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Aberration-Corrected STEM: Towards the Ultimate Resolution for Imaging and Analysis

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Aberration-Corrected STEM: Towards the Ultimate Resolution for Imaging and Analysis

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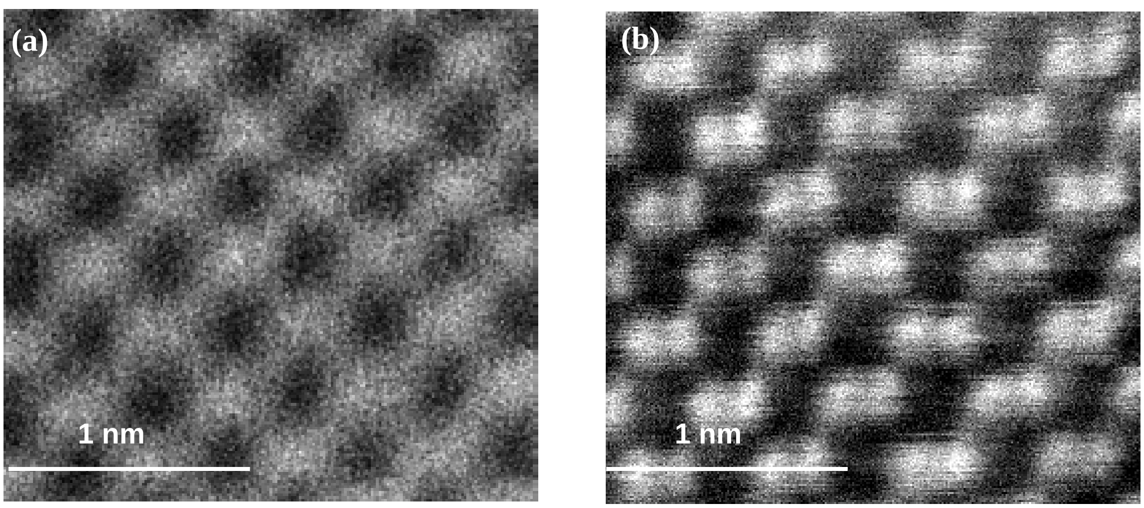
With probe sizes of 0.5 Å predicted after correction of aberrations, microscopy of zone axis crystals is poised to reach its quantum mechanical limit. For thickness greater than the kinematical limit, interpretable resolution will be limited by the size of the smallest Bloch states, the 1s states, which are typically 0.5 – 0.8 Å in diameter. In phase contrast microscopy, imaging with 1s Bloch states can be achieved by selecting a sample thickness in which the contribution of the 1s state to the exit face wave function is maximized. However, this thickness is dependent on composition and at greater thickness the contrast reverses. In Z-contrast imaging the detector selects 1s states. As the probe size is reduced, eventually, the Z-contrast image will become a direct image of the 1s Bloch states. Similarly with core loss EELS, provided the acceptance angle is large, delocalization is negligible. For single atoms the ultimate resolution becomes the geometric size of the core electron orbital, but in a zone axis crystal the ultimate resolution is again the 1s Bloch state. The aberration corrector installed on the 100 kV STEM at Oak Ridge has improved its resolution to 1.36Å, giving images comparable to those obtained with the uncorrected 300 kV STEM.



Z-contrast images of silicon "dumbbells" taken in a 100 kV VG STEM (a) before and (b) after the correction of spherical aberration.