Sub-Å STEM resolution from 60-300kV

Maunders, C.[1], Bischoff, M.[1], Miestadt, M.[1], Altin, V.[1], Henstra, A.[1], Tiemeijer, P.[1], Freitag, B.[1], Hartel, P.[2], Yucelen, E.[1] and Van Cappellen, E.[3]

[1] Thermo Fisher Scientific, Netherlands, [2] Electron Optical Systems GmbH, Germany, [3] Thermo Fisher Scientific, United States

Interest in low-kV STEM imaging has been fueled by increasing research on novel materials such as carbon-based nano-materials and other low-dimensional materials. Atomic resolution imaging of these classes of materials is seriously affected by radiation damage and weak signals leading to low contrast in the images. Therefore high contrast, beam-damage-free imaging can often only be achieved at low to very low accelerating voltages. Imaging below the critical knock-on damage threshold is the key to success and for some materials this can be well below 60kV.

To maintain optical performance at lower voltages, higher opening angles of the probe have to be used (diffraction limit). Hence the higher order aberrations of the optics, which increase dramatically with higher opening angles and lower voltages, need to be measured and corrected with high precision. Further, reducing the energy spread of the electron beam is critically important for reducing the effects of chromatic aberration which limit the achievable image contrast.

The probe corrector should be able to reduce the resolution limiting aberrations up to 5^{th} order even at low accelerating voltages, so that optimum imaging performance is achieved for all accelerating voltages between 60-300kV. Therefore, the high tension can be selected to best suit the material being investigated. We will discuss in this presentation how to achieve optimized imaging performance for a wide high tension range with excellent reproducibility and stability so that ultimate precision in atomic imaging can be obtained. Under these conditions, results like the example shown in figure 1 are routinely achievable on a system with full high tension flexibility.

Figure 1 : 60kV ADF of Si<110> (left) with FFT of the image (right)