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Supervisor Expression of Interest
MSCA-IF Marie Sklodowska Curie Action-Individual Fellowship 2019

Supervisor name:	Prof. Stefano Beretta
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Department Name: Research topic: (https://www.polimi.it/en/scientific-research/research-at-the-politecnico/departments/)	Mechanical Engineering Homogeneized properties of 3D printed cellular metamaterials and their application to component design
MSCA-IF Research Area Panels	☐ CHE_Chemistry ☐ ECO_Economic Sciences **X** ENG_Information Science and Engineering ☐ ENV_Environmental and Geosciences ☐ LIF_Life Sciences ☐ MAT_Mathematics ☐ PHY_Physics ☐ SOC_Social Sciences and Humanities
Politecnico di Milano Areas:	☐ Cultural Heritage ☐ Smart Cities ☐ Territorial Fragilities ☐ Health **X** Industry 4.0
Brief description of the Department and Research Group (including URL if applicable):	The Department of Mechanical Engineering is very active in the area of additive manufacturing with a lab (AddMe.Lab: www.addmelab.polimi.it) devoted to metal additive. The research activity will be hosted at interdepartmental laboratory METAMAT-Lab of Politecnico di Milano, located at the Department of Mechanical Eng., collecting the expertise of 5 different departments (Mechanical, Mathematics, Electronics, Energy, Design). The topic of this thesis proposal is fully aligned with the research lines of the lab. The Ph.D. student will benefit of the synergic environment of the METAMAT-Lab as well as of the laboratory equipment to experimentally validate the implemented models through a

	series of special experiments combining CT scans, DIC measurements and FE analysis. https://www.polimi.it/ricerca-scientifica/la-ricerca-al-politecnico/laboratori/laboratori-interdipartimentali/metamat-lab/ The research will be centered in the area of the mechanical behavior of materials and its application to design and assessment, which is the research topic of the supervisor within the research area Machine and Vehicle Design. https://www.mecc.polimi.it/us/research/research-lines/machine-and-vehicle-design/

Brief project description: **(max 1 page)**	The combination of different properties represents the front-end of the development and the application of different metamaterials (micro-lattices, stacked rods, bio-inspired trabecular structures) obtained with Additive Manufacturing (AM) techniques. In particular emerging areas for the application of periodic cellular structures are: i) the design of heat exchangers and industrial reactors, where the great surface per unit volume enhances the capacity to transmit heat to a gas/liquid flow; b) the ability to absorb shocks and deformations thanks to an appropriate gradient of density/stiffness or a new design of folding elements; c) the design of lightweight components through the adoption of different material densities within the same component. The literature shows a great variety of materials consistent of periodic cellular structures (that according to the load transfer mechanisms could be divided into 'stretch' or 'bending dominated') essentially characterized by computational models based on ideal geometries. However, from the mechanical point of view the structural properties (static and fatigue loads) appear far from the computed values because the effects due to the real 3D printed geometry of the micro-cells (surface roughness, micro-notches, geometrical imperfections). At the same time, those features (essentially related to the real surface of the 3D cellular structure) appear able to improve the computed bulk thermal properties and fluid permeation. The aim of the research is to combine experimental techniques and computational models to optimize the properties of different periodic cellular structures and their application to improved design of components. The research will be firstly devoted to: i) characterization of the microgeometry of different types of cells through X-CT; ii) realistic computational models based on the reconstructed geometry; iii) determination of the real physical and mechanical properties determined on 3D printed samples. The

	obtained properties will then be transferred to homogeneized CAD and FE tools. The optimal topology design of components is based on the determination of the optimal distribution in space of a nonhomogeneous metamaterial. The second phase of the research will be devoted to improve the 'local' properties of the cells by: i) the set-up of chemical and thermal treatments techniques able to smoothen the asperities and remove the unmelted powders; ii) the optimization of the cell mechanical properties by applying topology optimization techniques which involves optimizing a unit cell layout subject to several objective functions (in terms of properties of the unit cells) and design constraints related to the AM process.