POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

Number of scholarship offered	20
Department	DIPARTIMENTO DI FISICA

Description of the PhD Programme

The PhD Program aims at providing engineers and physicists with a general education in the basic areas of applied physics and specific knowledge in condensed matter physics, optics, lasers and photonics.To develop a research-oriented mind-set, the PhD students are guided to acquire problem-solving capabilities in a complex context, including in-depth problem analysis, identification of original solutions and capability of evaluating their applicability in given contexts. These skills will provide future doctors with major opportunities for their activities both in the academic field and in public and private companies and organizations.
The education contents are strictly related to the research activities carried out in the advanced experimental laboratories at the Department of Physics. In particular, 5 research lines can be identified:

- Ultrafast optics and spectroscopy: i) development of new nonlinear optics-based methods to generate broadly tunable pulses, from the infrared the extreme-ultraviolet, with duration down to single optical cycle limit (from a few femtoseconds to attoseconds); ii) application to the study of primary photoinduced processes in atoms, molecules and solid state materials.
- Solid state lasers and photonic devices: i) development of ultra-broad band solid-state lasers and amplifiers for optical frequency combs; ii) femtosecond laser micromachining of transparent materials for novel optofluidic devices and integrated quantum optical circuits; iii) theoretical investigation and design of optical nanostructures for sensing applications.
- Photonics for health, food and cultural heritage. Development of innovative photonic systems and techniques and application in interdisciplinary fields relying on non-invasiveness and high diagnostic potential of optical means (e.g., fluorescence or photon migration). Projects involve theoretical investigations and simulations as well as extensive experimental work, including development of advanced laboratory set-ups and dedicated prototypes for use in real settings.
- Epitaxial growth and nanostructure fabrication (Milano-Leonardo and Como): i) synthesis of artificial materials for microelectronics, optoelectronics, plasmonics and spintronics; ii) optical and electron beam lithography; iii) spectroscopy and microscopy; iv) SiGe/Si heterostructures; v) graphene nanoelectronic devices; vi) magnetic thin films, oxide thin films.
- Electronic, optical and magnetic properties of low-dimensional systems (Milano-Leonardo and international synchrotron radiation facilities): i) x-ray spectroscopies with synchrotron radiation;

ii) ultrafast magnetic and electronic phenomena; iii) positron annihilation spectroscopy, antimatter production (at CERN); iv) nano-optics and plasmonics.

The specific research subject will be assigned within the first months of the PhD activity, with the agreement of the candidate and the Board of Professors of the PhD Program.

Most research is integrated with the activities of the Institute of Photonics and Nanotechnologies of the National Research Council (IFN-CNR) and with the Interuniversity Center LNESS (Laboratory of Epitaxial Nanostructures on Silicon and for Spintronics). Collaboration is also active with the IIT (Istituto Italiano di Tecnologia) Center for Nano Science and Technology.

Several collaborations are on-going with high-level international institutions, both universities and advanced research centers (e.g., University of Cambridge, Massachusetts Institute of Technology, Stanford University, University College London, Harvard University). Students enrolled in our PhD Program will therefore have a real opportunity to gain experience also in prestigious laboratories abroad.

The Department of Physics is home to the PhD Program. Further information on the PhD Program and related research activities can be found at: www.fisi.polimi.it

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: ADVANCED MICROSCOPY OF NANOSTRUCTURED INTERFACES AND 2D MATERIALS

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Modern nano-fabrication techniques allow structuring of surfaces, far below the wavelength of visible light. The design and characterization of such metamaterials require sub-diffraction resolution microscopy. The thesis aims at investigating light-matter interaction at the nanaoscale by means of advanced microscopy techniques.Modern nano-fabrication techniques allow structuring of surfaces, far below the wavelength of visible light. The design and characterization of such metamaterials require sub-diffraction resolution microscopy. The thesis aims at investigating light-matter interaction at the nanaoscale by means of advanced microscopy techniques.
Methods and techniques that will be developed and used to carry out the research	Nano-imaging and nano-spectroscopy will be used to investigate light-matter interaction at the nanoscale, including excitons polaritons in 2D materials.
Educational objectives	Application of sub-diffraction limited microscopy.
Job opportunities	Developing new functionalities in nano-imaging microscopy and spectroscopy is constantly part of the research efforts of microscopes manufactures. Moreover, the application to 2D materials open to new possibilities in the emerging field of flat lightweight electronics.
Composition of the research group	1 Full Professors 4 Associated Professors 4 Assistant Professors 3 PhD Students
Name of the research directors	Antonio Ambrosio

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Contacts
antonio.ambrosio@iit.it https://www.iit.it/index.php/people/antonio-ambrosio; https://www.iit.it/it/web/vectorial-nano-imaging.

