POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 41st cycle

Number of scholarship offered	2
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.

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.

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PhD in FISICA / PHYSICS - 41st cycle

THEMATIC Research Field: NANOFABRICATION OF METASURFACES FOR THE PHOTONIC SYSTEMS FOR AUGMENTED AND VIRTUAL REALITY

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 augmented and virtual reality (AVR) is a new concept that describes the multilevel interaction between people, in which the real and virtual world are interlaced. The ultra-broad band Internet and the ubiquity of smart devices connected to a plethora of content providers has led to an increasing overlap of our digital and physical lives. Although such interactions use our sight and hearing, they are presently mediated by a multitude of devices unnaturally connected to human senses. Luxottica, a worldwide leading company in the eyewear market, has started a highly innovative project, in collaboration with Politecnico di Milano (POLIMI), to design and develop the eyewear of the future. The aim of the research project is to turn eyeglasses into the portal to the AVR, exploiting their natural coupling to our vision. In the long run, this result will be achieved by adding revolutionary capabilities of the AVR to the age-old devices designed to correct vision impairments and protect the eyes from the sunlight. The main objective of the PhD program is the nanofabrication of metasurfaces required for the photonic devices, which will be integrated in a new generation of smart eyewear.
Methods and techniques that will be developed and used to carry out the research	The eyewear of the future, featuring immersive AVR functions, requires new photonic devices that combine digital images with the vision of the real world in a natural and comfortable way. The photonic devices will comprise metasurfaces of different materials fabricated by electron-beam (e-beam) lithography on various substrates.

	The research and development activities will consist of four main tasks. i) Data preparation required for the realization of dense patterns by e-beam lithography, which comprises computer-aided design and proximity-effect correction. ii) Nanofabrication of metasurfaces by e-beam lithography. Different materials (e.g., TiO2, SiO2, Si3N4, pSi) will be used to realize metasurfaces on different types of substrates (e.g., SiO2 and Si). Such nanofabrication comprises e-beam resist-coating, e beam exposure, development, e-beam evaporation, reactive-ion etching, and lift-off processes. iii) Characterization of realized metasurfaces by atomic force microscopy and scanning electron microscopy. iv) Nanofabrication of metasurfaces by e-beam lithography on special master substrates. The masters will be used to realize the metasurfaces on a large scale on glass lenses by nanoimprint lithography. The topics addressed by the research project belongs to the fabrication of photonic devices, an EU Key Enabling Technology.
Educational objectives	The PhD candidate will work in a multidisciplinary team including top researchers in nanofabrication, photonics, electronics, and artificial intelligence. The student will learn the methods for the fabrication of nanostructrues, such as e-beam lithography, e-beam evaporation, reactive-ion etching, and nanoimprint lithography. The student will also learn the basics of digital holography, diffractive optics, physics of metamaterials, computational methods, and system integration.
Job opportunities	The candidate will work in a Joint Research Center POLIMI-Luxottica. Job opportunities will be in companies that develop devices and photonic systems for AVR, which represent a highly innovative and promising technology
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	Prof. Roman Sordan

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Contacts
Roman Sordan: Roman.Sordan@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	750.0 €
By number of months	6

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

Educational activities

Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences). Financial aid per PhD student per 3 years: max 6.114,50 .euros per student

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

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PhD in FISICA / PHYSICS - 41st cycle

THEMATIC Research Field: NANOSTRUCTURED QUANTUM MATERIALS FOR ELECTRONICS AND SPINTRONICS

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	Nanostructured materials allow to control and study novel effects in condensed matter. In this context, developing novel methodologies for crafting and studing the magnetic and transport properties of materials is crucial. The research aims to use advanced nanostructuring methodologies such as phase nanoengineering, for controlling the electronic and magnetic properties in thin film materials, with nanoscale spatial resolution and three-dimensional capability. The final goal will be the realization of novel platforms for unconventional neuromorphic or quantum computing platforms. The research activity is part of the project FARE Ricerca in Italia title “NAMASTE-NAnostructuring MAgnetism in crySTalline matErials” n. R20FC3PX8R – CUP D43C22004040001, funded by MUR.
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.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.
Educational objectives	Understanding of electronic transport and magnetism in nanostructured 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 2 Associated Professors 2 Assistant Professors 5 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	--

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: Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences). Financial aid per PhD student per 3 years: 5707,20 Euros.

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 computer and desk.