Transmission Electron Microscopy Study of Defects at the Interface between GaAs Nanowires and a Si(111) Substrate

V.T. Fauske[1,3], A.M. Munshi[2], D.L. Dheeraj[2], D.C. Kim[2], B.O. Fimland[2], H. Weman[2], and A.T.J. van Helvoort[1]

[1] *Department of Physics, NTNU*

[2] *Department of Electronics and Telecommunications, NTNU*

[3] *NTNU NanoLab*

Outline

- Motivation
- Introduction
  - Nanowire growth
  - Nanowire crystal structure
- Results
  - Stacking faults and phase transitions
  - Effects of growth conditions
- Conclusions

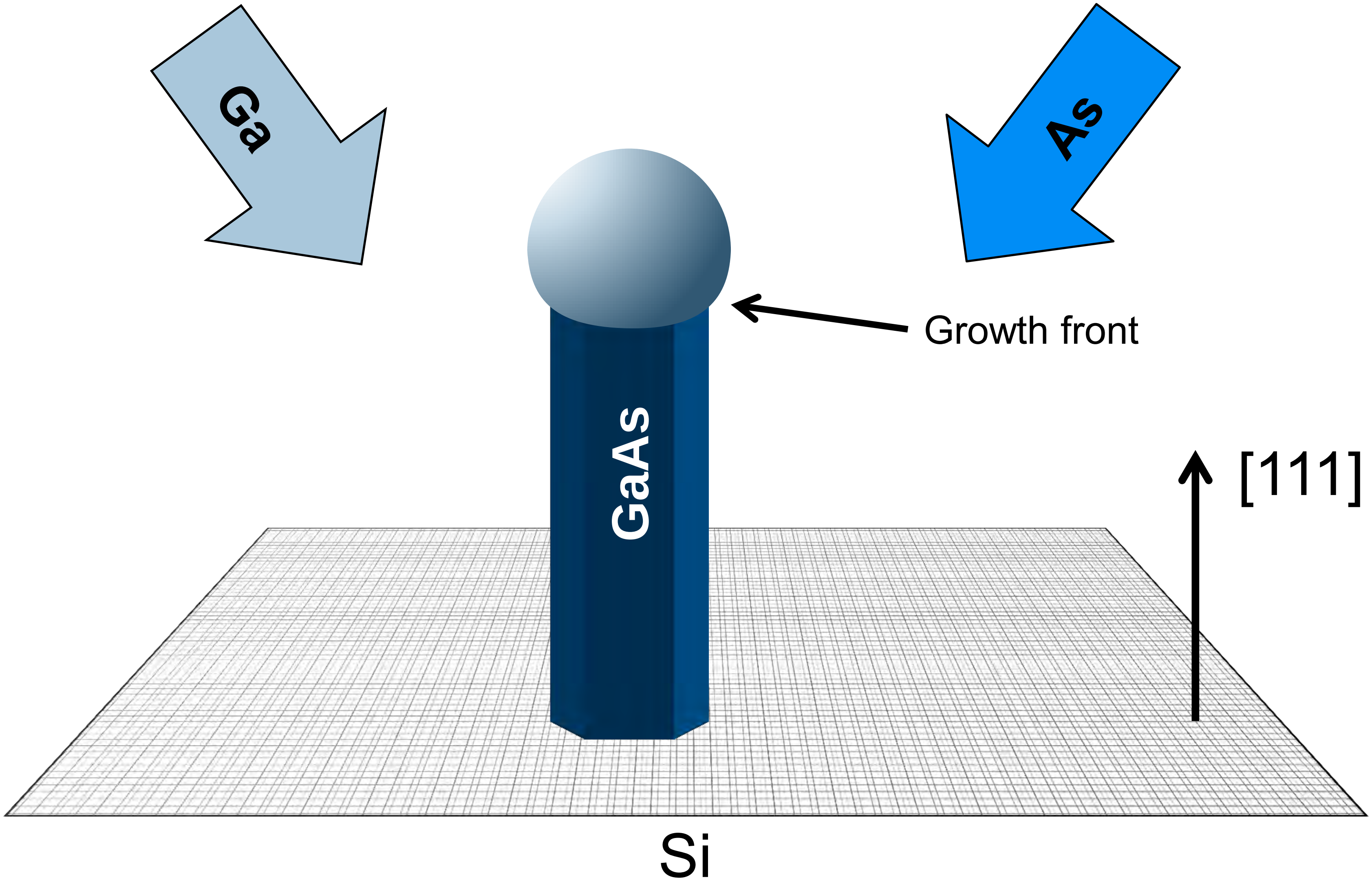
Motivation

- **Long term motivation (goal of NTNU nanowire group):** Controlled growth of nanowires for opto-electronic applications.