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	650.0 €
By number of months	6

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

Educational activities **per year :**

1.766,75 euros per student for each year.

Teaching assistantship**:**
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.

Computer availability: individual use

Desk availability: individual use

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: COMPUTATIONAL METHODS IN FLAT OPTICS.

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Designing and realization of optical metasurfaces that enable unprecedented manipulation of light is an important interdisciplinary topic, also attracting large industrial players. The thesis aims at implementing the most recent computational CPU- and GPU-based methods to design new metasurfaces in dielectrics and 2D materials.
Methods and techniques that will be developed and used to carry out the research	CPU- and GPU-based architectures for designing of metasurfaces.
Educational objectives	Implementation of new numerical and analytical methods
Job opportunities	Developing new functionalities in Flat Optics and 2D materials open to new possibilities in the emerging field of flat lightweight electronics.
Composition of the research group	1 Full Professors 4 Associated Professors 4 Assistant Professors 3 PhD Students
Name of the research directors	Antonio Ambrosio

Contacts
antonio.ambrosio@iit.it https://www.iit.it/index.php/people/antonio-ambrosio https://www.iit.it/it/web/vectorial-nano-imaging

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	650.0 €
By number of months	6

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

Educational activities **per year :**

1.766,75 euros per student for each year.

Teaching assistantship**:**
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.

Computer availability: individual use

Desk availability: individual use

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: EDIBLE ELECTRONICS

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch, 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 emerging field of edible electronics is creating great scientific resonance by envisioning a technology which is safe for ingestion, environmentally friendly, cost-effective, and degraded within the body after performing its function, either digested or even metabolized. Long-term opportunities include smart pharmaceuticals and direct food tagging. We offer one scholarship in the framework of the European FET project "ROBOFOOD", where edible electronics will be applied to edible soft robots.
Methods and techniques that will be developed and used to carry out the research	The study will be performed within the "Printed and Molecular Electronics" group, led by Mario Caironi in the Center for Nano Science and Technology @PoliMi, of the Istituto Italiano di Tecnologia. The study will specifically focus on edible power supplies, in particular edible galvanic couples and batteries.
Educational objectives	Expanding the knowledge of the electronic and electrochemical properties of food and food derivatives, learning solution-based fabrication techniques, exploring the toxicological properties of synthetic carbon based materials, working in a multidisciplary field.
Job opportunities	Edible Electronics is new multidisciplinary research field, providing a great opportunity to be exposed to several different environments, from academia to industry. Careers in academia, in industry, industrial R&D and consulting are possible.
Composition of the research group	1 Full Professors

	4 Associated Professors 6 Assistant Professors 9 PhD Students
Name of the research directors	Mario Caironi (PI)

Contacts
Mario.caironi@iit.it, tel. 0039 02 2399 9875; https://www.iit.it/research/lines/printed-and-molecular-electronics

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	650.0 €
By number of months	6

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

***Educational activities* per year :**

1.766,75 euros per student for each year.

***Teaching assistantship*:**
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.

Computer availability: *possible to acquire a laptop (to be discussed with the supervisor)*

Desk availability: Individual use computer and desk.

