PhD Proposal 2017

School: CentraleSupélec	
Laboratory: MSSMat	**Web site: www.mssmat.ecp.fr**
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Collaboration with other partner during this PhD: **In France:**	**In China:**

Title: Numerical modeling of recrystallization kinetics by use of ultrasonic waves
Scientific field: Computational Mechanics, Materials Science, Metallurgy
Key words: Recrystallization, Finite Element Modeling, Elastic wave propagation

Details for the subject:

Background, Context:

Ultrasonic waves have long been used as non-destructive tools to investigate the internal integrity of metallic parts. They are also an indirect means to follow the microstructure evolutions, e.g. the recrystallization kinetics, during thermal and thermomechanical processes. Indeed, when propagating, ultrasonic waves interact with the microstructure of polycrystalline materials at the very local scale and are constantly attenuated and scattered. The attenuation level, the scattered noise signals and the wave velocity strongly depend on the spatial variations of elastic moduli and on the presence of microstructural barriers such as grain or phase boundaries. It is thus possible to record the recrystallization kinetics by using ultrasonic testing as the wave propagation is affected by the dislocation density and the grain growth, so by the evolution of the morphologic and crystallographic texture.

However, despite of extensive research, precise modeling of the correlation between ultrasonic wave propagation and polycrystalline microstructures still remains an open research problem, except for some idealized and averaged microstructures. Therefore it is believed that numerical modeling should be a powerful alternative to access more real and complexe polycrystalline microstructures and to improve the understanding of their interactions with ultrasonic waves.

Research subject, work plan:

The research project deals with the modeling of the recrystallization kinetics by use of ultrasonic waves. Based on the theoretical and numerical tools developed during two former PhD works, the present research will be focused on the coupling between a wave propagation model and an evolving polycrystalline model; this will allow to simulate and to measure the effects of microstructural evolution as grain growth or crystallographic texture changes on the propagation of ultrasonic waves. The numerical modeling is based on the finite element transient analysis. Simplified or real polycrystalline structures will be provided through metallographic studies and EBSD-SEM analyses. The objective is to obtain efficient and robust approaches to identify, during a metallurgical process as recrystallization or grain growth, the pertinent information to extract from the recorded ultrasonic signals that are related to the microstructural parameters to be predicted.

After a bibliographic survey, the first step will be to adapt the existing theoretical and numerical tools to the specific problem to be studied. A polycrystalline texture with an evolving bimodal grain size distribution will be at first modeled. The simulation will give complete wave characteristics and evolutions with time. A precise analysis of the signal will then be performed and linked to some microstructure parameters; the final goal is to define a few mechanical parameters accounting for metallurgical evolutions. Then, other types of metallographic microstructures will be simulated in order to take into account some representative situations, especially real metallographic microstructures defined by EBSD-SEM data. Finally, the simulation results will be compared with experimental data obtained by a partner team of the University of British Columbia carrying out experiments on a Gleeble system coupled with a laser ultrasonic transmitter, which is a non-contact testing technique allowing *in situ* experiments at high temperature or within a specific environment. As the shape and the dimensions of tested specimens can greatly influence the propagation of ultrasonic waves, their effects will also be taken into account. The scientific collaboration on the dynamic recrystallization with a team of University of Paris-Sud will also be continued within this research project.

References:

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