Mitigating the space charge effect in the aberration-corrected XPEEM: core-level imaging

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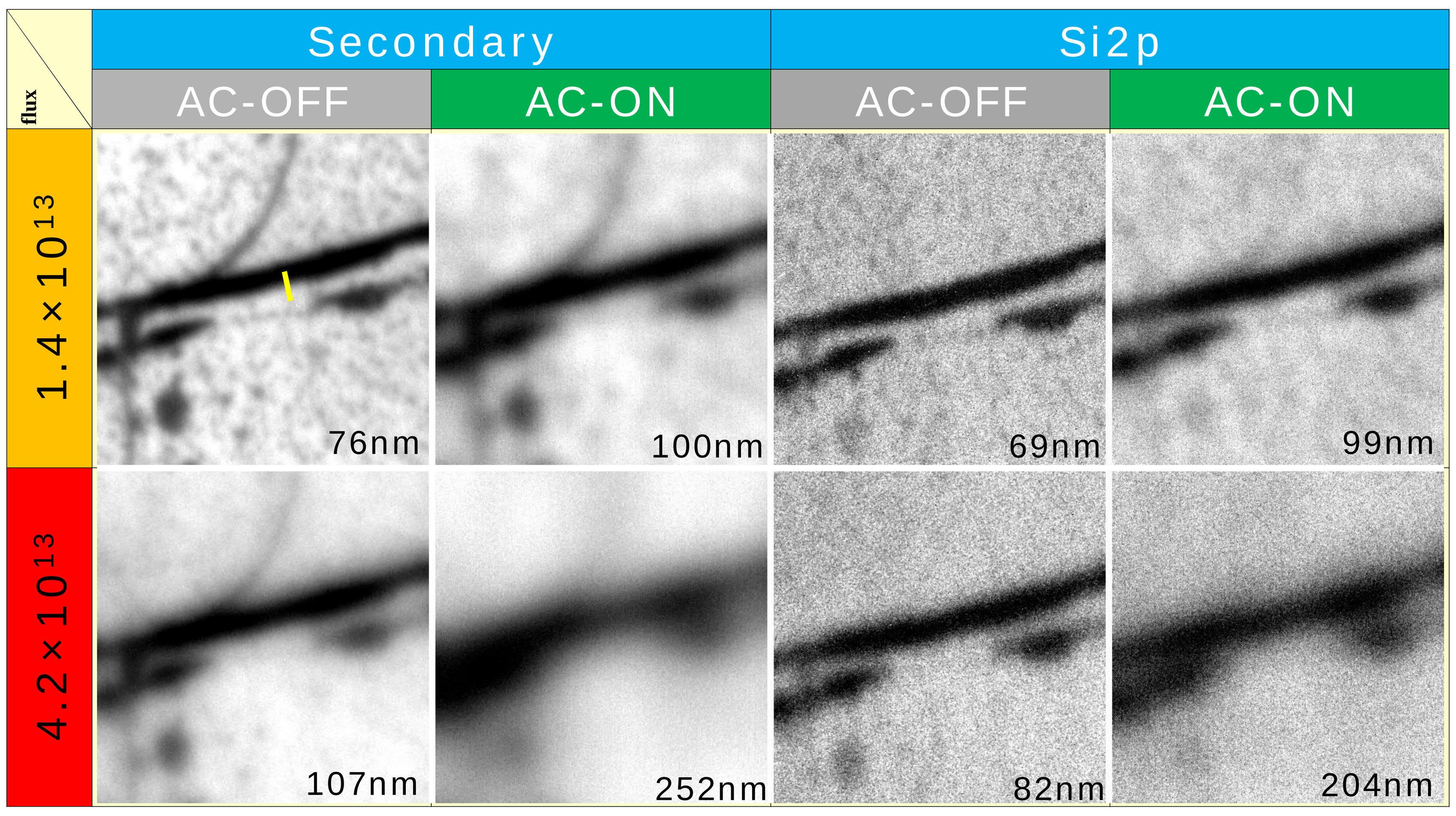
Space Charge Effects in AC-PEEM

The aberration-corrected LEEM/PEEM could reach much higher spatial resolutions compared with the non-corrected ones. However, this is only true when the space charge effect close to the aberration corrector is neglectable. Inside the corrector, especially when pulsed photon sources, e.g., synchrotron light or laser, are used, the slow and dense photoelectrons repel each other for a longer time by the Coulomb interaction, which deteriorates the final resolution of the microscope, even worse than that obtained without using the corrector [1, 2].

