Call for 2 Post-Docs

Summary of the position and institute

- Two 2-year post-doc positions
- Supervisors: Manas V. Upadhyay, Véronique Doquet and Daniel Weisz-Patrault
- Affiliation: LMS, CNRS, École Polytechnique, Institut Polytechnique de Paris
- Tentative start date: March 2025 for first post-doc and September 2025 for the second

General context

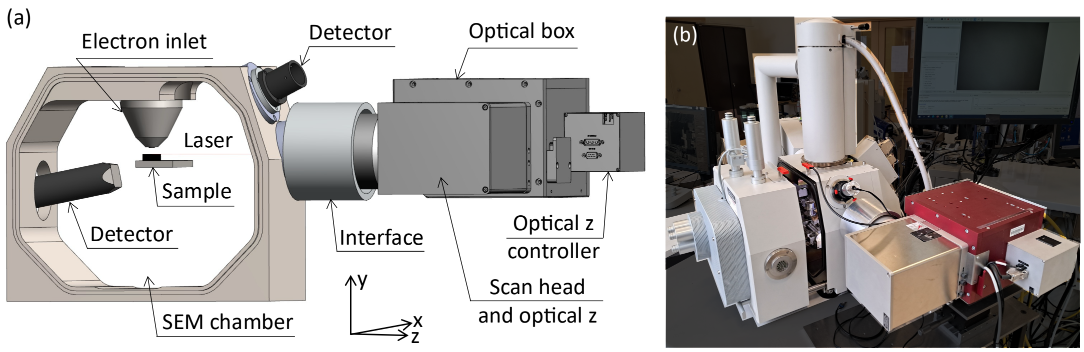

Figure 1: Novel CW laser-SEM coupling taken from [2]; illustration of the CW laser-SEM coupling (a) and image of the experimental setup (b).

Metal parts from additive manufacturing (AM) generally have high surface roughness, as well as residual tensile stresses, which adversely affect their fatigue resistance. Heat treatments and/or long and expensive polishing are then necessary to improve this resistance. The project aims to replace them with very fast, more economical and more energy efficient laser treatments.

At the LMS laboratory, we have recently developed a novel coupling between a continuous-wave laser with a scanning electron microscope (CW Laser-SEM in Figure 1) [1,2] in order to study microstructure evolution during laser scanning under highly controlled conditions and identify the micromechanisms occurring during heat-matter interactions. In one of the first studies conducted with this device, experiments were performed to validate a coupled computational fluid dynamics and phase-field model to study grain structure formation in 316L stainless steel [3] as well as an elasto-viscoplastic model [4] to study intergranular stress and plastic deformation formation due to lasering.

Following this successful experiment-modelling synergistic campaign, laser scanning experiments were performed on AM 316L stainless steel with the aim to alter and improve the mechanical response (strength-ductility tradeoff and fatigue limit; the latter is shown in Figure 2) [2]. This study revealed that high-speed surface treatment using a laser of small spot size (inside SEM) makes it possible to increase the fatigue limit by 25% [2]. This beneficial effect has been attributed to a reduction in surface roughness and a strong refinement of the intragranular microstructure (dislocation cells and chemical micro-segregation cells), which was accompanied by an increase in the elastic limit, without any loss of ductility. This approach has very recently also been applied to improve the mechanical properties of the Ti-based alloys.

References:

[1] Patent (under evaluation): A. Tanguy, M. V. Upadhyay, J. G. Santos Macías, "System to treat samples using a continuous-wave laser and characterize them using an SEM". Submission date: 16 Dec 2022

[2] J. G. Santos Macías, A. Tanguy, K. Chen, L. Cornet, M. Vallet, M. V. Upadhyay. "Post-process lasering improves strength-ductility tradeoff and fatigue limit of additively manufactured stainless steels." Preprint: https://hal.science/hal-04530203

[3] A. F. Chadwick, J. G. Santos Macías, A. Samaei, G. J. Wagner, M. V. Upadhyay, P. W. Voorhees. "On microstructure development during laser melting and resolidification: An experimentally validated simulation study", *Acta Materialia* 282 (2025) 120482 https://doi.org/10.1016/j.actamat.2024.120482

[4] N. Mohanan, J. G. Santos Macías, J. Bleyer, T. Helfer, M. V. Upadhyay. "Intergranular stress and plastic strain formation during laser scanning of additively manufactured stainless steel: An experimentally-driven thermomechanical simulation study", *Materialia* 34 (2024) 102082 https://doi.org/10.1016/j.mtla.2024.102082

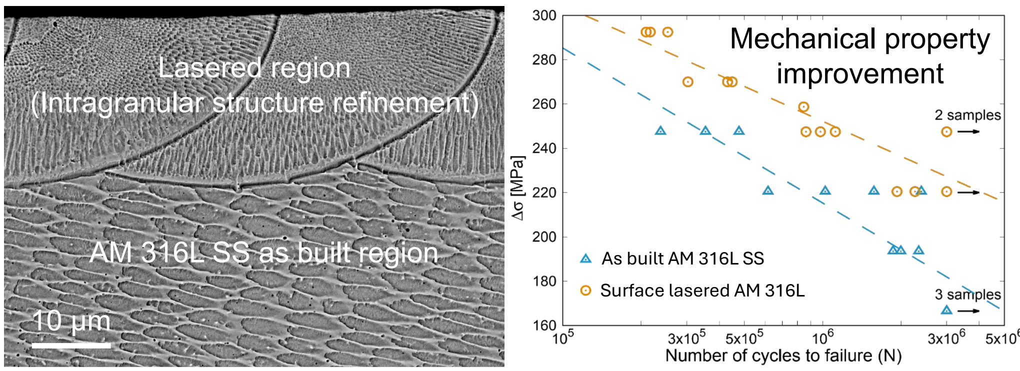

Figure 2: Graphical abstract of [2] showing improvement of fatigue limit after laser scanning.

Project and tasks

These studies and the novel CW Laser-SEM device have paved the way to study the precise role of microstructural features on the tensile, fatigue and wear properties and a thorough understanding of the process-microstructure-properties relationship are still open questions. Answering these questions is crucial to engineer alloys with desired material properties.

First, the protocol for studying the effects of micro-lasing on fatigue resistance must be improved, via the direct printing of cylindrical specimens (instead of walls) and their laser treatment in a single phase, the sample being rotated around its axis (instead of the consecutive treatment of each face, which introduces an asymmetry of their residual stress state). Technical developments are already in progress at LMS to allow such treatment inside the SEM.

Using this modified device, the recruited post-docs will optimize the laser treatment for stainless steels and Ti-based alloys, and thus fully clarify the effect of the process parameters on the microstructures formed on the surface, the residual stress state, the tensile behavior, the mechanisms of fatigue damage or wear, and their consequences in terms of durability.

Candidate profiles

- A Ph.D. in Mechanical Engineering, Materials Science and Engineering or equivalent obtained after January 2024. Interested candidates graduating before January 1, 2025 can also apply.
- Proven skills and experience in mechanical testing (at least tension and fatigue) and microstructural characterization techniques (SEM, EBSD, EDS, XRD…) acquired during a Ph.D.
- Very good communication (oral and written) skills in English. Applicants from non-English speaking countries should provide factual information on their proficiency in English.

Interested candidates please send an email to the address below with

- 1-page motivational letter
- Up-to-date and detailed CV
- Contact information of at least 2 referees willing to provide recommendation letters on your behalf

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