Localized crystallization of Germanium nanowires

- Travaux pratiques IVa, Applied Physics - Master

Supervisors: Anna Fontcuberta i Morral, Santhanu Panikar Ramanandan

Laboratory of Semiconductor Materials

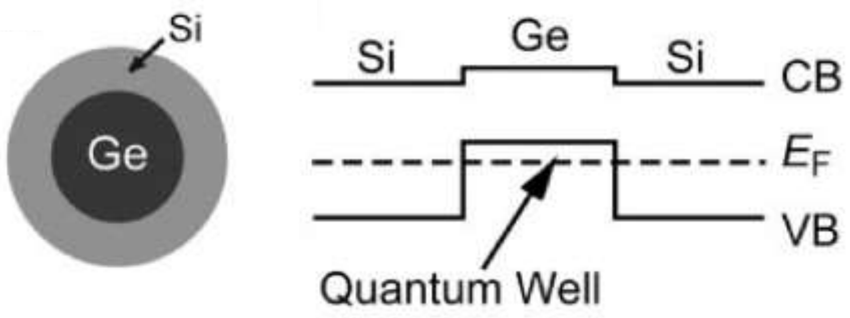
Motivations

Goal : Investigating which are the **best rapid thermal annealing (RTA) parameters** for **crystallizing** Germanium NWs

What we look for :

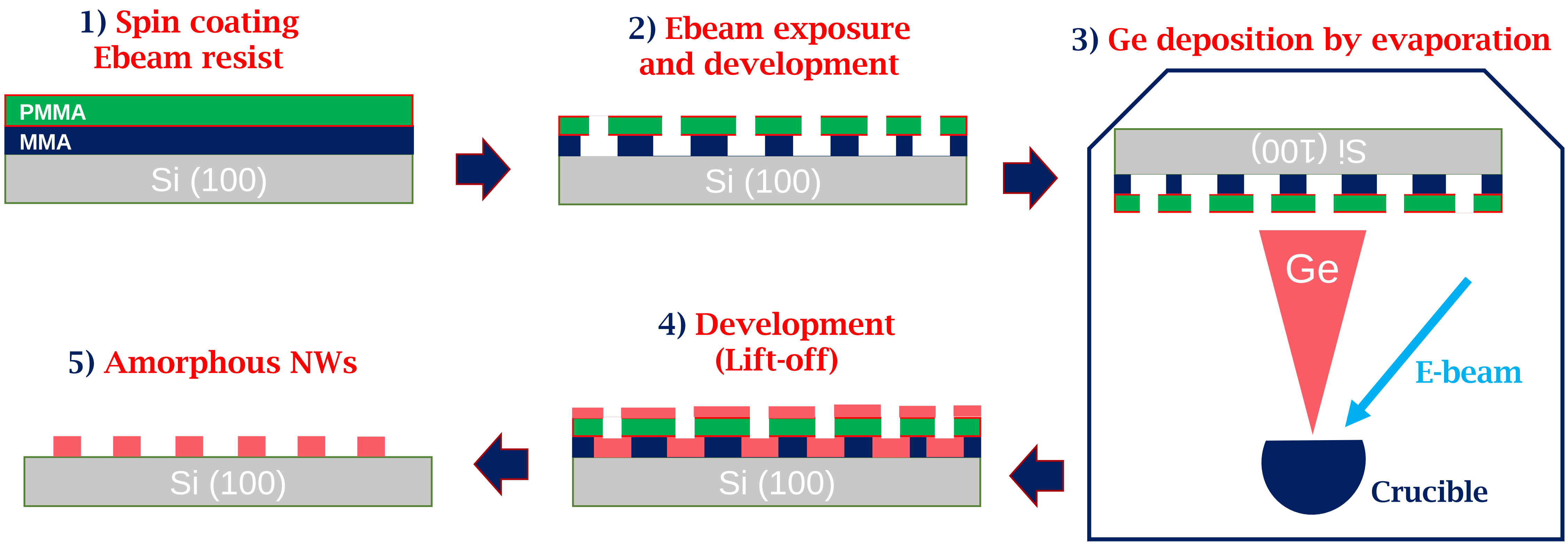
- Good **quality** and **defects free** crystal structure
- **Epitaxy** with the Silicon substrate
- Simple way to grow **nanowires networks**
- Possibility of **mass production**

