Aberration Corrected FE-LEEM P90 New Result: 2.0 nm Resolution

Technical Notes

In this technical note the current status of the aberration corrected FE-LEEM P90 is presented. The data was obtained from the laboratory of Dr. Rudolf Tromp at the IBM Watson Research Center in Yorktown Heights, USA. The microscope used was a SPECS FE-LEEM P90 with integrated energy filter, and then upgraded with the aberration corrector. The corrector was constructed in collaboration with Dr. Tromp and SPECS and is now commercially available. The layout of the system is shown in Figure 1.

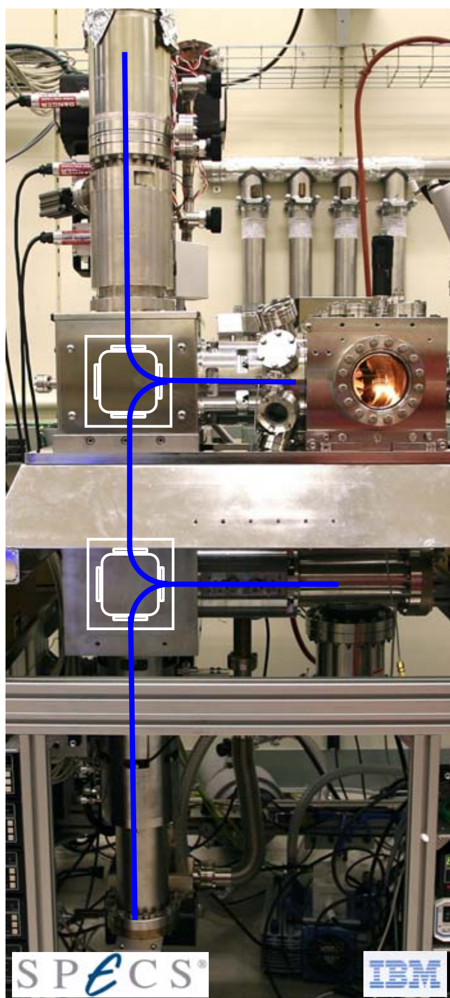
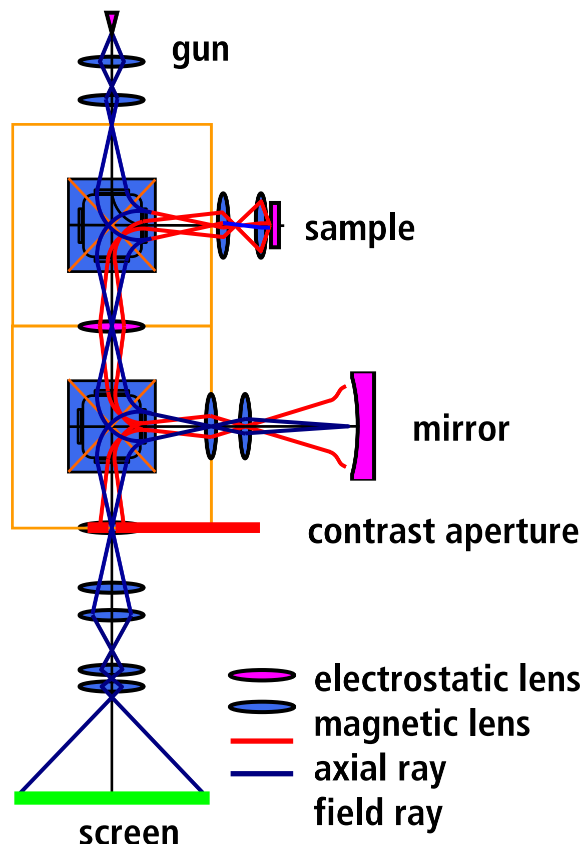


Figure 1: Layout of the aberration corrected FE-LEEM P90.



The electrons emitted from the electron source mounted at the top of the instrument are deflected by the first magnetic prism towards the sample. Electrons that were first reflected (or have been just emitted by the sample) pass through the first magnetic prism again. In a non-aberration corrected instrument, these electrons would be projected onto a screen. The lateral resolution of such an instrument is limited by the chromatic and spherical aberration of the objective lens in front of the sample. These aberrations can be corrected by using a second magnetic prism with a mirror.

Test measurements have been performed on thin graphene layers to determine the lateral resolution of an aberration-corrected FE-LEEM P90. Figure 2 shows an image taken from graphene on SiC(111). Areas with different numbers of carbon layers show different gray levels. Step contrast is seen in areas with the same layer number. Figure 3 shows the respective step profiles. The profiles have been averaged over strips 10 pixels wide, as indicated in the image by the yellow boxes.

