PhD Student Day

Wednesday, 28th June

GANIL, Guest House

Program Of The Day:

Chairperson: MONNET Isabelle

9h00: Accueil

9h10: Ben Hammar Hichem (PM2E) Spontaneous strain accumulation and growth disruption in lattice matched InAl(Ga)N/GaN heterostructures

9h35: GOUESMEL Anaïs (NIMPH) Rare earth doped Si-based frequency conversion layers for an efficient light management of Si solar cell

9h50: AUGE Basile (MADIR) Effets du rayonnement cosmique galactique sur les petits corps glacés du système solaire externe : indices pour la formation de la matière organique des micrométéorites antarctiques ultra-carbonées

10h15: HADDADI Sofiane (LIOA) Oscillation laser sur un mode transverse d’ordre élevé LG_p0

10h35: Coffee break

Chairperson: BRAUD Alain

10h50: LEPLEUX Charlotte (LARIA) Study of Bystander signals emitted by Cartilage cells grown in 3D and irradiated in vitro during conventional radiotherapy and Hadrontherapy

11h10: GUILLAUME Clément (NIMPH) Study of rare earth doped ZnO(n)/Si(p) junctions for electroluminescence applications

11h25: CHERY Nicolas (PM2E) Local structure and composition versus the optical properties of InGaN/GaN QWs for emission in and past the green gap

11h45: NORMANI Simone (MIL) Nd^{3+} and Lu^{3+} Doped CaF_2 Crystals as Novel Amplifier Materials for High-Energy Infrared Lasers
12h10: Lunch Time

Chairperson: ROTHARD Hermann

14h00: DUBOSQ Clément (SIMUL) Simulation of photo-excited F-(H₂O)n and OH-(H₂O)n: Toward excited state dynamics in solution

14h25: SALHI Mohamed (MIL) Microchip and waveguide laser around 2 µm based on highly doped Tm³⁺:LiYF₄ thick single crystalline layer elaborated by liquid phase epitaxy

14h50: LI Siqian (PM2E) Study on polarity inversion at the <0001> ZnO/GaN heterostructure

15h15: KUMAR Vishant (AMA) Studying the fragmentation dynamics and possible geometry of Homo and Hetero Molecular Clusters with low energy ion beam

15h30: Coffee break

Chairperson: LABBE Christophe

15h45: RIBET Alexis (MADIR) Structural modifications induced by swift heavy ions in α-Al₂O₃ substrate

16h00: EHRE Florian (NIMPH) High efficient infrared quantum cutting in Ce³⁺-Yb³⁺ codoped silicon oxynitride for solar cell applications

16h25: LI Quantong (PM2E) The compressive strain release in InₓGa₁₋ₓN/GaN heterostructures

16h50: MIKA Arkadiusz Piotr (AMA) Interaction of multiply charged ions with metal clusters

17h15: End

17h30: Aperitif (GANIL)*

19h00: Dinner (GANIL)*

*If you want to attend the laboratory dinner, at the GANIL site, please contact Isabelle to register (monnet@ganil.fr)
Spontaneous strain accumulation and growth disruption in lattice matched InAl(Ga)N/GaN heterostructures


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Due to their band gaps which may extend from InN (0.65 eV) to AlN (6.2 eV), the InAlN alloys are expected to be used for many applications such as: high electron mobility transistors (HEMT), distributed Bragg reflectors (DBR), and ultraviolet light emitting diodes (UV LED). Recently, it has been pointed out that, depending on the metal organic vapor phase epitaxy deposition chamber geometry, gallium can be incorporated in the intended ternary layer leading to a quaternary alloy [1]. However, the InAl(Ga)N can also be lattice matched with the GaN as no misfit dislocations or stacking faults have been reported. This is a major advantage over AlGaN/GaN where the strain at the interface cannot be avoided. Unfortunately, structural degradations have been reported when the thickness of the layer is increased and several degradation mechanisms have been proposed in the literature. The first mechanism suggested that the threading dislocations from the GaN were systematically connected with pinholes [2]. Subsequently, Perillat-Marceroz et al. [3] reported similar degradations of InAlN layers on free standing (FS) GaN as the thickness was increased. The low density of threading dislocations in FS substrates led the authors to propose that the acting mechanism was the spontaneous formation of pinholes at the coalescence of hillocks. Other authors have put forward the role of a critical value for the thickness [4].

In this work, we have used a combination of microscopy techniques and theoretical modelling in a detailed study of InAl(Ga)N layers grown in both horizontal and vertical close coupled shower head reactors. The microstructure of the defects was studied by conventional TEM and STEM in an atomic resolution JEOL ARM200 microscope for chemical sensitive imaging and the local composition by EDX. By atomic force and scanning tunneling microscopy we analyzed the surface structure of the layers and its evolution versus the growth conditions. From this investigation, it comes out that a robust mechanism which could explain the structural disruption of InAl(Ga)N/GaN still needs to be proposed, towards this objective we have obtained some hints. It is clear that understanding the layers growth and relaxation is critically important for obtaining optimal quality barriers for high performance HEMTs.