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: INTEGRATED QUANTUM PHOTONIC PROCESSOR

Monthly net income of PhDscholarship (max 36 months)
€ 1200.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	In the context of the EU FET-OPEN project with acronym PHOQUSING, the objective of the research activity is to develop reconfigurable integrated photonic circuits to be used as quantum processors in the next generation of Noisy, Intermediate-Scale Quantum (NISQ) devices
Methods and techniques that will be developed and used to carry out the research	Femtosecond laser micromachining of transparent materials to create the photonic circuits and photolithography of electrical circuits on the same chip to implement device reconfigurability. Vacuum packaging of devices. Photonic techniques to characterize, interface, and exploit the devices.
Educational objectives	Solid understanding of photonics and light-matter interaction. Hands-on training in femtosecond laser micromachining. Participation and presentation of the results at major international conferences. Writing of scientific articles.
Job opportunities	Post-doc opportunities in academia, both in Italy and abroad. R&D activity in high-tech companies.
Composition of the research group	4 Full Professors 1 Associated Professors 4 Assistant Professors 3 PhD Students
Name of the research directors	Roberto Osellame

Contacts
roberto.osellame@polimi.it, +390223996075,

http://www.mi.ifn.cnr.it/people/roberto-osellame

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	600.0 €
By number of months	6

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

***Educational activities* per year :**

1.630,80 euros per student for each year.

***Teaching assistantship*:**
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.

Computer availability: individual use

Desk availability: individual use

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: INTEGRATION OF LED-FREE PIEZOELECTRIC MATERIALS IN MEMS

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,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 research program will focus on the integration of lead -free piezoelectric materials on MEMS devices (sensors, actuators, energy harvesters, etc.). Given the regulatory standards of the European Commission on reducing the use of lead also in microelectronics, there is an urgent need to replace PZT, the piezo material widely used in MEMS, with innovative lead-free materials. However, there are currently no solutions compatible with industrial applications. The project aims to fill this gap by working in synergy with one of the major players in the MEMS field: STMicroelectronics.
Methods and techniques that will be developed and used to carry out the research	The candidate will work in a team made of a full professor, an assistant professor and a PhD student in the framework of the Joint Research Centers STEAM between Politecnico di Milano and STMicroelectronics. Experimental activities will be carried out in Polifab (www.polifab.polimi.it). In particular the candidate will work on a new, fully automatized cluster tool for confocal sputtering on 8" wafers, equipped with two chambers for functional oxides and metals.The following activities are foreseen: (i) identification of emerging lead-free materials compatible with silicon processes in cooperation with DFT theoreticians; (ii) syntheses of piezoelectric films by PVD processes on 8" wafers; (iii) film characterization, (iv) integration in MEMS prototypes.
Educational objectives	Development of interdisciplinary knowledge at the boundary between physics, microfabrication technology,

	micromechanics and electronics.
Job opportunities	This activity will be carried out within the Joint Research Center of STM and Politecnico di Milano (MEMS lab), in strong connection with the world of MEMS development and production. This PhD will represent a solid basis for careers both in academia and in MEMS industry.
Composition of the research group	1 Full Professors 2 Associated Professors 2 Assistant Professors 4 PhD Students
Name of the research directors	Riccardo Bertacco

Contacts
riccardo.bertacco@polimi.it tel. 0039 02 2399 9663; https://www.fisi.polimi.it/en/people/bertacco. *http://nabis.fisi.polimi.it* *In collaboration with the staff of Polifabwww.polifab.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

Educational activities **per year :**

1.902,37 euros per student for each year.

Teaching assistantship**:**
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.

Computer and Desk availability: *individual use*

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: LAB-ON-A CHIP FOR BIO-APPLICATIONS - PHOTONICS MEETS MICROFLUIDIC AND LIFE SCIENCE

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,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 World Health Organization has put forth ambitious milestones moving toward an early stage detection of high social impacts diseases. In this framework, Photonics in combination with Lab-on-a-chip technologies provide a key pathway towards the development of a automatic, portable, high-sensitivity and affordable diagnostic platform, as well as key tools to be able to simulate the behavior of 2-3D cellular systems (up to organ mimicry - 3D Scaffolds) already at the laboratory stage. In particular, this approach allows to study, almost in real time, the cells response to light stimuli and/or drug delivery. Nano science and technology are at the forefront of such activity. They are also involved in humanoid technology and the development of new organ-on-a-chip. The main objective is innovation, exploiting new knowledge in proof of concepts devices.http://cnst.iit.it/
Methods and techniques that will be developed and used to carry out the research	Femtosecond Laser Micromachining; Hybrid wet etching; Co2 laser polishing; Inkjet printing; Raman Spectroscopy; Manufacture and optimization of integrated Optofluidic "Lab on a chip" devices for various bio-photonics application: liquid biopsy, study of mechanical properties of cells in real time and/or subjected to external stimuli (optical, electrical and magnetic). Cell-lines management.
Educational objectives	The topic is highly interdisciplinary. The main outcome is a trans-disciplinary language that able to provide useful skills and tools to push forward Lab-on-a-chip / Organ-on-a-chip frontier research, while keeping a physical and

