

# Défauts dans le Si cristallin pour les applications Photovoltaïques

Appel visé dans le programme de travail Energie 2019-2020  
d'Horizon 2020

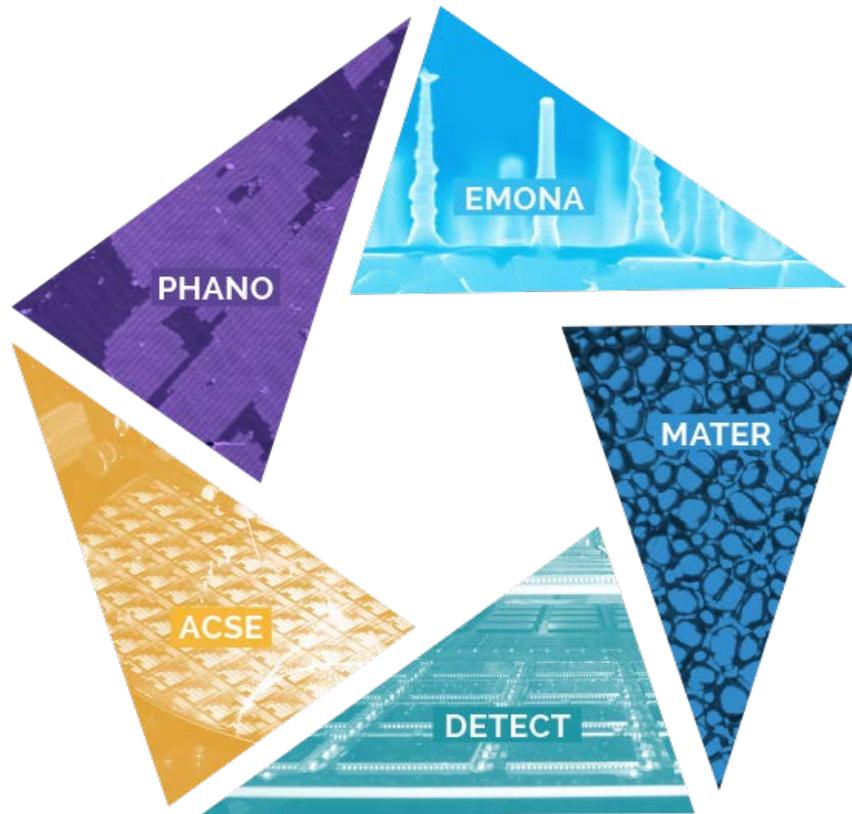
Thématique (Energy Efficiency / Renewable  
energy solutions)