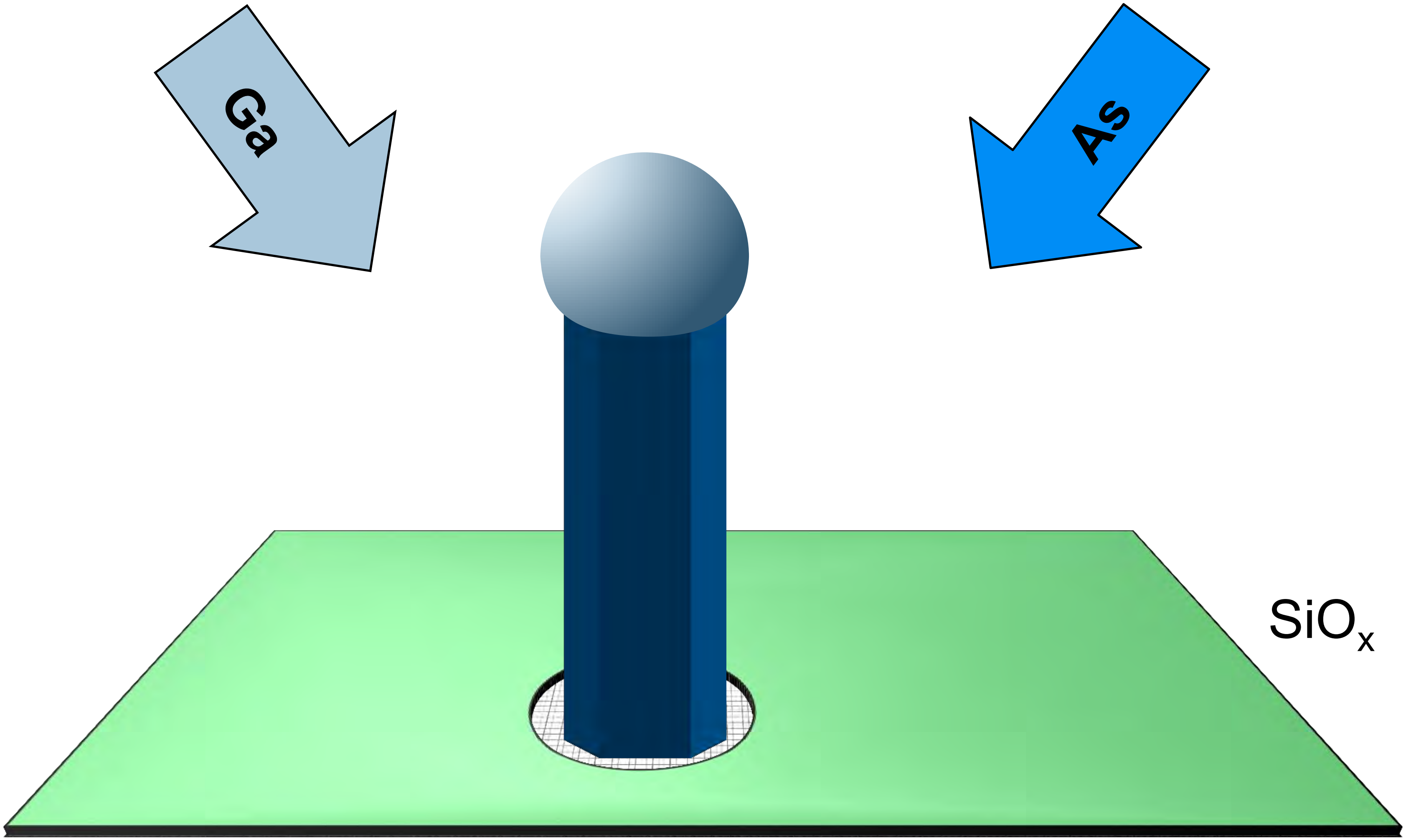
- **Interface study:** Determine the presence of any features which could affect growth or performance (strain, defects, dislocations).

- **TEM:** Need high resolution imaging of crystal structure. TEM sample prepared by Focused Ion Beam (FIB): Maximum control, site specific, thin slices.

