Post-doctoral fellowship proposal

"Development of a nanostructure-based pseudomorphic laser on Si: modelling, optoelectronic characterisations, laser processing and design"

Context of the proposal:

The post-doctoral position described below is funded by the French National Research Agency (ANR) through different projects such as the OPTOSI project (epitaxial integration of III-V OPTO electronic devices on SI) or the SINPHONIC project (Silicon photonics with diluted nitrides coherent integration). The position is open on October 2013, and will last for 12 months, potentially extended to 18 months. The candidate will be welcome in the FOTON laboratory (CNRS) of INSA (engineer school) in the city of Rennes (western part of France).

Scientific content:

Silicon microelectronics has been the engine of the modern information revolution for almost 50 years. In our never ending quest to process more and more data faster while using the smallest components, the silicon industry has successfully overcome many critical issues. The next critical problem in the evolution of modern information system is to overcome the limitations of metal interconnects. The integration of photonics functions with electronics circuits at wafer scale manufacturing level, into optoelectronic integrated circuit (OEIC), has the potential to overcome this critical issue. Among all envisaged routes for OEIC, the monolithic integration of OEIC devices appears ideal. Especially, the monolithic integration of electrically pumped laser sources on Si is the cornerstone for the OEIC devices but a practical solution has not been achieved to date. [1]

Our approach is based on "defect-free" growth of direct bandgap, closely lattice-matched, GaPN-based diluted-nitride materials[2,3,4,] on silicon via a novel Molecular Beam Epitaxy (MBE) route involving the use of an unique epitaxial tool, a MBE-UHVCVD epitaxial cluster prototype with independent, interconnected Si- and III-V- growth chambers.[5] Such heterogeneous growth ensures a defect-free single crystal coherent growth, which is very promising for the development of highly efficient devices. While such heterogeneous growth is known to imply issues related to the formation of planar defects: antiphase boundaries (APB), stacking faults (SF), or microtwins (MT), we have developed growth strategies in order to dramatically reduce such structural defect, making the development of high performance devices incorporating quantum wells and quantum dots a potential reality on the GaP/Si pseudo-substrate.[6,7]

---

[1] D. Liang and J. E. Bowers, Nat. Photon. **4**, 511 (2010).
[2] K. Volz et al., J. Cryst. Growth **315**, 37 (2011).
[3] K. Yamane et al., J. Cryst. Growth **312**, 2179 (2010).
[4] T. J. Grassman et al., Appl. Phys. Lett. **94**, 232106 (2009).
[5] T. Quinci et al., J. Cryst. Growth 380 (2013) 157
[6] O. Durand et al., Proc. SPIE, Vol. 8631, 863126-1.(2013)

The post-doctoral position proposed here aims at realizing laser devices based on the GaPN-based/Si platform elaborated at FOTON lab, including nanostructures-based active area (quantum wells or quantum dots). The applicant will have to work on optoelectronic characterisations of nanostructures and their properties at the atomic scale, laser processing development and modelling/design of laser structure.

Collaborations:

He/She will work in strong collaborations with other members of FOTON-INSA involved in the project. He/She will also benefits from collaboration at the national level in the frame of the OPTOSI project (TEM-STM, tr-PL, device processing), or at the international level especially with European partners (positron annihilation, pressure-dependant PL, supercell tight-binding calculations, ab initio calculations). Finally, he/she will participate to the dissemination of the results in international conferences.

About FOTON Laboratory (INSA-Rennes):

FOTON laboratory is part of the CNRS (biggest French research institute). FOTON is recognized at the European level through participations to European Networks of Excellence on nanostructures properties and devices SANDIE and EPIXNET. FOTON has also been recognized as part of "Labex" (Laboratory of excellence) and is being selected for IRT (Technological Research Institute) at the national level.

The laboratory has a large experience in the growth,[8] structural,[9] optical[10] and electrical characterisation of III-V semiconductor nanostructures, and for the development of semiconductor-based devices such as Light emitting diodes[7], edge lasers[11], saturable absorbers[12] or Vertical Cavity Surface Emitting Lasers (VCSELs).[13] In order to use its know-how on the conventional and low-cost silicon substrate, FOTON-INSA has explored recently the coherent integration of III-V semiconductors on Silicon; The postdoctoral fellow will be able to leverage the very promising results obtained since 2009 for the success of the project.[14]

About the candidate:

The candidate should have convincing experience in the field of semiconductors nanostructures fundamental knowledge and devices. He/She should show good capacities in oral and written english expression and be able to present research results verbally in international conferences. The candidate should show a real motivation to work in a group, and participate actively to the ANR regular meetings and reports. During the post-doctoral fellowship, the gross income is 28 k€/year.

Contact :

O. Durand, Olivier.durand@insa-rennes.fr, (+33) 2 23 23 86 28, OPTOSI ANR project local coordinator.
C. Cornet, charles.cornet@insa-rennes.fr, (+33) 2 23 23 83 99, SINPHONIC ANR project coordinator.
FOTON : http://foton.insa-rennes.fr/
INSA Rennes : http://www.insa-rennes.fr/

---

[7] C. Robert et al. Phys. Rev. B **86**, 205316 (2012).
[8] C. Paranthoën et al., Appl. Phys. Lett. **78**, 1751 (2001).
[9] A. Létoublon et al., Phys. Rev. Lett. **92**, 186101 (2004).
[10] C. Cornet et al., Phys. Rev. B **74**, 035312 (2006).
[11] D. Zhou et al. Electron. Lett. **45**, 50 (2009).
[12] M. Gicquel-Guézo et al. Appl. Phys. Lett. **85**, 5926 (2004).
[13] O. Castany et al. Appl. Phys. Lett. **98**, 161105 (2011).
[14] T. Nguyen Thanh et al., J. Appl. Phys. **112** 053521 (2012).