



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

Number of scholarship offered	19
Department	DIPARTIMENTO DI MECCANICA

Description of the PhD Programme
<p>The Doctoral Programme in Mechanical Engineering of Politecnico di Milano offers top-level knowledge in one of the most profitable sectors in Italy and worldwide; it is a key instrument to access leading enterprises and to achieve prominent positions in large international companies devoted to research and development, innovation and design. The primary employment market is composed of leading companies and organizations dedicated to innovation, research and technical development, high-tech SMEs and governmental departments.</p> <p>The research topics of our Programme fall in the category <i>Mechanical, Aeronautical & Manufacturing Engineering</i> of the <i>QS World University Rankings</i>, where Politecnico di Milano currently ranks 7th in the world (<i>QS Rankings by Subject 2023</i>).</p> <p>The Programme covers a number of different disciplines, being devoted, in particular, to innovation and experimental activities. It relies on the development of an interdisciplinary and integrated high-level educational offer, by focusing on a comprehensive scientific proposal, from conception to realization; the core of our research lines falls within the societal trends identified at international and national levels: sustainable transport, health and wellbeing, clean energy, innovation and job creation. We also have ongoing collaborations with national and international most renowned research groups and laboratories.</p> <p>Within our Programme all Doctoral Candidates follow a minimum path of three-years, which includes specific courses and lectures, held by Faculty members and foreign professors and experts: in particular, our candidates have access to a series of research seminars delivered monthly by international top-level faculty (<i>MeccPhD Lectures</i>) and to full courses provided by European and non-European academic experts. They also experience in-depth research, lab activities and active cooperation with international industries, institutions and research groups. With this background, our Doctorates are able to blend the soundness of scientific knowledge with the ability to deal with management and industrial issues. In this view, their scientific profiles are suitable for prestigious positions at national and international level within universities and research institutions, large industrial and consulting companies, SMEs.</p>



Further information on our Doctoral Programme and on the Department of Mechanical Engineering of Politecnico di Milano may be found at the following link: <https://www.mecc.polimi.it/en/>.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: ADDITIVE MANUFACTURED HETEROGENEOUS MATERIALS
OBTAINED WITH COLD SPRAY**

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

The low working temperature of cold spray technology offers a unique possibility to deposit a wide variety of composite materials by mixing two or more constituent powders. Materials that are sensitive to high temperature or to oxidation can easily be deposited by cold spray, without the challenges associated with other commonly used additive manufacturing techniques that are based on melting and solidification. However, there are still some issues to be resolved before we can gain full control on the deposit characteristics in cold spray. While it is possible to precisely control the chemical composition of the powder mixture before spraying, the compositional yield in the deposit remains uncertain. The compositional deviation with respect to the feedstock is mainly due the differences in thermo-mechanical and morphological properties of different phases. Apart from that, the contribution of each phase to the mechanical performance of the integrated structure varies depending on their respective mechanical properties. This thesis plans to tackle these challenges and aims at defining cold spray design and evaluation procedures that lead to optimal structures made of two or more constituent phases. The project will account for the interaction of the dissimilar powders and estimates their respective contribution to the load-bearing capacity of the integrated structure.

Methods and techniques that will be developed and used to carry out the research

The research involves using various tools including multiscale finite element modelling (process simulation



	<p>multiscale finite element modelling (process simulation (single and multiple particle impact), structural failure modelling of the integrated deposit, and advanced experimental analysis for depositing and evaluating the performance of multi-material cold spray additive manufactured parts (microstructural and interface properties, static and fatigue tests, etc.).</p>
Educational objectives	<p>The aim of this project is to educate an expert in cold spray additive manufacturing, with soft and hard skills able to direct research, development and innovation in this field; the PhD student will develop skills and attitudes that can be translated in other industrial fields. The candidate will also develop knowledge and skills in additive manufacturing sector in general and in the numerical and experimental techniques requested for a correct and competitive application of kinetic additive manufacturing processes.</p>
Job opportunities	<p>The research work is carried out within the European Research Council (ERC)-2021-CoG research project ArchIDep (<i>Revolutionary solid state deposition system to obtain heterogeneous materials</i>, GA n. 101044228).</p> <p>Collaborations are envisioned with: École des Mines de Paris - Université PSL (FR), Helmut Schmidt University (DE), Impact Innovations (DE), University of Brno and Institute of Physics of Materials (CZ).</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 4 PhD Students</p>
Name of the research directors	<p>Prof. Sara Bagherifard</p>

Contacts	
<p><i>Email:</i> sara.bagherifard@polimi.it <i>Phone:</i> 02-23998252</p>	



For questions about scholarship/support 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	700.0 €
By number of months	6

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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: ADVANCED COATINGS AND ALLOYS

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

Innovative research in mechanical engineering today is increasingly focused on the study of advanced engineered materials, which combine functional and bulk properties and on the control of surface conditions. The final performance of the component is provided by materials that must combine different, sometimes opposed, properties derived from chemical composition, morphology and manufacturing process; however, it must be taken into account that the interaction with the stimuli from the environment around, mainly originates from the surface, and from it often result degradation phenomena. Moreover, an optimization of surface conditions is a key factor to addressing the ever-increasing environmental requests from industry and global society.

Methods and techniques that will be developed and used to carry out the research

Production techniques from powder or casting will be used on a laboratory scale, with emphasis on the possibility of combining different materials (metal/metal, or metal/ceramic). Simulation analysis will also guide the materials selection. Moreover the research will involve, optical and electron microscopy, EBSD, XRD, DSC, and mechanical characterization by wear test, tensile testing, fracture toughness, fatigue testing. For more details about infrastructures, see:
<https://www.mecc.polimi.it/us/research/departmental-laboratories/>.

