Université Lille Nord de France
Pôle de Recherche et d'Enseignement Supérieur

Ecole doctorale régionale Sciences Pour l'Ingénieur Lille Nord-de-France - 072

Titre:
Développement d'une nouvelle génération de composants actifs & passifs à base de matériaux semi-conducteurs grand gap- Application à la photonique

New generation of active & passive photonic devices based on wide band gap semiconductors

Financement prévu : recherche de financement en cours
Cofinancement éventuel :

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Descriptif:

This Research constitutes an important part of Nanophotonics, which is an exciting new frontier in Nanotechnology that deals with the interaction of light with matter on a nanometer size scale [1,2].

Taking advantage of large refractive index differences in the III-nitrides family of materials, the research is intended to demonstrate that a new class of devices can be designed and fabricated based on optical guiding in nanoscale waveguides in relationship with different high level collaborative institutes in Europe and Asia such as :

- Centre de Recherche sur les Hétéroépitaxies et Application (CRHEA) Nice Sophia Antipolis
- Technische Universität Darmstadt (DTU), Dept High Freq Electronics, Darmstadt Germany
- Institute of Materials Research and Engineering (IMRE A*Star), Singapore
- Korean Advanced Institute of Science and Technology (KAIST), Republic of Korea

Thanks to the knowledge of electrical and optical properties expected for new semiconductor Ga(InAl)N materials, eligibility criteria of these materials for the realization of new integrated circuits for future photonic systems concern the mastering in the realization of such materials, its characterization and the integration and hybridization with other standard semiconductor materials.

Ga(InAl)N materials are considered as the materials of choice for solid state lighting, high density data storage and high power electronic devices, etc. By tuning the composition, the band-gap energy of the Ga(InAl)N materials can cover the range from deep UV to infrared. It is a good platform material for producing various optoelectronics devices and the integration of them. To fully explore the potential

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of the Ga(InAl)N materials for the application in photonics, the optical properties of the material need to be known. For example, the refractive index of thin film and quantum well structures is critical in design and modelling waveguide based devices, especially in the nanoscale devices. The strong piezoelectric field and the Wurtzite crystal structure make the refractive index of Ga(InAl)N film change with not only material composition but also film thickness. In this project, we will study the optical properties of the Ga(InAl)N thin films and grown on different substrates, with different material compositions and under different electrical and thermal conditions.

The targeted objective of the PhD research is to establish and explore potentialities of this material which seems to be the candidate able to answer simultaneously to the whole set of criteria in Nanophotonics. Collaborative Institutes as CHREA, IMRE, DTU & KAIST, will grow different Ga(InAl)N thin films and structures using MOCVD. IEMN will do the characterization of the optical properties of the Ga(InAl)N film. The technology to process nanoscale Ga(InAl)N structure based on different substrates will be developed and novel nano-waveguide devices will be demonstrated by IEMN.

The knowledge and technology developed will be useful for GaN based optoelectronic device development, such as high brightness LEDs, GaN lasers sources and Optical switches – modulators.

With this project, we will establish a strong and deep knowledge of Ga(InAl)N, a new semiconductor material, particularly for the growth conditions, and the expected properties. The international scientific community will be sensitive to the suitability of this new material to be applied to the domain of the nanotechnologies. The Ga(InAl)N material has never been used yet in a device; any result will be original and constitute a breakthrough. The essential scientific headway is connected, on one hand, in the elaboration of a new family of material and its fundamental properties, allowing nanophotonic solutions. On the other hand, these headways will be integrated into a realization process of new optical features. The originality of the project holds the major innovation in terms of materials growth and nano-photonic device process.

This project is ambitious as far as on, one hand, it concerns a fundamental scientific domain and on the other hand, it aims at the development and at the implementation of an innovative technology allowing its industrial application of the project holds the major innovation in terms of materials growth and nano-photonic device process.

Clean room technology training as well as optical/electrical characterization will be proposed during this PhD thesis. Numerous travel in Singapore & South Korea will be planed to develop the international interactions.

[1] A. Gokarna, A. Gauthier-Brun, Y. Androussi, E. Dogheche, D. Decoster, E. Dumont, J. H. Teng, W. Liu, S. J. Chua, Optical and microstructural properties of varying In content $In_xGa_{1-x}N$ films grown by MOCVD, Applied Physics Letter *96, 191909 (2010)*
[2] A. Stolz, E. Dogheche, Y. Androussi, D. Troadec, D. Decoster, E .Cho, D. Pavlidis, Low-loss GaN structure for optical waveguiding using prism coupling, Applied Physics Letter (in press 2011)