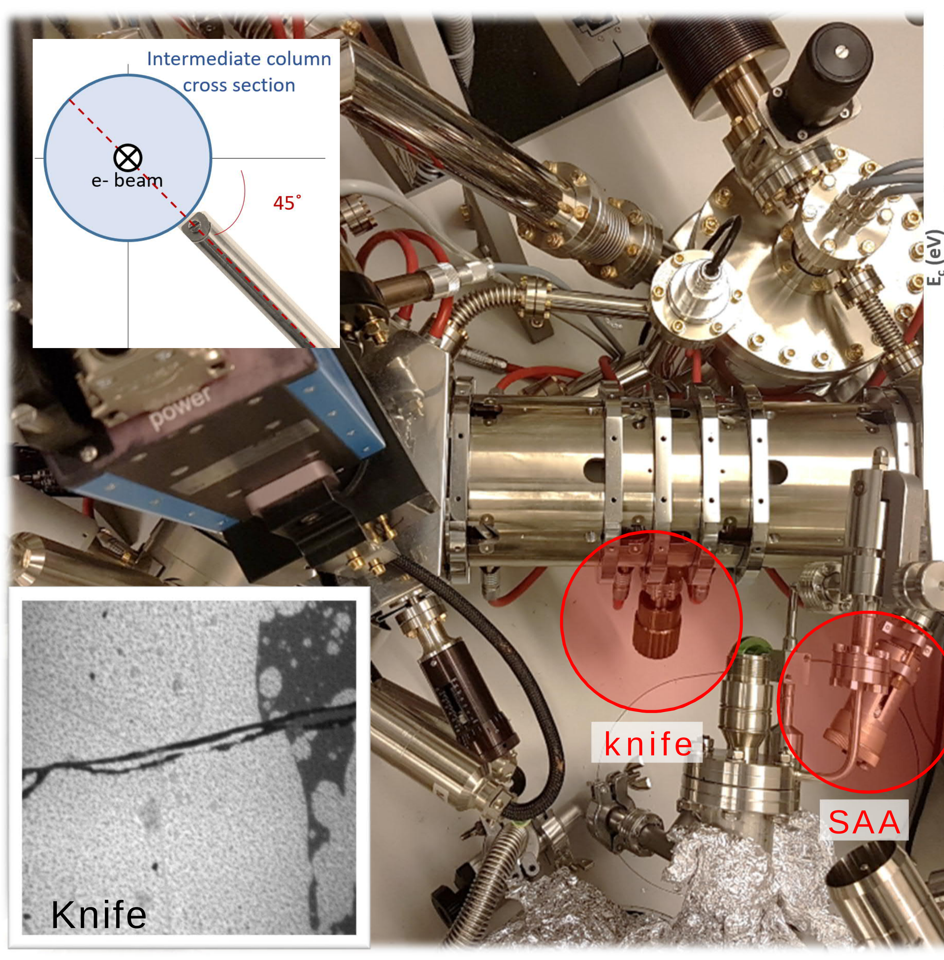


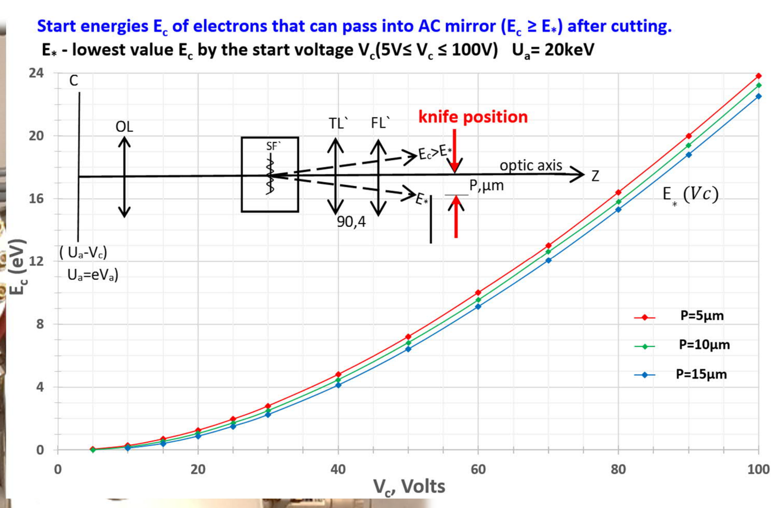
All mages were taken from a monolayer graphene sample grown on SiC with a few bilayer islands. Each image, 2.5×2.5 μm² (512×512 pixels) was cropped from the raw image with a FoV of 10 μm. The resolution of each image was measured from the profile crossing the mono- and bi-layer's boundary, indicated by the yellow line and fitted with error function. The photon energy used here is 150 eV. The energy slit (ES) used in both modes was 25 μm while the contrast aperture (CA) = 30 μm and 70 μm were used in the corrector OFF and ON modes respectively.

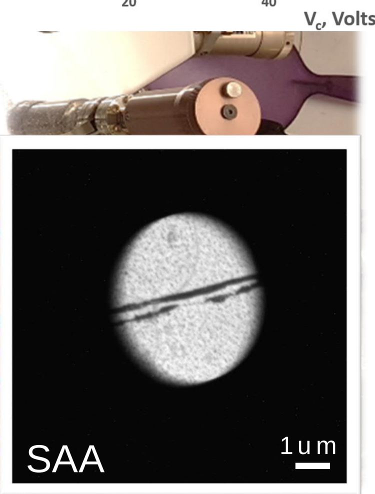
Ways to Mitigate Space Charge Effects

- ❑ Time structure of the synchrotron light source: longer pulse structure and/or more bunches.
- ❑ Focus the photo beam as needed: minimize the useless photoelectrons from outside the FoV, i.e., close exit slit.
- ❑ High resolution detector with higher sensitivity and lower noise: high detective quantum efficiency (DQE)
- ❑ Select needed photoelectrons as soon/much as possible after the sample surface: where and how?

