



COPIL n°10 chaire BIGMECA, 02 février 2023 ■■

■ Mécanique des matériaux et des procédés de fabrication via l'apprentissage statistique

Henry Proudhon, David Ryckelynck

MINES ParisTech, université PSL, Centre des Matériaux, Evry



SAFRAN

Ordre du jour

15h00 Connexion à la réunion

15h05 Dernières nouvelles de la chaire BIGMECA (Henry Proudhon)

15h20 Simulation numérique de la nano-indentation (Emilie Despinoy)

15h40 Vers l'identification des lois de plasticité cristalline par apprentissage statistique et jumeau numérique (Daria Mesbah)

16h10 Influence of casting defects on Ni based superalloys under high cycle fatigue regime (Arjun Kalkur)

16h40 Discussion

Ordre du jour

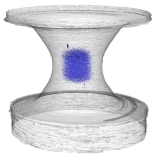
- 1 Point sur les études en cours
- 2 Dissémination et collaborations internationales
- 3 Thèse en collaboration avec Damien Texier

Plan

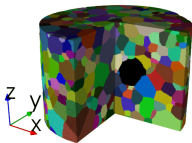
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Développements de la plateforme de données BIGMECA

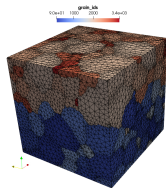
Avec la contribution d'Aldo Marano (maintenant à l'ONERA)



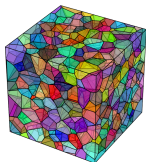
tomography



EBSD/DCT/labDCT



segmentation, meshing
(F. N'Guyen)



neper



PYMICRO

AMITEX

FFT simulations



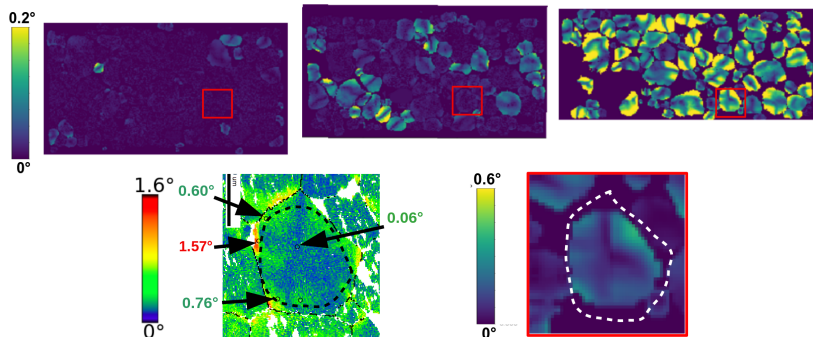
FE simulations

- Continuous development, paper in progress
- Deployment at ID11 (ESRF)

Statistical 4D tomography of polycrystalline materials

PhD thesis Clément Ribart oct 2019 – mar 2023

- develop **4D tomography** at the Psiché beamline (paper submitted) + collaboration with Lund university and Xnovotech
- **simulation** at the scale of the microstructure ($10^4 - 10^5$ grains)
- **statistical** analysis of deformation and failure mechanisms.

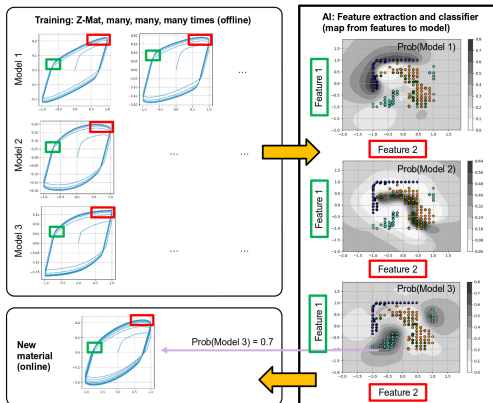


[Ribart et al., 2022] accepted in J. Synchr. Rad.

DMS project of Jordan Ngucho Mbeutchou

Machine learning pour la sélection des lois de comportement en mécanique non linéaire des structures

- Standardised feature extraction (SSM, CNNs) ?
- Generation of representative numerical datasets using Z-mat ?
- Heterogeneous database (multiple experiments with different number of cycles, available metadata) ?



