High contrast scanning electron microscopy for high resolution cross sections using conductive polymer-metal coating

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In scanning electron microscopy (SEM), imaging nanoscale features by means of the cross-sectioning method is becoming increasingly challenging with shrinking feature sizes towards the single-digit regime. Nevertheless obtaining sharp and high contrast images is crucial for high throughput patterned feature evaluation at high magnification.

In this work we present a new sample preparation method for high performance cross-sectional imaging in SEM. Unlike conventional carbon or metal deposition, it was found that a stacked coating of conductive polymer and metal (CPM) greatly enhance contrast between the features and background. For comparison, cross sections using different coating methods can be seen in figure 1. Contrast of CPM coatings can be optimized by changing the thickness of the metal layer, therefore contrast formation will be discussed in detail.
Figure 2 shows a schematic cross section and corresponding secondary electron generation important for detection. Unlike in top down imaging, secondary electron pathways through the top surface of the sample and the cross sectional surface have to be taken into account for explanation.

CPM coating can be used for features of sub-100 nm in height. Advantages are the ease of use, cleanroom compliance and especially removability by simple water immersion, enabling sample reusability. Due to its high contrast in some cases, CPM coating for SEM might be able to substitute difficult TEM cross-section preparation. For example figure 3 shows 6-7nm features in a SEM cross section imaged using CPM coating.

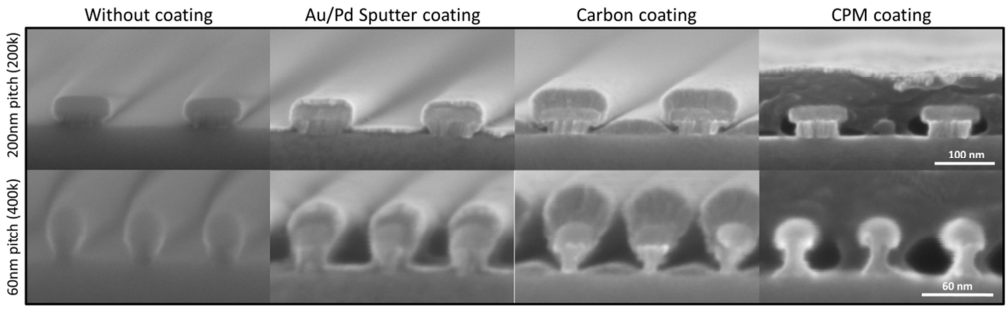

Figure 1: Comparison of cross-sections with different coatings. From left to right: without coating, Au-Pd sputter coating, carbon coating, and CPM coating. Sample type 1: 25 nm HSQ on etched 20 nm chromium using SiO2 substrate. Top row: 200 nm pitch, imaged with 200k magnification; Bottom row: 60nm pitch, imaged with 400k magnification. All images are taken under the same conditions (0.7 deg. stage tilt, same contrast and brightness).

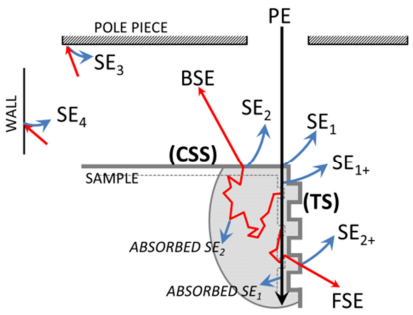

Figure 2: Schematic side view of cross-section under electron beam exposure during imaging showing cross-sectional surface (CSS) and top surface (TS) of the sample. Interaction of the electron beam with the sample creates multiple secondary and scattered electrons to be considered for detector signal generation.

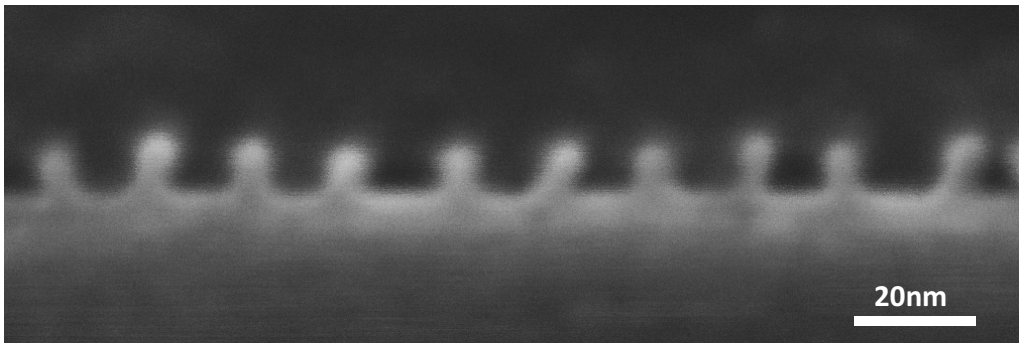

Figure 3: Cross section of 15nm pitch TiO2 features at 700k x magnification using CPM coating. Profile 6-7 nm features can be clearly seen.