



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 38th cycle

Research Area n. 3 - Engineering Design and Manufacturing for the Industry of the Future

Number of scholarship offered	8
Department	DIPARTIMENTO DI MECCANICA

Description of the Research Area

Industrial production in Europe accounts for the 16% of the European GDP and is a keydriver for innovation, productivity and job creation. As stated in the 2014-15 road map of the PPP Factory of the Future "future factory will be clean, highly performing, environmentally friendly and socially sustainable". This research area focuses on improving the performance of the industry of the future through the innovative application of technologies, processes and methods to the design and manufacturing of industrial products. The entire life cycle of the product is considered and in particular:

- R&D&I activities for product and process innovation
- product ideation and development
- manufacturing process investigation, optimisation, planning and control
- manufacturing system design and planning
- product service and disposal

Hence, all the activities required to transform ideas into final products making use of zero defect, affordable, personalised, and eco-efficient manufacturing processes are integrated and investigated within the context of a highly competitive and globalized world from prototyping to mass production. PhD candidates working in this area will be involved in research activities that address the above targets through projects possibly involving other universities and research institutes, as well as Italian and international companies interested in the same topics.

There are 8 available scholarships in this area:

- 1 generic
- 7 thematic (to be specifically selected during application procedure)



One generic scholarship referring to the following field:

- Methods and Tools to Develop New Products for the Industry 4.0

7 thematic scholarships, on the following topics:

- Advanced, smart and sustainable manufacturing (three scholarships)
- Development of advanced monitoring systems (two scholarships)
- Solid state metal powder deposition for new additive design solutions
- Novel temporal and spatial laser beam shaping approaches for defect-free, flexible, and automatized welding

Applicants should select thematic scholarships following the instructions provided in the call for application/application procedure.

The PhD scholarships available in this area are partially funded with the support of the Italian Ministry of Education, University and Research, through the project Department of Excellence LIS4.0 (Integrated Laboratory for Lightweight e Smart Structures).



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THEMATIC Research Field: ADVANCED, SMART, AND SUSTAINABLE MANUFACTURING

Monthly net income of PhDscholarship (max 36 months)

€ 1325.0

In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Research, during the three-year period, the amount could be modified.

Context of the research activity

Motivation and objectives of the research in this field

The fourth industrial revolution (namely Industry 4.0) and European starting plans (Horizon and NextGenerationEU), with their strategic orientations for EU research and innovation, calls for accelerating the twin (i.e., green and digital) transition. A paradigm shift to address various challenges including digital production, big data analysis and artificial intelligence, global production sustainability and circular economy, climate changes and smart cities is required. In this framework, advanced, smart, and sustainable manufacturing processes and systems act as key enabling technologies for providing high-precision, high-value, and high-performance custom-designed components at minimum waste. The research activity carried out with this scholarship can specifically focus on one or more subtopics within these main research frameworks:

- *Advanced manufacturing processes:* Among others, additive manufacturing for metals, ceramics, and polymers, micromachining, laser, and waterjet-based technologies are the available technological platform where production digitalisation and self-consciousness can be pursued. Research at this level can concern new process development as well as innovative hybrid solutions conception.
- *Smart process monitoring, inspection, and*



	<p><i>control</i>: Smart solutions for sensing and inspection and innovative strategies for intelligent data fusion, big data analysis, quality process monitoring, control and inspection are key factors to achieve sustainable zero-defect manufacturing.</p> <ul style="list-style-type: none"> • <i>Advanced manufacturing systems</i>: Innovative solutions for configuring and managing manufacturing and de-manufacturing systems are eventually needed to drive the whole production system toward smart, high-performance, and sustainable solutions.
Methods and techniques that will be developed and used to carry out the research	Rigorous experimental methods, physical models, and numerical simulations will be combined to design, implement, and validate the innovative solutions proposed. Team-working will be stimulated with the aim of providing appropriate solutions to actual challenges, which require multidisciplinary skills.
Educational objectives	Doctoral candidates will acquire competences on design, optimisation, and sensing/controlling of new advanced manufacturing processes and systems.
Job opportunities	<p>Italy and Lombardy Region have leading positions in manufacturing worldwide. 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> <ul style="list-style-type: none"> - MIT - Massachusetts Institute of Technology - TUM - Technical University of Munich - ESA - European Space Agency - Shanghai Jiao Tong University - Georgia Tech University - MUSP Lab, www.musp.it - STIIMA-CNR, www.stiima.cnr.it - ATV S.p.A. - Ansaldo Energia S.p.A. - Avio Aero - BLM Group - GE Avio s.r.l.



