PhD position

Context and goals of the PhD

Influence of grain boundary pinning on recrystallized grain size homogeneity : multiscale modelling and application to nickel based superalloys used in aeronautic industry

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 ModelIng 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.

During the last six decades, Smith-Zener pinning phenomenon has been widely studied and many different analytical models have been proposed in the literature. In this context, abnormal grain growth (AGG) is a versatile phenomenon and its prediction is extremely complex. AGG can be seen as a particular metallurgical configuration where few grains grow much faster than the mean grain growth rate, leading to a bimodal grain size distribution or eventually to a single population of very large grains. At stable subsolvus configuration, if only capillarity force is considered, this phenomenon is always driven by a kind of growing advantage for some grains comparatively to their neighbours (grain size, high anisotropy of boundary energy and/or boundary mobility) but this phenomenon can also be triggered by critical stored energy distributions. In the last case, even if AGG remains the accepted term in the literature, we should rather discuss of a particular regime of ReX. Recently, a new level-set (LS) numerical approach to consider inert second phase particles (SPP) in a FE framework has been proposed and used to perform 2D GG and static recrystallization (SRX) simulations for Inconel™ 718. Such approach seems very promising in context of AGG. Indeed, the Smith-Zener drag effect is naturally modeled by the modification of the local mean curvature when the grain boundaries pass through the particles. AGG in 2D framework, critical stored energy context and stable subsolvus configuration were also discussed thanks to this method[a]. Next steps that we will consider in the proposed work will be to deal with realistic and large 3D simulations by considering all the different metallurgical mechanims which can lead to overgrown grains. Possible evolutions of second phase particles and resulting interactions with grain interfaces in context of near-solvus static TT will be studied. Homogenization will also be considered in order to build improved mean field models.

Moreover a large piece of the proposed work will also be dedicated to experimental investigations. Firstly, large databases capitalized by the DIGIMU industrial partners concerning microstructure evolutions of Inconel™ 718 during TMT will be used to discuss the full field simulations and the proposed new main field models. Secondly, in order to validate more finely the different modeled mechanims for more prospective materials, TMT and microstructural characterizations will be realized for two other nickel-based superalloys: N19™ and AD730™.

[a] A. Agnoli et al. Metallurgical and Materials Transactions A, 46(9):4405-4421, 2015.

Mines ParisTech
CEMEF rue Claude Daunesse CS 10207
06904 Sophia Antipolis, France
marc.bernacki@mines-paristech.fr
nathalie.bozzolo@mines-paristech.fr
+33 (0)4 93 67 89 23, +33 (0)4 93 67 89 45

Partners

Keywords

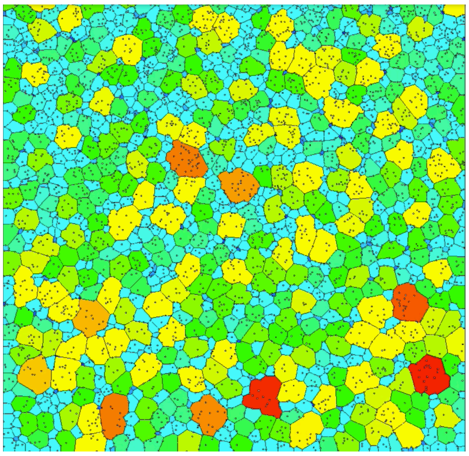
Metallurgy – Smith-Zener pinning - AGG – FE Method – HPC – C++.

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 2D full field Level Set modeling of GG for a nickel-based superalloy - DIGIMU consortium.