Introduction: Nanowire synthesis



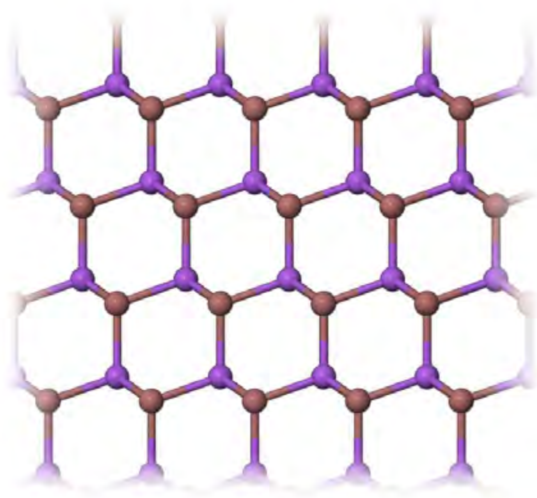
Introduction: Nanowire synthesis



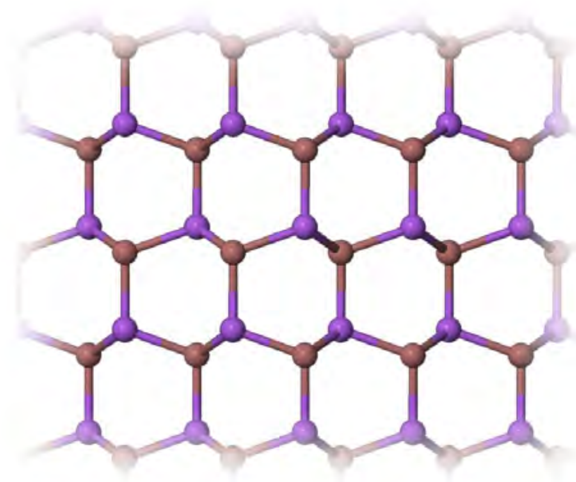
Electron-beam lithography

Introduction: GaAs Crystal Structures

Two crystal structures are observed for
GaAs nanowires



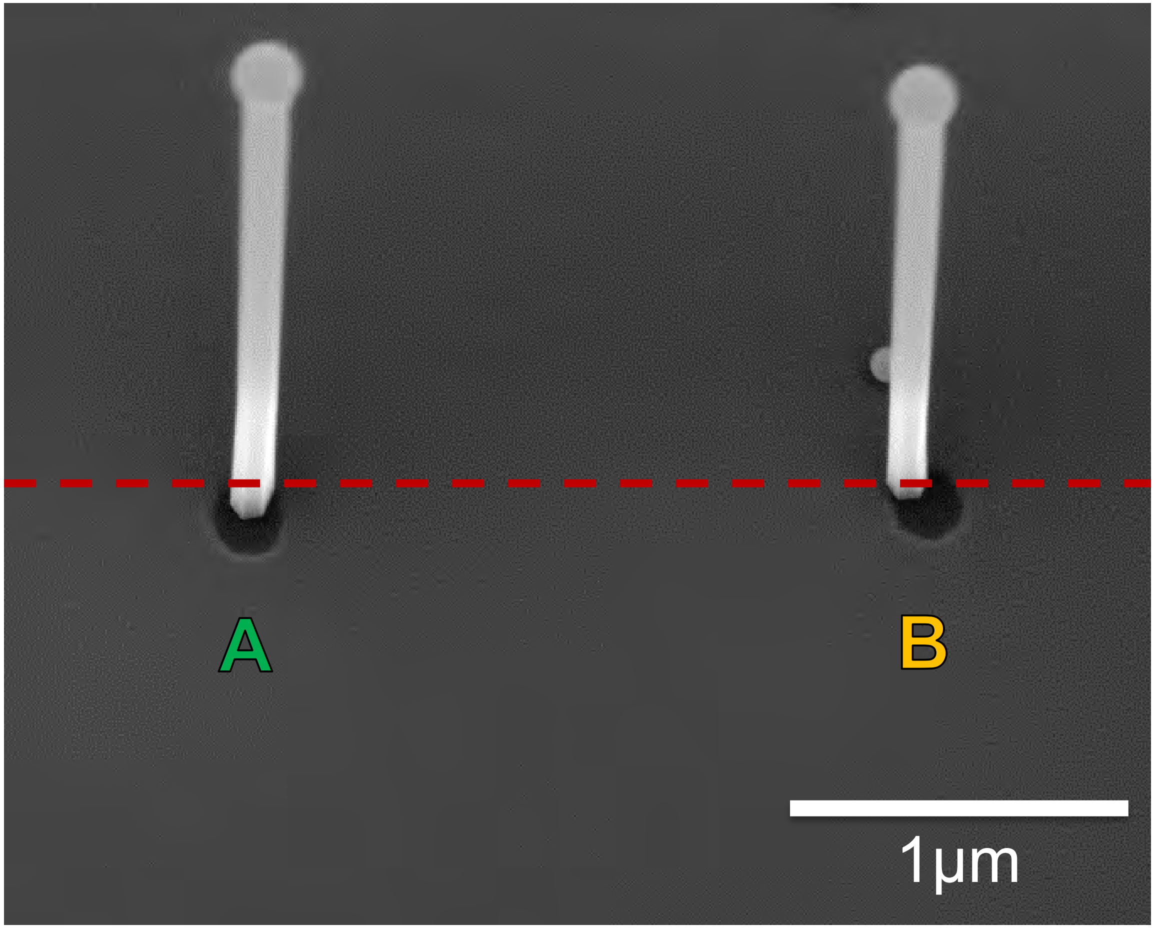
Growth
direction



Zinc blende (ZB)
Bulk phase

Wurtzite (WZ)

