



PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: INTEGRATED SIMULATION AND SENSOR SOLUTIONS FOR A
DIGITAL LASER WELDING PLATFORM IN ELECTRIC MOBILITY**

Monthly net income of PhDscholarship (max 36 months)

€ 1500.0

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 electrification of mobility requires a significant change in the manufacturing processes involved in the next generation of vehicles. The battery systems and the electric motor require fewer components with a wider variety of materials, shapes, and thicknesses assembled via fusion welding processes. The rapid evolution of the products requires a rapid adaptation of the manufacturing processes while maintaining a robust production in several locations in a distributed manufacturing scheme. Laser based manufacturing is an inherently adaptable to these products being a versatile and digital tool. Lasers can be adapted to cutting, welding, heat treating, and surface texturing operations by selecting the appropriate beam properties in time, space, and wavelength. Moreover, laser systems lend themselves very well to process monitoring integrating sensors inside the source and or the processing heads. For the end user, the laser technology provides a key solution to the technological requirements, while it also poses challenges in terms of a rapid selection between the different laser technologies. An integrated platform towards a digital twin of the manufacturing process incorporating the manufacturing system, sensor equipment and the product are a requirement for the next generation of sustainable production. This project aims to provide a digital framework to laser-based manufacturing, in particular laser welding, for electric mobility by a complete integration between physical and digital process domains.



	<p>The project involves the use of contemporary high-power lasers with beam shaping capabilities in space and time with novel wavelengths with integrated optical monitoring sensors. The project will integrate the process to multi-physics simulations to provide. The simulation platform will be designed to be flexible to be adapted to the different product needs and will be regulated from high fidelity to mid-fidelity configurations on demand to fit with the needs. High fidelity simulations will be exploited to assess process transients to better understand defect formation mechanisms, while mid-fidelity models will help setting processing conditions at reduced simulation times. The physical process and the virtual simulations will be linked through the sensor systems such as OCT, coaxial cameras, and photodiodes providing data for simulation calibration, validation, and continuous adjustment. The project will demonstrate the applicability of the approach in a fully integrated digital platform across different manufacturing plants. The main application fields will cover the production of the electric drive stator and the contacting of Li-ion battery electrodes. The results will provide the end-users higher flexibility in system design and higher robustness in industrial production enhancing the manufacturing sustainability over higher process efficiency and reduced scrap generation.</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 spatial and temporal beam shaping solutions along with wavelength combinations with high power lasers. 2. Experimental study of laser welding on the main electric mobility materials namely Cu, Al, and steel in single and heterogeneous combinations. 3. Process monitoring with OCT and coaxial camera, and photodiode for the development of novel control strategies and data for multi-physics models. <p>Development of a multi-physics simulation solution in loop with the process hardware.</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</p>



	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.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research: IMA Automation, University of Stuttgart
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 5 PhD Students
Name of the research directors	Prof. Ali Gökhan Demir

Contacts
<p><i>Research director:</i> 0223998590 aligokhan.demir@polimi.it</p> <p>https://www.mecc.polimi.it/ricerca/sezioni/tecnologie-meccaniche-e-produzione/</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	750.0 €
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 6.114,50. 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. 750 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</p>



activities, within the limits allowed by the regulations.