



## PhD in FISICA / PHYSICS - 39th cycle

### PNRR 117 Research Field: NANOFABRICATION OF METASURFACES FOR THE PHOTONIC SYSTEMS FOR AUGMENTED AND VIRTUAL REALITY

#### 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 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. The PhD project fulfils the requirements of the Next Generation EU in terms of innovation and strengthening competitiveness. The functionalities of smart eyewear will also help to increase inclusion and social relations.

##### 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



	<p>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.</p> <p>i) Data preparation required for the realization of dense patterns by e-beam lithography, which comprises computer-aided design and optimization of metasurfaces and proximity-effect correction.</p> <p>ii) Nanofabrication of metasurfaces by e-beam lithography. Different materials (e.g., <math>\text{TiO}_2</math>, <math>\text{SiO}_2</math>, <math>\text{Si}_3\text{N}_4</math>, pSi) will be used to realize metasurfaces on different types of substrates (e.g., <math>\text{SiO}_2</math> and Si). Such nanofabrication comprises e-beam resist-coating, e-beam exposure, development, e-beam evaporation, reactive-ion etching, and lift-off processes.</p> <p>iii) Characterization of realized metasurfaces by atomic force microscopy and scanning electron microscopy.</p> <p>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.</p>
<b>Educational objectives</b>	<p>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 nanostructures, such as e-beam lithography, e-beam evaporation, and reactive-ion etching. The student will also learn the basics of digital holography, diffractive optics, physics of metamaterials, computational methods, and system integration.</p>
<b>Job opportunities</b>	<p>The candidate will work in a Joint Research Center POLIMI-Luxottica and carry out an internship at a Luxottica site in Italy or abroad. Job opportunities will be in companies that develop devices and photonic systems</p>



	for AVR, which represent a highly innovative and promising technology.
<b>Composition of the research group</b>	0 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
<b>Name of the research directors</b>	Roman Sordan

<b>Contacts</b>	
Prof. Roman Sordan: Roman.Sordan@polimi.it	
<a href="https://lness.como.polimi.it/ndg.php">https://lness.como.polimi.it/ndg.php</a>	

<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	700.0 €
<b>By number of months</b>	6

<b>National Operational Program for Research and Innovation</b>	
<b>Company where the candidate will attend the stage (name and brief description)</b>	Luxottica
<b>By number of months at the company</b>	6
<b>Institution or company where the candidate will spend the period abroad (name and brief description)</b>	The PhD student will have the opportunity to do an internship in a leading foreign University.
<b>By number of months abroad</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<p><b>Educational activities</b> per year (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences): financial aid for the PhD student for 3 years: max euros 5.707,20.</p> <p><b>Teaching assistantship:</b> 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> <p><b>Computer availability:</b> Individual use.</p>



**Desk availability:**

Individual use.