PhD position

Context and goals of the PhD

Towards a precise description of the mobility and its numerical integration in finite element modeling of recrystallization mechanisms

DIGIMU is an ANR industrial Chair handled by ARMINES MINES ParisTech and co-funded by ANR and ArcelorMittal, ASCOMETAL, AUBERT & DUVAL, CEA, Framatome 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. This Chair is a project of the DIGIMU consortium constituted by the previous cited partners along with TIMET, CONSTELLIUM and TRANSVALOR companies. Moreover this ANR industrial Chair is supported by the PNB (Nuclear Industry) and Astech (Aeronautics / Space) competitiveness clusters. DIGIMU® is also the name of the resulting software developed by the company TRANSVALOR.

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 in a static context[a] or a dynamic one[b](see Figure). 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. This aspect is today a big numerical challenge for existing full field numerical approaches but also an open question from a metallurgical point of view. These developments will be motivated, criticized and validated thanks to experimental investigations on 304L and 316L stainless steels.
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]L. Maire et al. Materials & Design, 2017, 133:498-519.

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Partners

Keywords

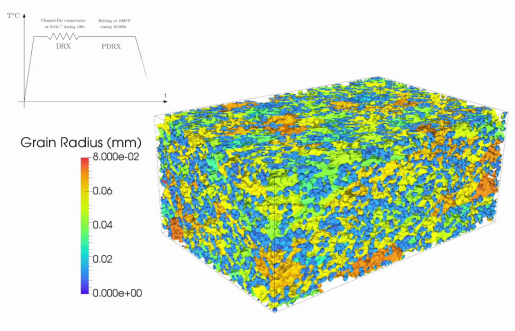
Metallurgy – Grain interface mobility – FE Method – HPC – C++.

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 N. Bozzolo.



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