Supplemental information for article:

Surface Morphology of Au-Free Grown Nanowires After Native Oxide Removal

*Martin Hjort[1], Johan Knutsson[1], Bernhard Mandl[2], Knut Deppert[1], Edvin Lundgren[1], Rainer Timm[1], and Anders Mikkelsen[1]**

[1]*Department of Physics and the Nanometer Structure Consortium, Lund University, P.O. Box 118, 22 100 Lund, Sweden*
[2] *Institut für Halbleiter- und Festkörperphysik, Johannes Kepler Universität Linz, Altenbergerstrasse 69, 4040 Linz, Austria*
*e-mail: anders.mikkelsen@sljus.lu.se

Tip asymmetry

During imaging, a sudden change in the tip within a single scan line could change the appearance from a zigzag pattern to a square pattern, see Figure S1.

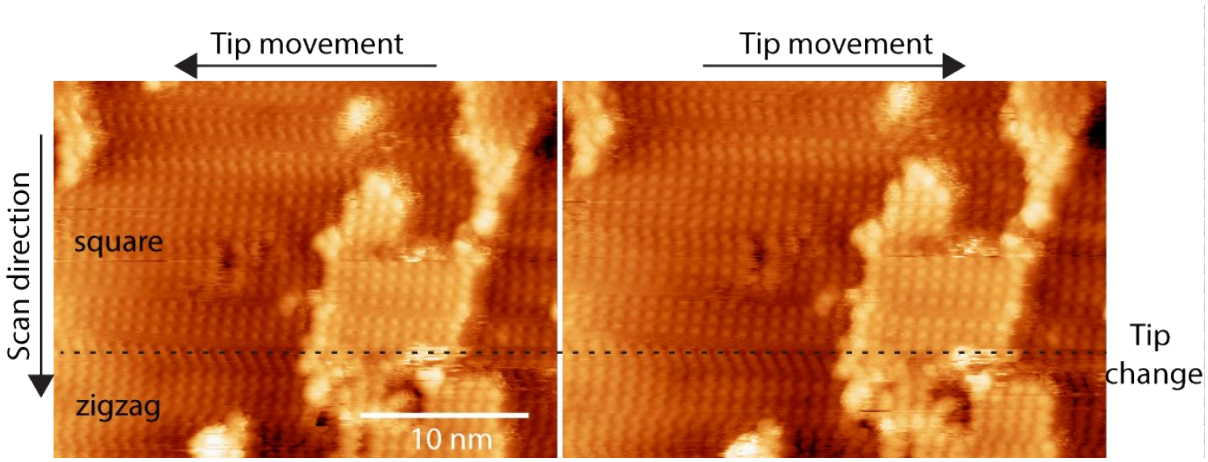

Figure S1. STM images showing the instantaneous change in appearance between the zigzag and square patterns. The approximate place for the tip change is marked by the dashed black line. $V_t = -1.8\ V$, $I_t = 80\ pA$

The observed change occurred frequently, and is surprising since the surface is expected to be symmetric. No correlation to sample bias, tunneling current, or scan speed was observed. Instead, we conclude that the observed difference was related to a change in the tip. Dramatic changes in STM images as a function of tip configuration is a well-known phenomenon, which has been scrutinized in quite some detail up to this day[1, 2]. It was for example shown that the presence of an adsorbate atom close to the apex of the tip will strongly influence even the qualitative appearance of the resulting STM images[1]. It can further be noted that the presence of such an adsorbate that moves to and from the tip apex is consistent with the sudden and recurring switching observed between the two image appearances.

