OFFER OF THESIS AT CEA / LETI

Characterization of mechanical strain by polarization degree (DOP) measurements of light during Laser III-V fabrication for Lidar applications

keywords : cathodoluminescence, Instrumentation, clean room manufacturing processes, strain, Laser Lidar, photonic

Contexte

LiDAR (light imaging, detection, and ranging) is a remote sensing technology that uses the pulse of a laser to create 3D models and maps of objects and environments. Most automakers are now betting on this technology to develop autonomous vehicles. The tremendous progress made in integrated photonics on Si, allow today to consider the development of LIDAR on chip at low cost. However, to achieve this goal, several technological issues are to be solved including the design, manufacture and characterization of power III-V laser sources integrated on silicon. In terms of specifications, the sources will emit around 1.55 microns in wavelength to ensure better eye safety in continuous operation, for optical powers of the order of one hundred mW. In order to maximize the optical power emitted, the III-V stacks of the laser must be designed to withstand high levels of emitted optical power as well as good thermal drift management by self-heating of the laser operating at high injection current. (> 400-550 mA). **One of the key parameters to control in order to ensure optimal operation of the laser and ensure its aging are the deformations/strain generated during the manufacture of the laser, and also during its use**. There are several techniques for measuring strain: X-ray diffraction, Raman spectroscopy, and transmission electron microscopy, each with its strengths and limitations in terms of spatial resolution, field of view, sensitivity, and accuracy. ease of use. In 2019, CEA / Leti and CNRS / LTM developed **an original technique for measuring deformations, which is based on the degree of polarization (DOP) of cathodoluminescence (CL)**. This technique is promising because it has excellent sensitivity (10^{-5}), a spatial resolution of about 100 nm intermediate between the TEM and the RX, an adjustable field of view, and above all it is easy to implement. At a time when the effect of mechanical stresses on the reliability of semiconductor lasers has become an industrial concern, the development of such a method of characterization seems appropriate

The thesis project aims to develop the cathodoluminescence DOP measurement technique to evaluate the deformations generated during the fabrication of a high-power laser emitting III-V and reported on Si for the development of Lidar on chip.

It is a subject of experimental and fundamental research whose scientific advances will be crucial for the industrial actors of Lidar technologies, and more broadly Laser technologies.

Travail demandé

Ce projet de recherche s'articulera selon 3 axes:

This research project will focus on 3 axes:

1. Consolidation of DOP Cathodoluminescence Technique for Deformation Measurement

- Improvement of the measurement protocol by DOP CL on simple structures of InP: automation of the measurements and the exploitation of the data

- Master the optical chain, quantitative measures of constraints by DOP.

- Compare several techniques available at Leti: DOP CL, RX, Raman or TEM precession

2. Evaluation of deformations by DOP CL in Lidar laser III-V stacks

- Development of plasma etching processes for the structuring of the complex III-V semiconductor stack constituting the laser

- Application of the experimental protocol DOP on these complex structures

- Evaluation of the deformations introduced by certain technological steps of laser manufacturing (eg the molecular bonding step)

- Evaluation of the impact of self-heating by measuring temperature DOP

3. Confrontation with laser optical performance

- Correlate the deformations measured by DOP CL with the optical performance variations of the lasers (in particular the transmission power which is fundamental for Lidars)

Cadre de la thèse

The doctoral student will carry out his research work in the LPMS laboratory of CEA / Leti de Grenoble on the Minatech campus. This laboratory specializes in the characterization of materials and has a unique panel of equipment for the characterization of materials such as optical spectroscopies (luminescence, Raman, IR), RX, SEM, TEM among others. The research project is based on close collaboration with two other laboratories on the Minatec campus: the LTM / CNRS, a laboratory with unique know-how in patterning technology and in particular in plasma etching processes, and the LIPS of the optical department (DOPT) CEA / Leti which has a unique expertise in integrated photonics on Silicon. The PhD student will have access to all the equipment and characterization techniques available in these 3 laboratories: the technological steps necessary for the realization of the Laser will be carried out on the equipment of the LTM / CNRS and the CEA / leti located in the clean rooms of the CEA , material characterizations will be performed at LPMS and laser optical characterizations at LIPS. The PhD student will take advantage of this unique scientific environment to carry out his research project.

Formation/Compétence

The candidate must have a degree from an engineering school or a research master's degree. To be eligible, the candidate must have obtained good results during his studies. The requested thesis requires a taste for experimental work, a good scientific level in general. Skills in semiconductor physics, optical spectroscopy and materials science will be highly useful to carry out the project. Basics in nanofabrication technologies would also be advantageous. The candidate is also expected to demonstrate a good ability to communicate in both French and English and to report on their work. The candidate must demonstrate autonomy, rigor, and dynamism.
At the end of the thesis, the candidate will have a solid experience in material characterization, optical spectroscopy, electron microscopy, clean room manufacturing processes and characterization of optoelectronic devices.

Informations pratiques

- **Beginning of the thesis**: from October / November 2019
- **Contacts :**

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Attach to your application your CV with the grades and rankings of master 1 and 2, as well as a letter of reference from your Master's supervisor (specifying your ranking), and a letter from the master project leader.