Position Description

1. General Information

Name of the position	**Fatigue behavior of architectured materials obtained by additive manufacturing**
Foreseen date of enrolment	1 October 2023
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • École Nationale Supérieure D'Arts et Métiers (ENSAM) • The University of Sydney (USYD)
Research Host	École Nationale Supérieure D'Arts et Métiers
PhD awarding institutions	École Nationale Supérieure D'Arts et Métiers & The University of Sydney
Locations	Primary: Bordeaux-Talence, France Secondary: Sydney, Australia
Supervisors	Prof. Nicolas SAINTIER (ENSAM) Prof. Gwénaëlle Proust (USYD)
Group of discipline	Mechanics, Materials

2. Research topics (only one of these projects will be funded)

Project 1: *Effect of cell morphology and microstructure on the mechanical behaviour of architectured materials*

The development of new additive manufacturing processes has changed the way we consider process/microstructure/properties relationships of materials. Furthermore, architectured structures obtained by additive manufacturing can be specifically designed to be used as structural components under complex fatigue loadings. The light-weighting of these structures, and their capability to dissipate energy are advantageous for the development of a new class of components.

To conceive more efficient and robust structures, it is necessary to further understand the effect of the specific microstructures induced by additive manufacturing in the particular case of architectured materials. Indeed the small dimensions of the structural elements (walls, struts) of the elementary cells of the lattices with respect to the microstructure induce some specific local anisotropy that may govern the overall behaviour of the lattice under cyclic loadings. The aim of this project is to establish the link between the process, the microstructures and the mechanical behaviour. There is a current lack of detailed understanding of the underlying damage mechanisms of architectured materials under cyclic loadings and their dependence to process parameters.

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement № 101081465

A methodology will be developed to (1) understand the microstructures of architectured materials obtained by selective laser meting (SLM) technology using different microstructure characterisation techniques such as transmission electron microscopy (TEM), scanning electron microscopy (SEM) and electron backscatter diffraction(EBSD); (2) to characterize the quasi-static and fatigue behavior of lattices structures produce by metallic additive manufacturing architectured (3) to identify the damage mechanisms at the local scale and the link with the microstructure by performing in-situ micro-computed tomography loading of the structures. The final step of this study will be to include these aspects into a modeling framework for fatigue prediction of lattices structures.
Supervisors: Prof. Nicolas SAINTIER (ENSAM) & Prof. Gwénaëlle PROUST (USYD)
Research Fields: Mechanics, Architectured materials, Additive Manufacturing, Fatigue, Metallurgy, Modeling, Microscopy & Microanalysis

Project 2: *Effect of multiaxial loadings on the mechanical behaviour of architectured materials*
The development of new additive manufacturing processes has changed the way we consider process/microstructure/properties relationships of materials. Furthermore, architectured structures obtained by additive manufacturing can be specifically designed to be used as structural components under complex fatigue loadings. The light-weighting of these structures, and their capability to dissipate energy are advantageous for the development of a new class of components. To conceive more efficient and robust structures, it is necessary to further understand the effect of the cell morphology on the cyclic behavior and in particular in the case of multiaxial loadings. Indeed the complex geometries of the elementary cells of the lattices induce some competitions between microstructures and local stress states that are rarely encounter in standard structures. The aim of this project is to propose a global strategy for the fatigue life prediction of architectured materials including multiaxiality and non local effects. A methodology will be developed to (1) develop some specific geometries for multiaxial tests on lattices structures ; (2) to process the design structures and evaluate the impact of the process on the multiscale geometrical characterisation of the lattices by the mean of microtomography and in-situ loading, (3) to characterize the mulataxial fatigue behavior of specific cell geometries and (4) to propose an adequate modeling framework for these structures under complex loadings.
Supervisors: Prof. Nicolas SAINTIER (ENSAM) & Prof. Gwénaëlle PROUST (USYD)
Research Fields: Mechanics, Architectured materials, Additive Manufacturing, Fatigue, Metallurgy, Modeling

Project 3: *Development of new post-treatment routes to improve the mechanical behaviour of architectured materials*
The development of new additive manufacturing processes has changed the way we consider process/microstructure/properties relationships of materials. Furthermore, architectured structures obtained by additive manufacturing can be specifically designed to be used as structural components under complex fatigue loadings. The light-weighting of these structures, and their capability to dissipate energy are advantageous for the development of a new class of components. To conceive more efficient and robust structures, it is necessary to further understand the effect of the specific microstructures induced by additive manufacturing in the particular case of architectured materials. Indeed the small dimensions of the structural elements (walls, struts) of the elementary cells of the lattices with respect to the microstructure induce some specific local anisotropy that may govern the overall behaviour of the lattice under cyclic loadings. The aim of this project is to optimize the microstructures obtained by additive manufacturing with respect to

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement № 101081465

the mechanical behavior (static, cyclic) of thin walled structures by optimising the post-treatment of additively manufactured metallic alloys. There is a current lack of detailed understanding of the role of microstructural length scales on the mechanical behavior of architectured materials under cyclic loadings and their dependence to post processing parameters. A methodology will be developed to (1) understand the microstructures of architectured materials obtained selective laser meting (SLM) technology using different microstructure characterisation techniques such as transmission electron microscopy (TEM), scanning electron microscopy (SEM) and electron backscatter diffraction(EBSD); (2) to develop specific post treatments such as hot isostatic pressing, heat treatment or case hardening treatments and characterize the obtained microstructures and their on cell morphologies using micro-computed tomography and (3) to evaluate the effect of the post-treatments on the static and fatigue mechanical behavior of the architectured structures.
Supervisors: Prof. Nicolas SAINTIER (ENSAM) & Prof. Gwénaëlle PROUST (USYD)
Research Fields: Mechanics, Architectured materials, Additive Manufacturing, Fatigue, Metallurgy, , Microscopy & Microanalysis

3. Employment Benefits and Conditions

The École Nationale Supérieure D'Arts et Metiers (ENSAM) offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). There is a probation period of 3 months and the total working hours per week is 35 hours.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 23,098.20. Of this amount, the estimated net salary to be perceived by the Researcher is 1,924.85. However, the definite amount to be received by the Researcher is subject to national tax legislation. The % tax cannot be defined in advance with certainty, but will be between 6 and 7% of the monthly net value described above.

Benefits include

- Access to all the necessary facilities, technical platform and laboratories at ENSAM and The University of Sydney.
- Tuition fees exemption at both PhD awarding institutions.
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events.
- 10,000 EUR allowance to cover flights and living expenses for 12 months in Australia.
- 25 days paid holiday leave.
- Sick leave.

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement № 101081465

4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

ENSAM

To be admitted in a Doctorate program, Applicants must hold a Master's degree. A security investigation will also be carried out. In case of unfavourable result, ENSAM will not proceed with the enrolment.

More information: https://artsetmetiers.fr/en/formation/doctoral-school

The University of Sydney

To apply for a PhD, you need to demonstrate sufficient prior research experience and capability and prove English language proficiency (see: https://www.sydney.edu.au/study/how-to-apply/international-students/english-language-requirements.html). In most cases, you will have either:

- a Bachelor's degree with first or upper second class Honours; or
- a Master's degree performed at a high academic standard, and which includes a substantial component of original research; or
- an equivalent qualification that demonstrates research experience, excellence and capability.

These are the minimum requirements for eligibility, but they do not guarantee admission. Admission remains at the discretion of the Associate Dean (Higher Degree by Research) for each faculty.

For more information on admission requirements, please visit the University of Sydney's Apply for postgraduate research page: https://www.sydney.edu.au/study/how-to-apply/postgraduate-research.html

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement № 101081465