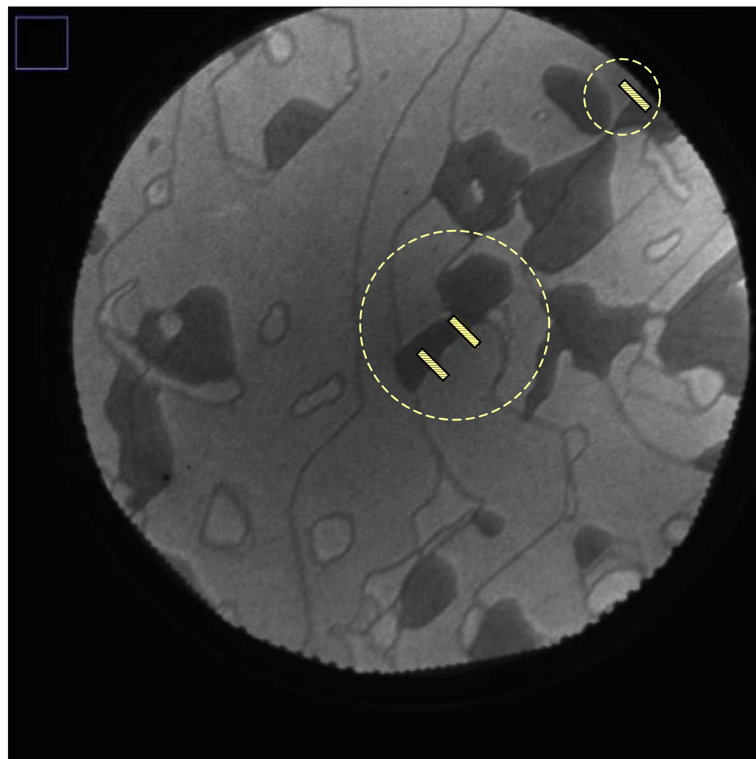


Figure 2: 0.75 μm field of view image of Graphene on SiC(111).

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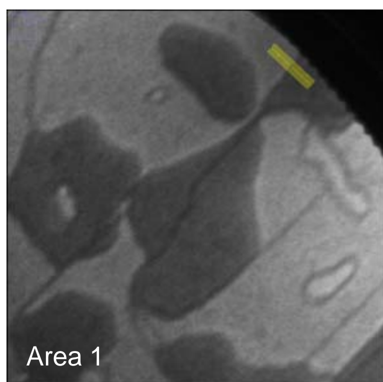

