RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM
(one page maximum)

Field: Energy, Processes

Subfield: Materials Science and Mechanical Engineering

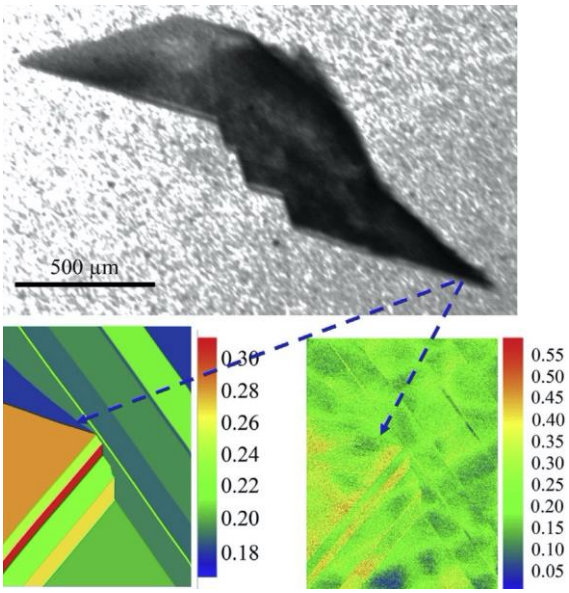
Title: Multiscale stress/strain analysis of polycrystalline silicon for photovoltaic applications

ParisTech School: Arts et Métiers Sciences et Technologies

Advisor(s) Name: Pr. Laurent BARRALLIER
Advisor(s) Email: laurent.barrallier@ensam.eu
Research group/Lab: MMS Team - MSMP Lab.
Lab location: Aix-en-Provence, France
(Lab/Advisor website): msmp.eu

Short description of possible research topics for a PhD:

Polycrystalline silicon (PS) is a raw material used by the solar photovoltaic (PV) and electronics industry. The reduction of the cost of PV cells production is largely possible by using PS. Nevertheless, the limitation of PS use is directly linked to the microstructure of the material i.e. i) the active defects such as grain boundaries, dislocation arrangements, ... ii) but also the mechanical fields induced by these defects. The efficiency of PV cells is depending on the mastering of the defect generation, their repartition and the induced strain/stress fields during the fabrication of PS.
The aim of this project is to characterize the induced residual stress fields of PS in relation with their microstructure. Experimental methods used to determine residual stresses fields will be based on multiscale diffraction in-lab technics such as High-Resolution Electron Backscatter Diffraction (HR-EBSD), X-ray diffraction (XRD) of synchrotron facility. To understand the origin of residual stress fields in PS cells, the temperature HR-EBSD and XRD measurements will be coupled with polycrystalline thermo-elasto-plasticity simulation using finite element method (FEM).



Strain in polycrystalline silicon [3].

Required background of the student:
Materials Science and/or Mechanical Engineering

A list of 5 (max.) representative publications of the group:

1. M. Becker, E. Pihan, F. Guittonneau, L. Barrallier, G. Regula, H. Ouaddah, G. Reinhart, and N. Mangelinck-Noël. Investigation of subgrains in directionally solidified cast mono-seeded silicon and their interactions with twin boundaries. *Solar Energy Materials & Solar Cells*, 218(110817):1-10, décember 2020.
2. N. Mangelinck-Noel, H. Ouaddah, M. Becker, T. Riberri-Beridot, M. Tsoutsouva, V. Stamelou, G. Regula, G. Reinhart, I. Péricaud, F. Guittonneau, L. Barrallier, J.-P. Valade, A. Rack, E. Boller, and J. Baruchel. X-ray based in situ investigation of silicon growth mechanism dynamics-application to grain and defect formation. *Crystals*, 10(7):1-25, july 2020.
3. T. Riberi-Béridot, M.G. Tsoutsouva, G. Regula, G. Reinhart, F. Guittonneau, L. Barrallier, and N. Mangelinck-Noël. Strain building and correlation with grain nucleation during silicon growth. *Acta Materiala*, 177:141-150, 09 2019.
4. M.G Tsoutsouva, T. Riberi-Béridot, G. Regula, G. Reinhart, J. Baruchel, F. Guittonneau, L. Barrallier, and N. Mangelinck-Noël. In situ investigation of the structural defect generation and evolution during the directional solidification of 110 seeded growth si. *Acta Materiala*, 115:210-223, August 2016.
5. T. Riberri-Beridot, N. Mangelinck-Noel, A. Tandjouai, G. Reinhart, B. Billia, B. Lafford, J. Baruchel, and L. Barrallier. On the impact of twinning on the formation of the grain structure of multi-crystalline silicon for photovoltaic applications during directional solidification. *Journal of Crystal Growth*, (418):38-44, 2015.