ParisTech

Arts et Métiers Sciences et Technologies

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Materials Science, Mechanics, Fluids

Subfield: Materials Science and Manufacturing

Title: Effect of process parameters on the functional capability of High Temperature Shape Memory Alloys fabricated by laser additive manufacturing

ParisTech School: Arts et Métiers

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Research group/Lab: MSMP - Mechanics Surfaces and Materials Processing
Lab location: Châlons-en-Champagne, France
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Short description of possible research topics for a PhD:

Shape memory alloys (SMAs) are one class of materials exhibiting functional properties, which can return to a predetermined shape when heated. During the two last decades, intensive research has been carried out to enhance their properties at high temperature (above 100°C), thus trying to fill industrial need for applications of shape memory alloys at higher temperatures. In recent years, NiTi-based high temperature shape memory alloys (HTSMAs) have been introduced via substitution of Ni or Ti by a third element such as Hf, Zr, Pt, Pd, and Au. However, the commercialization of HTSMAs struggles as they suffer from either high elemental costs, limited workability, poor shape-recovery performance or brittleness. Recently, laser additive manufacturing (LAM) technologies, including powder feeding or powder bed, have been considered as one possible near net-shaped process to overcome these shortages.

In this project, the multi-scaled characterization methods, such as, 3D tomography, optic and electron microscopies will be employed for analysis of the densification behavior, microstructure, thermal and mechanical properties of laser additive manufactured NiTiHf HTSMAs. Nickel loss and oxygen pick up after SLM processing have been reported, which might be due to the associated high-power laser melting. This PhD program aims at optimizing the microstructure and laser power. Since the connection between manufacturing process control parameters and actual functional capability is of paramount importance, the understanding of the operational variables needs to be improved. Full-field methods (Phase-field and Level-set) will be developed to address the issue concerning the effect of process parameters on the final performance of a manufactured HTSMAs part.

Required background of the student:

The PhD candidate must have a solid knowledge of metal manufacturing process, in particular laser additive manufacturing, Materials Science, Metallurgy and Characterization methods (SEM, MET, XRD). Besides, numerical skills (Python) and good understanding of finite element methods are required.

A list of 5 (max.) representative publications of the group:

[1] N. Kang, X. Lin, M. El Mansori, Q.Z. Wang, J.L. Lu, C. Coddet, W.D. Huang, Additive Manufacturing 31 (2020) 100911.
[2] Kang, N., El Mansori, M. (2020) Tribology International, 149.
[3] Kang, N., Lu, J.L., Li, Q.G., Cao, Y.N., Lin, X., Wang, L.L., Huang, W.D., El Mansori, M. (2020) Vacuum, 179, art. no. 109557.
[4] Kang, N., Lin, X., Mansori, M.E., Wang, Q.Z., Lu, J.L., Coddet, C., Huang, W.D., (2020) Additive Manufacturing, 31, art. no. 100911.
[5] Kang, N., El Mansori, M., Lu, J.L., Lin, X., Huang, W.D. (2019) Wear, 426-427, pp. 934-941.