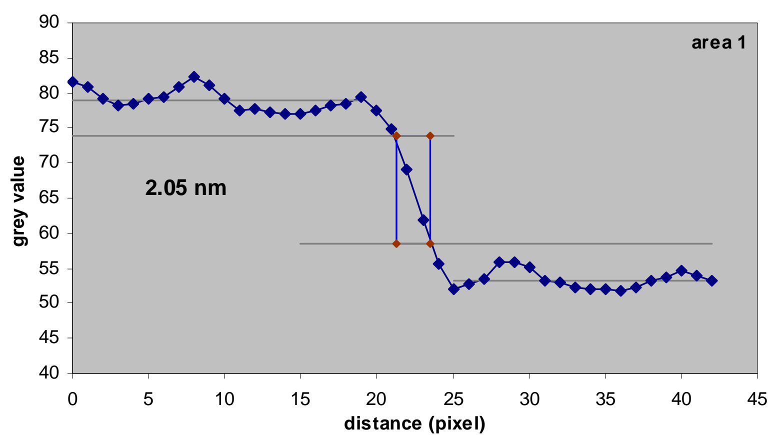

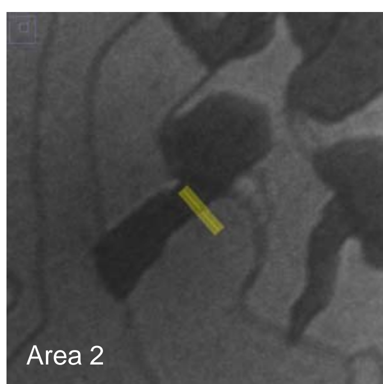

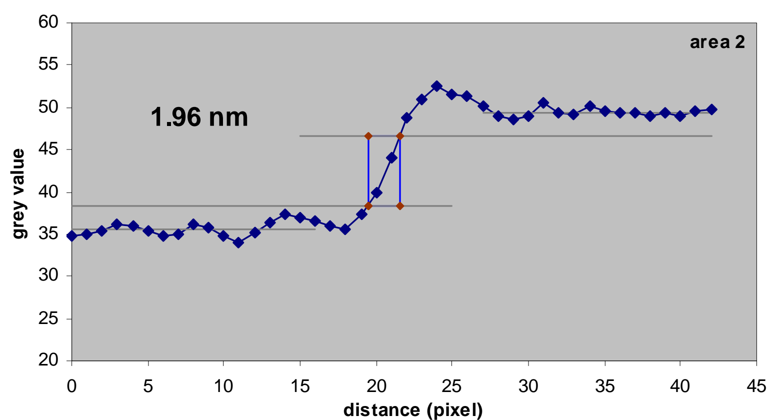

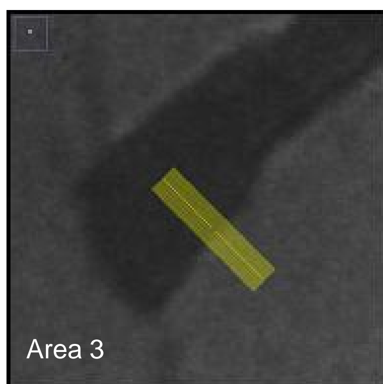

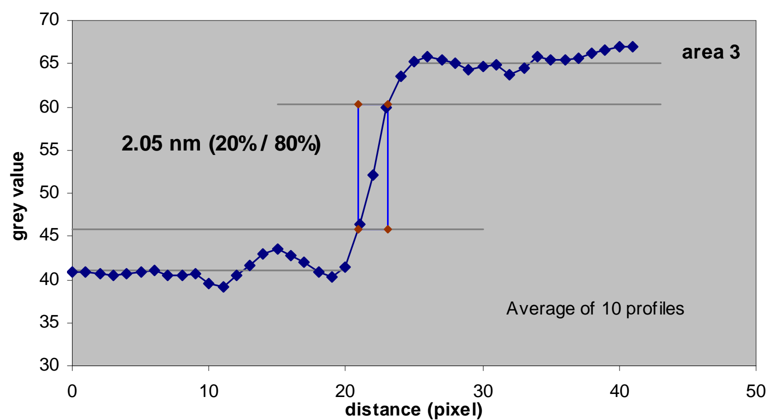

Figure 3: Step profiles determined from area 1, 2, and 3.

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Figure 4 shows the status of correction: The blue circle indicates the measured resolution with the uncorrected instrument using the optimum aperture size of 20 µm. The red circle shows the measurement with the corrected instrument: the optimum aperture is now 50 µm and the achieved resolution of 2.0 nm is close to the theoretical value of 1.5 nm. In addition, the transmission of the instrument is increased by a factor of more than 6.

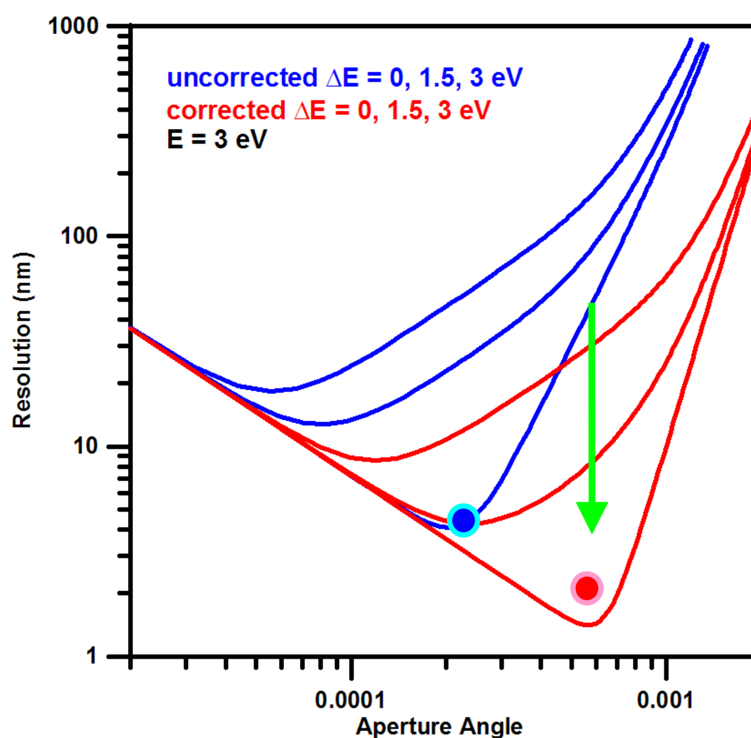

Figure 4: Lateral resolution of the uncorrected and corrected instrument as a function of the aperture angle. Data is given for 3 different energy windows, where the highest resolution is achieved for the smallest energy window.

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