Results: FIB-SEM

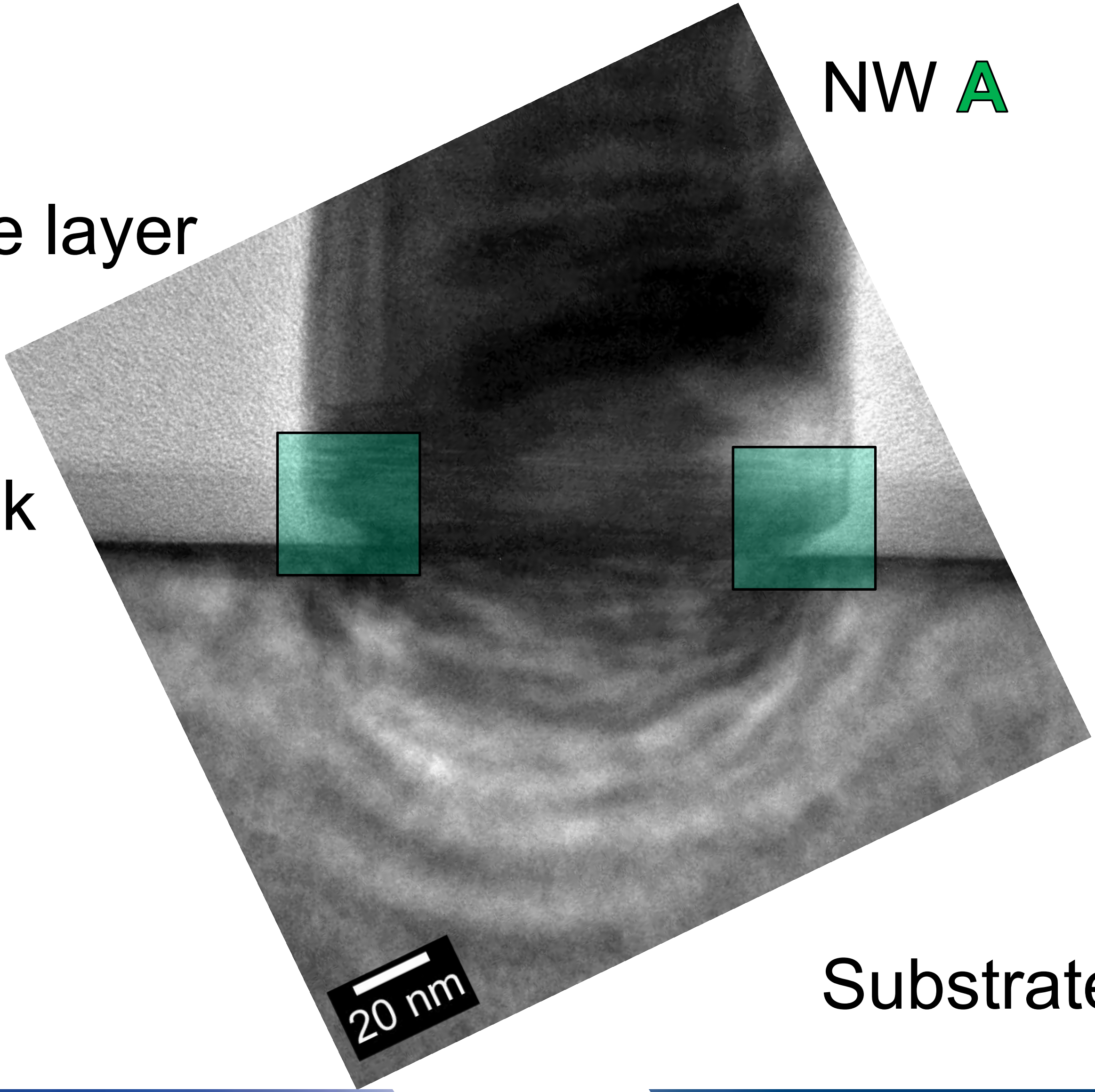


NW A: Interface overview

NW A

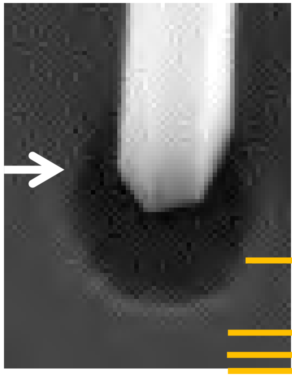
