Maximising the resolving power of the scanning tunneling microscope

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The usual way to present images from a scanning tunneling microscope (STM) is to take multiple images of the same area, to then manually select the one that appears to be of the highest quality, and then to discard the other almost identical images. This is in contrast to most other disciplines where the signal to noise ratio (SNR) of a data set is improved by taking repeated measurements and averaging them. Data averaging can be routinely performed for 1D spectra, where their alignment is straightforward. However, for serial-acquired 2D STM images the nature and variety of image distortions can severely complicate accurate registration. Here, we demonstrate how a significant improvement in the resolving power of the STM can be achieved through automated distortion correction and multi-frame averaging (MFA) and we demonstrate the broad utility of this approach with three examples. First, we show a sixfold enhancement of the SNR of the Si(111)-(7×7) reconstruction. Next, we demonstrate that images with sub-picometre height precision can be routinely obtained and show this for a monolayer of Ti_2O_3 on Au(111). Last, we demonstrate the automated classification of the two chiral variants of the surface unit cells of the (4 × 4) reconstructed $SrTiO_3$(111) surface. Our new approach to STM imaging will allow a wealth of structural and electronic information from surfaces to be extracted that was previously buried in noise.

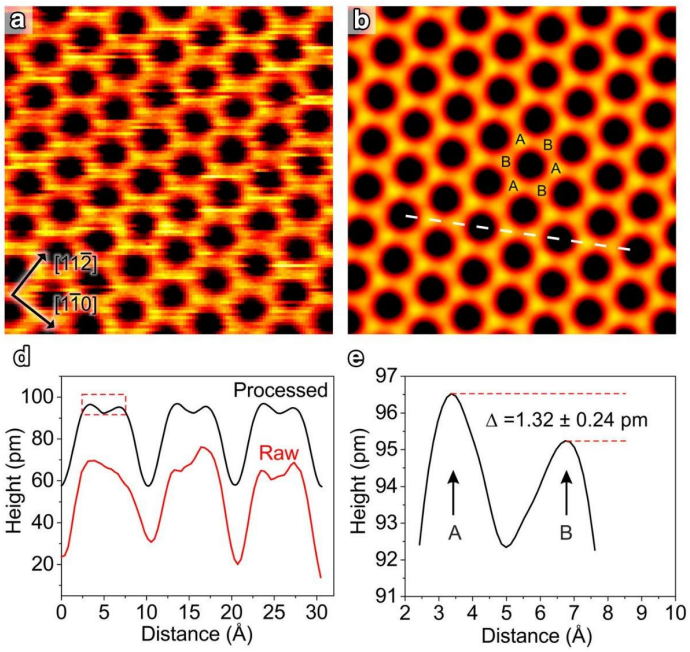

Figure: STM images and histogram showing better than one-quarter pico-metre resolution.

References:
[1] L. Jones, S. Wang, X. Hu, S. U. Rahman and M. R. Castell, Adv. Struct. Chem. Imaging **4**:7 (2018).