Standard Project

Experimental Report template

Proposal title: **II-V/Si integration: Selective growth in Nanotube templates**			**Proposal number:** 20131291
Beamline: BM32	**Date(s) of experiment:** from: 9th to: 14th April +18-21 june 2014		**Date of report:** 13/02/2015
Shifts: 18	**Local contact(s): J.-S. MICHA**		*Date of submission:*

Objective & expected results (less than 10 lines):

GIXRD measurements of GaAs nanowires (100, 80, 60, 40 nm nominal diameters) in 4x4 mm^2 arrays, 1 µm spacing between NWs. The four sample are realized by IBM Resarch-Zurich. The Si NW seed is obtained by ICP etchning (from Si(111) substrate) GaAs grows outside the Si NW template.

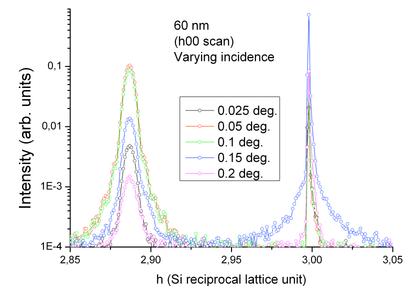
Study of GaAs internal strain: in-plane and out-of-plane measurement. Determination of an interfacial dislocation network in-between Si and GaAs materials inside the wires.

Results and the conclusions of the study (main part):

The orientation matrix is defined with respect to the Si (111) surface unit cell with hexagonal unit cell vectors 1/ 2 [1-10] , 1/ 2 [01-1] and [111] . Si peaks have integer indexes.

<u>In-plane measurements:</u>

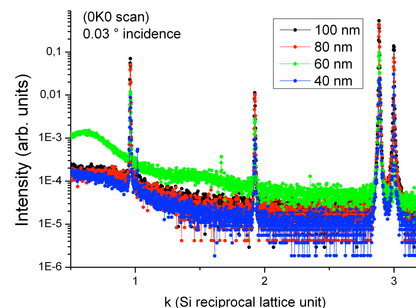
- ✓ **No difficulties to have the GIXRD signal for the small GaAs NWs.**
- ✓ **Wavelength: 0.6888 A, Measurements at two Incidences 0.03 and 0.1 deg.**
- ✓ **Standard epitaxial relationship demonstrated by (H00), (0K0), (HK0) scans in the Si reciprocal lattice unit.**
- ✓ **Estimation of in-plane strain relaxation.**
- ✓ ***- The in-plane lattice parameter is* directly obtained from the peak positions (higher sensibility at higher orders)**
- ✓ ***- The shape function is mainly visible for 40 nm. It can be analyzed quantitatively to get the sizes.***



Example: *Choice of incidence with 60 nm sample*: GaAs NW signal is max for 0.1 deg. For 0.03 deg, we are less sensitive to the Si signal, which has 2 contributions: bulk and template.

Results obtained by *fitting with Gaussian function for large large index reflections:*

	100nm GaAs/Si	80nm GaAs/Si	60nm GaAs/Si	40nm GaAs/Si
In-plane :				
HOO 0.03°:	2.8850/2.9990	2.8860/2.9990	2.8868/2.9990	2.8870/3.0005
HOO 0.1° :	2.8850/2.9990	2.8860/2.9990	2.8869/2.9990	2.8872/3.0005
0K0 0.03°:	2.8850/-----	2.8860/-----	2.8870/-----	2.8876/------
NB/ perhaps we see in these last curves the strained Si template…				
0K0 0.1° :	2.8849/2.9990	2.8861/2.9990	2.8869/2.9990	2.8872/3.0005
HK0 0.03°:	1.9232/1.9990	1.9239/1.9990	1.9244/1.9985	1.9247/1.9990
NB/ perhaps we see in these curves the strained Si template for the 100nm sample…				
HK0 0.1° :	1.92314/1.9990	1.9239/1.9990	1.92446/1.9980	1.92471/1.9990



GaAs: 5.65325 A ; Si : 5.413 A 5.413/5.65325=0.9575

	100nm(X)	80nm(Y)	60nm(Y)	40nm(Y)
1	0,962	0,962	0,962	0,962
2	0,962	0,962	0,962	0,962
3	0,962	0,962	0,962	0,961
4	0,962	0,962	0,963	0,923
5	0,962	0,962	0,963	0,923

The structures are therfore mostly relaxed in the plane even for large diameters.