Protective layer

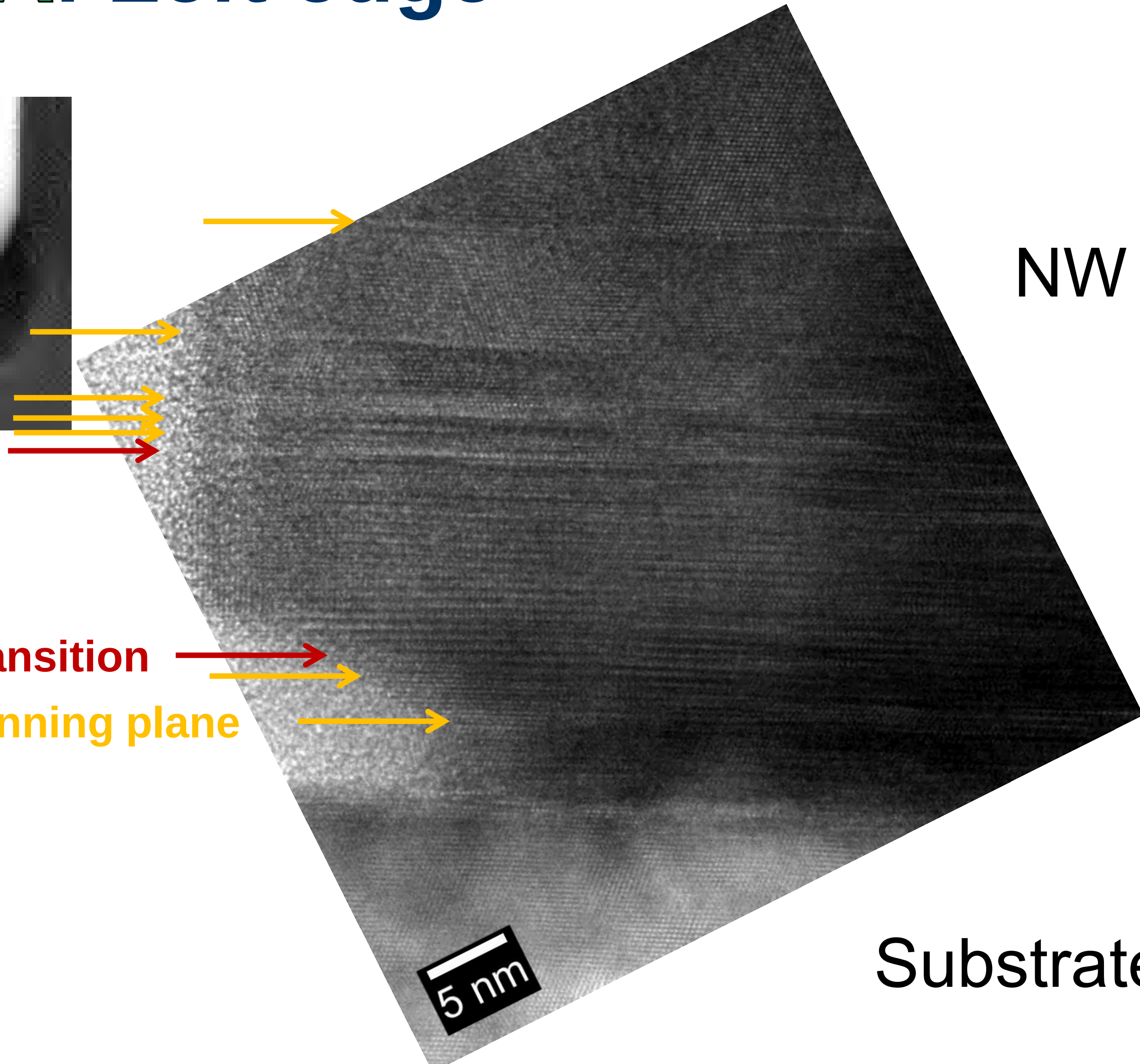
SiO_x mask



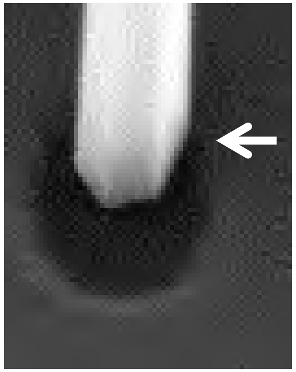