Journée SHS/Energie dans Horizon 2020

Paris, le 11 avril 2019



Institut **M**atériaux **M**icroélectronique **N**anosciences de **P**rovence



**Directeur de l'IM2NP:**  
**Prof. J.L. Aufran**

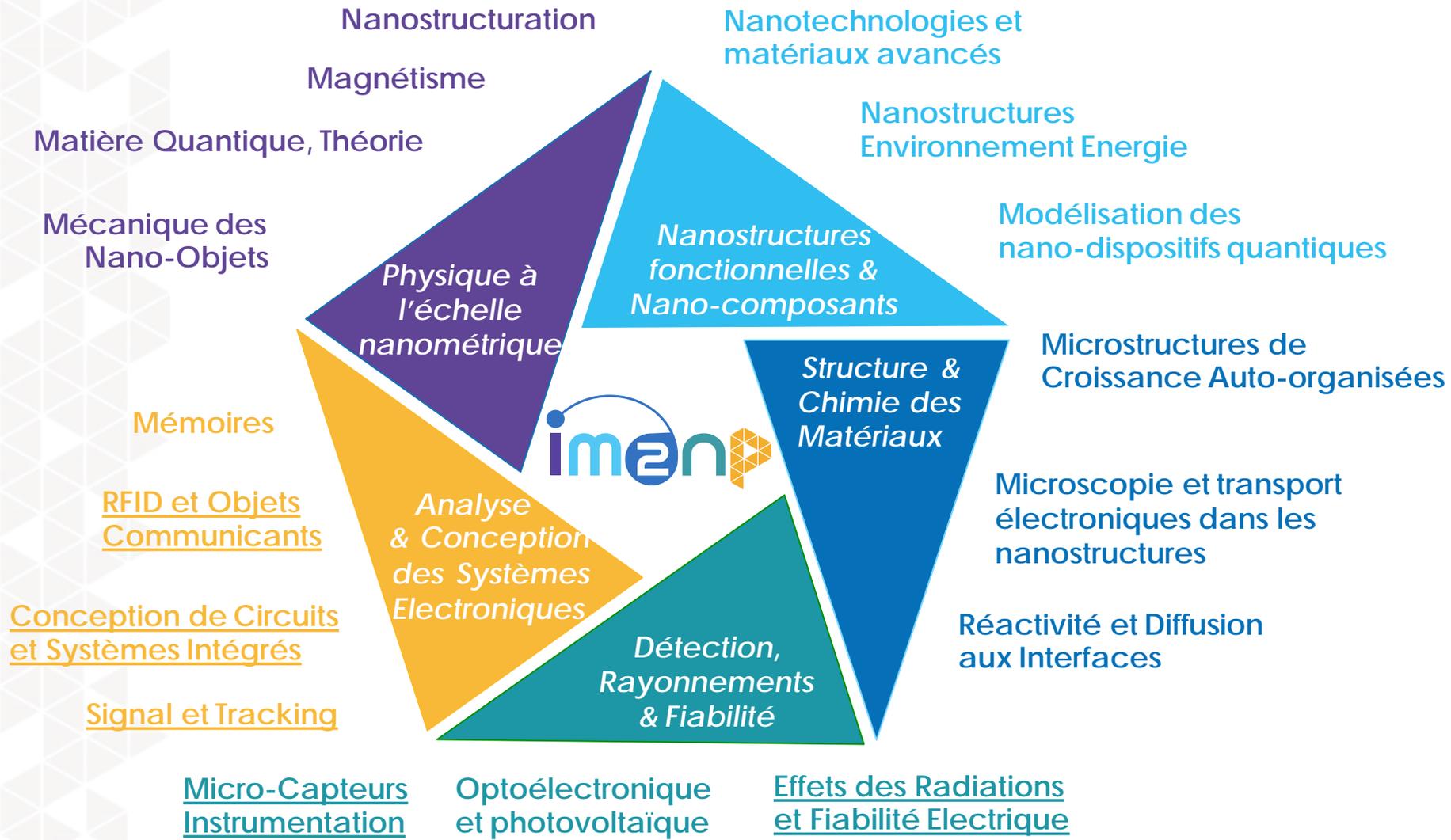
**Directeurs adjoints de l'IM2NP:**  
**Prof. L. Escoubas**  
**Prof. C. Girardeaux**

**Responsable de site IM2NP Toulon :**  
**Prof. H. Barthélémy**

**Relier le fondamental  
aux applications  
dans nos domaines  
d'expertise**



# Structuration de l'unité





Institut Matériaux Microélectronique Nanosciences Provence

# CrySaLID

## Crystallisation of seeded Silicon, impact of Light Impurities and Defects

Projet financé par l'ANR: (2015–2019)

Nathalie Mangelinck–Noël (coordinatrice)

IM2NP CNRS UMR 7334

[nathalie.mangelinck@im2np.fr](mailto:nathalie.mangelinck@im2np.fr)



