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

Field: Materials Science, Mechanics, Fluids

Subfield: Mechanics of Materials

Title: Phase field modeling of damage and fracture in polycrystalline materials under thermomechanical loading

ParisTech School: Arts et Métiers Sciences et Technologies

Advisors Names: Saber EL AREM, Amine Ammar
Advisors Email: saber.elarem@ensam.eu, amine.ammar@ensam.eu
Research group/Lab:LAMPA
Lab location: Angers, France
(Lab/Advisor website):http://lampa.ensam.eu/

Short description of possible research topics for a PhD:
In the present work, we are interested in the development of a model which is dedicated to the description of damage in polycrystalline metallic materials. This study aims at building a model that would describe how cracks initiate, propagate and interact with each other at the micro-scale.
To reach this objective, it is proposed to use the phase field method (PFM) within the context of polycrystalline plasticity. Indeed, within the framework of irreversible thermodynamics, the phase-field method has proved to be extremely powerful in the description of microstructural transformations without having to track the evolution of individual interfaces, as in the case of sharp interface models. In the present case, it is expected that the introduction of an order parameter associated with damage will allow for capturing some complex phenomena like crack kinking or crack branching.
The proposed study would therefore consists of:
(1) Defining an appropriate set of internal variables (and the associated energy potential) to deal with both elasticity, plasticity and damage in crystalline materials at the micro-scale
(2) Deriving the evolution equations associated with the different internal variables within the context of the phase field method
(3) Implementing the constitutive equations within an appropriate numerical solver (finite element solver for instance)
(4) Validating the proposed formulation by testing its ability to reproduce some known experimental results.
At the end of this PhD research program, the numerical model will allow for investigating the interactions between various physical mechanisms governing the macroscopic behavior (e.g. plasticity, damage) at different length scales.

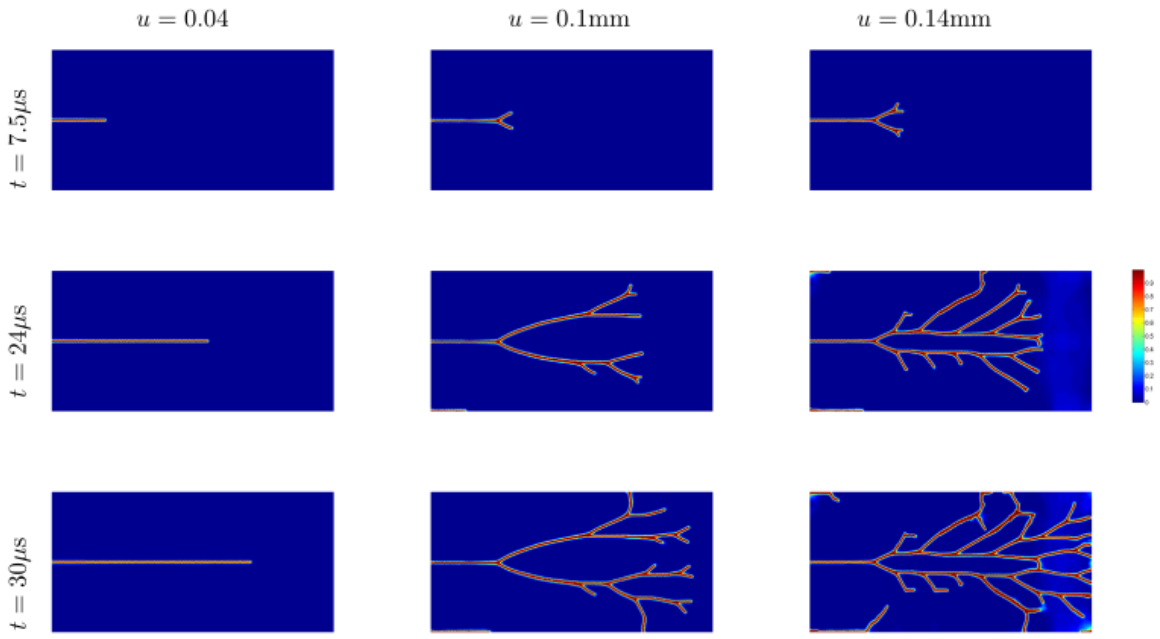

Figure 1: Notched rectangular plate under dynamic tension (Gmati 2020)

Required background of the student:
Mechanics, Physics, Applied mathematics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Gmati,H. "Phase field modelling of fracture of elastic and elastoviscoplastic solid materials", Thèse de doctorat ENSAM, 2020
2. Gmati, H, Mareau, C, Ammar, A, El Arem, S. A phase-field model for brittle fracture of anisotropic materials. *Int J Numer Methods Eng*. 2020; 121: 3362– 3381. https://doi.org/10.1002/nme.6361
3. H. Gmati C. Mareau,S. El Arem, A. Ammar. « Phase field modeling of damage and fracture inp olycristalline materials », MECAMAT, Aussois, France,2019
4. Modèle de champ de phase pour l'étude de l'endomagement et la rupture dans les matériaux cristallins », Colloque national MECAMAT, Aussois, France, 2018