	<ul style="list-style-type: none"> - GF Machining Solution - Leonardo Agusta Westland S.p.A. - Lima Corporate - Marposs S.p.A. - Prima Industrie S.p.A. - Tenova S.p.A.
Composition of the research group	7 Full Professors 7 Associated Professors 9 Assistant Professors 30 PhD Students
Name of the research directors	Proff. Colosimo, Matta, Monno, Moroni, Previtali, Tolio

Contacts
phd-dmec@polimi.it

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	662.5 €
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) of a total amount of 5401,42 euro.</p> <p>Accommodation in Politecnico's Residences (http://www.residenze.polimi.it) is available for PhD candidates; special rates will be applied to selected out-of-town candidates (detailed info in the call for application). 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. An increase in the scholarship will be applied for periods up to 6 months (approx. 550 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.</p>



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Research Area n. 3 - Engineering Design and Manufacturing for the Industry of the Future

THEMATIC Research Field: DEVELOPMENT OF ADVANCED MONITORING SYSTEMS

Monthly net income of PhDscholarship (max 36 months)	
€ 1325.0	
In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Research, during the three-year period, the amount could be modified.	
Context of the research activity	
Motivation and objectives of the research in this field	Continuous monitoring of the environmental or process parameters is essential in many situations to warrant the safety of people, quality of products or to provide information for policy makers. Development of new measurement systems, implementation of data collection and processing techniques for autonomous measurements correction and validation, are key factors to advance the monitoring systems.
Methods and techniques that will be developed and used to carry out the research	The development of new measurement systems requires the capability of modelling the full systems from a structural, thermal and dynamic point of view and of optimizing the systems from the point of view of the measurements quality. Moreover, the implementation of experimental set-up for modelling validation and for the assessment of the metrological performances of instruments is a key tool for system development.
Educational objectives	The candidate will eventually fully master the modelling tools and methods required for the analysis of the measuring systems. Applications for different fields, from space to industrial environment will be considered. Capability of designing test set-ups and test procedures, developing of data processing techniques for measurements validation and uncertainty reduction will be among the developed skills.



Job opportunities	The skills developed are of interest for the manufacturers of measurement instruments and for any R&D department developing intelligent systems and/or performing experimental activity such as ESA-ESTEC, INAF-IAPS, CNR-IIA, Leonardo Company, SITAEI. 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.
Composition of the research group	3 Full Professors 6 Associated Professors 1 Assistant Professors 15 PhD Students
Name of the research directors	Prof. Bortolino Saggin

Contacts	
Names of the research directors: Prof. Alfredo Cigada, Prof. Paolo Chiariotti, Prof. Stefano Manzoni, Prof. Paola Saccomandi, Prof. Bortolino Saggin, Prof. Diego Scaccabarozzi, Prof. Marco Tarabini, Prof. Emanuele Zappa.	
Contacts:	
Prof. Bortolino Saggin	
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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	662.5 €
By number of months	0

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
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 5401, 42.

Accommodation in Politecnico's Residences (<http://www.residenze.polimi.it>) is available for PhD candidates; special rates will be applied to selected out-of-town candidates (detailed info in the call for application).

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. An increase in the scholarship will be applied for periods up to 6 months (approx. 660 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.



