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Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2022

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Department Name:	Mechanical Engineering
Research topic:	Solid state powder deposition for additive manufacturing and functional surfaces
MSCA-PF 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 **X Horizon Europe Missions** ☐ Health ☐ Industry 4.0
Brief description of the Department and Research Group (including URL if applicable):	The research group led by prof. Mario Guagliano (H-factor=41 Scopus database) belongs to the Department of Mechanical Engineering. The Group has reached an outstanding reputation in the field of kinetic mechanical treatments and surface treatments for superior mechanical properties and functional coatings. Considering cold spray process, the group has been awarded with three European Commission Collaborative Projects (2 as coordinator) in the Programs FP7 (CORSAIR), H2020 (ATLAS) and Horizon Europe EIC Pathfinder (Thermodust) and one PRIN project. The Group is formed by: Prof. Mario Guagliano, Ing. Sara Bagherifard (RTDB, H-factor 31, Scopus), Prof. Chiara Colombo (Associate Professor), Ing. Asghar Heydari Astaraee (RTDA), Ing. Erfan Maleki (PhD student), Ing. Jan Kondas (Phd student), Ing. Amir Lordejani (PhD candidate), Ing. Magesh Kumar (PhD candidate). At present, the Group is involved in many activities related to cold spray, both as regards EC and National funded projects and as regards contractual research with national and well-known international companies.

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Title	Kinetic energy for overtaking the limits of additive manufacturing (KEAM)

Brief project description:

The fast pace of technological developments is promoting a quick shift towards digitalized production systems. This fits well with the current emerging paradigm for sustainable industrial production. It also enables convenient design and manufacturing aimed at obtaining unprecedented material properties paired with geometrical complexities. Developing more efficient manufacturing systems and simultaneously prolonging the expected life of complex systems bring in new industrial challenges. These issues are to be addressed to face the main driver of the XXI century, i.e., reducing the environmental impact by reducing the toxic emissions, decreasing the CO_2 emission thus dropping the green-house effect and limiting the use of raw materials through developing sustainable products. When focused on design and manufacturing, the "additive manufacturing" (AM) processes offer ideal solutions for sustainable industrial production.

The most common AM technologies work based on thermal energy (material melting and solidification) and are characterized by high cost, low deposition rate, limited deposition area bounded to an inert environment, in addition to the subsequent issues related to material melting, including undesired thermal residual stresses, phase change, and recrystallization.

A significantly greener, low-temperature, non-combustion alternative process with an extraordinary potential to address many of the abovementioned drawbacks is the emerging kinetic (non-thermal) deposition method known as cold spray (CS). In CS, high kinetic energy is achieved through accelerating particles (10-50 μm) to supersonic velocities (300-1200 m/s) by preheated compressed gas (helium/nitrogen) passing through a convergent-divergent nozzle. CS has numerous undeniable advantages as an AM technique: much higher deposition rates (up to 15 kg/h), no need for chambers with controlled atmosphere and not strict constraint in terms of dimension of the part, ability to spray mixed materials for functional properties, no limitation in terms of sprayed metal, since the only required property is ductility, and no problems in trapping ceramics particles into the metal deposit, for multifunctional parts.

Despite these undeniable advantages, CS is still considered a surface coating technique rather than an AM process for 3D part production. This is due to three main factors: a) the need to develop an advanced approach to automatize and digitalize the process and make it a real I4.0 technology, b) the lack of standard methods for characterization of the properties of cold sprayed parts, c) the complexity of development of customized of pre/post treatments able to fully exploit the advantages of the process. While these problems have been recognized and are being faced in the USA industrial environment, it is not the same for the European Union, which remains more than one step behind.

The aim of the present proposal is to overcome the present limitations of cold spray additive manufacturing (CSAM) by developing a general digital approach to define the best deposition strategy with respect of the material of interest and the geometry of the part and its function, minimizing the post processing and finishing process. The goal will be reached by means of three main tasks: 1) definition of a digital twin of the CS process able to assess the final deposition with respect of the process parameters and the sprayed materials, 2) developing advanced characterization of the physical and mechanical properties of the sprayed deposited parts, 3) development of a demonstrator able to exhibit the unique features of CS as an AM process, leading to the final achievements that cannot be reached with any other available technology.