What for : Ge-Si core-shell nanowires **quantum dots**



Wei Lu et al. "One-dimensional hole gas in germaniumsilicon nanowire heterostructures". In: Proceedings of The National Academy of Sciences - PNAS (Jan. 2005)

NWs fabrication



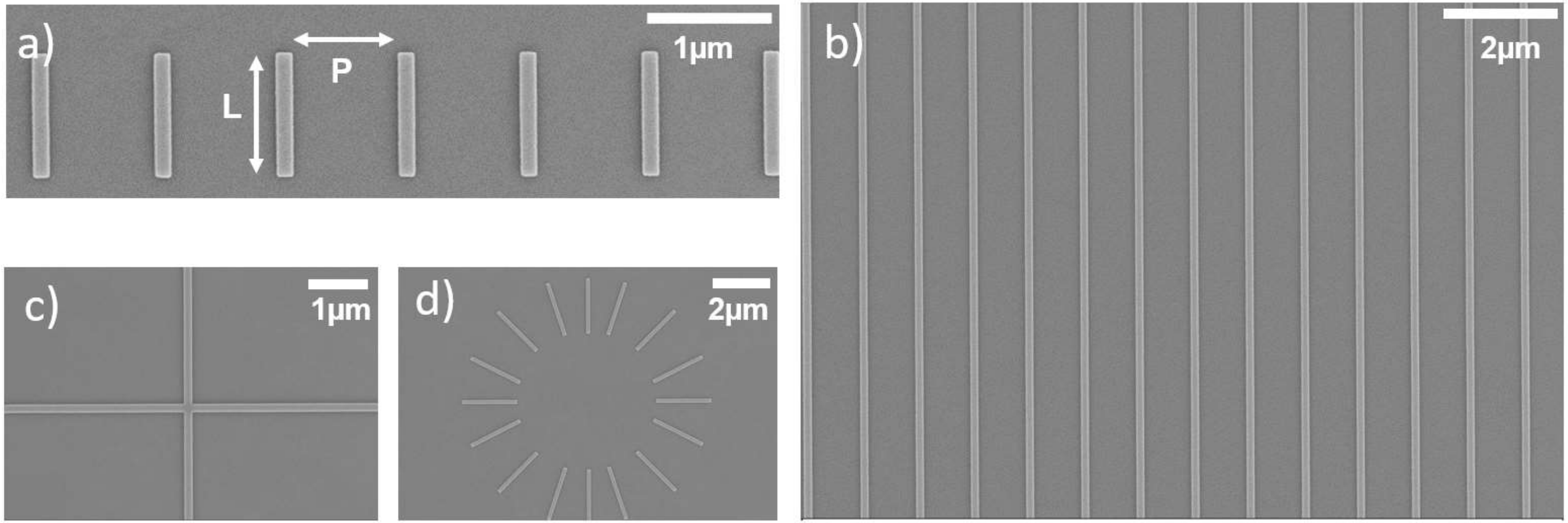
evaporator Leybold optics Lab 600H
(Ge 99,99%)

Evaporation and **lift-off** →

- Simple way to grow **nanowires networks**
- Possibility of **mass production**

Speaker

NWs fabrication



Pitch distance (P)	1µm, 3µm, 5µm
Length of NWs (L)	1µm, 5µm, 10µm, 25µm, 50µm
Width of NWs	45nm, 65nm, 95nm,135nm
Height of NWs	20nm
Orientation	100, 110, 010

Crystallization

Rapid Theremal Annealing
(RTA)

Solid Phase Epitaxy approach

JETFIRST 200

Performed series:

- 500°C for 10 sec
- 650°C for 10, 60, 120 sec
- 800°C for 10 sec

Analysis

Raman spectroscopy

- *Renishaw confocal Raman (PH dept.)*
- *Raman spectrometer (MX dept.)*

SEM and TEM (with EDX analysis)

Zeiss Merlin SEM

Talos F200S TEM

- Talos™ F200S TEM for Materials Science (thermofisher.com)
- Metrology – Center of MicroNanotechnology CMi - EPFL
- inVia™ confocal Raman microscope (renishaw.com)

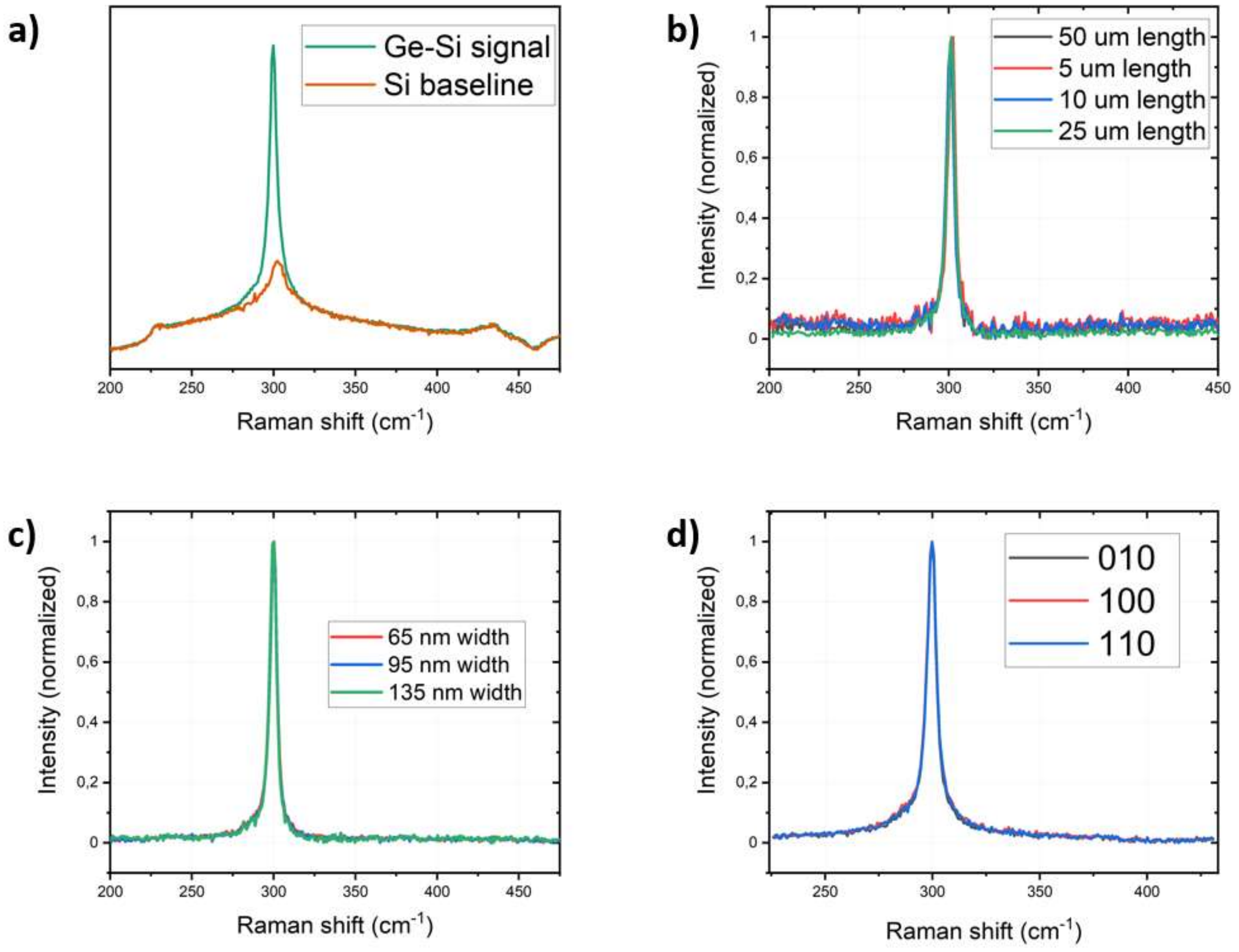
Results

Variations in crystal quality as a function of NWs morphology and orientation

No significant differences

↑

presence of an **oxide layer**

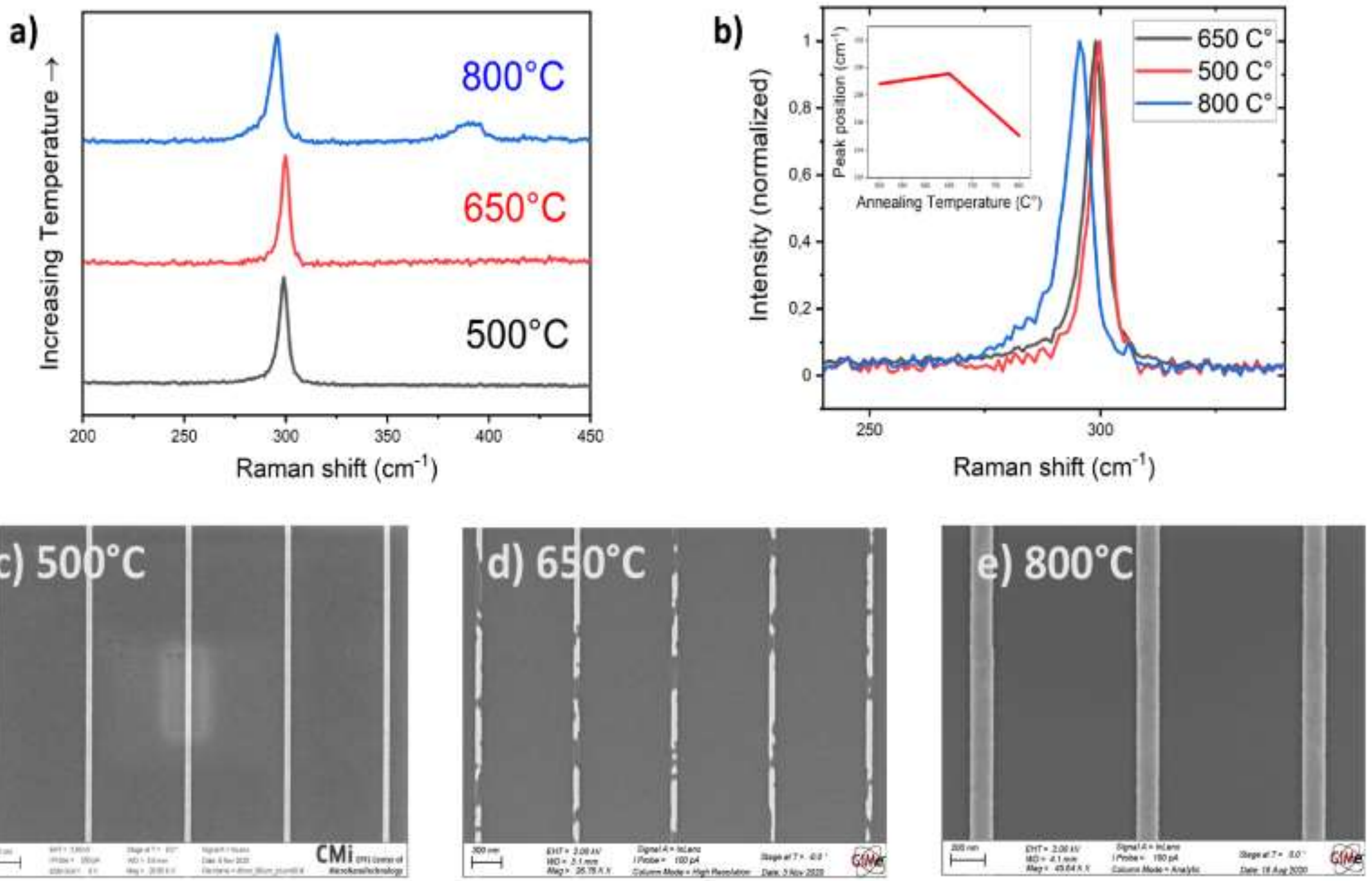


Results