References:

Keywords: nitrides, defects, stem.
The typical silicon solar cells (SC) that currently dominate the market operate with an energy conversion efficiency of at most 20%. Silicon PV industry aims at lowering the cost process and increasing the SC efficiency, but one of the main issues is the efficiency limitations that exist, especially the mismatch between the solar spectrum and the energy that can be absorbed by a Si-SC. One solution to overcome the thermalization effect due to high-energy photons with respect to the Si bandgap consists in using frequency conversion layers. Down-Conversion (DC) layers convert one UV photon into two NIR ones while Down-Shifting (DS) layers allow the conversion of one UV photon into a visible one.

This paper aims at proposing solutions compatible with the Si-PV industry allowing an efficient absorption of the solar spectrum. DC and DS layers consist in a Si-based matrix doped with rare earth (RE) ions fabricated by a co-sputtering approach. DC layers use Tb$^{3+}$ and Yb$^{3+}$ ions because of the Yb energy level at 1.26eV, slightly above the Si bandgap, and the cooperative energy transfer between one Tb$^{3+}$ and two Yb$^{3+}$, whereas for DS layer only Tb$^{3+}$ ions are incorporated in the Si-based matrix. The use of metallic nanoparticles has been developed to increase the optical path length of pumping photons and thus improve the efficiency of the system. EQE measurements and electrical and optical characteristics have been carried out on industrial Si-SC and will be presented.
Effets du rayonnement cosmique galactique sur les petits corps glacés du système solaire externe : indices pour la formation de la matière organique des micrométéorites antarctiques ultra-carbonées

Basile AUGE

Plusieurs campagnes de collecte de matières extraterrestres dans les neiges Antarctiques bordant la station franco-italienne Concordia ont permis de découvrir deux nouvelles familles de micrométéorites : les micrométéorites non fondues à grains fins poreux et les micrométéorites ultra-carbonées. Ces dernières sont exceptionnelles tant du point de vue de leur rareté que de leur composition structurale, chimique et isotopique [1-3]. En effet, plus de 20% de leur partie minérale est sous forme cristalline alors que la limite communément admise est de 2.2% dans le milieu interstellaire. De plus, des mesures ont révélé que ces objets présentaient un enrichissement isotopique en deutérium pouvant atteindre 20 fois la valeur de référence terrestre. Enfin, la matière organique représente au moins 50% de la masse de ces poussières, dépassant largement les 5% en masse des chondrites carbonées, tout en présentant une incorporation d'azote inédite avec des rapports N/C pouvant approcher les 20%. Ces micrométéorites sont le résultat de processus physiques complexes dont la compréhension est indispensable. Il a été postulé qu'elles proviendraient d'un corps parent orbitant au-delà de la ligne des glaces de l'azote, au niveau du nuage d'Oort à plus de 20 000 fois la distance Terre-Soleil et dont la surface aurait une composition similaire aux objets transneptuniens [4]. L'interaction entre le rayonnement cosmique galactique baignant cet endroit et la surface de l'objet, puis sa lente sublimation lors de son injection dans le système solaire interne, aurait produit un précurseur de ces micrométéorites. Des expériences ont été menées en utilisant des dispositifs permettant de produire des analogues de glaces d'azote et de méthane pour ensuite les exposer aux faisceaux d'ions du GANIL [5]. Ma présentation fera état des derniers résultats obtenus à ce sujet tout en les contextualisant dans un cadre astrophysique.

Oscillation laser sur un mode transverse d’ordre élevé $\text{LG}_{p0}$

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Le mode susceptible d’osciller dans une cavité laser est le mode qui présente le niveau des pertes le plus faible ; en l’occurrence c'est le mode gaussien $\text{LG}_{00}$, dans le cas d'une cavité constituée de deux miroirs. En revanche, si on souhaite obtenir une oscillation sur autre mode, $\text{LG}_{p0}$ ou $\text{HG}_{H0}$, d'autres éléments optiques doivent être insérés à l'intérieur de la cavité. Il a été montré que faire osciller un laser sur un mode d'ordre élevé permettra à la fois d'augmenter le volume du mode et d'améliorer le rendement d'extraction du laser [1].

L’objectif de cette thèse, en plus de la génération de mode d’ordre élevé, est d’illustrer plusieurs possibilités de mises en forme simples et à faible coût des faisceaux lasers. Dans la première partie de cette thèse, nous avons étudié la focalisation d’un mode $\text{LG}_{p0}$ redressé avec un Elément Optique Diffractif de Phase Binaire (EODPB), les résultats montrent qu’un faisceau $\text{LG}_{p0}$ redressé permettra d’améliorer l’intensité comparativement à celle qu’on aurait obtenue avec le faisceau gaussien habituel [2]. Nous avons aussi expérimenté la génération de mode $\text{LG}_{p0}$, en utilisant un SLM pour réaliser un masque intra-cavité reconfigurable, au National Laser Centre-CSIR en Afrique du sud.

