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Allocations de Doctorat du China Scholarship Council :

Soumission d'une proposition pour 2020

PhD proposal for 2020

More information about the thesis subject:

Title: Studies of electronic properties of wide band gap semiconductor related materials and nanowires by space charge techniques coupled with electrical mode scanning probe microscopy.

Worldwide in many semiconductor material and device laboratories there is a growing research interest for nanowires (NW) of group III-N (nitrides) for application in the field of optoelectronic devices (LEDs, solar cells) in the framework of " sustainable energy". In more recent years, lighting applications based on LED using III-N have become an alternative solution for replacing incandescent lamp and offering energy saving potential due to their high luminous efficiency and lower energy consumption. Use of LED technology is estimated to decrease world electric consumption by 40%.
In the field of solar energy, hybrid solar cell as III-V(N)/silicon have a great interest to benefit from the complementary band gap energies of both materials for absorbing a large majority of the solar spectrum. Use of NWs in these two fields instead of 2 D layers have a lot of advantages and could

solve some bottlenecks associated with 2D planar materials: Electrical doping, light extraction/ absorption, elastic relaxation of epitaxial strain which favor the decrease of structural defects with the aim to enhance yield of optoelectronic devices for energy.

Taking into account this scientific and technological context, it is very important to develop some specialized techniques to measure and control the electronic properties of NWs for energy. In close collaboration with the epitaxy group of the Institut Pascal (University of Clermont-Ferrand) we aim in developing new analysis methodologies and measures specifically adapted to 1D nanostructure geometry to understand and improve the electrical properties of III-N wide band gap NWs.

The INL (Institute of Nanotechnologies of Lyon) laboratory is worldwide known since a long time on space charge spectroscopy on semiconductor materials (bulk, 2D and 0D structures) and devices characterization (MOS, MIS, MESFETs, HEMTs) devoted to characterization of defects and the associated electronic properties. Prof. G. Bremond is an expert of such domain. The techniques used up to now are electrical spectroscopy called deep level transient spectroscopy (DLTS) based on capacitance and current transient analysis on Schottky, on p-n junctions or on gate and drain-source capacitance and conductance spectroscopy on FET transistors.

With this thesis, we propose to develop electrical characterization techniques based on space charge depletion zone measurement on NWs network. Indeed, one main bottleneck is today to establish electrical characterization techniques on NW. In fact classical techniques as Hall Effect measurement is extremely difficult to perform on NW. So, we propose also to link such macroscopic measurement on NW network to local measurement by nanoscale electrical characterization thanks to atomic force microscopy (AFM) approach using conductive AFM tip which has been developed in the team of Prof. G. Bremond at INL laboratory at INSA Lyon. We have successfully developed scanning capacitance microscopy and spectroscopy (SCM-SCS), scanning spreading resistance microscopy (SSRM) and conductive AFM (CAFM) on quantum dot (or nano island) and very recently on ZnO nanowires.

The main objectives of the proposed thesis would be:

1) To extend such nanoscale technique approach to space charge measurements on NW which could be integrated on diode under test.
2) To make links between transports measurements at the macroscopic level on NW network and at the microscopic or at the nanoscale level on a single NW. For this characterizations on single NW will be performed by AFM under different modes for a local determination of main electrical properties on each NW. For macroscopic measurements on NW networks, a planarization process will be made via a dielectric deposition of layer. Standard I(V) and C-(V) measurements versus temperature will be performed on these test structures.
3) To study by coupling space charge techniques with nanoscale techniques the electrical defects and their influence on the doping mechanism and on the functioning of the future devices integrating NWs.

Supervisor:

- Georges BREMOND

Current position: Professor of the universities at INSA Lyon

G. Bremond has a large experience in electronics and optoelectronics materials and devices based on InP, GaAs, GaN and related materials wide band gap– in solid state physics –in semiconductor and surface physics. He is experts in optical (Photoluminescence, optical measurements by FTIR) and electrical (I-V, C-V, admittance, capacitance, DLTS, DLOS, photoconductivity) spectroscopies on semiconductor nanostructures, materials and devices. He is an expert in scanning probe microscopy for electrical property analysis and he has recently successfully developed scanning capacitance microscopy and spectroscopy (SCM-SCS), scanning spreading resistance microscopy (SSRM) and conductive AFM (CAFM) on ZnO nanowires.

Laboratory and Reseach team :

The Institut of Nanotechnologies of Lyon (INL) is a laboratory of INSA Lyon as a mixt-unit of CNRS (UMR 5270), Ecole Centrale de Lyon and University of Lyon. There are more than 250 peoples working on materials, technologies, electronic devices and photonics devices in the field of nanotechnology. The "Spectroscopy and Nanomaterial" research team has a strong background in electrical characterization of semiconductor materials and devices at macro / nano scales, with a strong activity in the characterization of deep levels in GaN or SiC. They developed for long time the deep defect level spectroscopy techniques (DLTS and DLOS) for very deep levels measurements acting as generation- recombination traps,. They have developed in complementarity electro-optical spectroscopy as photocurrent spectroscopy for minority carrier life time analysis and electroluminescence on p-n structures for knowledge of radiative defects. They develop currently scanning probe microscopy for electrical property analysis.

Lyon city:

https://en.visiterlyon.com/visites-guidees.html?_ga=2.157663353.2126605784.1554109007-314792532.1554109007

Lyon is France's #2 city for culture according to Journal des Arts, just behind Paris. And for good reason, as the city has an abundance of museums, from the Musée des Confluences (opened in December 2014) to the Musée d'Art Contemporain (Contemporary Art Museum), to the Musée de la Résistance and the Institut Lumière (Cinema Museum), allowing you to immerse yourself in Lyon's history and heritage.

The city's cultural life is also punctuated by over 21,000 events all throughout the year, ranging from exhibitions, concerts and plays, to festivals, biennial celebrations and much more. These include major international events such as the Festival Lumière (Grand Lyon

Film Festival), the Biennale de la danse (Biennial Dance Festival), the Biennale d'Art Contemporain (Biennial Modern Art Festival), the Nuits Sonores (electronic music festival) or the renowned Festival of Lights.
Finally, you can stroll through the city's historical districts, such as Vieux Lyon (Old Lyon) and its traboules, the hillsides of Croix-Rousse, Fourvière and its stunning view of the city. Lyon is a city of history, listed as part of UNESCO's World Heritage since 1998, making it Europe's 2nd-largest Renaissance site after Venice.

ONLYLYON Tourisme & Congrès offers a host of fun, original ways to discover the city.

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