	photonic engineering solid base.
Job opportunities	Academic, Research institutes. Engineers, physics, research or technical managers in high-tech industry: Optics&Photonics, Bio Photonics Companies, Microfluidic, Lab on a Chip manufacturing, Bio Tech R&D, Electronics devices, biomedical engineers, smart packaging (serialization and anticounterfeiting) and QC on Pharmaceutical industry.
Composition of the research group	1 Full Professors 1 Associated Professors 5 Assistant Professors 5 PhD Students
Name of the research directors	Guglielmo Lanzani; Luigino Criante

Contacts
luigino.criante@iit.it; silvia.matti@iit.it; guglielmo.lanzani@polimi.it +39 2399 9877/67 - http://cnst.iit.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	650.0 €
By number of months	6

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

Educational activities **per year :**

1.766,75 euros per student for each year.

Teaching assistantship**:**
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.

Computer availability: individual use

Desk availability: individual use

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: LIGHT-MATTER INTERACTION IN METAMATERIALS AND METASURFACES.

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,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 thesis aims at investigating light-matter interaction at the nanaoscale by realizing new nanostructured surfaces, metasurfaces. Advanced nano-fabrication techniques will be used, supported by numerical simulations of the designed devices.The thesis aims at investigating light-matter interaction at the nanaoscale by realizing new nanostructured surfaces, metasurfaces. Advanced nano-fabrication techniques will be used, supported by numerical simulations of the designed devices.
Methods and techniques that will be developed and used to carry out the research	Cleanroom nano-fabrication techniques will be used for the device production. Complex laser and microscopy setups will be used for the characterization of the devices.
Educational objectives	Investigation of light-matter interaction at the nanoscale.
Job opportunities	Lightweight and wearable optoelectronics is now experiencing large interest from big industrial players, for devices ranging from cell phone cameras to augmented and virtual reality.
Composition of the research group	1 Full Professors 4 Associated Professors 4 Assistant Professors 3 PhD Students
Name of the research directors	Antonio Ambrosio, Guglielmo Lanzani

Contacts
antonio.ambrosio@iit.it https://www.iit.it/index.php/people/antonio-ambrosio

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	650.0 €
By number of months	6

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

Educational activities **per year :**

1766,75 euros per student for each year.

Teaching assistantship**:**

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.

Computer availability: *individual use*

Desk availability: *individual use*

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: NANO MATERIALS FOR THE NEW GENERATION HUMAN MACHINE INTERFACE

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Evolution in human-machine interface requires the use of bio-compatible, bio-mimetics and functional materials, with high performance also in terms of durability and robustness, and the understanding of complex interface mechanisms taking place between the abiotic and biotic realms. The proposed activity concerns the characterization of nano-materials (nanoparticles, molecular aggregates, fibrillis) that can be used to develop interfaces; the study of interface model systems; the realization of hybrid systems. The project has broad implications in the world of robotics and life science. In particular, they could lead to revolutionary applications in fields such as prostheses (see the retinal prosthesis developed by our laboratory https://www.novavido.it/it/), the treatment of paralyzed patients or patients who have undergone amputations and soft robotics.
Methods and techniques that will be developed and used to carry out the research	Spectroscopy: steady state absorption and emission; time resolved photoluminescence and pump-probe. Spettro-electro-chemistry. 3D bio printing, other deposition techniques for fabricating hybrid samples. Electrophysiology on cell-lines.
Educational objectives	The topic is highly interdisciplinary. The main outcome is a trans-disciplinary language and the understanding of multi-scales problems, while keeping a photphysics solid base.
Job opportunities	Academic; Research institutes; Bio Tech R&D; Bio

	photonics companies;
Composition of the research group	1 Full Professors 1 Associated Professors 5 Assistant Professors 5 PhD Students
Name of the research directors	Guglielmo Lanzani

Contacts
guglielmo.lanzani@polimi.it; *silvia.matti@polimi.it;* *https://www.iit.it/it/web/nanomaterials-for-energy-and-lifescience*

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	650.0 €
By number of months	6

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

***Educational activities* per year :**

1.766,75 euros per student for each year.