# CrySaLID partners : Consortium

1. IM2NP UMR CNRS 7334, Person in charge: Nathalie Mangelinck-Noël,  
<http://www.im2np.fr/>



2. *Emix / FerroAtlántica*, Person in charge : Elodie Pereira



3. SIMAP UMR CNRS 5266, Person in charge : Kader Zaïdat,  
<http://simap.grenoble-inp.fr/>



4. ARMINES CEMEF, Person in charge : Charles-André Gandin,  
<http://www.cemef.mines-paristech.fr/>



5. SINTEF, Person in charge : Gaute Stokkan, <http://www.sintef.no/>



6. NTNU, Trondheim, Norvège, Person in charge : Marisa Di Sabatino Lundberg,  
<http://www.ntnu.edu/>



7. KAU, Karlstad, Suède, Person in charge : Markus Rinio, <http://www.kau.se/en>



# Crystalline silicon fabrication processes

Monocrystalline / Multi-crystalline

PV efficiency



25 %  
commercial  
cell



20,4 %  
commercial  
cell

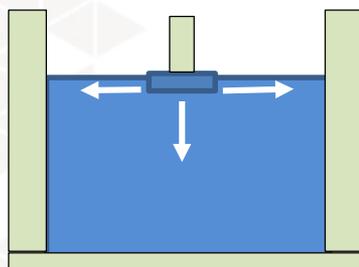
Conventional  
fabrication process

**Cost** Czochralski (CZ) >

**Cost** directional  
solidification/  
casting

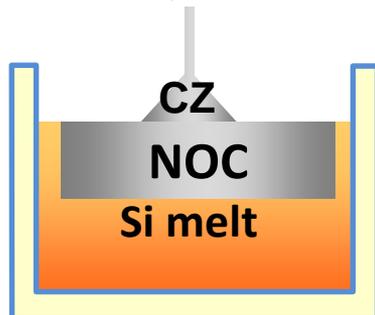
## Proposed innovative alternatives

Kyropoulous



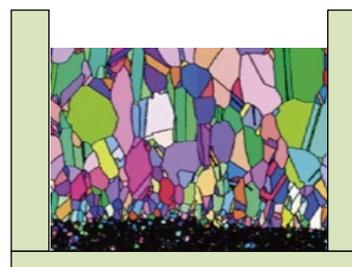
*G. Chichinoud, K. Zaïdat  
et al*

NOC (Noncontact crucible)



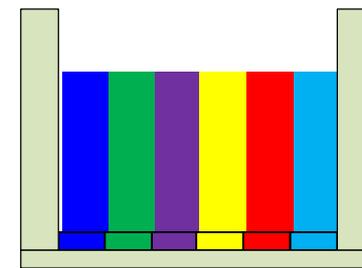
*K. Nakajima et al. JCG  
468 (2017) 706-709*

HP mcSi



*C. W. Lan et al, JCG 468  
(2017) 17-23*

Mono – like

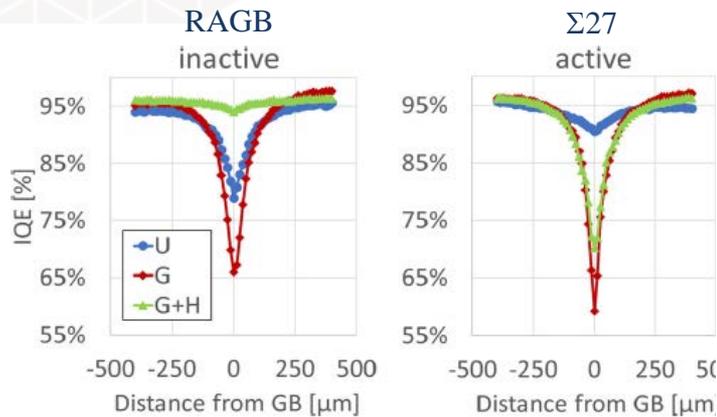


*A. Jouini et al, Progress. PV  
Res. Ap. 20 (2012) 735-746*

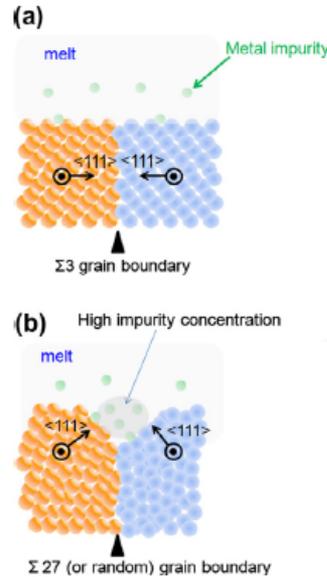
# Impact of growth features on PV performance

The structural defects can be electrically active and/or interact with impurities:

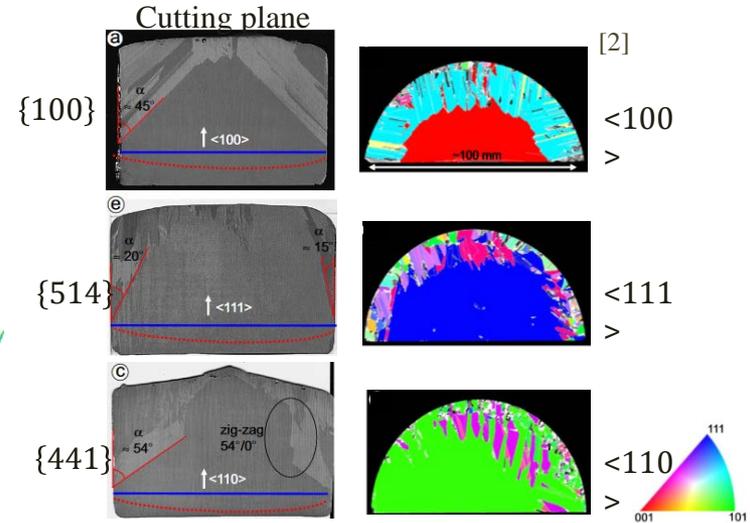
- Grains
- Twins and associated twin boundaries
- Dislocations



