Laboratoire Interdisciplinaire Carnot de Bourgogne | icb

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PHYSIQUE
CHIMIE
INGÉNIERIE

PHOTONIQUE - NANOSCIENCES - TECHNOLOGIES QUANTIQUES
SCIENCES DES MATÉRIAUX ET CARACTÉRISATION

PhD offer (M/F)

Numerical Study of the Effect of Pulsed Currents in SPS Sintering on Contaminants at Prior Particle Boundaries (PPBs)

The project focuses on the use of powder metallurgy to produce high-performance materials through Spark Plasma Sintering (SPS). This process is based on the simultaneous application of high pressure and an electric current through a graphite die containing the powdered material. It enables very high heating rates, leading to rapid densification. Prior to the flash sintering process, the powder consists of numerous individual particles whose surfaces may be covered with native oxides or carbides. After sintering, this results in the formation of prior particle boundaries (PPBs), which mark the former contact areas between particles before sintering through the presence of inclusions.

These inclusions at PPBs can hinder diffusion and bonding between particles. As a consequence, they adversely affect mechanical properties and fatigue resistance, both of which are critical for the aerospace industry. Understanding and controlling PPBs is therefore essential to optimize the properties of the synthesized materials. The use of pulsed electric currents could be a potential solution to eliminate PPBs during the SPS process. However, the state of the art shows that the effectiveness of pulsed currents depends on the selected material as well as on the characteristics of the applied current (amplitude, pulse frequency, etc.), and the mechanisms involved in the reduction of PPBs remain poorly understood.

The PhD candidate will conduct a numerical study on the influence of pulsed or continuous currents on PPBs during flash sintering. Finite Element modeling using the Abaqus software and a multiphysics framework will be employed to quantify the processes occurring during sintering (temperature and current fields, resulting stresses, etc.). These fields will then be used as input conditions for Molecular Dynamics simulations in order to observe in situ atomic-scale mechanisms such as decohesion, accelerated diffusion, and interfacial responses under rapid thermal cycling. In parallel with the numerical approaches carried out at the ICB laboratory, partners of the ANR Consortium (CIRIMAT, Institut PPrime, Sintermat, and SafranTech) will conduct experimental work, including instrumented sintering cycles, microstructural and mechanical characterizations, industrial-scale transfer, and the fabrication and characterization of real components.

Context: The PhD thesis will be carried out at the Interdisciplinary Carnot Laboratory of Burgundy (ICB, UMR 6303, Université Bourgogne Europe), under the supervision of Professors Jean-Philippe Chateau-Cornu and Olivier Politano (UBE), with co-supervision by Dr. Mostapha Ariane (Sintermat).The project is funded by the French National Research Agency (ANR) through the ePulse2 project (https://anr.fr/Projet-ANR-25-CE08-0397), which focuses on two aeronautical materials exhibiting carbides and/or oxides at prior particle boundaries (PPBs).

Expected Skills:

1. The candidate will have a strong background in numerical–physical modeling in the field of materials science.

2. Solid knowledge in at least one of the following areas is required: physics or materials science, thermodynamics.

3. The candidate must have strong foundations in scientific computing, preferably with experience in molecular dynamics and/or finite element methods (Abaqus, Comsol, etc.).

4. Proficiency in at least one programming languages is required (Python, fortran, Matlab, C, C++).

To apply: Applications must be submitted via the CNRS job portal
https://emploi.cnrs.fr/Offres/Doctorant/UMR6303-OLIPOL-006/Default.aspx