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PhD open position at Institut FOTON

Experimental and theoretical investigation of low noise semiconductor lasers driven by intracavity nonlinearities

A 36 months duration PhD will start at Institut FOTON, on the modelling, processing and characterizing very low noise vertical cavity surface emitting lasers (VCSEL) in the optical telecommunication wavelength range (1.55 µm).

PhD starting : October 2024
Duration : 36 months
PhD director : M. Alouini ***PhD co-supervisors :*** C. Paranthoen, M.Perrin
Funding : PEPR électronique
Involved Institut FOTON teams : OHM (Optoélectronique, Hétéroépitaxie) and DOP (Dynamique des lasers, Optique hyperfréquence, Polarimétrie)
Keywords : photonic devices, lasers, VCSELs, Two Photon Absorption, microwave photonics, quantum noise.

PhD context

Since few years there is (and there will be) an increasing demand of high frequency and green electronics, covering a large variety of applications such as health care, defense, communications (satellites, 6G). To date, conventional electronics are reaching their limits, and are still limited to bulky and power consuming systems, whereas they could be replaced by less power consuming and fully integrated optical systems. This is one of the key point that has been recently pointed out by Europe and FRANCE2030 actions, through the national call PEPR Electronique (Programme et Equipements Prioritaires de Recherches). Accordingly, photonic integrated circuits (PIC) have to be developed, gathering all the necessary optical functions to go over electronics limitations, including compact and noiseless lasers, optical modulators and optoelectronic oscillators.

The main objective of this PhD project is to develop a 1550 nm VCSEL presenting an unprecedent low relative intensity noise, based on the insertion of optical non linearities (ONL) within the semiconductor microcavity. This approach has been proposed and experimentally demonstrated with success by Institut FOTON in glass and crystal doped solid-state lasers [1] leading to the development of a versatile and robust concept called "*buffer reservoir*". Indeed, by controlling the properties of the nonlinear process introduced in the laser, the noise reduction can reach up to 50 dB over several tens of GHz [2]. Such performances are by far unattainable by any other noise reduction approaches including optoelectronic electronic servo-locking. Nevertheless, the transition from long cavity solid state lasers to short semiconductor cavities such as a VCSEL will need additional refinements from both theoretical and experimental points of view to enable the buffer reservoir mechanism to be implemented during laser processing. Accordingly, the candidate will have to adapt buffer reservoir approach to semiconductor materials involved in both laser

oscillation and noise reduction based on realistic inputs. Different ONL strategies (materials, doping, …) will be investigated and tested in order to fulfill the final device prerequisites. In addition, part of the thesis will focus on the possibility and relevance of actively controlling the physical properties involved in the buffer reservoir mechanism. To reach these objectives, the PhD candidate will benefit from Institut FOTON in house facilities (molecular beam epitaxy, cleanroom) [3], and from the >20 years long experience of Institut FOTON in modelling, designing, fabricating and characterizing lasers and more specifically InP based V(E)CSELs [4,5].

About the PhD candidate

The candidate will have a master or engineer degree. As this project covers a wide panel of scientific fields (material science, optical characterizations, quantum nanostructures physics, laser physics, processing), the candidate will have to show a strong motivation and interests for experimental sciences and theoretical modelling. Moreover, a good team spirit will be required in order to efficiently interact with different members of Institut FOTON (people involved in epitaxy, processing, laser physics, optical characterizations). Basics skills in optoelectronic devices and processing would be appreciated.

About Institut FOTON laboratory

The FOTON Institute is a research unit of the French National Centre for Scientific Research (CNRS) associated to University of Rennes 1 and the National Institute for Applied Sciences (INSA) of Rennes. FOTON is composed of three research teams: the “Optoelectronics, Heteroepitaxy and Materials” team, the “laser Dynamics, microwave photonics, Polarimetry, terahertz, imaging” team located in Rennes, and the “Photonic Systems” team located in Lannion. The OHM research team has an established reputation in the area of advanced materials for photonics, photovoltaics or energy conversion applications. The DOP team research activities cover laser physics and microwave photonics. This team is in particular expert in low noise lasers and has in particular pioneered the buffer reservoir approach. The candidate will carry out research in Rennes, France. More information about FOTON can be found at: http://foton.cnrs.fr

Additional information - Contact

More information by contacting :
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How to apply

Contact: cyril.paranthoen@insa-rennes.fr and mehdi.alouini@univ-rennes1.fr
Documents asked for :

- Motivation letter
- Detailed curriculum vitae (CV)
- Educational grades and marks (at university level)
- Recommendation letters or people to contact for recommendation.

Deadline for submission : 15th may 2024

References :
[1] Kevin Audo "Étude théorique et expérimentale des lasers solides bi-fréquences auto-régulés en bruit d'intensité via des non-linéarités intracavité", PHD (2018), https://www.theses.fr/224573365
[2] K. Audo, M. Alouini, “Intensity noise cancellation in solid-state laser at 1.5 µm using SHG depletion as a buffer reservoir”, Applied Optics, 57, 1524 (2018)
[3] http://nano-rennes.insa-rennes.fr/
[4] A. Kerchaoui et al, « Electrically pumped shot-noise limited class A VECSEL at telecom wavelength”. Opt. Lett. 46, 2465 (2021)
[5] C. Paranthoen, et al, “Low Threshold 1550-nm Emitting QD Optically Pumped VCSEL.”, IEEE Photon. Technol. Lett. 33, 69–72 (2021)