***Teaching assistantship*:**
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.

Computer availability: individual use

Desk availability: individual use

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: NANOSTRUCTURING QUANTUM MATERIALS FOR NANOELECTRONICS AND SPINTRONICS

Monthly net income of PhDscholarship (max 36 months)
€ 1250.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Controlling at the nanoscale the magnetic, transport and optical properties of quantum materials enables the study of new phenomena and the realization of complex functionalities for next generation devices.The research aims to employ a technique called ¿phase nanoengineering¿ for producing highly controlled changes in the phase, defectosity or surface chemistry of thin films. This will in turn allow to tune their transport and magnetic properties. The technique will then be used for realizing artificial nanomaterials and devices with enhanced functionality. The research activity is part of the H2020-ERC-2020-Stg: ¿Beyond Nanofabrication via nanoscale phase engineering of matter (B3YOND - GA 948225)¿
Methods and techniques that will be developed and used to carry out the research	Growth of thin film multilayer structures via magnetron sputtering.Nanoscale surface characterization of the morphology, electric and magnetic properties via Scanning Probe Microscopy. Conventional Nanofabrication techniques, e.g. optical lithography, e-beam lithography, ion milling.Advanced Nanofabrication via thermal scanning probe lithography and direct UV laser writing.Magnetic characterization via Kerr microscopy, vibrating sample magnetometer and synchrotron-based techniques.Electronic transport measurements: Magnetoconductance, Hall measurements. Cryogenic transport measurements in cryostat.Numerical methods: Micromagnetic simulations and Finite Elements Method simulation of electronic and thermal transport.

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Educational objectives	Understanding of electronic transport and magnetism in nanostructured quantum materials. Training in cleanroom techniques, nanoscale measurements, transport measurements and micro-nanofabrication methods. Participation and presentation in local and international workshops and conferences. Writing of scientific articles and proposals.
Job opportunities	Post-doc opportunities in academia both in Italy and abroad. R&D positions in companies, universities and research centers in Italy and abroad. Managerial positions in the field of innovation and technology
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	Edoardo Albisetti, Daniela Petti

Contacts
edoardo.albisetti@polimi.it, daniela.petti@polimi.it. PhyND group. https://phynd.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	625.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
***Educational activities* per year :** **1.698,65 euros per student for each year.** ***Teaching assistantship*:**

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.

Computer availability: individual use

Desk availability: individual use

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

OPEN SUBJECT Research Field: PHD IN PHYSICS

Monthly net income of PhDscholarship (max 36 months)
€ 1195.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Translation of scientific knowledge into new technology and transfer of innovation to the production system represent a needed step for many companies, also dictated by an increasingly global market. For the purpose, individuals with broad cultural background are needed. In particular, many advanced sectors of industry and research require a good knowledge in topics such as condensed matter physics, optics, laser technology and instrumentation, and nanostructured materials.
Methods and techniques that will be developed and used to carry out the research	The PhD Program has application-oriented character that clearly distinguishes it from PhD Programs at the Schools of Science. Candidates are also encouraged to carry out part of their research activities in contact with other research groups in their field of interest, possibly abroad.
Educational objectives	The aim of the PhD in Physics at Politecnico di Milano is the training of personnel with strong research capacity, able to operate in basic and applied research and development facilities, and to manage and design high-tech and innovative products and processes in various industrial sectors.
Job opportunities	Manager of devices, equipment and systems in large industries and companies. Designer of new components and advanced optoelectronics devices in high-tech industries as well as small innovative enterprises.Researcher in industries, universities, research centres.

