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PhD open position at Institut FOTON

Quantum dot based VECSEL investigation for the realization of innovative microwave photonic devices : from ultra-fast up to coherent dual wavelength lasers

A 36 months duration PhD will start at « Institut FOTON », on the processing and characterizations of vertical and external cavity surface emitting lasers (VECSEL) integrating quantum dots emitting at telecommunication wavelength. Main objectives of this study will concern the optical generation of microwave and THz signals, for radio over fiber communications and radar applications.

PhD starting : between 1er Septembre 2018 and 1er Novembre 2018
Duration : 36 months
PhD director : Alain Le Corre ***PhD co-director :*** Mehdi Alouini
Funding : Already available, ordinary doctoral contract (grant ~1400 € / month)
Involved Institut FOTON groups : OHM (Optoélectronique, Hétéroépitaxie et Matériaux) and DOP (Dynamique des lasers , Optique hyperfréquence, Polarisation) both localized in the same area, respectively in INSA Rennes and University of Rennes 1 buildings
Keywords : VECSEL, quantum dots, tunnel junction, SESAM, Tera Hertz.

PhD context

Since few years, microwave photonics has led to an ever-increasing interest for a large panel of applications, from optical generation of microwave and THz signals, radio over fiber communication, up to generation and detection of optical signals for radar purposes. In this objective, microwave and THz signals can be obtained from frequency stabilized mode-locked lasers, or from the beating of two different wavelength lasers, covering thus optical signals from few GHz up to the well-known THz gap ([0.2, 3] THz). Different type of laser architectures have been proposed and demonstrated, with various level of success. On the one hand, compact semiconductor edge emitting lasers have demonstrated mode locking in particular when exploiting unique properties of quantum nanostructures such as quantum dashes or dots, and dual wavelength lasers have been achieved based on complex fabrication rules. On the other hand, Vertical and External Cavity Surface Emitting lasers (VECSEL) structures have demonstrated also mode locking behavior when integrating Semiconductor Saturable External Mirror (SESAM). In addition, dual wavelength operation has been recently demonstrated based on a rather complex two optical axes configuration. In this last case, both lasers performances have shown improved characteristics (laser linewidth, noise, versatility) inherent to the VECSEL specificity.

The main objectives of this PhD project is to build the different technological blocks necessary to make quantum dots (QD) based VECSELs devices emitting at telecommunication wavelength. This VECSEL platform will enable to conceive frequency stabilized lasers and innovative coherent dual wavelength lasers for the generation of microwave photonics optical signal in the GHz up to the THz frequency range.

About Institut FOTON laboratory

Institut FOTON is a CNRS joint research unit of the INSA engineering school and Rennes 1 University, located in Rennes (OHM and DOP groups) and Lannion (SP group). It gathers facilities in semiconductor growth (MBE), device fabrications (cleanroom) and a unique know-how in dual wavelength solid-state and semiconductor lasers[1,2]. In particular Institut FOTON has a unique and long expertise in the growth of semiconductor nanostructures, and the realization of original photonic devices. In particular, this research laboratory has realized state of the art telecommunication wavelength emitting QDs lasers and mode-locked lasers[3,4], and more recently, the first VCSEL and VECSEL integrating quantum nanostructures in 2010 [5,6] and 2016.

PhD objectives

The main objective of this PhD is to build and develop the technological steps on an InP based QD VECSELs platform, for the realization of ultra-fast and/or coherent dual wavelength lasers emitting at telecommunication wavelength. This PhD proposal will benefit from an international ANR collaborative research project (IDYLIC) gathering teams from Institut FOTON (Rennes, France), IES (Montpellier, France), and LPN-EPFL (Lausanne-Switzerland). In this context, the PhD candidate will be in charge of the processing development of the VECSEL devices. It will mainly constitute in integrating within the already developed V(E)CSEL process a Carbon doped tunnel junction (thanks to recently acquired equipment (2017)), the fabrication of QD V(E)CSELs, and finally in developing the SESAM technology based on in-house facilities. Last but not least, the PhD candidate will be also implied in V(E)CSEL design, optical characterization of the fabricated devices and implementation in original optoelectronics schemes.

About the PhD candidate

The candidate will have a master or engineer degree.
As this project will cover a wide panel of scientific fields (from materials, advanced optical characterizations, quantum nanostructures physics, laser physics, processing, microwave

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[1] G. Baili et al, "*Experimental demonstration of a tunable dual-frequency semiconductor laser free of relaxation oscillations*", Opt. Lett. 34, 3421 (2009), F. A. Camargo et al, "*Coherent Dual-Frequency Emission of a Vertical External-Cavity Semiconductor*", IEEE Photon. Technol. Lett. 24, 1218 (2012).

[2] V. Pal et al, "*Measurement of the coupling constant in a two-frequency VECSEL*", Opt. Express 18, 5008 (2010).

[3] P. Caroff et al, "*High-gain and low-threshold InAs quantum-dot lasers on InP*", Appl. Phys. Lett 87, 243107 (2005), K. Klaime, "*23 and 39 GHz low phase noise monosection InAs/InP (113)B quantum dots mode-locked lasers*", Optics Express, 21, 29000 (2013)

[4] *K. Klaime et al, "23 and 39 GHz low phase noise monosection InAs/InP (113) B quantum dots mode-locked lasers",Optics express 21 (23), 29000 (2013)*

[5] J. M. Lamy et al, "*Polarization control of 1.6 µm vertical-cavity surface-emitting lasers using InAs quantum dashes on InP(001)*", Appl. Phys. Lett. 95, 011117 (2009), F. Taleb et al, "*VCSEL Based on InAs Quantum-Dashes With aLasing Operation Over a 117-nm Wavelength Span*", Photon. Technol. Lett. vol. 25,21, 2126 (2013)

[6] *S. Pes et al, "Class-A operation of an optically-pumped 1.6 µm-emitting quantum dash-based vertical-external-cavity surface-emitting laser on InP", Optics Express Vol. 25,(10),11760 (2017)*

photonics), the candidate will have to get a strong motivation and interests for experimental sciences. Also, the candidate will have to get good human relationship, as he/she will have to deeply interact with Institut FOTON members (people involved in epitaxy, processing, optical characterizations), and other PhD student more concerned in dual wavelength optical characterizations. The candidate will have strong background in semiconductor physics. Basics skills in optoelectronic devices and processing would be appreciated.

Additional information - Contact

More information by contacting :
OHM group : cyril.paranthoen@insa-rennes.fr, alain.le-corre@insa-rennes
DOP group : mehdi.alouini@univ-rennes1.fr

How to apply

All candidate have to send by email to C. Paranthoen (see mail above) the following documents : detailed curriculum vitae (CV), a letter describing the candidate motivations for the position, educational grades and marks (at university level), and optionally people to contact for any recommendations. Candidates from any countries are welcome.

Application deadline is 1/06/2018. Following the deadline, candidates will be rapidly informed of their status. Retained candidates will be invited for an interview, on site (Rennes) or by web seminar depending of their location.