Educational objectives

At the end of the PhD cycle the candidate will be able to



	define, design and carry out original research programs by working in a team or leading a research group in the field of coating and composite materials.
Job opportunities	All project activities are strongly connected to industrial needs and industrial partners are directly participating to project tasks. 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 2 Associated Professors 0 Assistant Professors 5 PhD Students
Name of the research directors	Prof. Maurizio Vedani, Prof. Nora Lecis

Contacts

E-mail: maurizio.vedani@polimi.it; nora.lecis@polimi.it

For questions about scholarship/support 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	700.0 €
By number of months	6

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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: ADVANCED MODELLING AND TESTING OF MATERIALS AND
STRUCTURES FOR MACHINE DESIGN**

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	
<p>Motivation and objectives of the research in this field</p>	<p>Working in the Machine and vehicle design group requires motivation in developing experimental and computational methods for the assessment of the structural integrity and advanced design of mechanical components and vehicles. The objectives of the research may range from the definition of new models of materials behaviour to the assessment of the structural integrity of large structures, from the experimental investigation on new materials to the design of components or vehicles with innovative features, with special focus on lightweight design. Between the problems related to Machine and vehicle design group, an actual topic is represented by modelling of structures, systems and components when subjected to extreme loading conditions. This is a scenario characterized by multiphysics, multiscale problems that may require innovative modelling approaches not limited to the standard non-linear numerical methods. The researcher's activity is then set in a highly interdisciplinary context, appropriately intersecting various branches of engineering related to expertise's of Machine and vehicle design group: e.g. material behaviour and structural integrity under several loading conditions including (but not limited to) extreme loading conditions as well as innovative modelling and design approaches including survivability approaches. Applications may be in, but not limited to, the field of Defense & Security and transportations (naval, aerospace, terrestrial).</p>



<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>Depending on the specific research topic assigned, methods and techniques will comprise Finite element modelling, Boundary element modelling, Fracture mechanics, structural health monitoring and prognosis, Digital Twin for structural integrity purposes, machine learning and artificial intelligence, low and high velocity impact on structures, survivability analyses, multi-axial fatigue tests on specimens or on parts, non-destructive tests, high temperature tests, residual stress tests, tests on vehicle components, tests on gears, tests on power transmission, driving simulator tests, etc.</p>
<p>Educational objectives</p>	<p>The Doctor in Mechanical Engineering will be able to define, start and carry out original research by working in a team or leading a research group. Both theoretical and experimental skills are mastered. We provide doctoral candidates with high-level scientific training, fostering and refining research and problem-solving abilities.</p>
<p>Job opportunities</p>	<p>Structures/organizations aimed at innovation and/or research and technical development, high-tech SMEs, government departments ruling on public needs. 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. Specifically, the skills and know-how developed during the PhD will allow to cover positions for design and integrity assessment of advanced systems and components in aerospace, automotive and mechanical companies involved in the green transformation.</p>
<p>Composition of the research group</p>	<p>1 Full Professors 3 Associated Professors 1 Assistant Professors 16 PhD Students</p>
<p>Name of the research directors</p>	<p>Prof. Marco Giglio, Prof. Andrea Manes</p>

Contacts
<p><i>Prof. Marco Giglio</i> marco.giglio@polimi.it</p>
<p><i>Prof. Andrea Manes</i> andrea.manes@polimi.it</p>



For questions about scholarship/support 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	700.0 €
By number of months	6

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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: ADVANCED, SMART, AND SUSTAINABLE 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

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 is required to address various challenges including digital production, big data analysis and artificial intelligence, global production sustainability and circular economy, climate changes and smart cities. 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, polymers, and biomaterials, micro-manufacturing, and laser-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 control*

Smart solutions for sensing and inspection and innovative



	<p>strategies for intelligent data fusion, big data analysis, quality process monitoring, control and inspection are key factors to achieve sustainable zero-defect manufacturing.</p> <p>- <i>Advanced manufacturing systems</i> Innovative solutions for configuring and managing manufacturing systems are eventually needed to drive the whole production system toward smart, high-performance, and sustainable solutions.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>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.</p>
<p>Educational objectives</p>	<p>Doctoral candidates will acquire competences on design, optimisation, and sensing/controlling of new advanced manufacturing processes and systems.</p>
<p>Job opportunities</p>	<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> <p>Universities, Institutions and companies cooperating in the research are: MIT - Massachusetts Institute of Technology, TUM - Technical University of Munich, ESA - European Space Agency, Shanghai Jiao Tong University, Georgia Tech University, STIIMA-CNR www.stiima.cnr.it, ATV S.p.A., Ansaldo Energia S.p.A., Avio Aero, BLM Group, GE Avio s.r.l., Leonardo - AgustaWestland S.p.A., Lima Corporate, Marposs S.p.A., Prima Industrie S.p.A., Tenova S.p.A., COMAU S.p.A.</p>
<p>Composition of the research group</p>	<p>4 Full Professors 3 Associated Professors 6 Assistant Professors 19 PhD Students</p>
<p>Name of the research directors</p>	<p>Proff. Colosimo, Matta, Moroni, Previtali</p>



Contacts

Names of the Research Directors:

Prof. Bianca Maria Colosimo

Prof. Andrea Matta

Prof. Giovanni Moroni

Prof. Barbara Previtali

For questions about scholarship/support 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	700.0 €
By number of months	6

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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: CFD SIMULATIONS OF ADDITIVE PROCESSES FOR RECYCLED CFRP

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

Three-dimensional printing (3DP), also known as additive manufacturing (AM), has rapidly evolved over the past few decades. Researchers around the globe have been putting their efforts into AM processes improvement and materials development. One of the most widely used extrusion-based technology under AM processes is Fused Deposition Modeling (FDM), also known as Fused Filament Fabrication (FFF). Numerical simulation tools are being employed to predict the FFF process complexities and material behavior. Specifically, CFD (Computational Fluid Dynamics) simulations can be used to model the additive manufacturing (AM) process of Carbon Fiber Reinforced Polymers (CFRPs) by simulating the flow and heat transfer within the printing material and around the printed part.