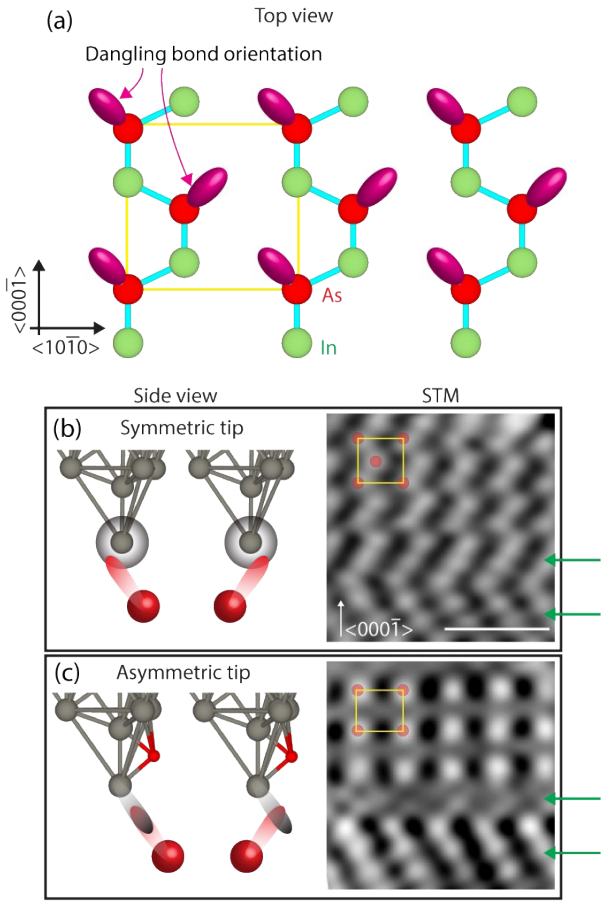

Figure S2. Tip symmetry and its effect on the observed STM images. (a) Top view schematic representation of an unreconstructed {11−20} surface with As-dangling bond (DB) directions marked by the pink ellipses. (b) A tip (gray) with symmetric, s-like, orbital at the apex gives equal orbital overlap for both DB orientations. The corresponding STM image shows equal intensity for all atoms, resulting in a zigzag-pattern, $V_t = -1.8$ V, $I_t = 80$ pA. (c) A tip with an adsorbate induced asymmetric orbital at the apex gives unequal orbital overlap for the DB orientations. The corresponding STM image shows strong corrugation for every second atom and a square-pattern, $V_t = -1.7$ V, $I_t = 80$ pA. The STM images of (b) and (c) were obtained subsequently at the same place. Scale bar denote 2 nm. Green arrows in (b,c) mark the positions of two small Zb segments separated by a twin defect.

Comparing the two patterns, see Figure S2, it is seen that the unit cell of the square pattern has the same size as the face-centered unit cell of the zigzag pattern. Explaining the square pattern, the As-dangling bonds (DBs) as seen from above are presented in Figure S2(a). From the symmetry of the surface, all As-DBs are expected to be similar, but oriented differently (assuming tetragonal bonding of the As-atoms). In Figure S2(b), the interactions between As-DBs and a symmetric or asymmetric W-tip are shown. With a symmetric tip, the orbital overlap between tip and As-atoms are the same for both As-DB orientations. For an asymmetric tip (illustrated by the presence of an adsorbate), the orbital overlap is different for the two orientations. A larger orbital overlap gives a larger tunneling signal[3], and therefore appears brighter in the images. Importantly, the observed sensitivity to the tip-symmetry is not observed at (defect free) InAs(110) surfaces since all As-DBs are oriented in the same direction at that surface. In the bottom part of the STM images in Figure S2, local Zb stacking with a twin defect can be observed and it is apparent that one domain is better resolved than the other with the asymmetric tip. This is related to the same DB orientation argument as was used for the Wz segments. These measurements also clearly demonstrate the presence of the tilted dangling bond on the surface as it is difficult to otherwise reconcile the changing appearance of the images. Further it can be noted that this phenomenon also can act as an interesting way to investigate the influence of adsorbates on the tip.

References

[1] Mönig, H.;Todorović, M.;Baykara, M. Z.;Schwendemann, T. C.;Rodrigo, L.;Altman, E. I.;Pérez, R.; Schwarz, U. D. Understanding Scanning Tunneling Microscopy Contrast Mechanisms on Metal Oxides: A Case Study. *Acs Nano* **2013**, *7*, 10233-10244.

[2] Hofer, W. A.;Foster, A. S.; Shluger, A. L. Theories of scanning probe microscopes at the atomic scale. *Rev Mod Phys* **2003**, *75*, 1287-1331.

[3] Chen, C. J. Microscopic View of Scanning Tunneling Microscopy. *J Vac Sci Technol A* **1991**, *9*, 44-50.