Substrate

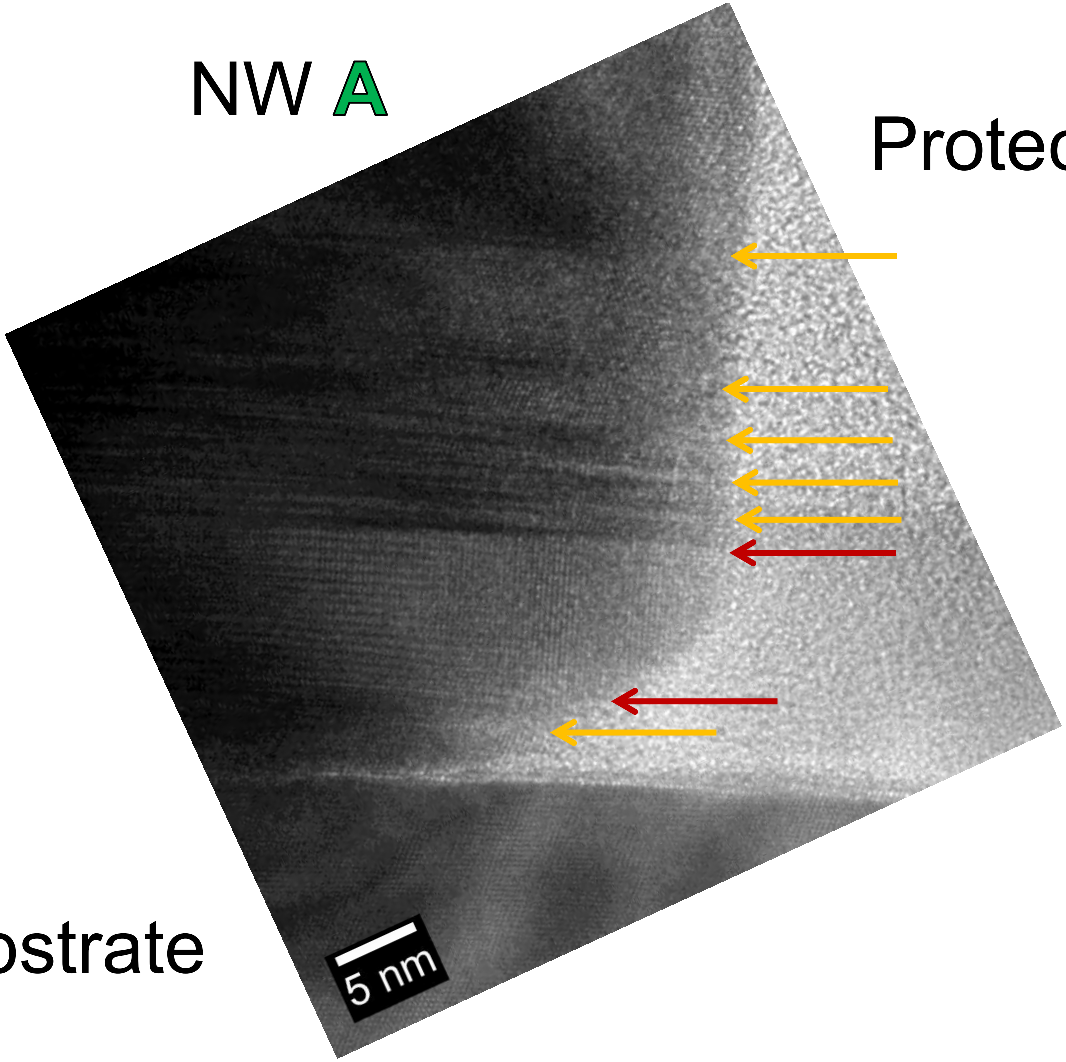
NW A: Left edge



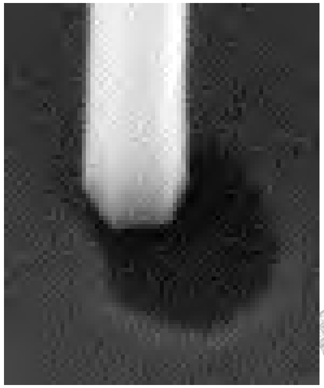