In this research project, the main objectives would be to develop CFD simulation modelling for predicting the temperature distribution, pressure, velocity, and viscosity of the molten material as it is deposited layer by layer. This information can be used to optimize the process parameters such as the print speed, temperature, and nozzle diameter to ensure the final part meets the required specifications in terms of mechanical properties, dimensional accuracy, and surface quality.

In addition, CFD simulations can be used to study the flow behavior of the molten material as it is extruded through



	<p>the nozzle and deposited on the build platform. This can help identify potential issues such as flow instabilities, non-uniform deposition, and cooling rates that can affect the quality of the final part.</p> <p>CFD simulations can also help predict the residual stresses and deformations in the printed part, which can occur during the cooling process. This information can be used to optimize the printing process to minimize distortions and residual stresses.</p> <p>Overall, CFD simulations can be used to optimize the AM process of CFRPs, and ensure the final part meets the required mechanical and physical properties. This can help reduce waste, increase efficiency, and improve the quality of the final product.</p> <p>In this specific research the focus would be on the 3D printing of recycled CFRPs. The developed simulation models require a proper validation through data from experimental campaigns.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<ul style="list-style-type: none"> - CFD simulations tools (e.g., Open Foam, ANSYS, etc.); - Development of specific material modelling of recycled CFRPs; - Proper model updating strategies need to be developed; - Since the model validation is essential, experimental activities on a test bench would be required. Sensorization of the test bench and data acquisition/processing skills would be required.
<p>Educational objectives</p>	<p>The candidate should attend courses/seminars for enhancing his/her soft-skills and specific courses that should help the research development.</p>
<p>Job opportunities</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> <p>The research activity will be conducted in cooperation with the Department of Energy (Politecnico di Milano).</p>



Composition of the research group	0 Full Professors 2 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	Proff. Paolo Albertelli, Tommaso Lucchini

Contacts	
<i>E-mail:</i> paolo.albertelli@polimi.it	
For questions about scholarship/support 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	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> <p>An increase in the scholarship will be applied for periods up to 6 months (approx. 700 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>	



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: COOPERATIVE CONNECTED AND AUTOMATED MOBILITY

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	
<p>Motivation and objectives of the research in this field</p>	<p>Autonomous driving will be among the goals of the 2030 agenda inspiring European and international partnerships and falling under Sustainable Development Goals 11, 12 and 17.</p> <p>Cooperative, Connected and Automated Mobility (CCAM) responds to one of the mega-trends identified by the European Commission for 2030: connectivity. As cited by the Commission, by 2030 almost all European vehicles will be connected to the Internet and, therefore, connected to each other as part of a network and not as individual entities.</p> <p>In this sense, PhD research will be oriented toward SDG number 11 with the aim of contributing to the functioning of smart cities by making them sustainable and promoting a reorganisation of city spaces reserved for mobility.</p> <p>The CCAM partnership addresses the need to develop a research network appropriate for autonomous driving. The aim is to make it possible to achieve results relevant to the wide market take-up by getting concrete feedback.</p> <p>The value of this partnership finds its place in SDG number 17 by wanting to develop European and international links to optimize research and development. Autonomous driving optimises the vehicle and its functionality by improving its fuel economy, travel time and safety.</p> <p>Autonomous vehicles, in conclusion, can help structure a production chain and mobility that reduce our ecological footprint, contributing to the achievement of Goal number 12 of the 2030 Agenda.</p>



	<p>Given the above, the PhD research will aim to the following objectives:</p> <ul style="list-style-type: none"> - understanding and applying EDGE technology for cooperation and connection between autonomous vehicles in a roundabout scenario; - studying the interaction between autonomous and humanly driven vehicles by understanding driver behaviours and models, city traffic flows, and enabling transitional mobility between full human and fully autonomous driving; - sensing forces acting at vehicle wheels in order to describe the domain of attraction for vehicle motion; - creating an autonomous driving policy that is effective both in meeting technical needs and adapting in interacting with humans in terms of comfort and safety; - conducting tests and experimental simulations at the driving simulator of the Politecnico di Milano (DriSMi) in order to reach the creation of a road prototype through collaboration with Automotive Companies; - collaboration with multiple stakeholders including universities and companies.
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>Methods and techniques:</p> <ul style="list-style-type: none"> - use of the driving simulator of the Politecnico di Milano (DriSMi); - optimization methods such as Deep Reinforcement Learning and neural networks; - measurements in a real city environment; - study of information flows to and from the vehicle; - simulation environment management, data acquisition and analysis using Python, Matlab, Simulink and VI-car.
<p>Educational objectives</p>	<p>The Doctor in Mechanical Engineering will be able to carry out original research by working in a team. Both theoretical and experimental skills will be fostered. The research group will provide doctoral candidates with high-level scientific training, fostering and refining research and problem-solving abilities.</p>
<p>Job opportunities</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</p>



