Advantages of a local gas injection system for charge compensation and contamination mitigation in FIB/SEM systems

J. Stodolka, H. Schulz[1], U. Zeile[1], and D. Kraft[1]

1. Carl Zeiss NTS GmbH, Carl-Zeiss-Strasse 56, 73447 Oberkochen, Germany

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j.stodolka@smt.zeiss.com
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In recent years the use of FIB/SEM instruments has become a well established standard technique for three dimensional imaging and analysis of both inorganic as well as biological materials. With ongoing miniaturization and optimization of materials, high resolution imaging becomes of increasing importance. The latest generation of FE-SEMs now has taken a significant evolutionary step towards the improvement of resolution possibilities, but one remaining challenge lies in the investigation of insulating specimens as any charging effects on the sample surface inevitably inhibit clear and stable imaging, analysis and also sample modification such as FIB milling.

The new FE-SEM systems of Carl Zeiss NTS are designed for a wide range of applications offering all kinds of information including imaging of material contrast and visualization of crystal orientation by utilizing a complete set of detectors. Due to new electronics, multi-channel mixing of all detector signals is possible, resulting in a final image with maximum information content. With additional integration of a charge compensation (CC) system these investigations are not restricted to conductive samples but can also be executed for all kind of nonconductive samples without encountering skirt effect issues, e.g. significant deterioration of image quality and reduction of resolution. The CC functionality is based on injecting a gas locally close to the area of interest. The gas molecules are ionized by collisions with charged particles and the thus formed electrons or gas ions are attracted by the opposite charges at the sample surface resulting in the desired compensation effect. Due to the fact that the gas is only applied locally the overall chamber vacuum remains in a regime that still allows employing all standard detectors commonly used in FIB/SEM instruments. In particular no special detection schemes with a typically inferior signal to noise ratio are required. Different insulating materials were used to investigate the advantages of this CC method for SEM imaging, FIB milling as well as in-situ analytics such as EDS, EBSD or SIMS. Possibilities for in-situ mitigation of contamination by locally injecting reactive gases make the CC system and its applications even more versatile including time-saving investigations of specimens contaminated prior to loading.

In this paper we will describe the impact of charging effects on FIB/SEM applications such as imaging, milling as well as the use of various analytical techniques and demonstrate how the use of the local charge compensation technique in the latest generation instruments can help to overcome some of the related issues. Additionally we will show how contamination can be reduced significantly or even be avoided while imaging.

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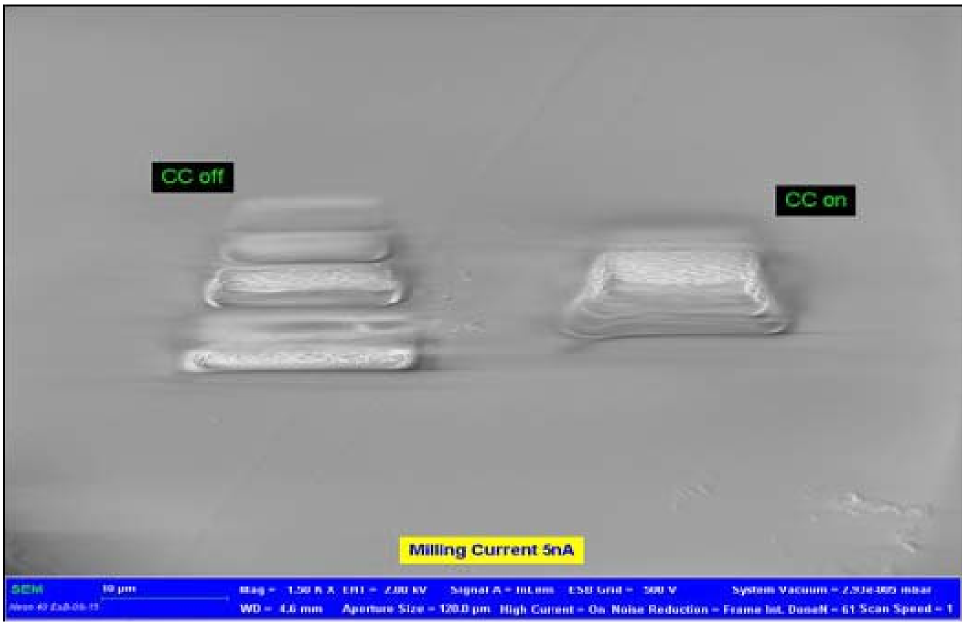

Figure 1. In the left cross section of Fig. 1 several discrete cutting lines are visible on the surface denoting a random deflection of the primary beam by simultaneously stimulated surface charges. Using the CC mode as demonstrated in the left cross section of Fig. 2 a proper cross section can be prepared

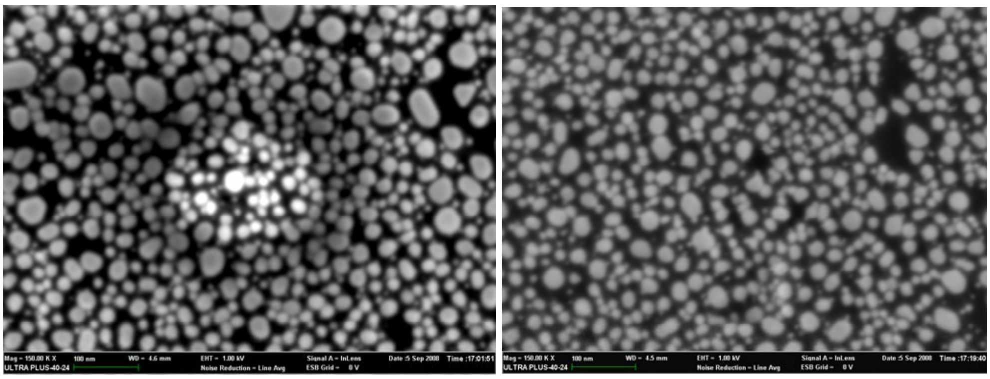

Figure 2. In-situ mitigation of contamination: O_2 significantly removes contamination while imaging: (images aquired at 150 kX mag after 1min scanning at 600kX, EHT 1kV, Scan Speed 3), left micrograph: gold on carbon sample, deliberately contaminated prior to loading, image acquired without oxygen flow, right micrograph: image of same sample acquired with O_2 flow

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