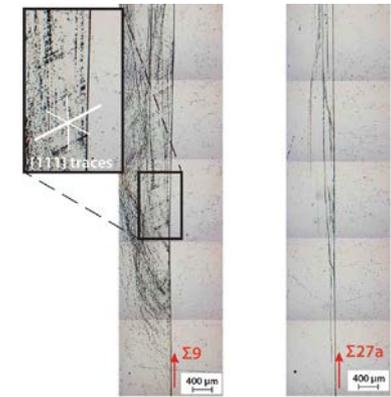
*K. Adameczyk et al. JAP 123 (2018) 055705*



*Fujiwara et al. Scripta Materialia 69 (2013) 266-269*

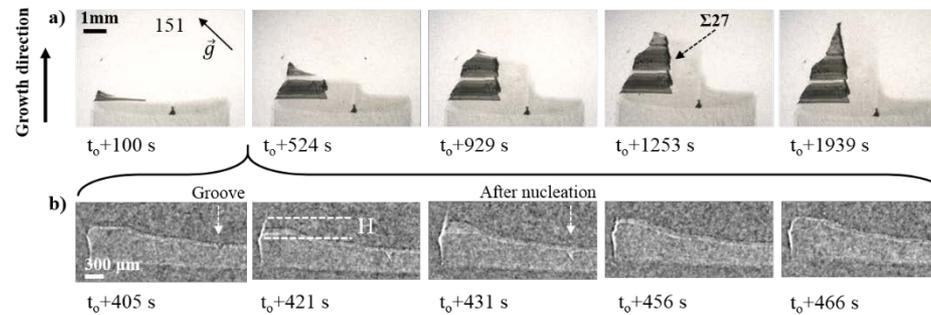
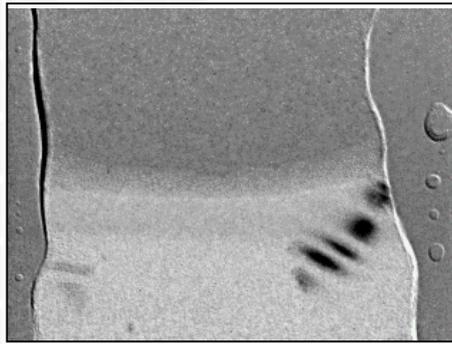


*M. Trempa et al. JCG 351 (2012) 131-140*

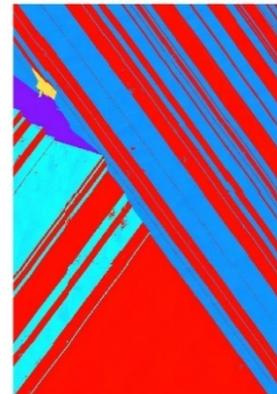
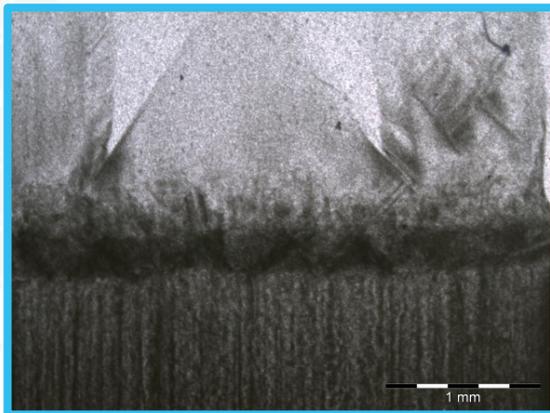


