



# PhD in FISICA / PHYSICS - 40th cycle

**THEMATIC Research Field: DEVELOPMENT OF PEROVSKITES BASED NIR LEDS**

**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**

Near-infrared light-emitting diodes (NIR-LED) are of interest for diverse applications, such as night vision, biomedical treatment, optical communication, and data storage. Commercial NIR-LEDs typically employ epitaxial heterostructures of III-V inorganic semiconductors as emitting materials, which, despite showing close to 100% internal quantum efficiency, are limited by the complexity of material processing and the device architectures - for example, they need highly reflecting mirrors to improve the light outcoupling due to their large refractive index. In recent decades, NIR-LEDs based on solution and vacuum processed emitting materials, including organic semiconductors (OLEDs) and colloidal quantum dots (QLEDs), demonstrated rapid development, offering a higher level of resilience for integration. Although OLEDs show high EQE in the range close to 700 nm, it is limited by the energy gap law and the performance of OLEDs is increasingly sacrificed with increasing wavelength. Currently, NIR-LED efficiency remains modest in NIR-I and NIR-II ranges, though deserving strong attention since such spectral regions, the biological transparency window (650nm - 950 nm) and telecom window (800 - 900 nm), support a wide range of applications, such as biomedical imaging, biomedical sensing, photodynamic therapy, optical communication, just to mention some.

Metal-halide perovskites have attracted increasing attention, especially given the relatively simple synthesis, excellent optoelectronic properties, and their broad-tunable emitting wavelength. With extensive efforts, the lead-halide perovskite LEDs demonstrated high efficiency



	<p>and high color purity, though with a maximum emitting wavelength of up to 800 nm. Tin-halide perovskites can extend the emission wavelength to 950 nm, and mixing Sn and other bivalence metals (e.g., Pb) can further extend the emission over 1000 nm through the bandgap bowing effect. This makes THPs highly promising for NIR-LEDs.</p> <p>The project will aim at the development of tin halide perovskites and at the design, fabrication and testing of stable and efficient light emitting diodes</p>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<ul style="list-style-type: none"> <li>- Materials solution and vacuum processing</li> <li>- Wet chemistry</li> <li>- Time resolved optical spectroscopy</li> <li>- Electronic microscopy</li> <li>- Electronic characterization</li> </ul>
<b>Educational objectives</b>	<ul style="list-style-type: none"> <li>- Material science</li> <li>- Optoelectronics</li> <li>- Photophysics</li> </ul>
<b>Job opportunities</b>	<ul style="list-style-type: none"> <li>- photonics and electronics industry</li> <li>- academia</li> </ul>
<b>Composition of the research group</b>	<p>1 Full Professors                  1 Associated Professors                  3 Assistant Professors                  4 PhD Students</p>
<b>Name of the research directors</b>	Dr. Annamaria Petrozza

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<b>Additional support - Financial aid per PhD student per year (gross amount)</b>			
	<b>1st year</b>	<b>2nd year</b>	<b>3rd year</b>
<b>Housing - Foreign Students</b>	1000.0 € per student	1000.0 € per student	1000.0 € per student
	max number of financial aid available: 1, given in order of merit (only for students with scholarship)..		
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--		



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
<p><b>Educational activities:</b> 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</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 and desk availability:</b> individual use computer and desk</p>