Reconstruction of an InAs nanowire using geometric tomography

RS Pennington[1,*], S König[2], A Alpers[2], CB Boothroyd[1], and RE Dunin-Borkowski[1,3]
1: Center for Electron Nanoscopy, Technical University of Denmark, DK-2800 Kongens Lyngby, Denmark
2: Zentrum Mathematik, Technische Universität München, Boltzmannstr. 3, D-85747 Garching bei München, Germany
3: Currently at Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany
*: rp@cen.dtu.dk

Introduction

Conventional algebraic tomographic reconstruction algorithms (e.g. ART / SIRT) in electron microscopy are useful for determining three-dimensional object morphologies. However, if the aim of tomographic reconstruction is to only determine the outline of the object for e.g. thickness measurements, ART or SIRT would require segmentation or post-reconstruction thresholding, which can be highly subjective and potentially misinterpretable. then *geometric tomography (GT)* may yield the required information for a convex object.[1,2]

Here, we present a dedicated geometric tomography algorithm [3], apply it to both simulated data and experimental data, and compare with a standard SIRT reconstruction [4].

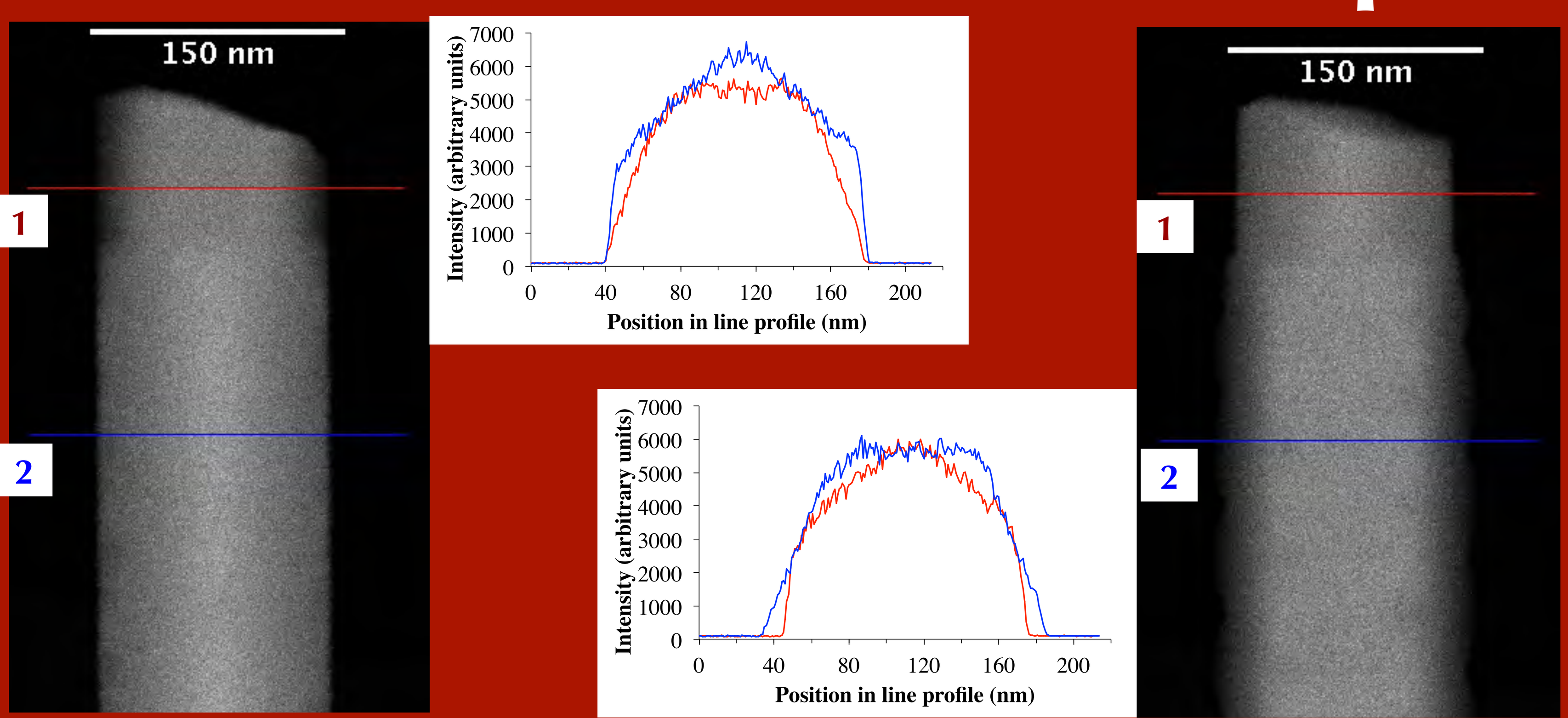
What is Geometric Tomography?