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Research Area n. 3 - Engineering Design and Manufacturing for the Industry of the Future

OPEN SUBJECT Research Field: METHODS AND TOOLS TO DEVELOP NEW PRODUCTS IN
INDUSTRY 4.0 CONTEXT

Monthly net income of PhDscholarship (max 36 months)	
<p style="text-align: center;">€ 1325.0</p> <p>In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Research, during the three-year period, the amount could be modified.</p>	
Context of the research activity	
Motivation and objectives of the research in this field	<p>The Industry 4.0 revolution does not only concern manufacturing but directly involves product development activities. This research field concerns the methods and tools providing systematic support to product development from idea generation to concept verification, embodiment, and detail phases, with the overall goal of increasing innovation success rates. The specific research objective of the thesis will concern at least one of the following topics: design creativity enhancement, early concept evaluation through functional digital mock-ups, Virtual and Augmented Reality applications, Digital Human Modeling, AI for Design Automation, Product Digital Twin, Green and Sustainable Design.</p>
Methods and techniques that will be developed and used to carry out the research	<p>The research will be developed by referring to both emerging and established methodologies and technologies such as: Collaborative creativity, Bio-Inspired Design, Interactive Virtual Prototyping, Augmented and Virtual Reality, Reverse Engineering, Knowledge Based Engineering (KBE) and AI for Design, multi-objective Optimization, Design for Additive Manufacturing, Design for Sustainable Behaviour, Digital Twin.</p>
Educational objectives	Operational competencies on up-to-date methodologies



	and technologies for developing innovative and user-friendly products. Capability to interpret technology evolution and the dynamics of product innovation. R&D skills for scientific and industrial applications. Soft skills in the delivery of scientific talks, drafting project reports and scientific papers, delivery of presentations to industry.
Job opportunities	The research experience in this area will nurture the ability to develop research activities within an academic and/or an industrial context, according to the specific objectives of the thesis. Therefore, career opportunities will be related to academic research and educational positions, industrial R&D departments, key roles in the product development cycle such as product manager, process manager etc. 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.
Composition of the research group	3 Full Professors 5 Associated Professors 5 Assistant Professors 12 PhD Students
Name of the research directors	Proff. Colombo, Cascini, Ferrise

Contacts
<p>Prof. Giorgio Colombo giorgio.colombo@polimi.it, +39 02 2399 8202 https://www.mecc.polimi.it/ricerca/personale-docente/personale-docente/prof-giorgio-colombo/</p> <p>Prof. Gaetano Cascini gaetano.cascini@polimi.it, +39 02 2399 8463 https://www.mecc.polimi.it/ricerca/personale-docente/personale-docente/prof-gaetano-cascini/</p> <p>Prof. Francesco Ferrise francesco.ferrise@polimi.it, +39 02 2399 8232 https://www.mecc.polimi.it/ricerca/personale-docente/personale-docente/prof-francesco-ferrise/</p> <p>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	662.5 €
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 5401, 42.</p> <p>Accommodation in Politecnico's Residences (http://www.residenze.polimi.it) is available for PhD candidates; special rates will be applied to selected out-of-town candidates (detailed info in the call for application). 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> <p>An increase in the scholarship will be applied for periods up to 6 months (approx. 660 euro/month - net amount).</p> <p>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.</p>



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**THEMATIC Research Field: NOVEL TEMPORAL AND SPATIAL LASER BEAM SHAPING
APPROACHES FOR DEFECT-FREE, FLEXIBLE, AND AUTOMATIZED WELDING**

Monthly net income of PhDscholarship (max 36 months)

€ 1325.0

In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Research, during the three-year period, the amount could be modified.

Context of the research activity

Motivation and objectives of the research in this field

Laser welding has demonstrated its capacity to generate high quality seams for highly demanding applications such as aerospace, aviation, automotive, and e-mobility. Both remote and proximity welding operations have been applied to robotic and cartesian systems seam types such as butt, lap and t-joint. The processed materials, thicknesses, joint configurations, and gaps can vary within the operation of a flexible welding system. This rises the necessity to control energy input both in spatial and temporal domains. Laser beam shaping with high brilliance solid state fiber lasers is a key ability that allows to form the power distribution of the beam with optical and electronical control means. The use of unconventional beam shapes such (eg. ring, flat-top, combined Gaussians), as well as beam oscillations on demand allow new parameter spaces to be explored and used. The PhD project is developed together with the BLM Group, leader in tube machinery and laser based machine tools. The project aims to study the novel beam shaping solutions to have a greater control over the heat input during the welding operation in order to resolve weld defects such as gaps, distortions, porosity and lack of penetration. Analytical and numerical modelling methods will be used to create mid-fidelity models to assist the process parameter selection reducing the experimental effort.



