



## PhD in FISICA / PHYSICS - 39th cycle

**THEMATIC Research Field: DEVELOPMENT OF INNOVATIVE FREQUENCY COMB SOURCES IN THE MID-INFRARED BASED ON SILENCE HETEROSTRUCTURES**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1195.5**

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**

Mid-infrared (mid-IR) spectroscopy is a nearly universal way to identify chemical and biological substances and to perform non-intrusive diagnostics. Indeed, the mid-IR spectral range contains the so-called “fingerprint” region (wavelength from 6 to 15  $\mu\text{m}$ ) in which most molecules have vibrational and rotational resonances. This wavelength range can hence be exploited to detect small traces of environmentally hazardous and toxic substances for a variety of applications including defense, security and industrial monitoring. A challenging task is to make mid-IR spectroscopy accessible in remote areas, driving the development of compact and cost-effective solutions to replace table-top systems. In this context, the project aims to investigate new routes for high resolution spectroscopic systems based on dual-comb spectroscopy by developing innovative frequency comb sources in the mid-IR. The strategy developed in the project ELECTROPHOT n. 101097569 (HE ERC-2022-ADG) is based on the unique properties of graded index Silicon Germanium (SiGe) photonics circuits, which are their transparency in a wide spectral range together with the ability to fine tune both the electronic bandgap and refractive index of SiGe alloys. Based on these capabilities, the original idea of the project is to exploit simultaneously optical nonlinear and electro-optic comb generation, to generate compact frequency comb sources providing simultaneously wideband operation with fine and tunable resolution. Four main cornerstones will be developed in the project:

(i) electro-optical frequency comb generators will be



	<p>demonstrated for the first time in these spectral range;</p> <p>(ii) supercontinuum generation will be developed with record low input peak power of only 100 W;</p> <p>(iii) resonator-based frequency comb sources will be developed above 6 <math>\mu\text{m}</math> wavelength;</p> <p>(iv) on-chip room temperature photodetector will be implemented for on-chip signal monitoring, establishing a complete mid IR photonics platform.</p>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>The activity of the PhD student will be focused on the growth and characterization of SiGe heterostructures. In particular the following methods will be used:</p> <ul style="list-style-type: none"> <li>-Epitaxial growth by LEPECVD</li> <li>-HR-XRD</li> <li>-Atomic Force Microscopy.</li> <li>- Device fabrication by standard microfabrication techniques.</li> <li>- Electrical characterization, in particular current-voltage, capacitance-voltage and deep level transient spectroscopy measurements.</li> </ul> <p>Data analysis with Matlab and Python.</p>
<b>Educational objectives</b>	<p>The PhD Course [<a href="http://www.dottorato.polimi.it/">http://www.dottorato.polimi.it/</a>] is characterized by a strong experimental character. It aims at providing high scientific education and training to develop general research abilities in all areas of applied physics. For this research project, the student will acquire an expertise in semiconductor epitaxial growth and device fabrication and characterization.</p>
<b>Job opportunities</b>	<p>The PhD student will acquire key competences in the fields of material science and micro/fabrication. Such competences will open job opportunities such as i) researcher in companies, universities, research centres or process engineer in semiconductor industries.</p>
<b>Composition of the research group</b>	<p>1 Full Professors 2 Associated Professors 3 Assistant Professors 3 PhD Students</p>
<b>Name of the research directors</b>	Jacopo Frigerio



### Contacts

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The research will be carried out within the “SiGe epitaxy” group of the L-NESS laboratory  
<https://lness.como.polimi.it/index.php>.

### 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	597.75 €
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 4.872,90 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 or shared use computer and desk*