- Reconstructs only the binary shape of the object
- Our algorithm [3]:
  - Disregards internal intensity changes (e.g. from diffraction contrast or changes in mass-thickness)
  - But object must be convex.
  - Uses binarized input data: shadow outline of specimen

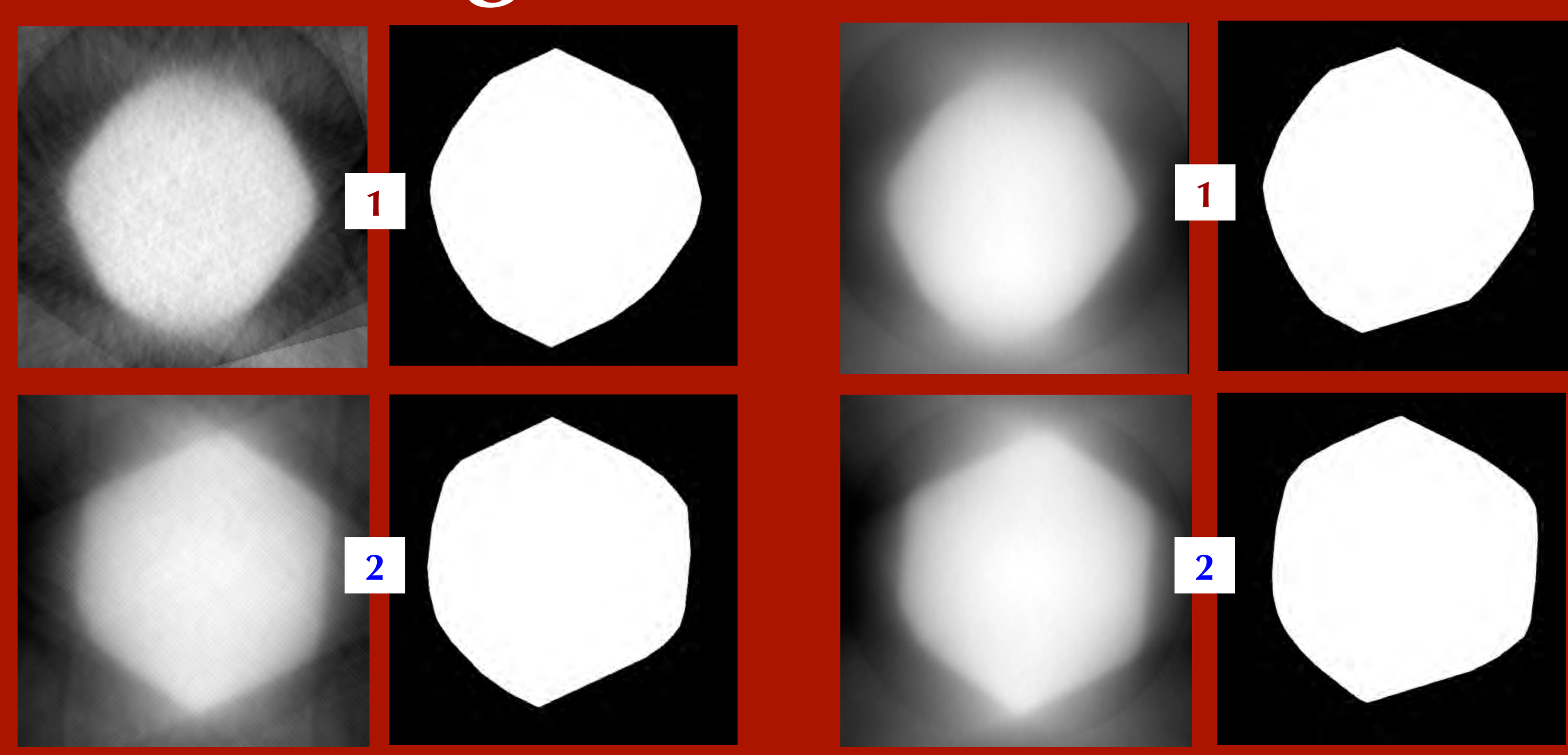
How it works:

1. Threshold images to allow for shadow outline determination
2. Input is binarized tilt series of a convex object
3. Fit polygon to outlines for each image in the tilt series
4. Output is a binarized polygon
5. Previous literature approach[5] has not used proved algorithm.

Reconstruction from experimental images of InAs wires



HAADF images from tilt series at 7° (left) and 37° (right). GT threshold at 300 counts



139°, 14 images; SIRT (L) vs. GT (R)

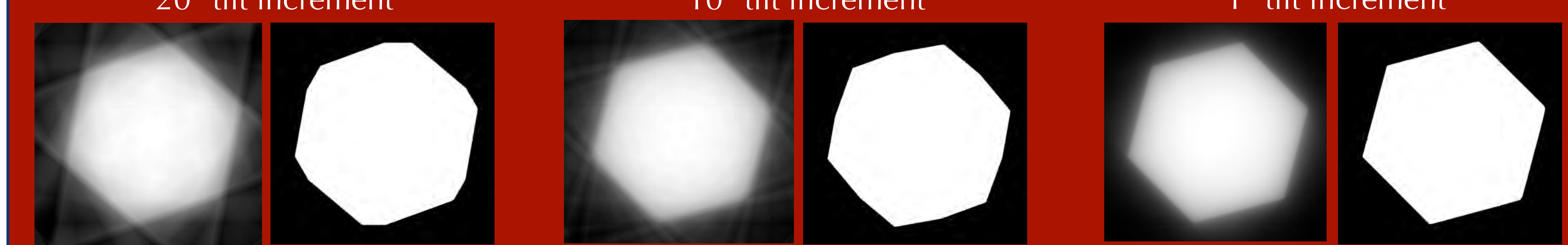
139°, 140 images; SIRT (L) vs. GT (R)

Conventional Tomography vs. Geometric Tomography

A simulated hexagon is used to determine what artifacts look like in both techniques.