	<p>Inline process monitoring equipment will be used to calibrate and validate models as well as keeping the process.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<ol style="list-style-type: none"> 1. Implementation of in-source and in-head beam shaping solutions in a flexible robotic laser welding system. Beam temporal and spatial characterization. 2. Optical and thermal modelling of the welding operation with shaped beams. 3. Experimental analysis and in-process diagnostics with high speed imaging, 2D and 3D coaxial imaging methods. Characterization of the welds and model validation.
<p>Educational objectives</p>	<p>We provide doctoral candidates with high-level scientific training, fostering and refining research and problem solving abilities by focusing on both theoretical and experimental skills. A PhD in Mechanical Engineering will be able to layout, draft and carry on original research, by leading a research group or working in a team.</p>
<p>Job opportunities</p>	<p>Italy and Lombardy Region have leading positions in manufacturing worldwide. Our last survey showed that MeccPhD Doctorates are 100% employed within the first year in national and international companies and academic and non-academic research institutions, engaged in innovation, research and technical development.</p> <p>List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:</p> <ul style="list-style-type: none"> - BLM Group (www.blmgroupp.com) - University of Cambridge - Delft University of Technology - University of Twente - Cranfield University
<p>Composition of the research group</p>	<p>1 Full Professors 1 Associated Professors 2 Assistant Professors</p>



	5 PhD Students
Name of the research directors	Prof. Ali Gökhan Demir

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phd-dmec@polimi.it

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	662.5 €
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) of a total amount of 5401,42 euro.</p> <p>Teaching assistantship: availability of funding in recognition of support to teaching activities by the PhD student; 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.</p> <p>Computer availability: 1st year: individual use 2nd year: individual use 3rd year: individual use</p> <p>Desk availability: 1st year: individual use 2nd year: individual use</p>



3rd year: individual use



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**THEMATIC Research Field: SOLID STATE METAL POWDER DEPOSITION FOR NEW
ADDITIVE DESIGN SOLUTIONS**

Monthly net income of PhDscholarship (max 36 months)	
<p style="text-align: center;">€ 1325.0</p> <p>In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Research, during the three-year period, the amount could be modified.</p>	
Context of the research activity	
<p>Motivation and objectives of the research in this field</p>	<p>Solid state deposition of metal powder by exploiting high energy impacts is becoming more and more used in different industrial sectors, mainly for offering surface coating solutions and repair of damaged parts. However, cold spray has many attractive properties for being considered as an additive process for free standing 3D parts (high deposition rate, no need of protected atmosphere, high flexibility in mixing powder of different materials,...). However, the full exploitation of cold spray in AM requires the digitalization of the process. Aim of this research is the definition of a digital approach to manage the cold spray deposition in terms of: 1. defining the deposition strategy with respect of the desired geometry 2. assessment of the expected properties of the deposited parts 3. optimization of the process by means of an AI approach 4. development of a meaningful case study.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The development of the thesis includes both numerical simulations (FEM and other methods) of the process and deposited materials under load conditions of interest as well as experimental cold spray deposition, by considering the different parameter combinations and the definition of the correct tool path according to the numerical simulation results. Finally, an accurate mechanical characterization of the deposited materials will be performed to find the</p>



	most performant processes in terms of mechanical properties.
Educational objectives	The aim of the position is to educate an expert in cold spray metal powder deposition for additive manufacturing, able to manage research, development and innovation in this field, developing skills and attitudes that can be translated in different industrial fields. The candidate will also develop knowledge and skills in Artificial Intelligence and in the numerical and experimental techniques requested for a correct and competitive application of these techniques.
Job opportunities	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.
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	Prof. Mario Guagliano, Dr. Sara Bagherifard

Contacts
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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	
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By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
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euro 5401, 42.

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