Supplementary Information for

Direct Probe of Interplay between Local Structure and Superconductivity in $FeTe_{0.55}Se_{0.45}$

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Supplementary Information

S1. Large Scale Image for the Distortion Boundary of Fe(Se, Te).

On the $FeTe_{0.55}Se_{0.45}$ surface, we observed the defect that typically has a width of 2-4 nm and a length of more than 100nm that extends beyond the area shown in the large scale image (Figure S1). The large scale image reveals both overall feature and local details around the long defect. At two sides of the defect, there are pristine surface areas, showing a square lattice formed by adjacent apical chalcogen atoms on the surface. Interestingly, the long defect is atomically

defined. Therefore the distortion on the defect is clearly visible down to a single unit cell level. The atomically defined long defect allows us to explore interplay between structure and superconductivity at a very local scale (down to atomic scale).

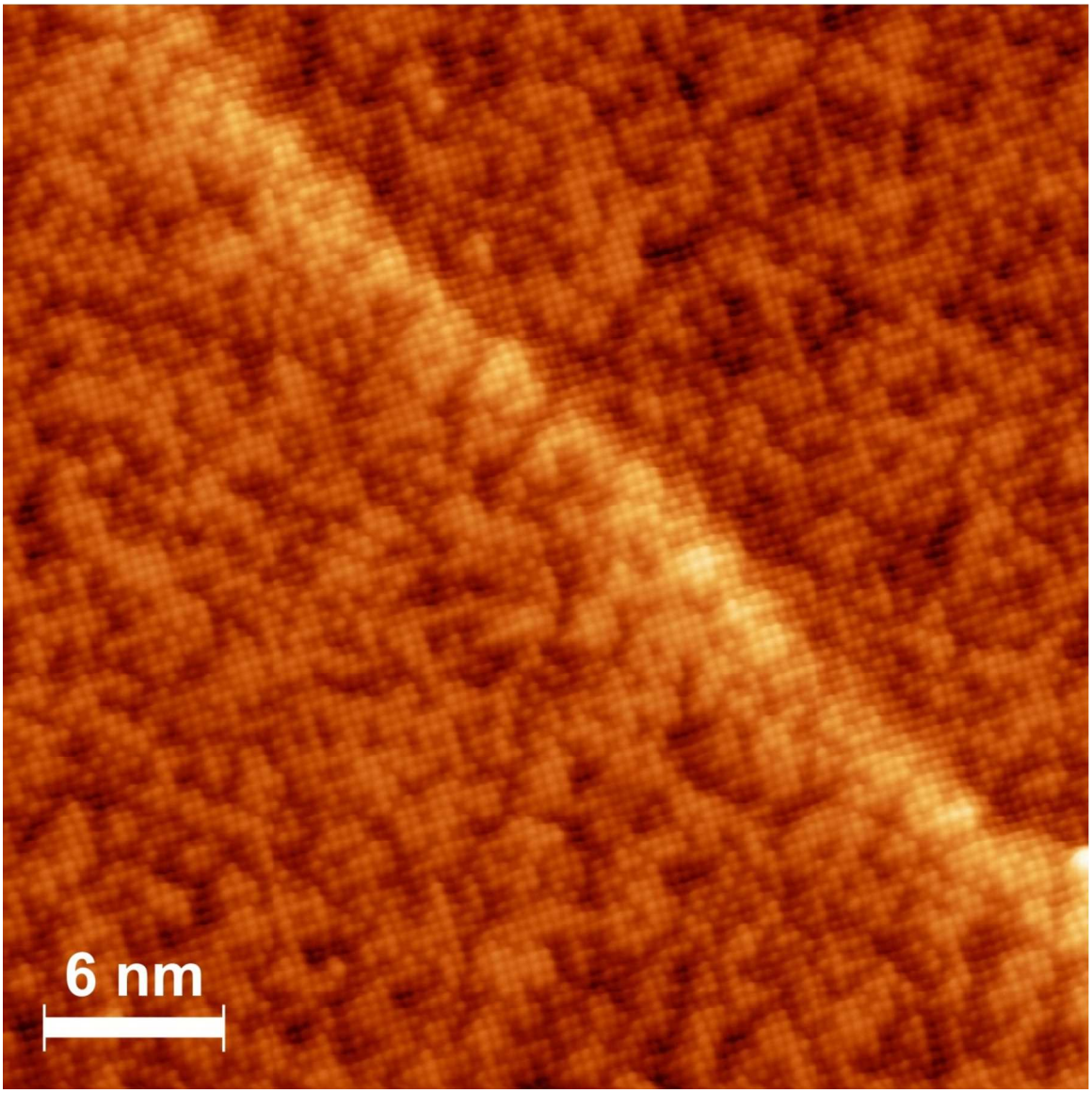

