Postdoctoral position at MSSMat, CentraleSupélec, (CNRS, Université Paris-Saclay), France

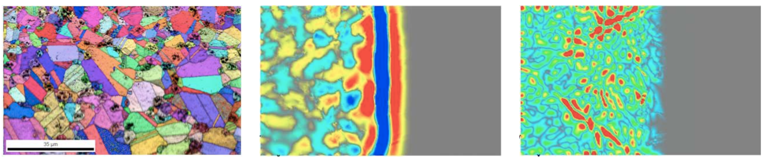
3D numerical modeling of ultrasonic wave propagation during heat treating of superalloys

Description of MSSMat Laboratory

The research scope of MSSMat[1] ranges from mechanical experiments to theoretical and numerical modelings of the mechanical behavior of structures and materials at various scales. The scientific policy of the laboratory aims at a proper balance between fundamental innovative developments and effective, robust and solidly founded answers to practical industrial problems within complex societal issues. One of two permanent teams, called "Digital Science and Engineering (DSE) team" and involving about ten researchers, is devoted to modeling and numerical simulation. Its strengths hinge on two points: putting forward appropriate models for specific mechanical media and developing well-suited, efficient and innovative numerical methods. To reach these challenging goals, MSSMat fully takes advantage of the CentraleSupélec and ENS Paris-Saclay's Moulon Mesocentre[2] environments and keeps on promoting High Performance Computing (HPC).

Context

The postdoctoral position is part of a LaSIPS project named ModUS3D funded by Labex LaSIPS[3], which is the continuation of the research works that have been developed at MSSMat for several years on the numerical modeling of ultrasonic wave propagation in polycrystalline materials.
The motivation for the project ModUS3D is found in ultrasonic testing (UT), a nondestructive testing technique widely used in the industry to inspect critical structural components, such as some superalloy parts of aircraft engines. The UT is also much used to characterize polycrystalline microstructures and the laser-ultrasonics, a recently developed non-contact UT technique, enables the in-situ monitoring of microstructural evolution during thermomechanical processes. The principle of the UT is based on the fact that, when propagating, ultrasonic waves are constantly attenuated and scattered by the polycrystalline microstructure. The success of the UT therefore depends on a good understanding and a precise modeling of the correlation between the recorded data (attenuation level, scattered noises, etc.) and the polycrystalline microstructure, which still remain an open research problem. It is believed that numerical modeling should be a powerful tool to go further with the access of more real and complex polycrystalline microstructures and the improvement of the understanding of their interactions with ultrasonic waves.



Example of numerical simulation of ultrasonic wave propagation in a real polycrystal
EBSD map/quasi-L wave propagation/quasi-S wave propagation

Missions

Based on the theoretical and numerical tools developed by former research works (two PhD theses[4,5] and one ANR project[6]), the project aims to develop an efficient approach combining numerical simulation and observation means to model ultrasonic wave propagation with taking into account both realistic 3D microstructural evolution and macroscopic effects of geometry change of tested samples.
The present postdoctoral position is mainly dedicated to the development of a 3D solver of ultrasonic wave propagation in polycrystalline materials in the C++ object-oriented finite elements code OOFE developed at MSSMat, and to its application to investigate realistic 3D microstructures.

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[1] http://www.centralesupelec.fr/en/soil-structures-and-materials-mechanics-laboratory-mssmat-umr-cnrs-8579

[2] http://mesocentre.centralesupelec.fr/

[3] https://www.universite-paris-saclay.fr/en/research/project/labex-lasips-laboratoire-systemes-et-ingenierie-de-paris-saclay-paris-saclay

[4] https://tel.archives-ouvertes.fr/tel-01483701

[5] https://doi.org/10.1016/j.ultras.2018.02.008

[6] https://doi.org/10.1016/j.cma.2018.04.018

- The first step will be the development of a numerical tool to generate 3D polycrystalline structures by coupling an open source software (such as Neper or Dream 3D) and the code OOFE. Then, the explicit parallel wave solver, which is based on the discontinuous Galerkin method, will be used at first to solve several 3D idealized microstructures, for which theoretical predictions exist, with a view of its validation. The HPC aspects are one of the key points at this step, because of the very large size of considered numerical models.
- Afterwards and successively in 2D and in 3D, other types of metallographic microstructures will be simulated to take into account some representative situations, especially the realist ones validated or the real ones defined by EBSD-SEM data. This should bring insight into the correlation between the attenuation and scattered noises levels and polycrystals' morphological and crystallographic textures and further the understanding of ultrasonic grain-scattering mechanisms, compared to the results already achieved in our previous works.
- Finally, the 3D ultrasonic wave solver will be coupled with the dynamic recrystallization code CA_ReX developed at ICMMO[7], which is able to generate realistic microstructure evolution during a heat treating.

Duration: 12 months

Location: MSSMat, CentraleSupélec, 3 rue Joliot-Curie, 91190 Gif-sur-Yvette, France

Beginning of contract: The position is available from January 2019 or as soon as possible hereafter

Permanent researchers in the project team: B. Tie (CR CNRS, HDR, MSSMat), D. Solas (MCF, ICMMO), A.-S. Mouronval (IR, MSSMat), J.-H. Schmitt (Pr., MSSMat), D. Aubry (Pr., MSSMat).

Educational qualifications/Required skills:
Candidates should have a recent PhD degree (obtained preferably after January 2017) in Computational Mechanics, Material Science, Applied Mathematics or a related field, and have a strong background of finite element methods, wave propagation in solid media. Skills in C++ and parallel programming (MPI) will be appreciated.

Application and Contact:
Applications (in French or English) should consist of a cover letter describing how your experience and background meet the requirements for this position, a current and detailed CV, a list of publications, and at least two reference letters, and should be sent to Bing Tie (bing.tie@centralesupelec.fr).

[7] https://www.icmmo.u-psud.fr/en/