	<p>the same field.</p> <p>Specifically, the skills and expertise developed during the PhD will allow covering positions for design and integrity assessment of advanced systems and components in automotive and mechanical companies involved in the green transformation.</p>
Composition of the research group	<p>2 Full Professors 2 Associated Professors 1 Assistant Professors 7 PhD Students</p>
Name of the research directors	Prof. Gianpiero Mastinu

Contacts
<p><i>Prof. Gianpiero Mastinu:</i> gianpiero.mastinu@polimi.it</p> <p>For questions about scholarship/support 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. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 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</p>



by the regulations.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: DESIGN, DEVELOPMENT AND QUALIFICATION OF ADVANCED
MEASUREMENT SYSTEMS**

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**

Nowadays the role of measurements is no longer limited to the estimation of physical quantities, but it also involves the smart processing of huge amounts of data in real time, to enable a full interaction with the surrounding environment and support the decision makers. The monitoring of mechanical and thermal quantities is quickly evolving, thanks to the possibility to share the data in real time in the cloud and to the availability of efficient processing approaches for big data manipulation. Applications of this approach are diverse, and can involve many fields, like structural health monitoring, industrial processes monitoring, biomedical parameters sensing, cultural heritage monitoring. Industrial sensing benefits from the huge innovations in space research and consumer electronics, that continuously push for a strong development of sensors. In these scenarios, the availability of reliable and accurate data plays a crucial role. This project is aimed at the development and metrological qualification of measuring solutions for networked sensors and big data manipulation, for industrial and scientific applications. The main goals of the research include the optimization of the measuring approaches and data analysis to obtain a reliable representation of the monitored system or process. The joint analysis and optimization of the data acquisition and data processing for a network measurement will be a key point of the research.



<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>Development of new sensing solutions based on modern low-cost and low-power hardware, to obtain efficient and reliable measuring nodes. Development of data processing strategies to obtain information on the monitored system by synergic analysis of data from a number of sensors.</p>
<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. The candidate will develop horizontal competences on data collection and management, as well as on experimental and analytical approaches, to be used in any field of engineering in the future step of the career. Indeed, 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>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>
<p>Composition of the research group</p>	<p>3 Full Professors 5 Associated Professors 2 Assistant Professors 10 PhD Students</p>
<p>Name of the research directors</p>	<p>Proff. Saccomandi, Cigada, Saggin, Zappa</p>

Contacts
<p>Prof. Paola Saccomandi <i>paola.saccomandi@polimi.it</i>, 02 2399 8470</p>
<p>Prof. Alfredo Cigada <i>alfredo.cigada@polimi.it</i></p>
<p>Prof. Bortolino Saggin <i>bortolino.saggin@polimi.it</i></p>
<p>Prof. Emanuele Zappa <i>emanuele.zappa@polimi.it</i></p>
<p>For questions about scholarship/support <i>phd-dmec@polimi.it</i></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

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.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: DEVELOPMENT AND QUALIFICATION OF MEASUREMENT
SYSTEMS FOR HUMAN-CENTERED APPLICATIONS**

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**

The monitoring of mechanical and thermal quantities is quickly evolving, thanks to the possibility to share the data in real time in the cloud and to the availability of efficient processing approaches for big data manipulation. Applications of this approach are diverse, and can involve many fields, like biomedical and physiological parameters sensing, structural health monitoring, industrial processes monitoring, cultural heritage monitoring. Industrial sensing benefits from the huge innovations in consumer electronics, that continuously push for a strong development of sensors. In these scenarios, the availability of reliable and accurate data plays a crucial role. This project is aimed at the development and metrological qualification of measuring solutions for networked sensors and big data manipulation, intended for scientific applications for human-centred applications. The main goals of the research include the optimization of the measuring approaches, based on the comparison and choice of the optimal sensors for the specific use, and data analysis to obtain a reliable representation of the monitored system or process. The joint analysis and optimization of the data acquisition and data processing for a network measurement will be a key point of the research.

**Methods and techniques that will be
developed and used to carry out the
research**

Development of new sensing solutions based on modern low-cost and low-power hardware, to obtain efficient and reliable measuring nodes applicable to obtain real-time



	reliable measuring nodes applicable to obtain real-time data for human-centered systems and applications. Development of data processing strategies to obtain information on the monitored system by synergic analysis of data from a number of sensors.
Educational objectives	We provide doctoral candidates with high-level and competitive scientific training, fostering and refining research and problem-solving abilities by focusing on both theoretical and experimental skills. A person holding a PhD in Mechanical Engineering will be able to layout, draft and perform original research, by working in a team in companies or universities, or leading a research group.
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	3 Full Professors 5 Associated Professors 2 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Paola Saccomandi, Prof. Marco Tarabini

Contacts	
<i>E-mail:</i> paola.sacomandi@polimi.it <i>Phone:</i> 02 2399 8470	
<i>E-mail:</i> marco.tarabini@polimi.it <i>Phone:</i> 02 2399 8808	
For questions about scholarship/support 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	700.0 €
By number of months	6



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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: DEVELOPMENT OF AN INTELLIGENT ACTUATED SECOND SKIN FOR HUMAN EMPOWERMENT