Composition of the research group	19 Full Professors 32 Associated Professors 18 Assistant Professors 105 PhD Students
Name of the research directors	Cerullo,P.Laporta,P.Taroni,F.Ciccacci,L.Duò

Contacts
PhD Program Secretary: daniela.rossi@polimi.it, +39-02-23996169 stefania.mosca@polimi.it +39-02-23996136 PhD *Program Coordinator*: marco.finazzi@polimi.it, +39-02-23996177 http://www.fisi.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	597.50 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activities per year : **1624,30 euros per student for each year.** *Teaching assistantship*: 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. Computer availability: 1st year: *individual use* 2nd year: *individual use*

3rd year: *individual use.*

Desk availability:
1st year: *individual use*
2nd year: *individual use*
3rd year: *individual use*

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

INTERDISCIPLINARY Research Field: PHYSICAL / CHEMICAL ANALYSIS OF NANOSTRUCTURED INTERFACES FOR NEW GENERATION BATTERIES

Monthly net income of PhDscholarship (max 36 months)
€ 1195.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Interdisciplinary PhD Grant The PhD research will be carried out in collaboration with research groups of the PhD programme in "**ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY**". See https://www.dottorato.polimi.it/?id=422&L=1 for further information. In the progress of new generation batteries (eg. metallic Li, Li-S, Li-air, Na, Zn, solid electrolyte, thin film), which promises advantages in terms of energy density, power, durability and safety, the development of new nanostructured materials and a better knowledge of the intercalation mechanisms at the micro-nanoscale length-scale become crucial. In particular, the stability, durability and performance of a battery are affected by phenomena at the interface during electrochemical cycles, which can lead to the formation of deposits, phase changes, structural modifications and degradation. Many studies focus on the physical / chemical properties of the surface, others on the effects on battery operation. In general, there is a lack of detailed studies that try to link local analysis at the nanoscale with device performances. The goal of this research is to fill this gap and to analyze the electrode / electrolyte interface using microscopic, spectroscopic and electrochemical techniques on model surfaces under in-operando conditions, i.e. similar to those of a real battery (https://www.fisi.polimi.it/en/research/research_structures/laboratories/solinano). We focus the study on intercalation in graphitic materials, and the modifications in oxide

	electrodes used as cathodes in Zn ion batteries.
Methods and techniques that will be developed and used to carry out the research	To study the physical / chemical properties of an interface, high surface sensitivity and high spatial resolution techniques are required. Scanning probe microscopy, such as the atomic force microscope (AFM), allows a local morphological analysis of the electrode surface. The combination with Raman spectroscopy and cyclic voltammetry allows then to simultaneously monitor the chemical and structural evolution of the surface and the electrochemical processes that take place there. An electrochemical-AFM (EC-AFM) is available at the Solinano-¿ interdepartmental laboratory which allows the investigation of solid-liquid interfaces in electrolytic solutions, in combination with voltammetry and Raman chemical maps. A parallel development activity of nanostructured films for batteries, active at the Nanolab, will allow to identify the model surfaces under study. It will be possible to combine further investigations, such as SEM microscopy, STM microscopy and photoemission spectroscopy.
Educational objectives	The research project brings the candidate to the frontier of research in the field of nanomaterials for batteries and energy storage. The preparation and formation increases the experimental abilities of the candidate and gives a solid knowledge in combined microscopy, spectroscopy and electrochemical investigations (https://www.fisi.polimi.it/en/research/research_structures/laboratories/solinano).
Job opportunities	Applied research in physical/chemical properties of materials and electrochemical and electrode analysis opens professional carriers in National and International Universities, gives opportunities in hiring in factories and companies involved in energy storage and batteries, such as De Nora, Merch, etc.
Composition of the research group	2 Full Professors 1 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Gianlorenzo Bussetti; Andrea Libassi

Contacts
gianlorenzo.bussetti@polimi.it (DFIS); *andrea.libassi@polimi.it (DENG).*

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	597.50 €
By number of months	6

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

Educational activities per year :

1624,30 euros per student for each year.

Teaching assistantship:
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.