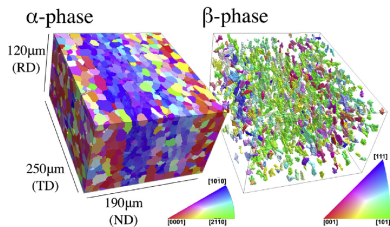
Advising team

P. Kerfriden (CDM), F. Casenave & Christian Rey (SafranTech)

DMS project of Hamza Jelidi

Modélisation microstructurale du phénomène Cold-Dwell dans le TA6V

Analyze microstructure effect using Finite Elements simulations for cold-dwell applications



- EBSD data analysis
- 3D microstructure generation
- FEM simulations

[Chatterjee et al., 2018]

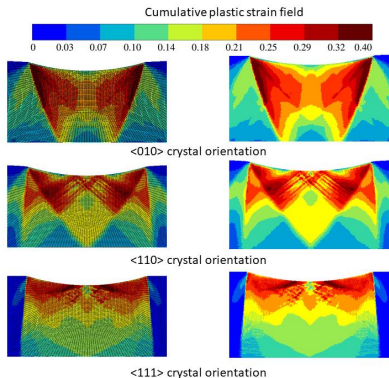
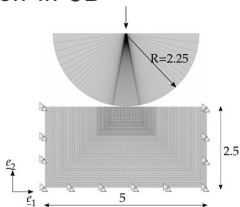
Advising team

H. Proudhon, F. Azzouz & F. N'Guyen (CDM), A. Longuet & L. Marcin (Safran AE)

M2 training of Émilie Despinoy (started 01/09/2022)

Numerical simulation of the nanoindentation in Ni-based and Ti-based alloys at the sub-grain level

- Strain gradient plasticity
- FE simulation in 3D
- Contact



Advising team

H. Proudhon, V. Yastrebov & S. Forest (CDM), D. Texier (Mines Albi)
& F. Coudon (SafranTech)

Nouveau projet DMS pour 2022-2023

Marwa Ben Bettaieb

- Etude et automatisation du contrôle non destructif surfacique de la qualité cristalline des aubes de turbine par diffraction des rayons X (A. Barbeau PFX – H. Proudhon CDM)



projet 3DEXPLORE SafranTech PFX

Plan

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Option IDSC 2022

- Effectif : 33 élèves ingénieurs
- Exposé de Fabien Casenave (méthode des EF à Safran)
- Voyage d'étude :
 - EPFL
 - Neural Concept
 - SafranTech
 - Synchrotron Soleil
 - Safran Analytics
 - FieldBox
 - Thales
 - Axa Climate
 - Owkin
 - Arcelor Mittal Digital lab

CVML 2022 (3^e édition)

- Comme en 2021 le cours s'est tenu en **mode hybride** sur Zoom. 89 inscrits (~ 70 doctorants, 4 industriels dont 1 Safran).
- **Notes et vidéos de cours** disponibles au fur et à mesure via Moodle sur <https://moodle.minesparis.psl.eu/enrol/index.php?id=993>
- Tutoriels sous **Google colab**
- **Channel Slack** pour poser des questions/poster du code durant les TPs.
- **Examen** en ligne pour tout le monde avec Moodle (note de 10/20 nécessaire pour l'attestation de suivi).
- **Nouveautés** : Conférence de Sam Daly, cours sur les GANs, cours sur la detection d'objets.



colab



Retour sur le workshop *mechanics of polycrystal*

- May 23-25 2022, hybride mode, sponsored by BIGMECA, CDM and Mecamat
- **2** days, **4** topics, **18** invited international speakers
- 50 participants + 30 on zoom
- Wine and Cheese in the honor of Georges Cailletaud



Articles

deep learning J. Bertoldo et al., *Frontiers in Materials* *A modular U-Net for automated segmentation of X-ray tomography images in composite materials*, published