Knife to Cut Secondary Photoelectrons

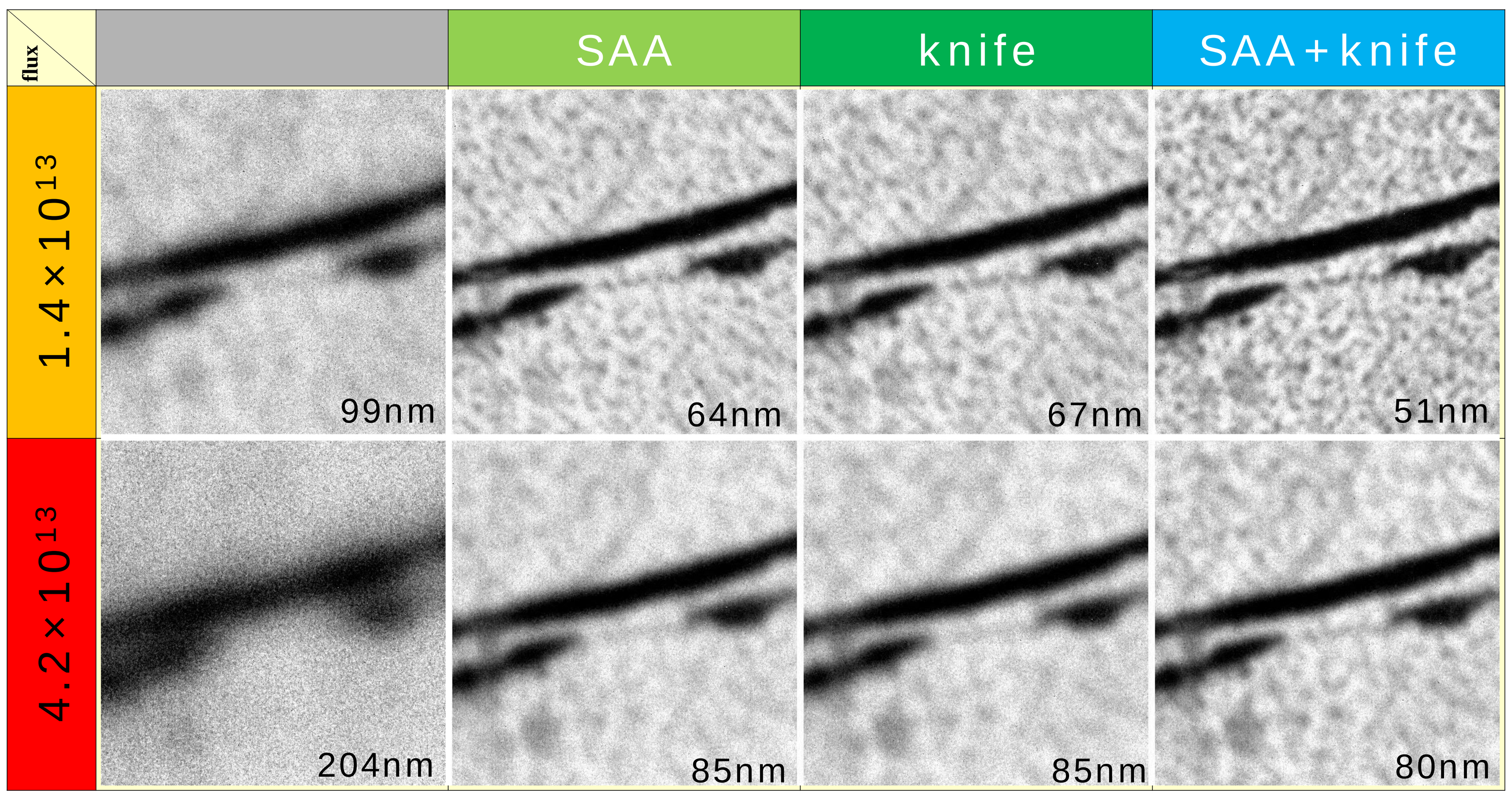