Computer and desk availability: shared use computer and desk

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: PRINTED ELECTRONICS FOR RADIO FREQUENCIES

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Printed Electronics is an emerging field, aiming at fabricating large-area, flexible and lightweight circuits by means of scalable printing techniques. Applications are broad, from wearable micro- and opto-electronic systems, to Internet of Things, and biomplatable, and even edible, devices for human body sensing. In this context, solution-processable organic semiconductors are one of the most promising options. However, to date, printed organic electronics fail in meeting the minimum requirements for being adopted in many wireless applications where operation in the the Ultra-High Frequency (UHF) bandwidth is necessary. Several fundamental aspects of the electronic properties of printed organic semiconductors (charge transport, injection, doping) have to clarified and implemented in UHF electronic devices. A PhD in this area will tackle both the challenges of developing new high performance printed devices, to the deep understanding of the device physics to boost the development of the field.
Methods and techniques that will be developed and used to carry out the research	The study will be performed within the ¿Printed and Molecular Electronics¿ group, led by Mario Caironi in the Center for Nano Science and Technology @PoliMi, of the Istituto Italiano di Tecnologia. The study will require the development of suitable architectures and printing protocols of high-performance electronic devices, mainly transistors, derived from a deep understanding of organic device physics.
Educational objectives	Expanding the knowledge of the electronic properties of

	printed organic semiconductors, learning solution-based and printing fabrication techniques, deep insight in device physics, working in a multidisciplary field.
Job opportunities	Printed Electronics is a worldwide expanding field, with several growing opportunities worldwide, particularly in EU and also in Italy. Careers in academia, in printed electronics industry, industrial R&D and consulting are possible.
Composition of the research group	1 Full Professors 3 Associated Professors 6 Assistant Professors 9 PhD Students
Name of the research directors	Mario Caironi

Contacts
Mario.caironi@iit.it, tel. 0039 02 2399 9875; https://www.iit.it/research/lines/printed-and-molecular-electronics

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	650.0 €
By number of months	6

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

***Educational activities* per year :**

1.766,75 euros per student for each year.

***Teaching assistantship*:**

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.

Computer availability: individual use

Desk availability: individual use

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: SPETROSCOPIC INVESTIGATIONS OF QUANTUM TRANSITION- METAL FLUORIDES

Monthly net income of PhDscholarship (max 36 months)
€ 1195.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,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 project Prin2020 QT-FLUO (ID 20207ZXT4Z) addresses a modern and challenging class of compounds which are transition metal fluorides (TM¿FLUO). The interest of TM-FLUO derives from the prediction that AgF2 based compounds, given their remarkable similarities with CuO based superconductors, should show superconducting behavior and exotic quantum magnetism.AgF_2 based compounds have therefore become subject of a recently funded national PRIN project "Quantum Transition-metal FLUOrides (QT-FLUO)" for the preparation and characterization of AgF_2 based compounds.Among the characterization techniques the applying group will focus on studies of Resonant Inelastic X-Ray Scattering and Time¿resolved ARPES. A team of chemists, expert in fluorination procedures will be responsible for the preparation of the highly reactive AgF_2 samples.The successful candidate will be mainly involved in the spectroscopic investigations, but in close contact and collaboration with the preparation team, to be aware of all aspects of these fascinating compounds.
Methods and techniques that will be developed and used to carry out the research	Time Resolved-ARPES will be performed to study fluorinated TMs samples to detect the evolution of the bands as the system is fluorinated. The time resolution of the setup (50 fs) allows a straightforward separation of electronic and phononic degrees of freedom taking place during the relaxation process induced in pump-probe experiments.RIXS is an energy loss spectroscopy that gives direct access to crystal field, charge transfer and

	spin excitations. Its measurement at the Ag L_3 edge or fluorine K edge can determine the main parameters involved in magnetic and charge excitations. RIXS experiments will be carried out at the ESRF (Grenoble) and DLS (Oxford).
Educational objectives	The student will learn the physics of quantum materials through advanced spectroscopy studies. She/he will become expert of soft x-ray resonant spectroscopy, inelastic scattering, resonant elastic scattering, pump-probe experiments with x-rays, time¿ and angle¿resolved photoemission. All aspects of experiments will be considered: experimental planning, data collection, data reduction and analysis, interpretation also through model calculations.
Job opportunities	RIXS and TR-ARPES are among the most modern and challenging spectroscopic methods for solids. A scientist skilled in one of these techniques can be highly seeked for research positions thanks to her/his expertise. The technical knowledge involved in the experiments will make the successful Ph.D student an interesting candidate also for highly technological industries.
Composition of the research group	2 Full Professors 1 Associated Professors 2 Assistant Professors 5 PhD Students
Name of the research directors	Claudia Dallera, Giacomo Ghiringhelli