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	<p>When coming to human empowerment in different fields, such as assistance during workdays, to frail or motor impaired persons, we are witnessing a technological push starting from more classical rigid wearable exoskeletons to hybrid or soft solutions. None of the current solutions disappear under the cloths towards an ecological and transparent assistance. With this project, we want to study and develop an intelligent actuated second skin which is able to assist human movement.</p>
Methods and techniques that will be developed and used to carry out the research	<p>The methods implemented in the research will be theoretical (numerical and analytical) and experimental. The research will develop along 3 main research lines closely related to each other and which will concern:</p> <ul style="list-style-type: none"> i) the development of a perception and a monitoring layer able to interact with the wearer, which implements a proper sensor network and human-machine interaction methodologies; ii) an actuation layer to support the intended motion, which will be developed building on current solutions based on cables or hydraulic units, but developing a solution able to actuate a second skin; iii) a brain layer to supervise and control the whole process. <p>The strong interdependence of the research lines is evident, which will be adequately supported by experimental activities at the basis of the validation</p>



	experimental activities at the basis of the validation procedures of the models created and will allow a robust development of the identified technical solutions. The main result of the PhD activity will consist in the creation of a prototype of an intelligent actuated second skin able to assist human movement.
Educational objectives	PhD graduate will be able to have a interdisciplinary knowledge of technologies and processes related to new paradigms in human assistance and empowerment, with a focus on soft robotics, control, and sensor network.
Job opportunities	Skills and competences in the field are extremely interesting for all the companies involved in manual working and for the whole society in terms of assistance of disabled or frail people. 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 0 Associated Professors 1 Assistant Professors 0 PhD Students
Name of the research directors	Prof. Francesco Braghin, Dr. Marta Gandolla

Contacts	
<i>Email:</i> francesco.braghin@polimi.it; marta.gandolla@polimi.it	
For questions about scholarship/support 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	700.0 €
By number of months	6

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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: DEVELOPMENT OF INSTRUMENTS FOR SPACE EXPLORATION

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	<p>The design of instruments for space exploration is experiencing epochal changes because of the challenges due to the introduction of the additive manufacturing processes and the massive usage of new data processing techniques. Design phases traditionally driven by designer's experience such as optomechanical structures optimization and numerical models validation, can potentially become automatic processes leveraging on the emerging data processing technologies.</p>
Methods and techniques that will be developed and used to carry out the research	<p>The research will focus on the design of optomechanical structures and thermal models' validation. Both processes are commonly based on experienced designers that translate the problems on parametric analysis that through a minimization process provide the optimal parameter set. Starting from this approach the feasibility and advantages of automatic systems will be investigated. The study will be applied to systems and test data available from instruments recently developed or currently under design in the laboratory.</p>
Educational objectives	<p>The candidate will eventually fully master the modelling tools and methods required for the analysis of the measuring systems. Applications to space and 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.</p>



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 3 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	Prof. Bortolino Saggin

Contacts	
<i>Phone:</i> 02 2399 8702 <i>E-mail:</i> bortolino.saggin@polimi.it	
For questions about scholarship/support 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	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. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 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>	



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: DIGITAL TRANSFORMATION IN INDUSTRIAL ENGINEERING

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	<p>The digital transformation is radically changing the way data and information related to products and industrial processes are generated, acquired, and elaborated. Digital technologies can be used to create smart products and processes, train operators, support, and guide maintenance activities. The goal is to speed up and optimize processes and exploit digital technologies as drivers toward sustainable development and innovation. This research field concerns the methods and tools to properly exploit the implementation of digital solutions within industrial contexts, with the overall goal of developing effective and innovative solutions. The specific research objective of the thesis will concern at least one of the following topics: Virtual, eXtended, and Augmented Reality applications, Metaverse, Digital Human Modeling, Artificial Intelligence (AI) for Design, and Digital Twin.</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: Virtual, eXtended and Augmented Reality, Reverse Engineering, Artificial Intelligence, Multi-objective Optimization, Digital Twin, Digital Data Management, Human-Computer and Human-Machine Interaction</p>
Educational objectives	<p>Operational competencies on up-to-date methodologies and technologies for developing innovative digital solutions and applications. Capability to interpret</p>



	technology evolution and the dynamics of technological and digital transformations. R&D skills for scientific and industrial applications. Soft skills in the delivery of scientific talks, drafting project reports and scientific papers, and delivery of presentations to industry.
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	3 Full Professors 8 Associated Professors 4 Assistant Professors 16 PhD Students
Name of the research directors	Prof. Colombo, Cascini, Bordegoni, Ferrise

Contacts	
<i>Prof. Giorgio Colombo:</i> giorgio.colombo@polimi.it, +39 02 2399 8259; https://www.mecc.polimi.it/ricerca/personale-docente/prof-giorgio-colombo	
<i>Prof. Gaetano Cascini:</i> gaetano.cascini@polimi.it, +39 02 2399 8463; https://www.mecc.polimi.it/ricerca/personale-docente/prof-gaetano-cascini	
<i>Prof.ssa Monica Bordegoni:</i> monica.bordegoni@polimi.it, +39 02 2399 8260; https://www.mecc.polimi.it/ricerca/personale-docente/profssa-monica-bordegoni	
<i>Prof. Francesco Ferrise:</i> francesco.ferrise@polimi.it, +39 02 2399 8232; https://www.mecc.polimi.it/ricerca/personale-docente/prof-francesco-ferrise	
For questions about scholarship/support 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	700.0 €
By number of months	6



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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: FROM SCRAP TO ULTRACLEAN ALLOY