*Autruffe et al. J. Cryst. Growth 411 (2015)*

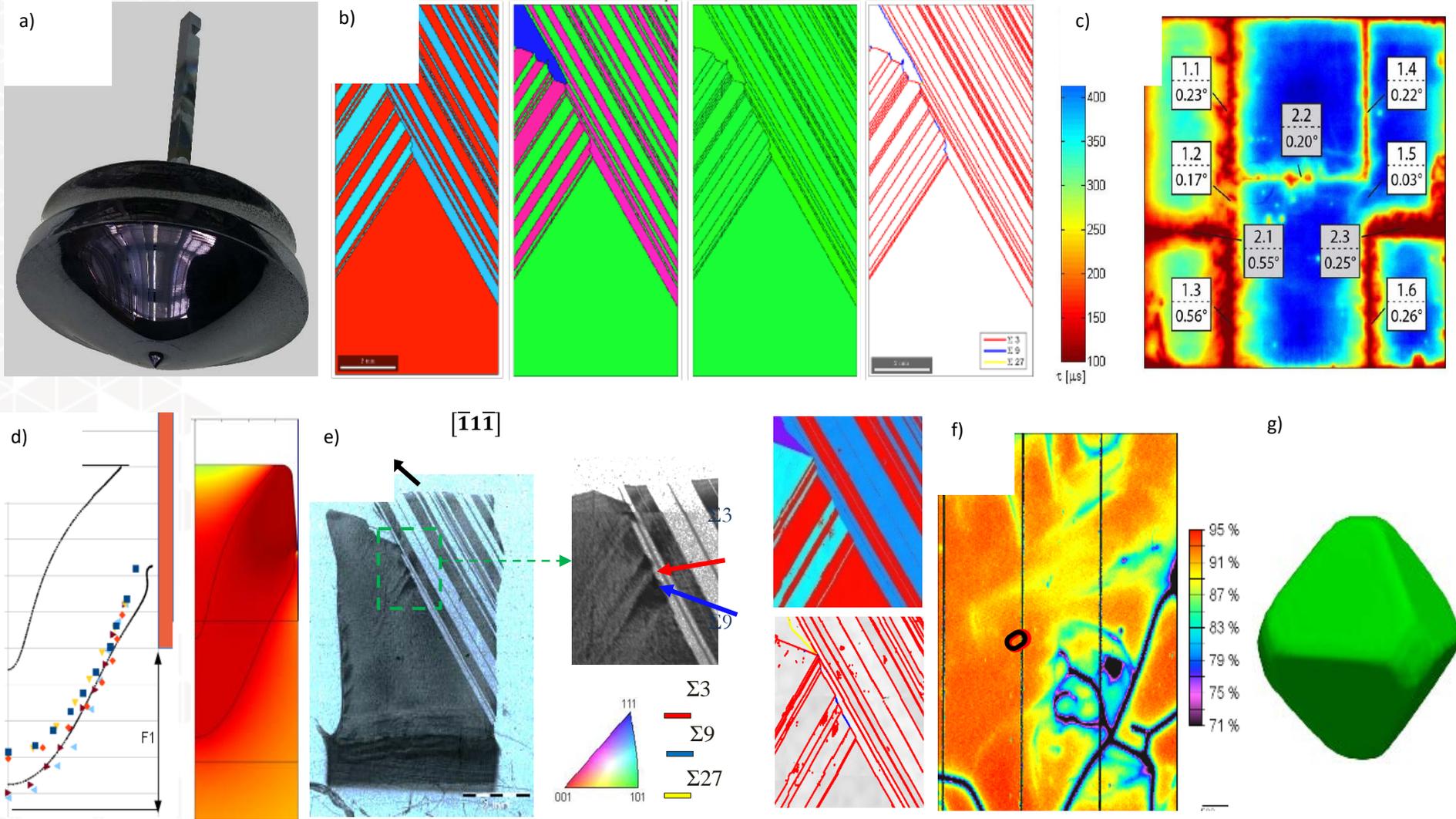
# Originality of our work at IM2NP



- Investigate the fundamental of growth mechanisms: structural defect generation and evolution, crystallographic orientation, grain structure and twinning boundaries
- *In situ* and real-time X-ray imaging during growth



# Main achievements: CrySaLID project



# Notre idée de projet et/ou expertise

- Etude de la **croissance du silicium** utilisé pour les **applications photovoltaïques**
- Influence des **défauts et des impuretés**: perspective plus large incluant le **recyclage**
- Plus largement à l'IM2NP: projet global incluant **les aspects matériaux, électriques et mécaniques**
- **Questionnement Sciences Humaines et Sociales**: Attentes dans les **différents pays** (acceptation, coût / rendement, procédés locaux, isolement / réseau...)

# Coordonnées

| Personne à contacter |  |
|----------------------|--|
| Organisation         | IM2NP  |
| Adresse              | IM2NP CNRS UMR 7334, Campus de Saint Jérôme, Case 142,<br>13397 Marseille Cedex 20 |
| Téléphone            | 04 91 28 87 37   |
| E-mail               | nathalie.mangelinck@im2np.fr   |