Contacts
claudia.dallera@polimi.it +39 02 2399 6171 giacomo.ghiringhelli@polimi.it +39 02 2399 6067 www.fisi.polimi.it ; www.polimix.fisi.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	597.50 €
By number of months	6

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

Educational activities per year :

1624,30 euros per student for each year.

Teaching assistantship:
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.

Computer availability:
1st year: *individual use*
2nd year: *individual use*
3rd year: *individual use.*

Desk availability:
1st year: *individual use*
2nd year: *individual use*
3rd year: *individual use*

POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: ULTRAFAST NEAR- AND MID-INFRARED FIBER LASER FOR HYPERSPECTRAL VIBRATIONAL MICROSCOPY APPLIED TO HISTOPATHOLOGY AND PRECISION MEDICINE

Monthly net income of PhDscholarship (max 36 months)
€ 1195.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch,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 main goal of this project is the development of innovative laser sources generating ultra-short pulses in the spectral region between 1 and 3 μm with all-fiber-laser technology for applications to vibrational hyperspectral microscopy for medical diagnostics. Microscopy is a crucial tool in the biological field and in medical diagnostics. For the analysis of biological tissues, microscopy requires preparatory activities on the samples, such as labeling, to allow their functional characterization, at the expense of irreversible sample degradation. The possibility of carrying out a functional microscopy on untreated, label-free samples, would allow to speed up tissue analysis and would open the possibility of real-time investigation of live samples and fragile biological systems. In this context, vibrational spectroscopy is widely recognized as a universal tool for the identification of molecular compounds in chemical and biological samples based on their selective response to light. The hyperspectral techniques that will be investigated within this project are direct vibrational spectroscopy methods (based on the use of fiber lasers in the mid infrared) and non-linear coherent Raman microscopy (through the use of two-color synchronized all-fiber lasers in the near-infrared).
Methods and techniques that will be developed and used to carry out the research	In collaboration with the start-up company CRI s.r.l., a spin-off of Politecnico di Milano, the scholar will develop ultrafast optical techniques (design, construction and

	characterization of ultrafast fiber-lasers working in the near- and mid-infrared) as well as mid-infrared spectroscopy techniques and nonlinear microscopy techniques (stimulated Raman scattering, second-harmonic generation and two-photo-excited microscopy).
Educational objectives	The scholar will receive a multidisciplinary training in topics including laser physics, nonlinear optics, vibrational spectroscopy, biomedical optics and microscopy. He/she will be exposed to steps required for the industrial development of a deep-tech instrument such as the coherent Raman microscope by the company CRI s.r.l..
Job opportunities	Due to the multidisciplinary training in cutting edge techniques of optics and photonics as well as vibrational spectroscopy and biomedical optics, the scholar will have excellent job opportunities in high-tech industries. In addition, he/she will be well positioned for an academic career.
Composition of the research group	2 Full Professors 2 Associated Professors 2 Assistant Professors 5 PhD Students
Name of the research directors	Gianluca Galzerano; Giulio Cerullo

Contacts
gianluca.galzerano@polimi.it giulio.cerullo@polimi.it +39-02-23996164;+39-02-23996185; http://www.fisi.polimi.it/en/people/galzerano; http://www.fisi.polimi.it/en/people/cerullo.

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	597.50 €
By number of months	6

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

Educational activities per year :

1624,30 euros per student for each year.

Teaching assistantship:
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.

Computer availability:
1st year: *individual use*
2nd year: *individual use*
3rd year: *individual use.*

Desk availability:
1st year: *individual use*
2nd year: *individual use*
3rd year: *individual use*