During the second part of the experiments, we focussed on the analysis of dislocation peaks. Data are under treatment but we think that we have a signature of the periodicity of the misfit dislocation by the presence of 0th-order satalletite and its FWHM

value. Other order measurements are limited by the very low intensity of the superlattice peaks and by the choice of the reflection.

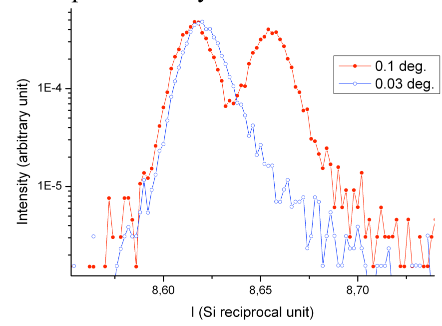
<u>Out-of-plane measurements:</u>

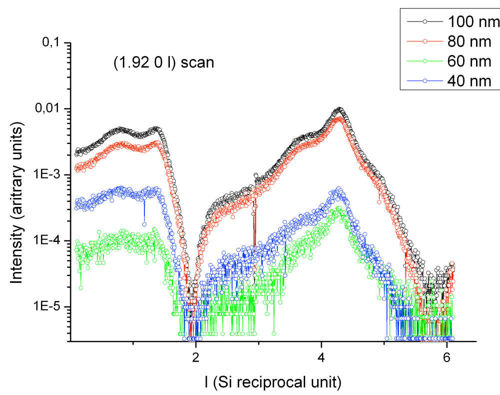
- ✓ The incidence angle must be smaller that the critical angle to avoid refraction effects (see example below).
- ✓ 0.03 deg is chosen in these measurements. We are close to transmission.
- ✓ We measure l-scan starting from (h0 k0) in-plane values.
- ✓ Deformation are directly extracted from the positions.

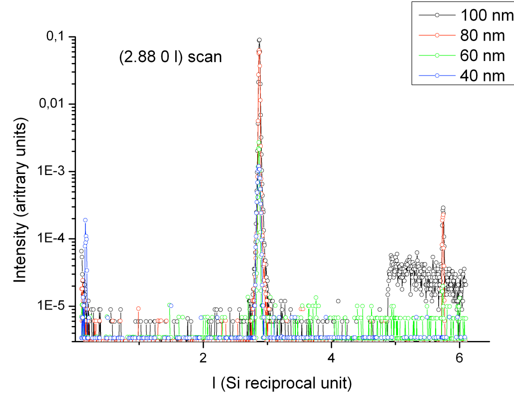
Refraction effects measured in the CTR:

Example of (X Y l) with l=8.2 and two incidence angles.

Examples of CTRs sensitive or not sensitive to stacking faults.







Out-of-plane:

2.88 O l :	2.875	2.87286	2.8665	2.86565
1.92 1.92 l:	2.87375	2.8727	2.8638	2.865(no fit)
0 2.995 l(ref):	3.0047	2.998	2.998	3.0009

	100nm(X)	80nm(Y)	60nm(Y)	40nm(Y)
1				
2				
3				
4				
5				
6	–	–	–	–
7	–	–	–	–
8	0,957	0,958	0,956	0,955
9	0,956	0,958	0,955	

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- ✓ Ratio between experimental and theoretical values are again very close
- ✓ The strain state is almost completely relaxed in this type of structures.

Justification and comments about the use of beam time (5 lines max.):

Very successful experiment.

The beam intensity was too limited to measure in details the dislocation network, but most of the goals of th eproposal have been reached.

Publication(s):

- This work has not been published yet.
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