Variation in crystal quality as a function of annealing temperature

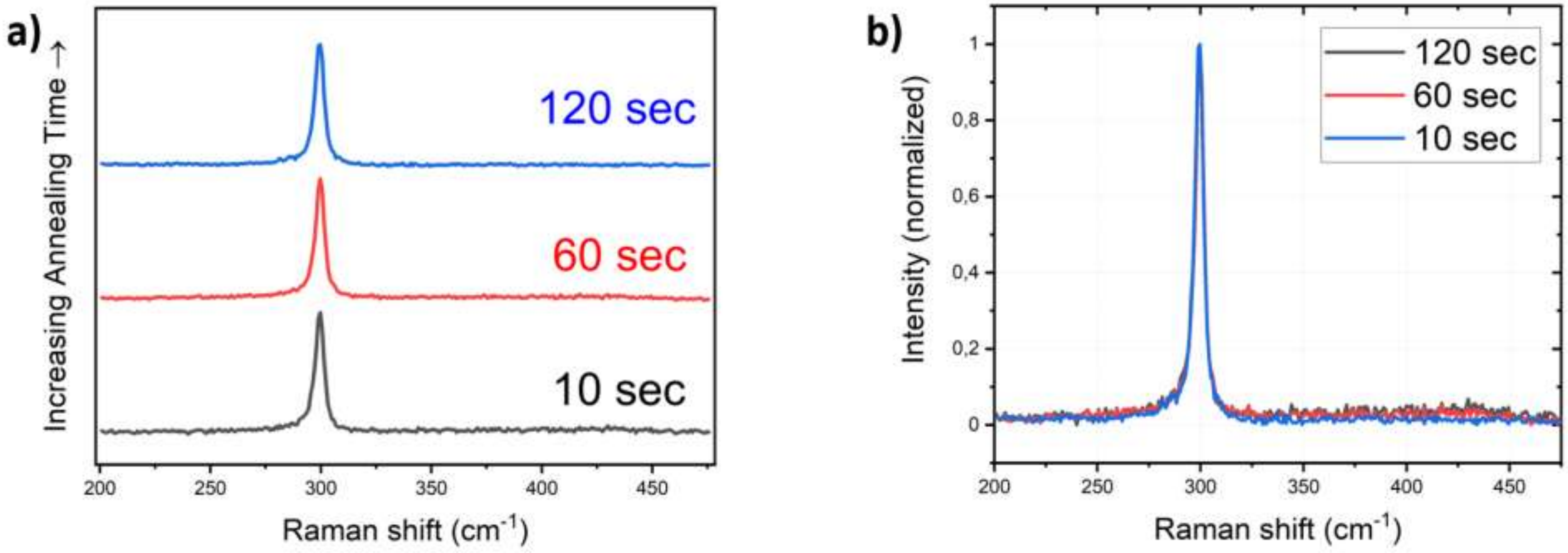
We observed:

- 650°C presented **cracks** and **holes**
- 800°C showed the presence of **intermixing**
- 800°C exhibited **peak shift** and **peak broadening**



Results

Variation in crystal quality as a function of annealing time (Sample 650°C-120 sec)



