PhD position

Context and goals of the PhD

Enhancement of a full field finite element framework to model recrystallization in context of strong anisotropies of mobility and grain boundary energy

DIGIMU is an ANR industrial Chair handled by ARMINES MINES ParisTech and co-funded by ANR and an industrial consortium formed by ArcelorMittal, AREVA, ASCOMETAL, AUBERT & DUVAL, CEA and SAFRAN. This Chair deals with the **D**evelopment of an **I**nnovative and **G**lobal framework for the Model**I**ng of **M**icrostr**U**ctural evolutions involved in metal forming processes. DIGIMU® is also the name of the resulting software developed by the company TRANSVALOR as a project partner.
Countless products involved in our every-day life rely on vital metal parts. Optimizing these parts requires a knowledge of how material properties change during forming operations. Although the understanding of the underlying metallurgical phenomena has improved thanks to the continuous progress of experimental facilities, the interest for increasingly fine and predictive simulations has been recently growing. In this emerging context of "digital metallurgy", the DIGIMU Chair and consortium have two main objectives. The first one is to develop an efficient multiscale numerical framework specifically designed to tackle such problems. The second one is to bring the corresponding numerical methods to an industrial level of maturity, by decreasing significantly their computational cost and by validating them against the industrial expertise existing in the DIGIMU consortium.

In order to accurately describe the 3D evolution of polycrystals (recrystallization, phase transformations…), full-field methods such as the phase-field (PF) or the level-set (LS) methods currently represent the best option. In this context, a new FE numerical framework to model grain growth (GG) and recrystallization (ReX) based on a LS description of the interfaces and meshing/remeshing capabilities has been recently developed[a]. Nowadays, the LS approach is used for Rex/GG modeling in the context of uniform grids with a finite-difference formulation or in a FE framework on unstructured mesh. LS method is also particularly interesting for the modeling of Smith-Zener pinning.

These PhD works will be dedicated to the enhancement of the existing numerical formalism in order to be able, in a smart and efficient way, to deal with strong and local anisotropies of mobility and grain boundary energy. This aspect is today a big numerical challenge for existing full field numerical approaches. Moreover a new modular crystal plasticity finite element method will be employed/improved during the PhD[b]. DRX (see Figure) and SRX phenomema for different austenitic stainless steels will be investigated with these developments and validated thanks to existing experimental results.
Finally, the resulting developments will be impleted aiming at its integration into the DIGIMU® software package.

[a] B. Scholtes et al. Computational Materials Science, 2015 109:388-398, and 2016 122:57-71.

[b] D. Pino Munoz, M. Bernacki, J. Signorelli, and A. Roatta. Numerical and Experimental (EBSD) study of the orientation gradients at grain boundaries of a polycrystalline AKDQ steel sheet. In WCCM 2016, Seoul, Korea, July 24-29 2016.

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Partners

Keywords

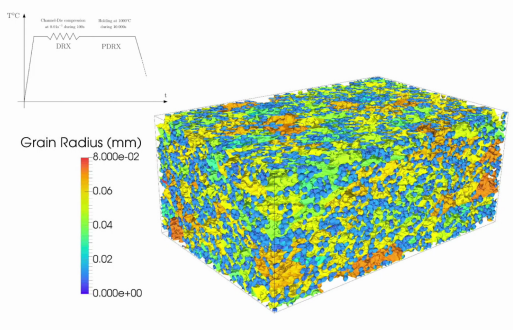
Metallurgy – Mechanics – Grain interfaces – FE Method – HPC – C++.

Candidate profile and skills

Degree: MSc or MTech in Metallurgy, Materials Science or Applied Mathematics, with excellent academic records. Skills: Finite Element Method, Metallurgy, proficiency in English, ability to work within a multi-disciplinary team.

Offer

The 3-year PhD will take place at CEMEF, an internationally-recognised research laboratory of MINES ParisTech located in Sophia-Antipolis, on the French Riviera. It offers a dynamic research environment, exhaustive training opportunities and a strong link with the industry. Annual gross salary: around 26k€. She/He will join the MultiScale Modeling (MSM) and the Metallurgy Structure Rheology (MSR) research teams under the supervision of M. Bernacki, and D. Pino Muñoz. Moreover Lukasz Madej, professor at the AGH University of Science and Technology in Poland will participate to this project and to the supervision of the PhD student.



Example of a 3D full field Level Set modeling of DRX for an austenitic stainless steel (304L) - PhD works of L. Maire - DIGIMU consortium.