Microsc. Microanal. 8 (Suppl. 2), 2002
DOI 10.1017.S1431927602105873

Performance and First Results of a New 200 kV FEG-EFTEM

Günter Lang, Gerd Benner, Alexander Orchowski, Wolf-Dieter Rau

LEO Elektronenmikroskopie GmbH, D-73446 Oberkochen, Germany

We present first performance results of a Field Emission Gun (FEG) TEM with a corrected imaging in-column energy filter. Such an instrument fulfils the advanced needs of state-of-the-art applications in nano-technology and material science and has recently been realized at LEO (SESAMe II).

The illumination system of the instrument is set up with a Schottky FEG in combination with a condenser system incorporating three lenses, thus enabling the realization of Köhler illumination conditions [1]. Advantages are uniformity of illumination-direction and -aperture over a large field of view. Such well defined illumination conditions are highly desirable not only for high resolution imaging, but also for nano-diffraction and STEM-applications. Furthermore in combination with the high brightness of the FEG, spot sizes in the sub-nanometer range can be realized and used for analytical investigations on the atomic scale [2]. The design of the FEG allows to incorporate an electron monochromator [3], enabling a further reduction of the energy width to below 0.2 eV and thus allowing for the most sophisticated energy filtering applications.

For EFTEM-applications, the instrument is equipped with an imaging in-column energy filter. Based on a design by Rose and Krahl [4], a newly developed 90° Omega filter provides full second-order aberration correction by means of multipole elements. A high transmissivity of T_{real} = 320 nm^2/eV (@ 200 kV and 1 eV energy width) is achieved, enabling transfer of highly resolved energy filtered images even at large fields of view. Due to the correction of the aberrations, only a small energy shift occurs for out-of-axis areas of the filtered image. For demonstration, a series of energy-loss images from a thin amorphous carbon-foil has been recorded with an energy window of 2 eV. Extraction of energy-spectra (energy loss corresponding to Carbon Kα-edge) from the recorded images show a shift of the edge of only 2 eV within a field of view of 2.5 µm (Figure 1).

In order to demonstrate the performance of the microscope with respect to Electron Energy Loss Spectroscopy, a spectrum of the Si K-edge is shown in Figure 2. Highly resolved EELS-spectra with good jump-ratios can be aquired even in the high energy loss range.

As a measure for the overall stability of the instrument, we determined the information limit by means of Young-fringes. Two exposures of an amorphous sample - being shifted with respect to each other – are summed up and Fourier-transformed. The fringe pattern in the frequencies transmitted from the "white object spectrum" reveal the extension of linear information transfer. As can be analyzed in the numerical spectrum (Figure 3), the microscope shows an information limit better than 7.1 nm^{-1}, corresponding to 0.14 nm distances in real space.

References

[1] Benner, G. and Probst, W., Journal of Microscopy, Vol.174, (1994), 133
[2] Benner, G. et al., (2002) Microsc. Microanal., this volume
[3] Uhlemann, S. and Haider, M., (2002) Microsc. Microanal., this volume
[4] Rose, H. and Krahl, D., Springer Series in Optical Sciences 75, (1994), 42

