POLITECNICO DI MILANO

PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 39th cycle

Research Area n. 2 - Electronics

THEMATIC Research Field: SPAD DETECTORS FOR SHORT-WAVE INFRARED PHOTON COUNTING

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	Applications like Non-Line-of-Sight (NLOS) imaging, quantum communications and quantum computing require single-photon detectors working in the SWIR (short-wave infrared) range with picosecond time-tagging capability and high detection efficiency. NLOS uses time-of-flight information encoded in multiple scattered light for reconstructing images of objects hidden from the camera’s direct line of sight. Quantum communications and quantum computing exploit the detection of single photons, at either 1310 nm or 1550 nm, for generating a secret encryption key and processing qubits, respectively. All such applications would also benefit from quantum photonic integrated circuits (QPICs) operating at 1550 nm because of their ability to provide compact, high-performance, and scalable systems for creation, manipulation and detection of single photons.This research project aims to develop new advanced SPADs (single photon avalanche diodes) for the SWIR range, exploiting either III-V materials (specifically, InGaAs/InP hetero-structures) or germanium-on-silicon platforms. Such new SPADs will target enhanced photon detection efficiency and higher count rate, and will be developed both as separate detectors to be coupled to optical fibers and as detectors integrated with waveguides into quantum photonic integrated circuits.

Methods and techniques that will be developed and used to carry out the research	The single-photon detectors will be modeled and designed with TCAD (technology computer-aided design) simulations and finite element model (FEM) tools, with the main goals of enhancing the collection and detection efficiency, improving the maximum count rate and making them suitable for integration in QPICs. Detectors will be grown and fabricated in external fabs and at POLIFAB (PoliMi?s cleanroom). The SPAD chip and its ROIC (read-out integrated circuit) will be assembled together inside a custom-made package onto a thermo-electric cooler, and fully characterized for assessing electrical and optical performance.
Educational objectives	The PhD student will learn how to model, simulate, design, prototype and characterize single-photon detectors (specifically, SPADs). The PhD student will acquire solid background in physics of semiconductor devices, electronic and photonic integrated circuit design, electronic systems. To this aim, the doctorate activity will include attendance of academic courses, conferences, summer schools and workshops.
Job opportunities	The PhD studies will allow to acquire all required skills and know-how to enable a swift transition to high-level R&D companies and institutes. The POLIMI’s research group has already many contacts with R&D centers and end-users, which employed PhD students and post-docs trained in this research group. Therefore, it is expected that this PhD experience will give access to a wide variety of jobs, from semiconductor industries to application-oriented companies, from academia to start-ups.
Composition of the research group	1 Full Professors 2 Associated Professors 0 Assistant Professors 6 PhD Students
Name of the research directors	Alberto Tosi, Franco Zappa, Federica Villa

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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

Premiality:
Premialities will be recognized to the PhD candidate:
i) up to 2,500.00 euro (gross amount) after completion of the I year, provided that she/he demonstrates a significant contribution to the growth of scientific excellence, the industrial valorization of the research, the networking and communication activities of the research group and of the Department;
ii) up to 2,500.00 euro (gross amount), after completion of the II year, provided that she/he has published at least one paper on a scientific journal and demonstrates a continuous and significant contribution to the growth of scientific excellence, the industrial valorization of the research, the networking and communication activities of the research group and of the Department;
iii) up to 2,500.00 euro (gross amount), after completion of the III year, provided that she/he has published at least two papers on a scientific journal and demonstrates a continuous and significant contribution to the growth of scientific excellence, the industrial valorization of the research, the networking and communication activities of the research group and of the Department.

EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences): financial aid per PhD student

COMPUTER AVAILABILITY: individual use

DESK AVAILABILITY: individual use