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	<p>All the industrial sectors show such a constant demand for innovative materials and processes and a consolidated availability to new solutions. The increasingly stringent performance requirements, the use of new materials and the application of technologically advanced production processes cannot disregard the need to more performant material free of as much as possible defects. The shortage of raw materials and the need of environmental impact reduction led to the search of new solutions in the recycle of metallic material turn out in the increase in the product quality, reducing the production footprint. This research aims at implementing new processes and operational practice in a vision matching the requirements of the circular economy and energetic improvement.</p>
Methods and techniques that will be developed and used to carry out the research	<p>Materials characterization of the raw materials and the final products, in relation to the microstructure and the mechanical properties and the corrosion resistance. Metallurgical techniques for metal production, casting, plastic deformation and heat treatment to assess the best properties. The recycle of metallic materials in laboratory furnace, the subsequent deformations and heat treatments will be simulated. Standard tensile test, fatigue test and fracture mechanics test will be performed to obtain the mechanical properties. Standard metallographic techniques, SEM-EBSD, XRD and DSC analysis will be performed for the material and defect characterization. Potentiodynamic test (EPR and EIS) for the corrosion characterization. Also LCA (life cycle</p>



	assessment) will be performed in order to evaluate the process improvement impact.
Educational objectives	At the end of this project the PhD candidate will be able to analyse several kinds of technological problems and choose the best solution for them. In particular, the candidate will gain deep technical knowledge on metal production and on the environmental impact reduction technologies. The candidate will also learn how to manage the data obtained in the laboratory testing in order to conduct numerical analysis of metallurgical processes. Furthermore, individual soft skills such as research planning, teamworking and lateral thinking for problem solving will be developed during the research period.
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 4 Associated Professors 0 Assistant Professors 3 PhD Students
Name of the research directors	Prof. Carlo Mapelli, Prof. Silvia Barella

Contacts	
<i>E-mail:</i> carlo.mapelli@polimi.it; silvia.barella@polimi.it	
For questions about scholarship support 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	700.0 €
By number of months	6



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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: GRADED MULTIFUNCTIONAL METALLIC AND HYBRID
MATERIALS**

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	
<p>Motivation and objectives of the research in this field</p>	<p>Innovative materials are more and more requested to react to external stimuli by providing a proper behaviour, that is, a proper set of properties. In this sense, they can be considered as 'smart materials'. The target behaviour can be met both by single or multiphase materials, with a homogeneous or inhomogeneous phase arrangement. The specific material response can be tailored to offer different behaviour to similar homogeneous components or to obtain the target behaviour by a graded material with locally modulated composition/structure/response. In both cases there is the need to identify design/processing/property correlations and to exploit them. These materials often require specific design methods (e.g. thermodynamics-based ones) and specific processing route (e.g. rapid solidification, powder metallurgy, additive manufacturing, plastic deformation processing, heat treatment cycles) to meet the proper phase distribution, properties, arrangement. Several research projects are available within this frame. Details about the specific topics will be supplied on request.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The Material research group has expertise on microstructural and mechanical characterization of advanced metallic alloys. The methods to be used will involve thermodynamic modelling, tools to identify phase arrangement and model properties, tools for experimental analyses on phase and microstructure analyses (optical and electron</p>



	phase and microstructure analyses (optical and electron microscopy, EBSD, XRD, DSC, ...), mechanical characterization (e.g. tensile testing, fracture toughness, fatigue testing, creep) and physical properties (e.g. thermal, electric). For more details about infrastructures, see: https://www.mecc.polimi.it/us/research/departmental-laboratories/ .
Educational objectives	At the end of the PhD cycle the candidate will be able to use and combine methods and technologies for material design, processing and multifunctional characterization. The candidate will be thus able to carry out original research programs by working in a team or leading a research group in the field of smart materials.
Job opportunities	Job opportunities are foreseen at national and international academic institutions, high-tech companies and SMEs involved in innovation and technical development. 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	4 Full Professors 7 Associated Professors 2 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Elisabetta Gariboldi, Prof. Maurizio Vedani

Contacts	
<i>Phone:</i> 02 23998224 <i>E-mail:</i> elisabetta.gariboldi@polimi.it	
For questions about scholarship/support 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	700.0 €
By number of months	6



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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: MANUFACTURING AND DEMANUFACTURING PROCESSES
AND SYSTEMS**

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**

Circular economy is changing the way companies conceive, produce, de-produce, and reproduce their products. Not only circular economy is supporting the preservation of the environment and reducing energy consumption but it can become profitable for companies that can recover the function and/or materials of their products. New processes and new systems are required to make the described change operational together with new business models. Moreover, processes should be designed to allow strict cooperation between humans and automation. Therefore, research and innovation are at the cornerstone of the circular revolution.

**Methods and techniques that will be
developed and used to carry out the
research**

Topics to be addressed are new processes to recover materials, new disassembly/reassembly processes to recover functions new system design to allow to cope with the variability of the cores and with the variability of the volumes. In particular methods and techniques for: the control of new processes and systems, design of cyber-physical systems, performance modeling of manufacturing/demanufacturing systems configuration and management of new manufacturing systems are to be studied to be addressed.

