X-ray Coherent Scattering on GaP/Si for III-V Monolithic Integration on Silicon

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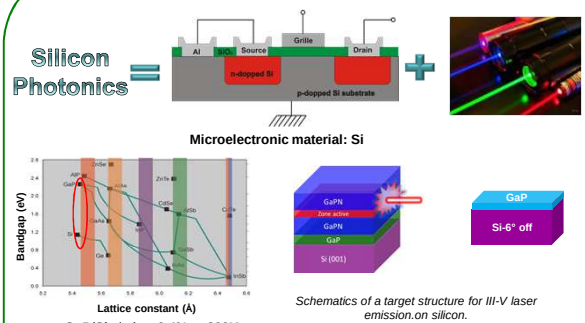
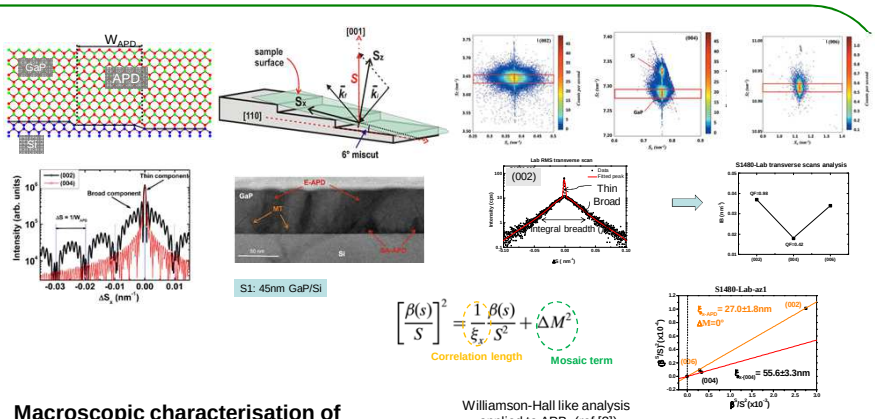
Motivation: Imaging of APB and other crystalline defects in GaP/Si nanolayers in the framework of III-V monolithic integration for photonics and PV on Si

Introduction



GaP as template for III-V/Si monolithic integration

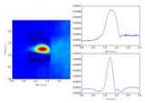


Macroscopic characterisation of antiphase boundaries

Williamson-Hall like analysis applied to APB (ref [3])

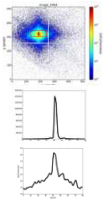
Coherent diffraction

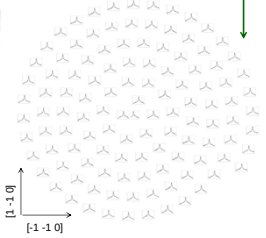
250nm (V) x 500nm (H) coherent beam



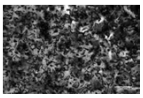
(002) Spiral scans 100nm step

S1: 45nm GaP/Si





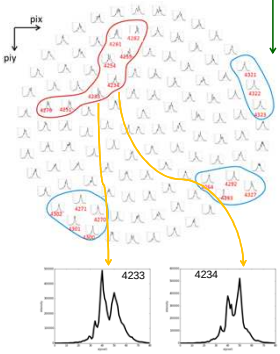
- Too high APB density / beam size
- Quite uniform XRS
- No ptychography convergence

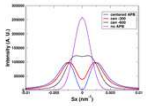


(002) DF-TEM plan view of a similar sample

S2: 218nm GaP/Si

- Lower APB denisty
- Large contrast
- But no ptychography convergence
- Still too high defect density (APB&strain)





Simulation of a single APB lateral scan ~75nm step

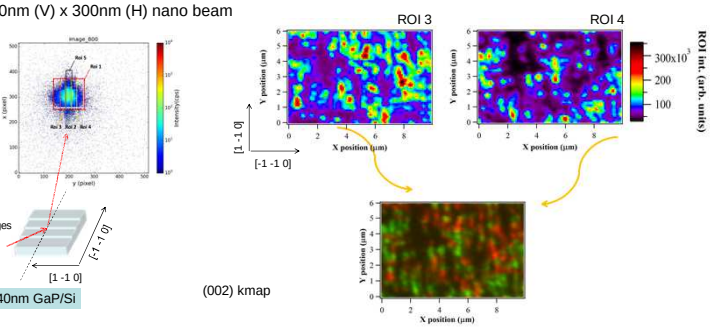
•Symmetric peak profile
•Peak splitting extension ~300nm for ~500nm beam width

- Peak splitting (single APB)
- Peak broadening (several APB)
- Asymmetric peak profiles
  - ➢ Tilt contribution ?

Fast XRS scanning *kmap* technique

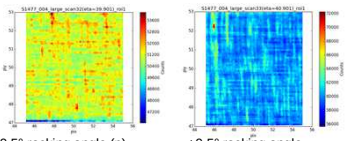
See ref [4]

100nm (V) x 300nm (H) nano beam

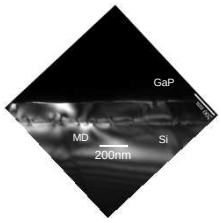


Combined Roi 3 & 4 image
- +-Tilt regions aligned along [1 -1 0]
- Strain related to APB ?

(004) Kmap
« Weak beam » conditions



-0.5° rocking angle (η) +0.5° rocking angle



Straight lines of contrast parallel to [110] & [1-10] directions

This high tilt contrast, may corresponding to regions surrounding misfit dislocations (see ref [4]&[5])

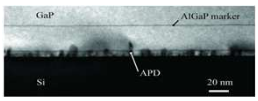
Conclusion and propects

First ptychography attempt

- **Observation of strong contrasts**
  - **splitting, broadening, tilt**

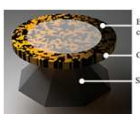
Fast scan *kmap:* 2 different contrasts

- **Weak tilt => strain related to APB ?**
- **High tilt => misfit dislocation ?**



Prospects:

- **Reproducible APB anihilation after 10nm**
  - **high perfection samples bellow critical thickness => ptychography imaging**
- **Combined analysis of local properties (crystallographic and physical)**
  - **Better comprehension of device performances**
- **Requires massive 3D Bragg peak analysis (WHL, strain&tilt…)**



GaP/Si microdisk for Second Harmonic Generation [6]

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