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Engineering the Contrast Transfer through the C_C/C_S Corrected 20−80 kV SALVE Microscope

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Modern aberration-corrected transmission electron microscopy (AC-TEM) is able to routinely image sample structures with true atomic resolution with a resolution better than 1 Å. Unfortunately, the energy of the electrons used for imaging accelerated with voltages of 200–300 kV damages the samples under observation. Especially, light elements suffer severe damage *via* the knock-on mechanism [1–3]. To avoid this kind of sample damage, imaging at lower acceleration voltages of 60–80 kV became popular recently to undercut the threshold for knock-on damage and thanks to geometrical aberration correction, an image resolution of below 2 Å can be maintained. One interest when performing atomic resolution microscopy of thin and/or light-element materials lies in interfaces and defects and there, the aforementioned damage threshold is significantly lowered calling for even lower imaging electron energies [4,5].

In TEM at acceleration voltages of 30 kV and lower, in addition to the spherical aberration, the chromatic aberration coefficient of the imaging lens limits the resolution. The chromatic aberration can be corrected by using a C_C/C_S corrector [5] or it can be minimized by employing a monochromator for the primary electrons [6].

In this contribution, we discuss the optimum imaging parameters for the contrast transfer through the 20−80 kV C_C/C_S corrected SALVE (sub angstrom low voltage electron microscope) instrument. This includes the influence of a partially adjustable positive fifth order spherical aberration. Positive and negative phase contrast transfer are compared with the help of graphene images taken at different electron acceleration voltages; in the example in Figure 1 imaging has been performed at 30 kV at positive and negative atom contrast; as can be seen from the Fourier transform inserted, frequencies up to $(107\ \mathrm{pm})^{-1}$ have been transferred [7].

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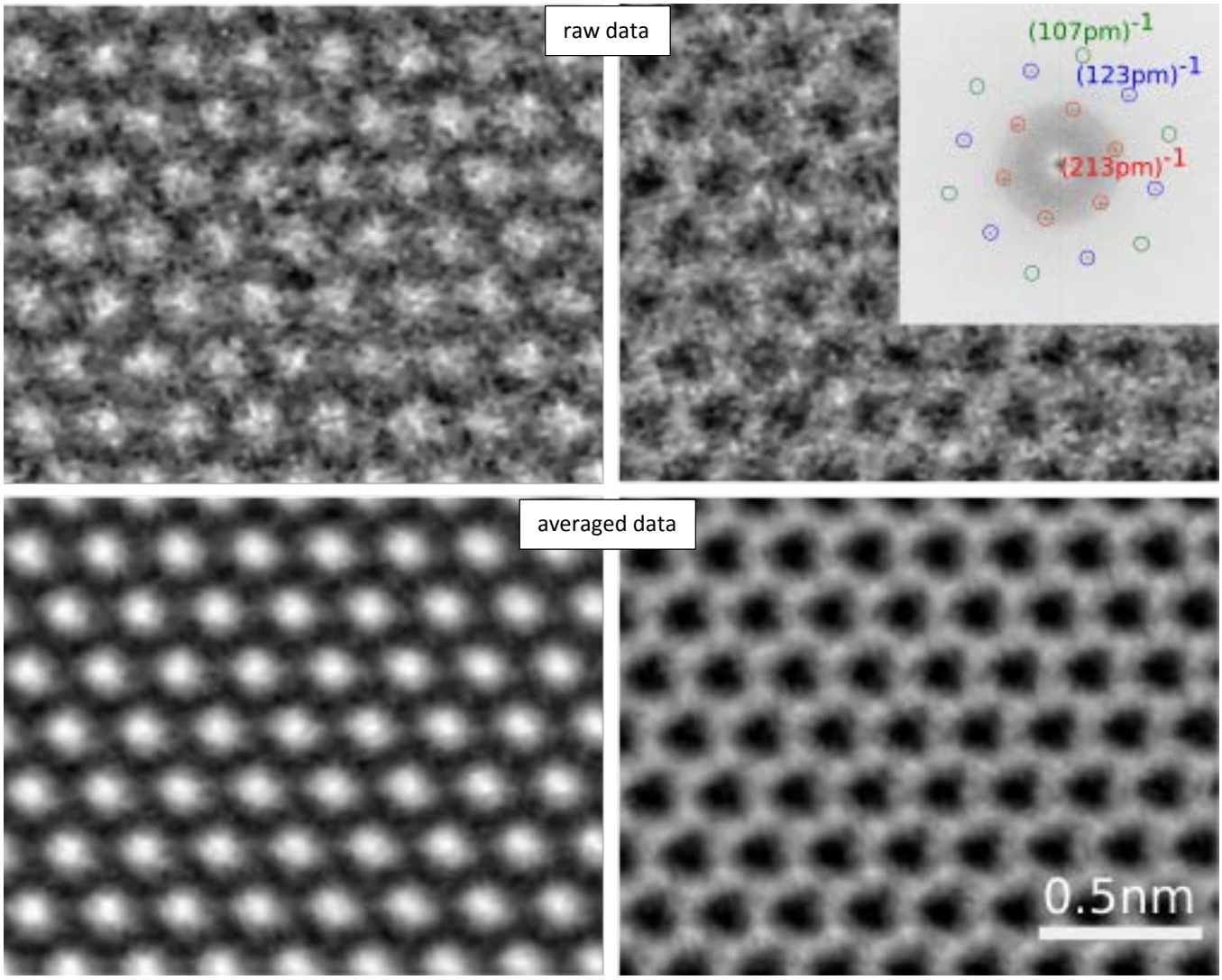

Figure 1. AC-HRTEM images of graphene taken with the C_C/C_S corrected SALVE microscope at 30 kV primary electron energy with positive (*left*) and negative (*right*) phase contrast. *Top row*—sections of raw images, *bottom row*—averaged images (several sections of the same experimental micrograph are overlayed). The inset shows the diffractogram of the micrograph indicating nonlinear frequency transfer up to $(107\ pm)^{-1}$.

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