Educational objectives

The goal is to create an expert in the circular economy who is able on the one side to understand processes and on the other side to cope with manufacturing systems



	design and analysis .
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 15 PhD Students
Name of the research directors	Proff. Tolio, Colledani, Urgo

Contacts	
<i>Prof. Tullio Antonio Maria Tolio</i> tullio.tolio@polimi.it; 320 8393664	
<i>Prof. Marcello Colledani</i>	
<i>Prof. Marcello Urgo</i>	
For questions about scholarship/support 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	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. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 euro/month-net amount).</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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**THEMATIC Research Field: PDE OPTIMIZATION OF ROBOT SWARMS FOR ACOUSTIC
INVISIBILITY CLOAK**

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	
<p>Motivation and objectives of the research in this field</p>	<p>Cloaking refers to the possibility to achieve perfect concealment of objects with respect to probing incident radiation. Acoustic cloaking can be obtained allowing the speed of sound around an object to be highly anisotropic to steer waves around and not into the object itself. Such anisotropy is not available in nature and must be obtained by the engineering of a microstructure. Currently, most approaches rely upon passive or active layers of (meta) materials covering the object to protect. However, the latter usually suffer from limitations due to the size and weight of the cloak itself and due to the loss of performances when exposed to different incidence angles. The aim of this project is to overcome these issues following a new paradigm: steering the incident waves using a field of controllable agents, that is a robot swarm. Using a PDE-optimization approach, the swarm can indeed be controlled and reconfigured to adjust the stiffness/density distribution around the object to conceal. Besides of the theoretical aspects of this research project, the candidate will have the opportunity to build and test the developed control logics on an underwater swarm in the instrumented pool of our laboratory.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>As anticipated above, the candidate will use and develop its own PDE optimization tools and routines (as necessary) to implement the control logics to be deployed on the robot swarm. In this second part, the basics of robotics and microcontrollers for embedded systems will</p>



	robotics and microcontrollers for embedded systems will be required to design the robots and the experiments.
Educational objectives	This research topic involves both cutting-edge technology development and the use of some refined state-of-the-art techniques which are becoming ever more relevant in the industry, with applications going from search and rescue operations to underwater pipelines inspection. As such, this PhD project is perfect for candidates pursuing either an academic or an industrial career.
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 0 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Francesco Braghin

Contacts

Phone: 02 2399 8306 *Email:* francesco.braghin@polimi.it

For questions about scholarship/support 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	700.0 €
By number of months	6

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 5.707,13.



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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

OPEN SUBJECT Research Field: PRODUCT DEVELOPMENT IN THE INDUSTRY 5.0 ERA

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	<p>The Industry 5.0 paradigm promotes the development of sustainable, human-centric and resilient industrial ecosystems. According to this paradigm, technological transformations should also satisfy the need for timely and effective long-term solutions to societal challenges. Manufacturing processes and how products are developed should be thus further rethought in light of this paradigm. This research field concerns the methods and tools that support product development in the Industry 5.0 era, from idea generation to concept verification, embodiment, and detail design. The goal is to support industries in developing cutting-edge products that can contribute to the growth of a sustainable, inclusive, and resilient society. 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, eXtended and Augmented Reality applications, Digital Human Modeling, Artificial Intelligence (AI) for Design, Product Digital Twin, Green and Sustainable Design, Human-machine interactions.</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, eXtended and Virtual Reality, Reverse Engineering, Knowledge Based Engineering (KBE) and AI for Design, multi-objective Optimization, Design for</p>



	Additive Manufacturing, Design for Sustainable Behaviour, Digital Twin.
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	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 8 Associated Professors 4 Assistant Professors 16 PhD Students
Name of the research directors	Prof. Colombo, Cascini, Bordegoni, Ferrise

Contacts

Prof. Giorgio Colombo: giorgio.colombo@polimi.it, +39 02 2399 8259;
<https://www.mecc.polimi.it/ricerca/personale-docente/prof-giorgio-colombo>

Prof. Gaetano Cascini: gaetano.cascini@polimi.it, +39 02 2399 8463;
<https://www.mecc.polimi.it/ricerca/personale-docente/prof-gaetano-cascini>

Prof. Monica Bordegoni: monica.bordegoni@polimi.it, +39 02 2399 8260;
<https://www.mecc.polimi.it/ricerca/personale-docente/profssa-monica-bordegoni>

Prof. Francesco Ferrise: francesco.ferrise@polimi.it, +39 02 2399 8232;
<https://www.mecc.polimi.it/ricerca/personale-docente/prof-francesco-ferrise>

For questions about scholarship/support 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	700.0 €
By number of months	6

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 5.707,13.

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. 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.



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

**INTERDISCIPLINARY Research Field: TAILORED PIEZOELECTRIC MATERIALS AND
OPTIMALLY DESIGNED METAMATERIALS FOR ENHANCED MECHANICAL ENERGY
HARVESTING**

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	
<p>Motivation and objectives of the research in this field</p>	<p>Interdisciplinary PhD Grant</p> <p>The PhD research will be carried out in collaboration with research groups of the PhD programme in "STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING".</p> <p>It has been recently demonstrated that introducing controlled porosity into the piezoelectric ceramic allows gaining relevant advantages for energy harvesting, compared to dense piezoelectric materials, due to the beneficial ratio between the piezoelectric coefficients and the permittivity. According to the results of the ERC project NEMESIS, completed in 2018, even better energy harvesting performance can be achieved in the case of layered piezoelectric materials where dense outer layers surround a highly porous sandwich layer: the longitudinal piezoelectric strain coefficient (d_{33}) increases as the thickness of the porous layer and total porosity level of the layered structure. These preliminary results open new and interesting perspectives for the application of energy harvesting devices in the MEMS field but, to be able to optimize the harvester for this specific purpose, thorough research in the multi-physics and multi-scale modeling of these new materials as well as in the analysis of the powder synthesis route and shaping technology is required. The piezoelectric features can be suitably designed, harnessing the capabilities of innovative</p>