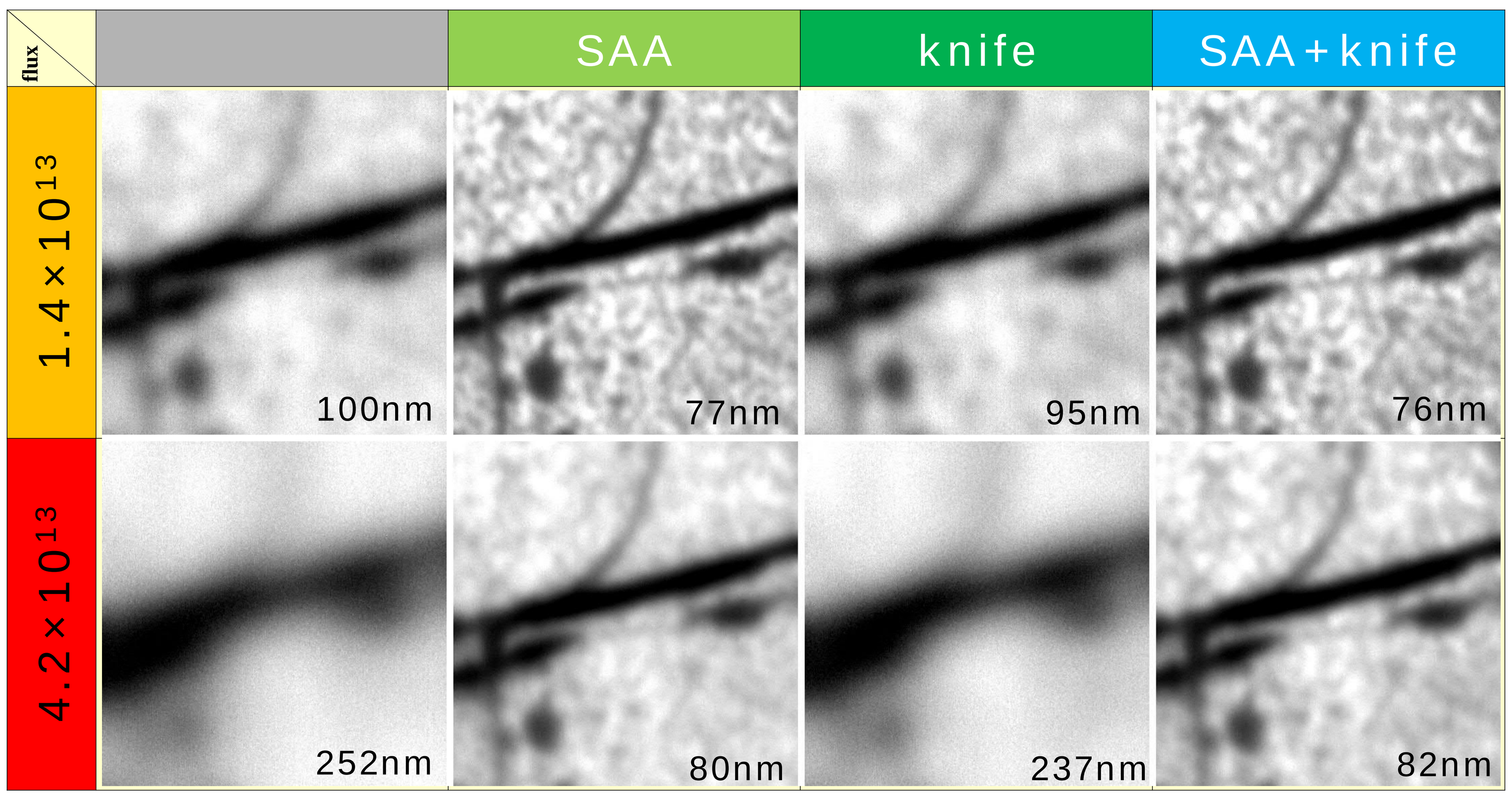


SAA crops the image, the