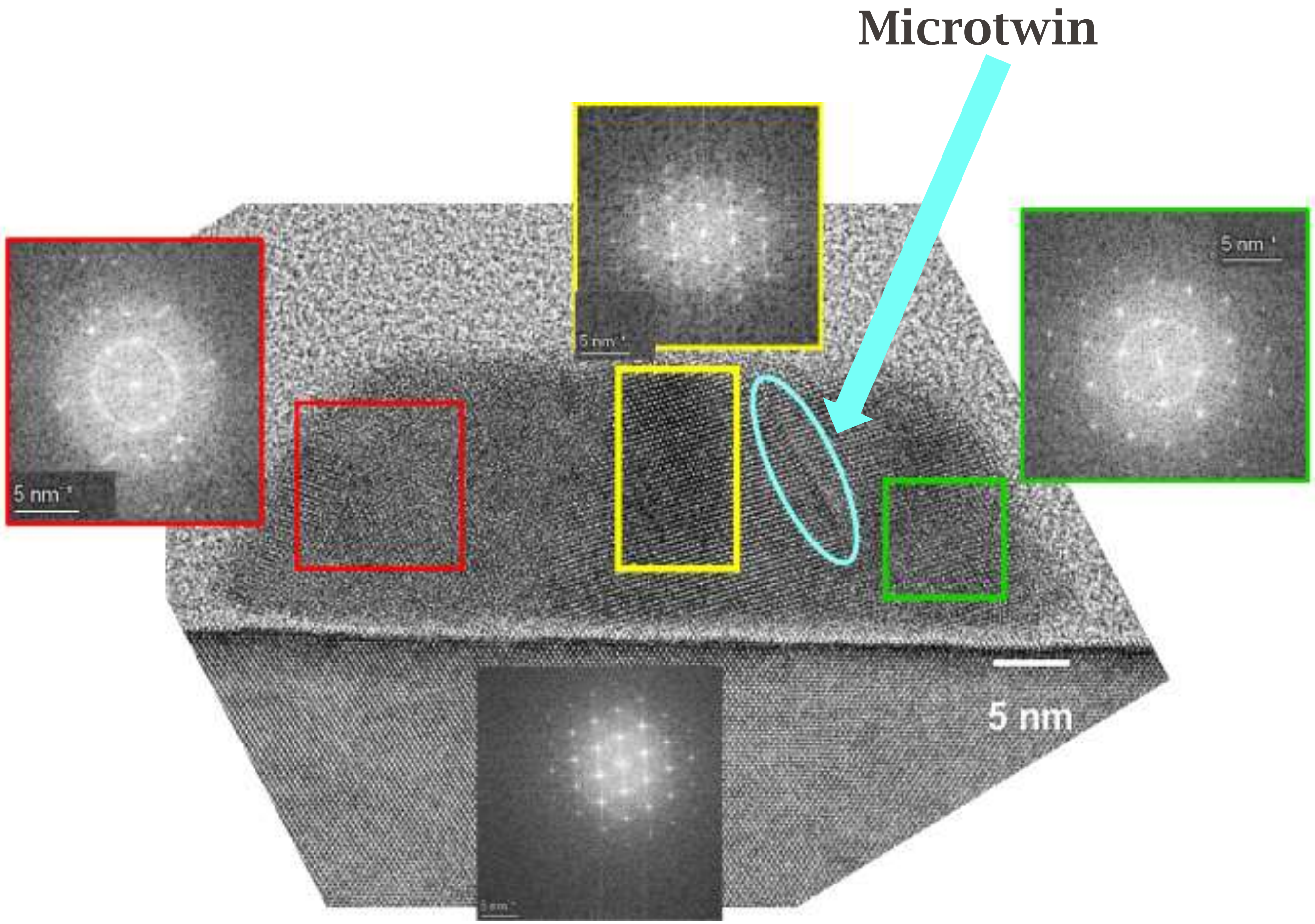
No significant differences

Results

TEM assessed:

- **Polycrystallinity**
- Presence of **microtwins**

oxide layer at the interface

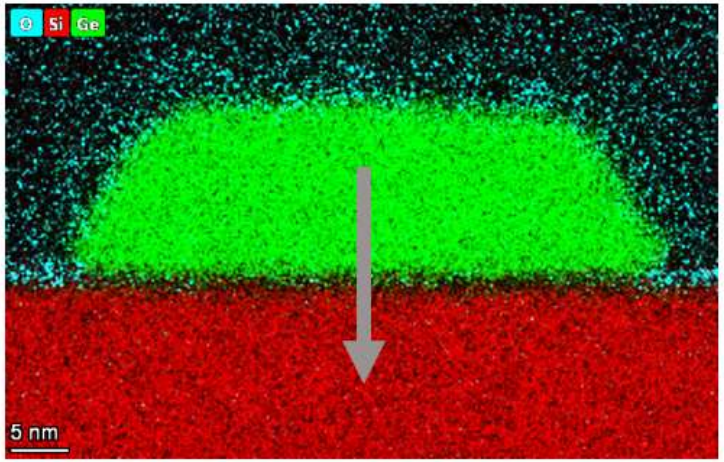


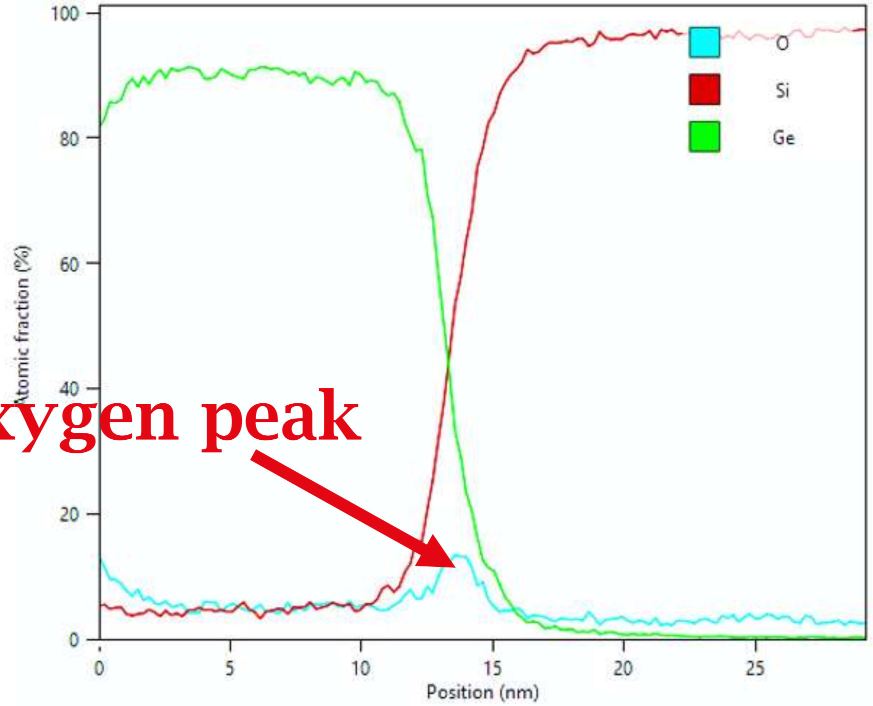
- *Ichiro Mizushima et al. "Oxide-Mediated Solid Phase Epitaxy (OMSPE) of Silicon: A New Low-Temperature Epitaxy Technique Using Intentionally Grown Native Oxide". In: Japanese Journal of Applied Physics 39 (Apr. 2000)*
- *I. Mizushima et al. "Effect of interfacial oxide on solid-phase epitaxy of Si films deposited on Si substrates". In: Journal of Applied Physics 63, 1065 (1988)*

Results

Chemical characterization

presence of **Oxygen** at the interface





Conclusion

Best RTA parameters: 500°C - **10** seconds

Future goal: improving **fabrication process**:

- avoid the formation of an **oxyde layer**
- Achieve strain induced **mobility enhancement**
- Obtain **monocrystalline** and **defect free** crystal structures