	<p>techniques of additive manufacturing. As a matter of fact, it is currently possible to create objects of complex shape, made of ceramic materials, both via binder jetting (powder-based additive manufacturing) and through inkjet printing. The research group has developed specific skills on such topics and may access to experimental equipment at the cutting edge of technology. The use of those machines, combined with a set of preliminary computational studies, may lead to the precise engineering of the porosity level, in order to achieve piezoelectric materials with unprecedented electro-mechanical features. The innovative piezoelectric materials can be applied to real devices for energy harvesting, also in view of recent research on the beneficial effect of metamaterials which are able to control the propagation of elastic waves. The research proposal aims at the optimal design of the metamaterial, so that the elastic energy can be focused on specific points, boosting the interaction with a piezoelectric resonator. The research group reached significant results in that field, but the shape optimization of the metamaterial is quite complicate. As a consequence, we plan to adopt the techniques of artificial intelligence, and more specifically of reinforcement learning, for the achievement of optimal metamaterials. In that way, the coupling of optimal metamaterials and innovative piezoelectric material may lead to interesting results in the ambit of vibration energy harvesting.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The methods and techniques that will be used and further developed within this PhD are:</p> <ul style="list-style-type: none"> - selection of the lead-free material, the composition and the geometry of the final components; - simulation of the production processes, in order to forecast the final properties of the ceramic materials; - engineering of the microstructure through modeling of the functional properties in relation to porosity amount and morphology; - design of new energy harvesting architectures, with special focus on the optimal design of metamaterials via reinforcement learning;



	<ul style="list-style-type: none"> - production of ceramic samples by synthesis of the piezoelectric powder, cold consolidation of the complex structure by binder jetting @Funtasma Lab. (to control pore distribution and morphology, or generate porosity graded structures), densification; - study of the dispersion of nanosized powders to produce inks suitable for ink jet printing of MEMS devices with controlled porosity @Polifab; - test of the piezoelectric properties and correlation with the microstructural parameters; - validation of the performance of the structures for mechanical energy harvesting and definition of the application parameters (frequency range, output energy etc).
Educational objectives	At the end of the PhD cycle the candidate will be able to define, design and carry out original research programs by working in a team or leading a research group in the field of smart materials. Opportunities will be offered for spending visiting periods hosted by project partners for scientific cooperation.
Job opportunities	<p>All project activities are strongly connected to industrial needs and industrial and academic partners are directly participating to project tasks.</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>0 Full Professors 2 Associated Professors 2 Assistant Professors 2 PhD Students</p>
Name of the research directors	Prof. Nora Lecis, Prof. Raffaele Ardito

Contacts	
<i>Email:</i> nora.lecis@polimi.it; raffaele.ardito@polimi.it	
For questions about scholarships/support 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	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. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 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>



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: UNRAVELING DAMAGE EVOLUTION IN BIO-INSPIRED MATERIALS: AN INTERDISCIPLINARY MULTI-SCALE STUDY FOR ENHANCED MECHANICAL DESIGN

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	
<p>Motivation and objectives of the research in this field</p>	<p>The investigation of damage and fracture mechanisms in bioinspired materials is a rapidly growing area of study that aims to understand how these complex materials can resist and recover from various forms of damage, including mechanical stress, and environmental factors. The research is motivated by diverse objectives, such as the development of more sustainable and resilient materials for use in medicine, mechanical and material engineering, as well as the achievement of a deeper understanding of the fundamental principles governing biological systems. The study seeks to identify multi-scale structural and functional features that allow bioinspired materials to withstand damage and to design and realize novel materials and techniques that can mimic these properties. The ultimate objective of this research is to design and produce materials that can resist damage and adapt to different conditions, thereby improving our quality of life and contributing to advances in various scientific and engineering fields.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>This research requires a multi-faceted range of methods and techniques to investigate multi-scale damage phenomena and to translate this understanding to the design of novel structures, including:</p> <ol style="list-style-type: none"> 1. Imaging techniques: micro-computed tomography, synchrotron analyses, scanning electron microscopy are



	<p>especially useful for identifying microstructural features that may contribute to a material resilience;</p> <ol style="list-style-type: none"> 2. 3D printing and 3D bio-printing for complex structure design; 3. Multi-scale mechanical testing to study material mechanical properties, including its strength, toughness, and elasticity; 4. Computational modeling, to simulate damage evolution, weakening and toughening phenomena at the multi-scale, including extended finite element (XFEM) strategies to model fracture progression; 5. Image analysis, adopting effective artificial intelligence-based tools for the post-processing of large size datasets, such as high-resolution imaging.
<p>Educational objectives</p>	<p>This cutting-edge research perspective on damage-tolerant bio-inspired materials is a unique opportunity for PhD students to:</p> <ol style="list-style-type: none"> 1. Deepen the multi-scale structure and properties of biological and bio-inspired materials, as well as the principles that govern their damage response; 2. Exploit a plethora of different methods and techniques, including advanced imaging techniques, mechanical testing, and computational modeling; 3. Develop critical thinking, problem-solving skills and foster innovation and creativity by guiding PhD students in the design of novel bio-inspired structures with enhanced mechanical properties; 4. Set up interdisciplinary collaboration between students and faculty in different fields, such as biology, physics, mechanical and material engineering.
<p>Job opportunities</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> <p>Further Institutions cooperating in the research are:</p> <ul style="list-style-type: none"> - MIT, Boston (<i>Laboratory for Atomistic and Molecular Mechanics, development of artificial intelligence-based solutions</i>); - TU Delft (<i>bio-inspired material design</i>);



	- Galeazzi Orthopaedic Institute (<i>biological tissues</i>); - Elettra synchrotron (<i>high-resolution real-time imaging of damage</i>).
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Laura Maria Vergani

Contacts

Phone: +39 022399249 Email: laura.vergani@polimi.it

For questions about scholarship/support 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	700.0 €
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