LMS Seminar

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Operando synchrotron Laser Powder bed Fusion (LPBF) for the development of in-situ monitoring techniques and understanding of microstructural phenomena

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ABSTRACT

Laser Powder-Bed Fusion (LPBF) is a dominant Additive Manufacturing (AM) technology. LPBF enables the production of complex geometries with short lead-time and low material wastage. Despite its versatility, the production of defect-free parts still remains a big challenge. During LPBF, thermo-mechanical melting regime instabilities bring about complex melt flow dynamics and formation of stochastic by-products (e.g. condensates, spatters) which result in emergence of stochastic defects even under optimized processing window. Furthermore, the often-narrow process window impairs a fine control and optimization of the microstructure and defect content at the same time.

As for remedies, we present advanced in-situ monitoring techniques such as heterogenous sensing (using acoustic emission (AE), optical sensors, etc.) trained through operando investigation of the laser-material interaction zone via high speed X-ray imaging. We have detected unambiguously the corresponding AE signature of melting regime instabilities. The stochastic regime instabilities (alternations between conduction and keyhole regimes) were provoked through carefully designed experiments and their corresponding AE signature were recorded in synchronization with the X-ray imaging. Consequently, defect healing methods were utilized to re-melt defect-concerning regions resulting in the removal of keyhole porosity in 316L stainless steel.

Additionally, in-house in-situ laser heat treatment techniques were developed and employed to modify microstructure of the LPBF parts at will. Investigations concerning Martensite decomposition in Ti6Al4V and recrystallization in 316L stainless steel, operando, at different high-energy X-ray diffraction beamlines. X-ray imaging hand-in-hand with numerical simulations of the laser heat treatment process provided a deeper understanding on the kinetics of these microstructural changes and enabled an improved heat treatment approach through control of temperature and cooling rates.

BIOGRAPHY

Dr. Milad Hamidi Nasab received his PhD with honor on February 2020 from Department of Mechanics at Politecnico di Milano on Additive Manufacturing (AM) of Metals. During his PhD, he worked on the laser-material interaction and the stochastic nature of the Laser Powder Bed Fusion (LPBF) process for a wide range of metallic materials. He did research on the surface integrity of the LPBF parts and the corresponding cyclic mechanical behavior. He has done 2 years of post-doctoral period at EPFL-LMTM laboratory working on different topics such as: microstructural design via incorporation of laser beam shaping into the LPBF process; incorporation of in-situ resource utilization and additive manufacturing for future deep space exploration; application of large-scale synchrotron facilities in AM of metals for development of advanced in-situ monitoring techniques and understanding of microstructural phenomena. He has concluded multiple self-acquired international projects in the domain of AM of metals.