Institut des Nanotechnologies de Lyon UMR CNRS 5270
http://inl.cnrs.fr

INL - site INSA   UMR 5270
INSA de Lyon
Bâtiment Blaise Pascal, 2ème étage
7, avenue Jean Capelle - Villeurbanne

Jean-Marie Bluet
Tél. (+33) 04 72 43 87 32(Sec : 04 72 43 83 29)
Fax (+33) 04 72 43 85 31
E-mail : jean-marie.bluet@insa-lyon.fr

Allocations de Doctorat du China Scholarship Council：

Soumission d'une proposition pour 2021

PhD proposal for 2021

More information about the thesis subject:

<u>Title:</u> Electro-optical characterization ofβ Ga_2O_3 epilayers grown on silicon

Ga_2O_3, which belong to oxide class of materials, could be a promising wide band gap semiconductor (Eg= 4,9 eV) to be used for high voltage power applications (high breakdown field of 8 MV/cm), deep UV detectors and largest band gap transparent conducting oxide (TCO) materials

Its main advantages are cheap bulk substrates grown by FZ or EFG methods, large doping range carrier concentration for n-type (10^{15} to 10^{20} cm^{-3}), various available epitaxy techniques (PVD, MOCVD, MBE,…). They are however many bottlenecks for an industrial development of Ga_2O_3: 1) low value of the thermal conductivity of Ga_2O_3 substrate, 2) difficulty of achieving p-type conductivity (essential for bipolar devices), 3) high concentration of traps levels affecting the mobility, the carrier lifetime, the compensation of doping level and device breakdown. Indeed, the electrical conductivity of $Ga_2O_3$is determined by the ability of electrical activation of shallow dopants and by the strength of compensation mechanism due to deep level defects.

The objective of this thesis is to detect, characterize and monitor defects in Ga_2O_3 by extensive complementary characterization techniques for further advancement of its technology. Material will be MOCVD epilayers of n and p-type Ga_2O_3grown on silicon substrates (in order to prevent disadvantage (1)) obtained by collaboration with GEMaC laboratory at Versailles University. Knowledge of the identities, energy positions of shallow and deep levels is critical for further developing applications as shown by the comparison with the development of other semiconductors like GaAs, SiC, GaN.

INL (Institute of Nanotechnology of Lyon), a laboratory of INSA-Lyon and University of Lyon has a very strong background in this field since a long time and it is world wide recognized by this type of work on III-V, III-N and SiC materials.

The first objective will be to develop Schottky and ohmic contacts for n (p) type conductive materials to make good test structures (Schottky Barrier Diodes (SBD), p-n junction if p-type doping controlled) for electrical characterization. In a second phase, we use admittance and capacitance measurement techniques in frequency or transient modes to accede to the spectroscopy (energy, capture cross section, concentration) of shallow (donor (D) or acceptor (A)) levels and of deep levels.
Admittance spectroscopy versus frequency and temperature give the ionization energy of shallow levels (D or A) introduced by the doping process or intrinsic shallow defects created by growth if any. Static admittance or capacitance techniques give the free carrier concentration profiles.
Deep levels introduced by intrinsic defects or impurities are generally detrimental for the electronic properties. But they could be used in electronic materials to get compensation and semi-insulating material. These defects will be analyzed by transient capacitance or current spectroscopy in a DLTS approach on n (and p) typeepilayers. As the energy range of the DLTS is limited within around 1 eV of the majority carrier band edge and the energy gap of β-Ga_2O_3 is 4.9 eV, we will use photo-capacitance technique such as DLOS (deep level optical spectroscopy) approach in order to accede to deeper energy in the band gap of β-Ga_2O_3 .This DLOS technique first established in our laboratory uses monochromatic incident light as a function of energy to photo-emit trapped carriers to a band edge, enabling to determine energy levels, concentration and optical cross-sections of deep states.The knowledge of the optical cross-section sopt is an unique fingerprint of defect identification in case of transition metal impurities through access to their excited states. Resistive materials (p doped) will be analysed by photo-induced current transient spectroscopy (PICTS) to detect compensation deep levels.
In collaboration with the Institut des Nanosciences de Paris (CNRS) making electron paramagnetic resonance (EPR), and using SIMS analysis and by correlating results with variations of the growth conditions, we may identify some underlying defects (natives or incorporated as impurities).

The critical steps expected will be: i) the identification of defects or impurities responsible for electrical compensation for the limited carrier lifetime and the reduced mobility; ii) the understanding of the p-type doping challenge; iii) the improvement of epi-layers growth with respect to efficient intentional doping and reduced formation or incorporation of point defects or impurities.

Supervisors:

- Jean-Marie BLUET
  Current position: Professor of the universities at INSA Lyon
- Georges BREMOND
  Current position: Professor of the universities at INSA Lyon

They have a large experience in electronics and optoelectronics materials and devices based on SiC, GaN and related materials wide band gap– in solid state physics –in semiconductor and surface physics. They are experts in optical (Photoluminescence, Raman, optical measurements by FTIR) and electrical (I-V, C-V, admittance , capacitance, DLTS, DLOS, photoconductivity) spectroscopies on semiconductor nanostructures, materials and devices.

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, approach strongly of importance for Ga_2O_3 electronic development. They develop 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. **Prof J.-M. Bluet**, is an expert in electro-optical spectroscopy; **Prof. G. Bremond** is an expert of deep defect physics analysis in WBG materials and devices

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.