Motivation: Strong degradation of OSG during observation in SEM

Organosilicate glass (OSG) thin films are low – k materials which are needed to reduce signal delay time and cross-talk in on-chip interconnects systems. The differentiation between OSG and etch stop layers, with different chemical compositions, and the exact determination of geometrical data of the Cu/low-k structures at cross-sectioned samples are important tasks for analytical labs in semiconductor industry, for both process control and physical failure analysis. However, during the electron beam application to the sample with Scanning Electron Microscopy (SEM), the OSG network is densified, which phenomenologically causes a significant shrinkage of the material. Low voltage SEM in combination with the use of the Energy selective Backscattered (EsB) electron detector improves the compositional contrast and mitigates the shrinkage of the OSG caused by electron beam-induced material damage.

Influence of the primary beam energy ($E_p$) on the shrinkage

At higher values of accelerating voltage the shrinkage effect increases, but it can be avoided by working with lower values of primary beam energy. It disappears completely at $E_p \leq 1$ kV.

Shrinkage in OSG thin films

$\kappa = 2.27$

Film thickness = 468 nm

Porosity $\approx$ 90%

Shrinkage effect in an OSG thin film (low – k material) after 3 min. scan, high primary beam energy ($E_p = 20$ kV) and high magnification.

Imaging advantages of EsB detector

The EsB detector offers material contrast between the OSG film and the Si. Additionally, it avoids the edge effect which is present on the InLens image using secondary electrons. It can be demonstrated on the intensity profile of both images across the phase boundary.

No shrinkage effect in an OSG thin film at $E_p \leq 1$ kV.

Due to the carbon content of the low - k material, contamination during longer exposition times occurs. This effect can be reduced by optimizing the image at a location, which is adjacent to the region of interest (ROI), and then moving to ROI for final image only.

Conclusions

- By decreasing the accelerating voltage, the severe shrinkage in the OSG thin films can be dramatically reduced, and it can be even avoided by working with $E_p \leq 1$ kV.
- Working with a shorter value of working distance ($WD \leq 2$ mm) is an essential requirement to image with low $E_p$, in order to improve the resolution.
- The energy selective backscattered-detector (EsB) can be used at lower values of $E_p$ to obtain a good compromise between avoiding shrinkage and offering a fine resolution.

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References

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