knife doesn't

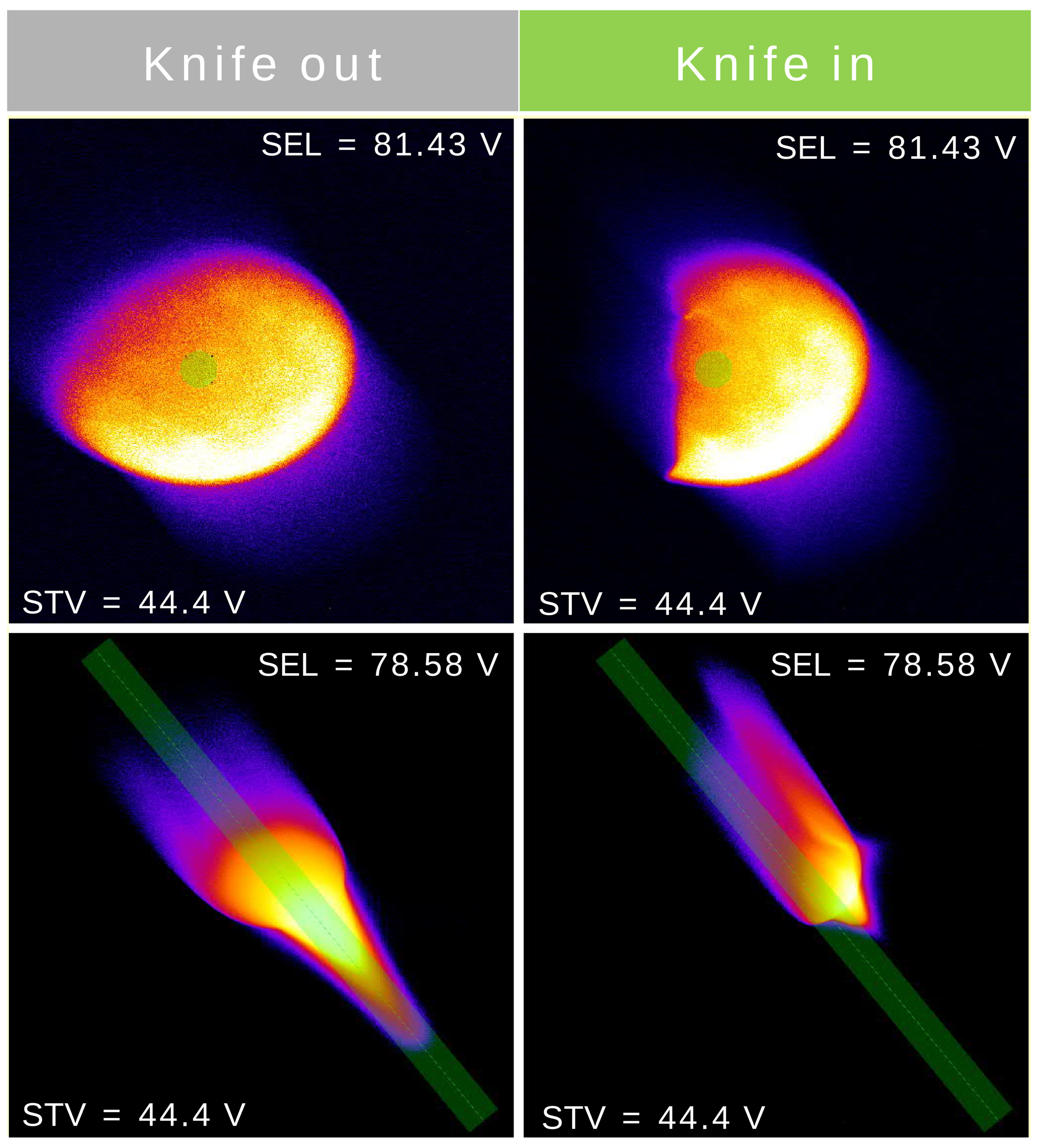
Si2p XPEEM (AC-ON)