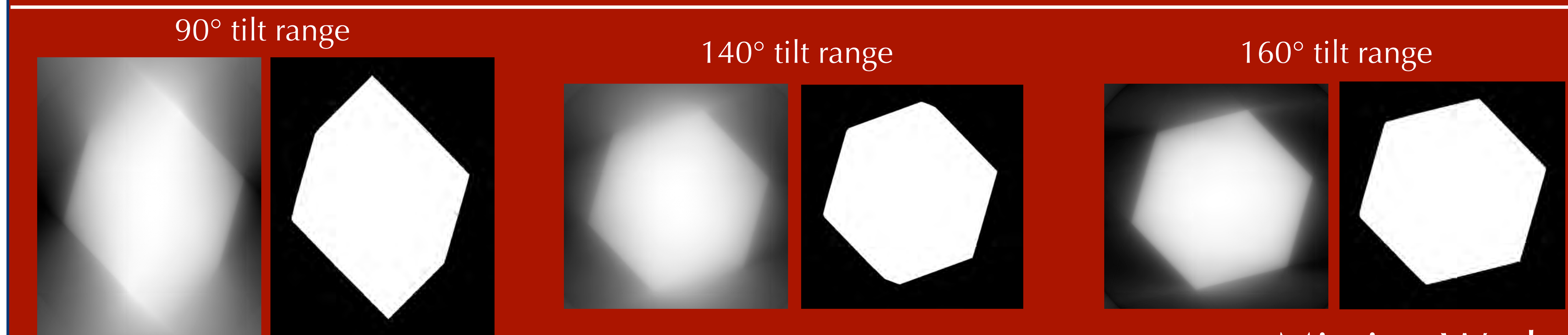
Input was a hexagon with 10 counts per pixel, 1° tilt increment, full 180° angular sampling, and no noise. Parameters were varied one at a time. All reconstruction pairs have SIRT (15 iterations) on left, GT on right.

20° tilt increment | 10° tilt increment | 1° tilt increment



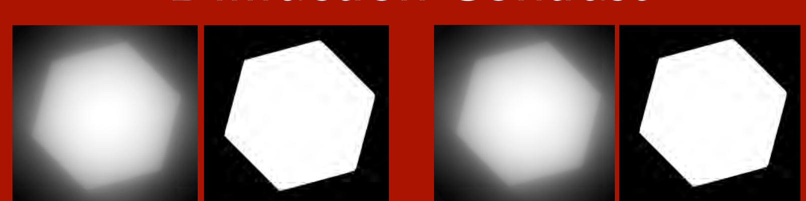
Tilt Angle Spacing

90° tilt range | 140° tilt range | 160° tilt range



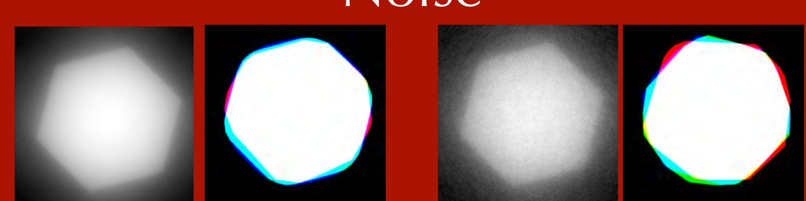
Missing Wedge

Diffraction Contrast



25% (left) or 75% (right) chance of ≤50% intensity multiplier

Noise



Noise at 100 (left) or 800 (right) counts (± 10(L) 80(R) px)

Conclusions

- Geometric tomography (GT) is potentially useful for reconstructing the outlines of objects
- GT works on experimental HAADF STEM data
- GT much faster to reconstruct (~2s vs. ~30s per slice)
- Comparing GT to SIRT on experimental data:
  - **If** missing wedge region is known, GT and SIRT artifacts are similar.
  - Both work well outside of missing wedge, but GT vulnerable to HAADF noise.
- Comparing GT to SIRT on simulated data:
  - GT is **less** robust against noise when thresholding
  - GT missing wedge area needs to be known for interpretation
  - GT is completely invariant to diffraction contrast.

Future Work

- More sophisticated input data thresholding
- BF/DF TEM instead of HAADF STEM – using clear edges
- Missing wedge mitigation
- Intensity data instead of only shadow outline data

DTU Cen
Center for Electron Nanoscopy
DTU

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[5]: Saghi Z, Xu X and Möbus G 2008 *Journal of Microscopy* **232** 186-195