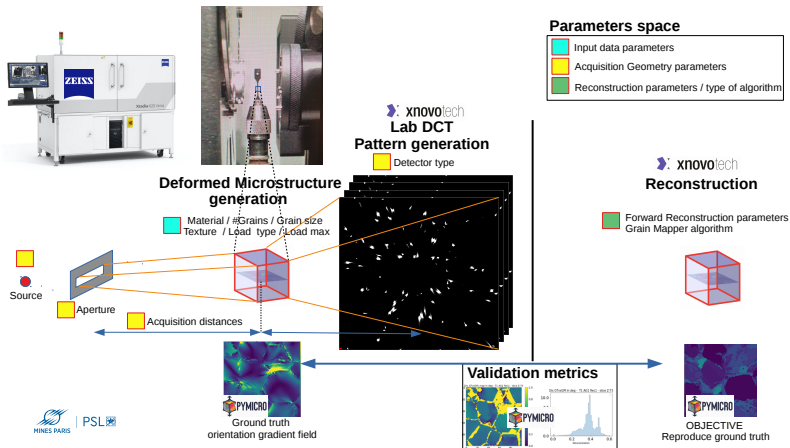
4D testing C. Ribart et al., *J. synchrotron radiation* *Advancement in the understanding of plasticity via in situ synchrotron methods*, published

data augmentation A. Aublet et al., *Frontiers in Materials* *Multimodal data augmentation for digital twinning assisted by artificial intelligence in mechanics of materials*, published

data platform A. Marano et al., *current opinion in solid state material science* *A new mechanics of material data platform*

Séjour de 3 mois de C. Ribart chez XnovoTech (Danemark)

Collaboration sur la technique labDCT



Samantha Daly, PSL Visiting fellow in 2022 2023

ADVANCED MECHANICS OF MATERIALS GROUP

*Experimental, Theoretical, and Computational Studies
of the Multi-Scale Mechanics of Advanced Materials*

"Machine Learning for Materials Discovery"

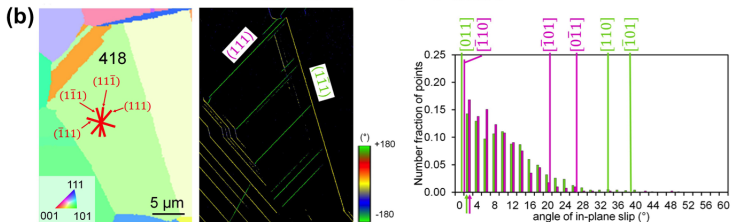
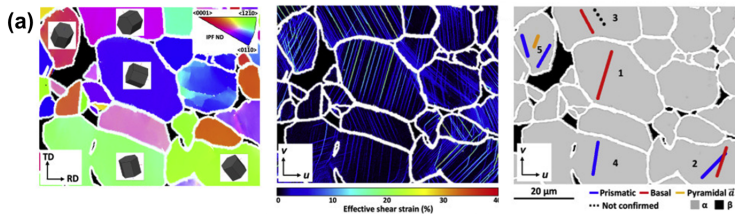
Research in the Daly group lies at the intersection of experimental solid mechanics, materials science, and data science. We develop new methods for multi-scale materials characterization and integrate physics-informed ML to understand how materials deform and fail.

Logos: NSF, GE, Mines Paris, RR, University of Queensland, INRS, NASA, GM, and another circular logo.

Zoom interface: Gallery View, Exit Full Screen, Samantha Daly (video feed), Leave.

- S. Daly visiting fellowship with BIGMECA and PSL
- funding : PSL 1/3, BIGMECA 1/3, Mines Paris 1/3
- Research collaboration and teaching (already started)
- **Postponed to 2023 due to COVID, arrival 12 march**

Collaboration with Jean-Charles Stinville, Univ Illinois



Automated slip trace analysis [Stinville et al., 2023]

- nano-speckle for μ -DIC experiments
- detection and quantification of slip localization
- several publications in common

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2e sujet de thèse chaire BIGMECA : détection d'anomalie en nano-indentation

Machine learning approaches using multi-modal data combination to identify crystal elastoplasticity properties at the sub-grain level



- 50%chaire BIGMECA 50% ERC Damien Texier
- doctorant inscrit à ISMME
- salaire payé par CNRS (ERC D. Texier)
- Budget validé par Jérôme Crépin



Chatterjee, K., Echlin, M. P., Kasemer, M., Callahan, P. G., Pollock, T. M., and Dawson, P. (2018). Prediction of tensile stiffness and strength of ti-6al-4v using instantiated volume elements and crystal plasticity.
Acta Materialia, 157 :21–32.



Stinville, J.-C., Charpagne, M.-A., Maaß, R., Proudhon, H., Ludwig, W., Callahan, P. G., Wang, F., J., B. I., Echlin, M. P., and Pollock, T. M. (2023). Insights into plastic localization by crystallographic slip from emerging experimental and numerical approaches.
Annual Review of Materials Research, Accepted for publication.