



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: DESIGN AND CHARACTERIZATION OF BIMODAL MATERIALS
OBTAINED WITH COLD SPRAY ADDITIVE MANUFACTURING**

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

This PhD program is intended to design and analyze the mechanical response of bimodal materials consisting of both fine grains and coarse grains. Bimodal grain size distribution in materials is known to improve the strength and elongation simultaneously, which is an effective strategy for the long-standing strength-ductility synergy. The certain proportion of coarse grains and fine grains in these materials can maintain high plasticity by taking advantage of the high work hardening rate of coarse grains, while improving strength through fine grains. The low working temperature of cold spray deposition technology offers the possibility to deposit a wide variety of materials including those that are sensitive to high temperature or to oxidation, without the challenges associated with other commonly used thermal deposition/additive manufacturing techniques that are based on melting and solidification. This characteristic offers a unique opportunity to deposit nanocrystallized materials. In this research, different methodologies will be implemented to induce bimodal grain size and bimodal texture distribution in cold spray deposits: i) using microcrystalline and nanocrystalline powder particles that will be consolidated through cold spray deposition inducing a bimodal structure while preserving the original structure of the powder particles. ii) through inhomogeneous recrystallization and grain size refinement induced by severe plastic deformation (SPD) post-processing. SPD will be implemented using mechanical



	<p>surface treatments including shot peening. Various individual and hybrid post-processing surface treatments like nitriding and plasma electrolytic oxidation (PEO) can be also implemented for inducing local hardening and chemical inhomogeneity. The project will investigate the role of bimodal structure on microstructural and mechanical response of the material and will account for the interaction of the zones with dissimilar grain structures to estimate their respective contribution to the load-bearing capacity of the integrated structure.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The research involves using various tools and techniques including ball milling, spraying sessions, sample preparation, post-processing, and multiscale finite element (FE, CP-FE) Modelling. Optical microscopy (OM), scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), transmission electron microscopy (TEM) characterization as well as micromechanical analysis will be used to assess the interaction between the zones, as well as the site specific and overall deformation behavior in the structure. The strengthening mechanisms will be identified and investigated to provide effective guidance for the design and regulation of bimodal structures.</p>
<p>Educational objectives</p>	<p>The educational aim of this project is to train an expert in solid state deposition technology, its development and characterization, with soft and hard skills able to direct research, development and innovation. The candidate will also develop knowledge and skills in coating and additive manufacturing sector in general and in the numerical and experimental analysis techniques requested for the correct and competitive design, application and characterization of various deposition techniques and surface treatments.</p>
<p>Job opportunities</p>	<p>The research work is carried out within the European Research Council (ERC)-2021-CoG research project ArchIDep (Revolutionary solid state deposition system to obtain heterogeneous materials, GA n. 101044228).</p> <p>Strong collaboration is envisioned with University of</p>



	<p>Lorraine (FR). In particular, the cooperation between POLIMI and University of Lorraine might result in a Double PhD Agreement between POLIMI and University of Lorraine, involving a 4-year Doctoral Programme with alternative periods of stay between POLIMI and University of Lorraine.</p> <p>Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared to Master of Science holders in the same field.</p>
Composition of the research group	<p>1 Full Professors 1 Associated Professors 2 Assistant Professors 5 PhD Students</p>
Name of the research directors	Prof. Sara Bagherifard

Contacts
<p><i>Email:</i> sara.bagherifard@polimi.it <i>Phone:</i> 02-23998252</p> <p>For questions about scholarship/support please contact phd-dmec@polimi.it.</p>

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707,13.</p> <p>Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor.</p>



An increase in the scholarship will be applied for periods up to 6 months (approx. 700 euro/month- net amount).

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.