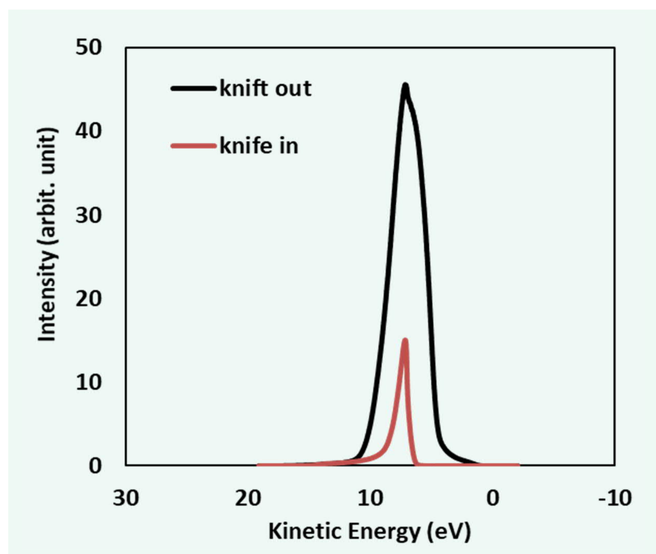


Secondary XPEEM (AC-ON)



Ewald Sphere in Momentum Space





nearly 87% secondary photoelectrons are cut by the knife.

Images were taken in the PED mode with a fixed STV. Secondary photoelectrons are seen by changing SEL in the electron energy analyzer. The green disk indicates the size and position of CA used (70μm) for XPEEM imaging. The width of the profile line is also 70μm. The SAA was 100 μm and no CA and ES were used.

Acknowledgement

We would like to thank Prof. Ernest Bauer for the idea to use the knife aperture in the intermediate column. We also would like to thank Torsten Franz and Florian Schütz from Elmitec GmbH for their technical support as well as Viacheslav Sachenko for his calculation support. This work has been financially supported by the Swedish Research Council.

References

[1] Andrea Locatelli, Tevfik Onur Menteş, Miguel Angel Nin, Ernst Bauer, Ultramicroscopy **111**, 1447 (2011).

[2] Th. Schmidt, A. Sala, H. Marchetto, E. Umbach and H.-J. Freund, Ultramicroscopy **126**, 23 (2013).

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