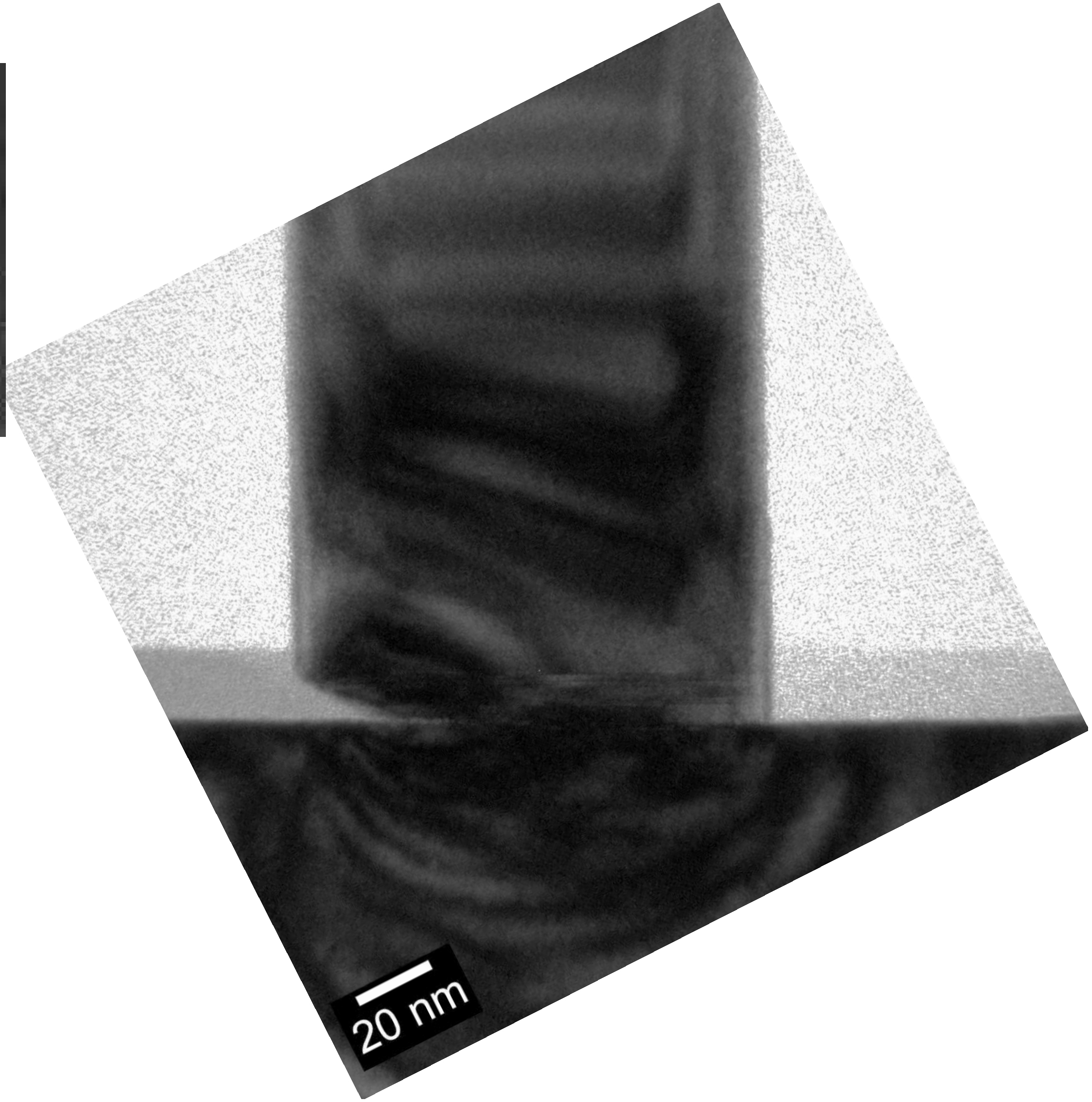
NW A: Right edge





NW B: Interface overview





Why do the defects appear?

