First performance measurements and application results of a new high brightness Schottky field emitter for HR-S/TEM at 80-300kV acceleration voltage

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The performance of a transmission electron microscope is determined by the optical performance of the lenses, the stability of the column and last but not least by the performance of the electron source.

Over the last years great improvements in electron optics due to spherical aberration correction [1] and monochromators [2] and in the stability of the Titan80-300 column have led to Sub-Ångström imaging performance in HR-S/TEM [3]. For a desired SNR in the HR-TEM image the brightness is limiting the spatial coherence of an ideal illumination system. Consequently the improvement of the electron source is an evolutionary next step to explore the frontier in electron microscopy. For the TEAM project [4], which is based on the Titan platform, a significant increase in brightness over the conventional Schottky field emitter was needed in order to achieve the 0.5Å resolution target.

The Schottky field emitter is designed to deliver high brightness and a relatively high total current with a good energy resolution for TEM and STEM application. Both the brightness and the total current are of importance for a flexible TEM/STEM column to cover the entire range of applications a modern electron microscope can provide. Especially in TEM the brightness is not the only performance parameter for mid-range magnification applications (EFTEM, Lorentz microscopy, etc.) but the total current of the source becomes one of the dominant performance parameters. Moreover the lifetime and long-term stability of electron emission without the need for `flashing` the tip are important and a prerequisite for complex optical or time consuming experiments, high throughput applications and ease of use. Nevertheless higher brightness is required to explore the limits in atomic resolution imaging or to gain speed and resolution in spectroscopy or dynamic experiment applications. This complex mix of requirements has led to the development of a new ultra stable Schottky emitter design with higher performance for S/TEM applications.

The new Schottky field emitter delivers a significantly higher brightness in combination with still a large total current. No compromise in the long time and short time emission stability of better than 1% has been made. This performance translates to ultra high current values in Ångström probe size on a probe Cs-corrected Titan at

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300kV acceleration voltage. As a result, the exposure times in monochromized HR-TEM applications with the new design are better than in non monochromized HR-TEM imaging using the standard Schottky field emitter. Using the ultra stable TEAM project columns as a platform [4], the present contribution demonstrates the performance of this new emitter with a number of applications to different materials (see figs.1,2).

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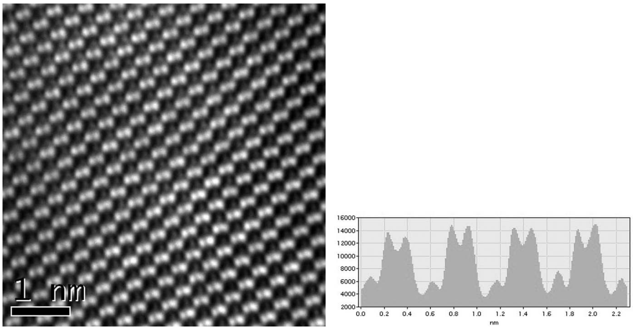

Figure 1. Monochromized Cs-corrected HR-TEM image of Ge<110> at 80kV. The dumbbell structure can be clearly resolved. The exposure time is only 1s. The intensity profile shows the germanium dumbbell distance clearly resolved with a count rate of 12000 counts/pixel in the image acquired with the monochromator switched on (ΔE=0.2eV).

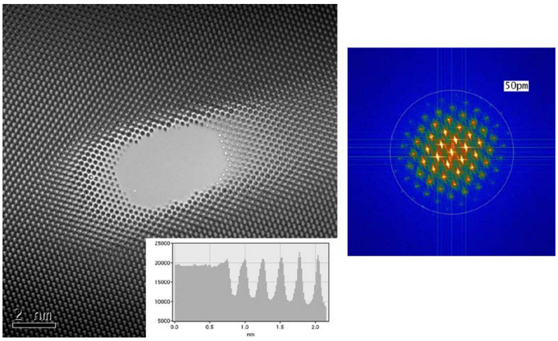

Figure 2. Monochromized Cs-corrected HR-TEM image of Au<110> at 300kV. Fourier components up to 50pm are transmitted. The exposure time is only 1s. The intensity profile shows a count rate of 15000 counts/pixel and the high contrast level in the image acquired with the monochromator switched on (ΔE=0.2eV).