PhD in Electrical, Electronics and Communications Engineering

Research Title: Multiscale & multiphysics modeling of optoelectronic devices

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Context of the research activity	The operation of all semiconductor optoelectronic devices (such as light-emitting diodes, lasers, optical modulators, photodetectors and solar cells) results from the interaction of carrier transport (modeled either in a semiclassical framework or with a full quantum approach) and optical phenomena (described by electromagnetic field theory). Most devices are also heavily affected by the temperature dependence of material parameters such as optical gain/absorption, radiative and Auger recombination rates etc. Optoelectronic computer-aided design cannot neglect any of these aspects, and requires the use/development of self-consistent multiphysics simulators including carrier transport, electromagnetic and heat models, as well as physics-based descriptions of all relevant material parameters. The Microwaves and Optoelectronics Group (MOG) of the Department of Electronics and Telecommunications is actively involved both in the development of multiphysics optoelectronic simulators and in their application for device demonstration and optimization. The activity of MOG is backed by cooperations with theoretical/modeling groups contributing to the code development (e.g., the Computational Electronics group led by Prof. Enrico Bellotti at Boston University, U.S.A, and the Applied Electromagnetics group at CNR-IEIIT, Italy), with experimental groups providing essential validation (Università di Padova, Chalmers University of Technology) and with industrial companies (Cisco Photonics, AIM Infrarot Module, Huawei).

Objectives	The goal of the project is to introduce the candidate to the research activity devoted, within the Microwaves and Optoelectronics Group of the Department of Electronics and Telecommunications, to the development of a comprehensive multiphysics numerical simulator for semiconductor optoelectronic devices, and to its application for the optimization of waveguide germanium-on-silicon *pin* photodetectors, which are critical components in optical interconnects on silicon photonics platforms. Thanks to the orthogonality of photon and carrier fluxes, these devices can be designed to maximize both responsivity and electrooptical bandwidth, but research in industry and academia has focused up to now only on their electromagnetic simulation (mostly with commercial tools), while a selfconsistent inclusion of the complex interactions with carrier transport (taking into account also semiconductor processing details) is essential for a realistic description.

Skills and competences for the development of the activity	Basic knowledge of semiconductor physics, applied electromagnetics, and operating principles of electronic/optoelectronic devices. Coding skills in a Matlab-like environment and/or in a programming language suitable for numerical analysis (Fortran, C/C++, Python…)