POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

BORSE TEF Research Field: SOLID-STATE COOLING VIA ACTIVE PIEZOELECTRIC FLOW CONTROL

Monthly net income of PhDscholarship (max 36 months)
1800.0 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 rapid advancements enabled by artificial intelligence come at the cost of increasingly high energy consumption. Modern CPUs and GPUs are thermally limited, requiring effective cooling solutions to maintain performance. Current systems rely on bulky, energy-intensive, and often noisy active or passive dissipators. This research aims to develop a solid-state cooling system based on a specially shaped duct integrated with piezoelectric membranes. These membranes actively control airflow or liquid movement with minimal energy use. The proposed system is compact, silent, and more efficient than current commercial solutions. It offers a promising alternative for high-performance computing environments. Our goal is to reduce energy consumption and acoustic pollution while enhancing cooling effectiveness. This innovation could significantly impact AI hardware scalability and sustainability.
Methods and techniques that will be developed and used to carry out the research	This project focuses on the development of an innovative solid-state thermal management system designed for high-performance electronic components, such as CPUs and GPUs. It introduces a new paradigm based on active flow control using piezoelectric membranes. The system consists of a microstructured duct with a tailored geometry, designed to optimize fluid dynamics. Along the duct walls, piezoelectric membranes are integrated and controlled to dynamically alter the shape of the duct. This deformation induces and regulates airflow or fluid

	deformation induces and regulates airflow or fluid movement without mechanical fans or pumps. Computational Fluid Dynamics (CFD) simulations are employed to design and validate the geometry and flow behavior. The ultimate objective is to create a compact, silent, and energy-efficient cooling device that significantly outperforms existing commercial solutions. By eliminating moving parts, the system not only reduces maintenance needs and operational noise but also aligns with broader goals of sustainability and miniaturization in electronics. This project bridges multiple disciplines—materials science, fluid mechanics, , and mechatronics—offering a promising foundation for the next generation of advanced, environmentally conscious thermal management technologies.
Educational objectives	The PhD project aims to develop a deep understanding of solid-state thermal management technologies, with a focus on piezoelectrically driven flow control for cooling applications. The candidate will gain expertise in the design, fabrication, and integration of active piezoelectric systems within compact cooling architectures. Through theoretical study and hands-on experimentation, the student will master principles of unsteady aerodynamics, microfluidics, and energy-efficient actuation. Advanced skills in numerical simulation (e.g., CFD with fluid-structure interaction), as well as signal acquisition and control, will be cultivated. The interdisciplinary nature of the research will strengthen the candidate’s ability to tackle complex engineering challenges at the convergence of mechanics, materials science, and thermal systems.
Job opportunities	This research supports the development of entrepreneurial ideas by addressing a concrete and growing market need: efficient, compact, and silent cooling solutions for high-performance electronics. By introducing a solid-state system based on piezoelectric actuation, the project opens the door to new hardware applications with strong commercial potential. The technology can be scaled and adapted for various sectors, including consumer electronics, data centers,

	electric vehicles, and aerospace. Its silent operation and low energy consumption are key differentiators, offering a competitive edge in sustainability-focused markets. The project fosters innovation through interdisciplinary collaboration, combining materials science, fluid dynamics, and mechatronics. Throughout the research, attention is given to patentability and technology transfer, laying the groundwork for future spin-offs or startups. By developing a functional proof of concept and validating performance in real conditions, the research reduces the time and risk associated with commercialization.
Composition of the research group	1 Full Professors 2 Associated Professors 0 Assistant Professors 1 PhD Students
Name of the research directors	Prof. Francesco Braghin

Contacts
For questions about scholarship/support Francesco.braghin@polimi.it, phd-dmec@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	900.0 €
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 €7.338,00. PhD candidates benefiting from this scholarship are required to spend a research period of at least 3 months abroad, joining high-level research groups in their specific research field, as agreed upon with their Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approximately €900/month – net amount). Additionally, candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3.000 to cover travel expenses. Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities related to teaching

support. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.