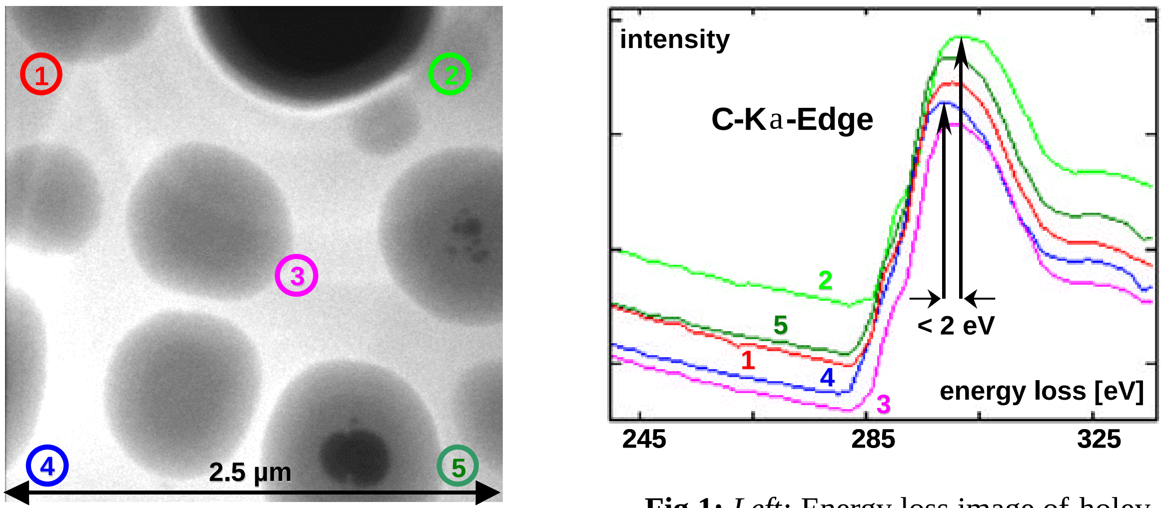

Fig 1: *Left:* Energy loss image of holey carbon foil taken with 2 eV energy width at the C Kα-edge. *Right:* Energy spectra extracted out of a series of energy loss images from the marked areas. Within the field of view of 2.5µm an energy shift < 2 eV is apparent.

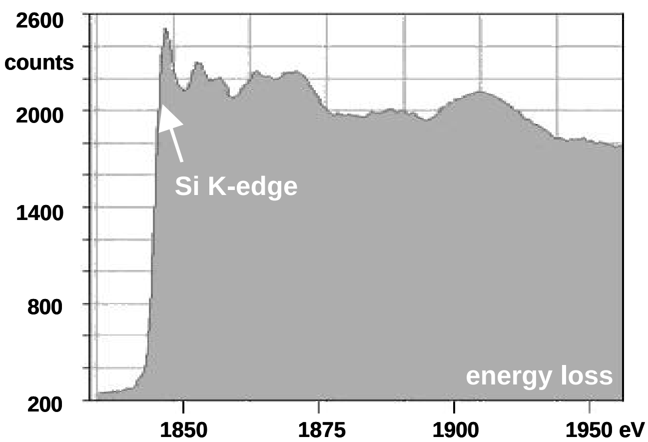

Fig 2: Energy loss spectrum of Si K-edge revealing excellent jump-ratio and resolution of fine structure.

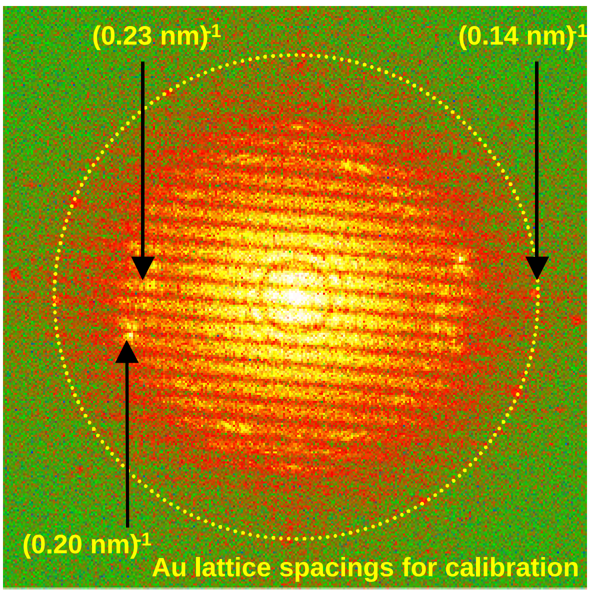

Fig 2: Information limit of the FEG TEM measured by means of Young fringes. Reflections from gold clusters on the amorphous carbon foil can be used for calibration. Linear information transfer down to below (0.14 nm)$^{-1}$ is clearly achieved, as can be seen from the visibility of fringe gaps in the amorphous signal beyond the indicated circle.

Corresponding author: Lang@leo.de

https://doi.org/10.1017/S1431927602105873 Published online by Cambridge University Press