- Defects formed during the start of GaAs growth
  - Self-catalyzed growth: Droplet size not yet stable
  - Arsenic diffusion: III/V ratio at growth front changing

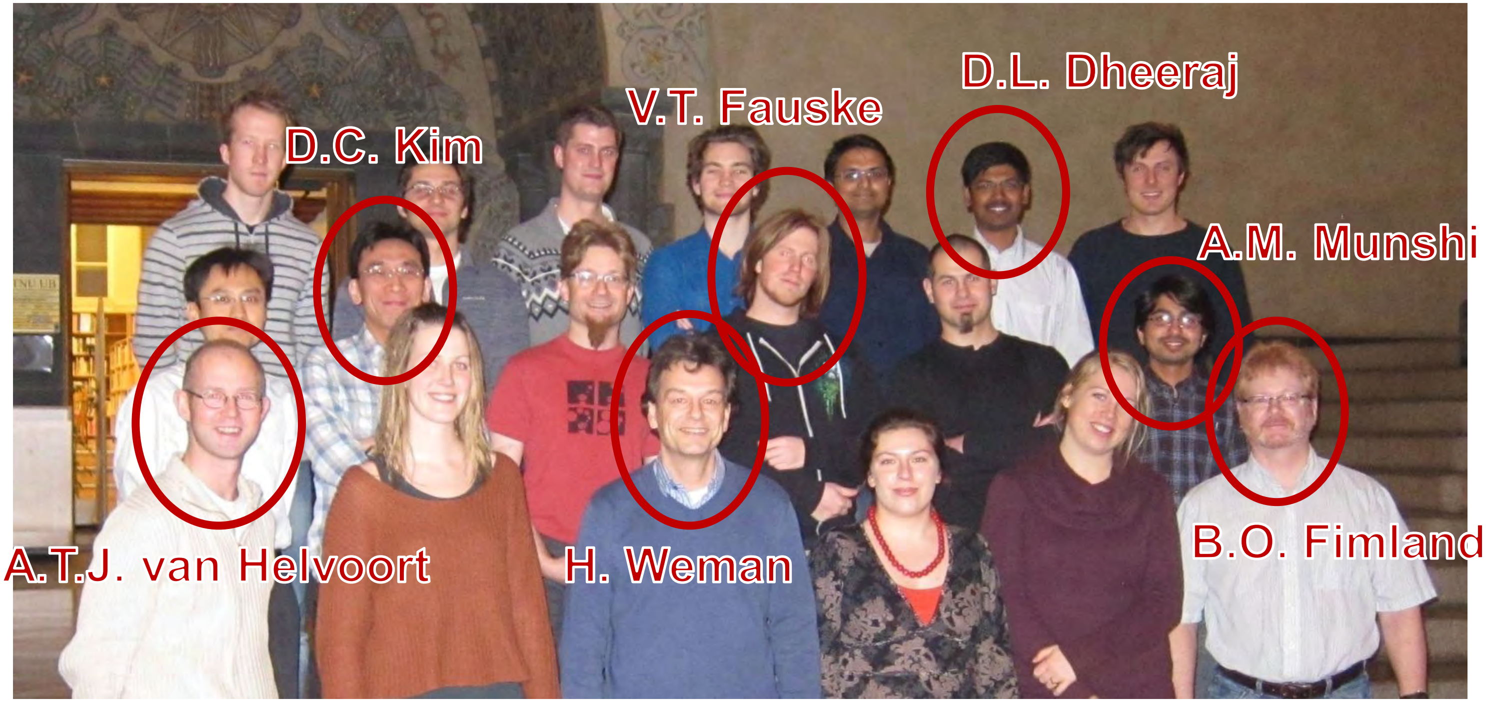
- Near interface: Lattice mismatch

- Droplet contacting mask edges
  - GaAs can grow on SiO_x, but Ga does not wet

Conclusions

- The interface of self-catalyzed GaAs NWs grown epitaxially on Si-111 substrates has been studied by TEM.
- NW structure near interface:
  - Zinc-blende twinning planes
  - Small regions (up to 10 nm) with wurtzite
- The actual contact area of the NW can be significantly smaller than the diameter of the NW body, which is determined by the droplet equilibrium size during growth.
  - Non-equilibrium conditions at start of growth

Thanks for listening!



This work was supported by NTNU NanoLab, and the RENERGI program of the Research Council of Norway under Grant No. 190871.