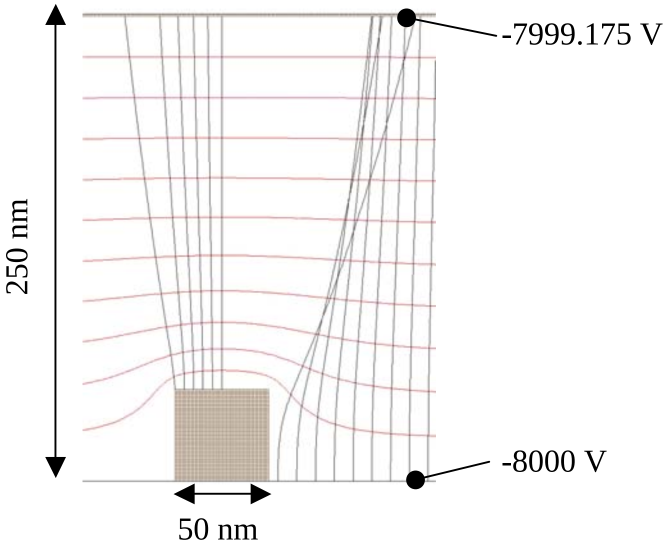

Figure 3: Effect of surface topography on secondary ion trajectories (black lines) from a nanocylinder 50 nm diameter x 50 nm high on a flat substrate. Equipotentials consistent with the extraction field of the NanoSIMS50.