Figure S1. Large scale image of distortion boundary of Fe(Se, Te). Large scale atomically resolved topographic image at the distortion boundary; image was taken at the bias of -50 mV with 100 pA current. Scan size is 36 nm x 36 nm.

S2. Line Profiles Across Distortion Boundary of Fe(Se, Te) at Different Setup Conditions.

In addition to Figure 3**a**, the supplementary Figure S2 **a** and **b** show the height profiles for the boundary at different setup conditions. All these demonstrate that the height of surface chalcogen atoms at the boundary region is about 1.0 Å higher than the average surface plane.

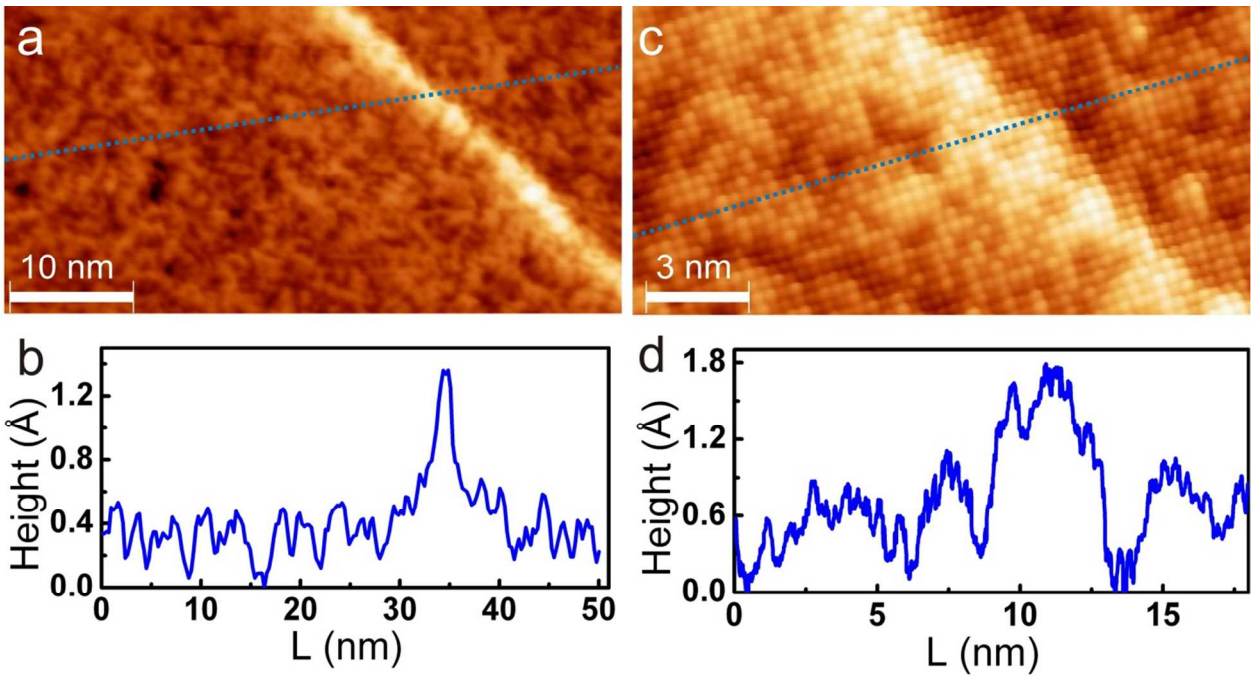

Figure S2. Line profiles across distortion boundary of Fe(Se, Te) at different setup Conditions. (a) topographic image at the distortion boundary taken at the bias of -200 mV with 100 pA tunneling current. (b) line profile over the line shown in **a**. (c) topographic image at the distortion boundary taken at the bias of -50 mV with 100 pA tunneling current. (d) line profile over the line shown in **c**.