Dans la deuxième partie nous avons étudié les propriétés de diffraction d’un $\text{LG}_{p0}$ traversant un diaphragme. Les résultats montrer que contrairement au faisceau gaussien occulté par un diaphragme le $\text{LG}_{p0}$ ne redevient pas gaussien en champ lointain mais peut changer radicalement de forme [3]. On s’est intéressé aussi à la transformation d’un mode $\text{LG}_{00}$ avec un diaphragme, en un faisceau de profil d’intensité spécifique tel que le flat-top et le creux OBB [4-5].

Dans la troisième partie, nous avons poursuivi les études de mise en forme du faisceau et nous nous sommes intéressé à l’autre technique, à savoir la technique interférométrique, pour réaliser des mises en forme remarquable d’une impulsion spectralement large. Nous avons tiré profit de résultats obtenus de la mise en forme d’un faisceau gaussien incident sur un interféromètre de Michelson non-symétrique [6-7] pour étudier les cas d’un interféromètre symétrique, i.e les deux bras de l’IM ont la même longueur, et nous avons généralisé cette étude sur une impulsion ultracourte. Nos résultats montrent la possibilité de réaliser des mises en forme remarquables d'une impulsion spectralement large, avec la méthode interférométrique, sans dispersion.
Référence :


Study of Bystander signals emitted by Cartilage cells grown in 3D and irradiated in vitro during conventional radiotherapy and Hadrontherapy

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In conventional radiotherapy (X-rays) and non-conventional radiotherapy (Hadrontherapy), the impact of irradiation on healthy tissues is not yet well known and asks essential questions of radiobiology, these healthy tissues being on the beam path during tumor treatment. Among these questions, what is the impact of the radio-induced bystander effect? This mechanism involves stress signals emitted by irradiated cells adjacent or very close to non-irradiated cells; bystander molecules can induce a biological response with damages usually observed in irradiated cells. To study this phenomenon, we use different technical strategies, such as clonogenic assay, to study the survival cells fraction after treatment, two-dimensional electrophoresis for proteome analysis, and conditioned medium for the identification of bystander signals emitted by irradiated cells. Our results of clonogenic assay showed the capacity of chondrosarcoma cells to secrete bystander signals, particularly at low irradiation dose (0.1Gy), and the capacity of chondrocyte cells to receive these signals. Also, we are developing a 3D model of cell culture, using "pellets" (cell aggregates). These pellets are irradiated with high (carbon ions) or low (X-rays) LET, to simulate and study the in vivo hadrontherapy of a tumor. In parallel, we use a proteogenomic strategy to discriminate the proteome from two cell types grown in a mixture in order to develop an innovative technique for studying the bystander phenomenon. Taken together, these results will allow an adaptation of the radiotherapy and hadrontherapy protocols, to limit the damaging impact of bystander effect within the healthy tissues.
Study of rare earth doped ZnO thin film

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A great interest is focused on ZnO which is a well-known transparent conducting oxide with a wide bandgap of about 3.37 eV at room temperature. ZnO is naturally n doped due to the presence of intrinsic defects in the structure such as oxygen vacancies which introduce donor levels in the band gap. An engineering of the materials by radiofrequency magnetron sputtering based on the Tb, Eu codoped ZnO(n)/Si(p) junction has allowed obtaining remarkable optical properties from such structures linked to the optical transitions of the rare earths [¹]. Energy transfer mechanisms between the matrix and the rare earth ions have been found to improve the light emission. Electroluminescence of such structures appears very intense upon thermal treatments. These treatments have given rise to a favourable configuration for the emission of the rare earths because they induced a diffusion process of the rare earths preferentially in the space charge region of the pn junction.

We propose in this PhD project to pursue this work. We will focus more particularly on the Yb doped ZnO(n)/Si(p) junction for potential use in solar cells as down shifting layers. We will also optimize this junction for rare earths such as cerium (blue), terbium (green) and europium (red) in order to obtain a light emitting diode [²]. Erbium doping will be also studied to achieve a laser diode at 1.54 µm, a key wavelength for telecommunication applications. At last, other rare earths codoped systems will be also considered to investigate energy transfer mechanisms in ZnO.

References:


Local structure and composition versus the optical properties of InGaN/GaN QWs for emission in and past the green gap

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The III nitrides (Ga, Al, In)N semiconductors exhibit remarkable properties, for instance, the GaInN alloys should cover the visible spectral range for the fabrication of light emitting diodes (LEDs) and laser diodes (LDs). The InGaN/GaN multiple quantum wells (QW) emission is very efficient in the blue range, the remaining challenge is to improve the efficiency in the green range and past by increasing the indium concentration. In this way, we investigate the local structure and chemical composition of these heterostructures produced by metalorganic chemical vapor deposition (MOCVD) in a close correlation with the growth parameters and the optical properties with the objective of optimizing the emission of these heterostructures at highest wavelengths. For the investigation of local structure and chemistry scanning transmission electron microscopy (STEM) at atomic level and quantitative composition evaluation are used to determine the indium composition along with the possible local fluctuation¹,². The results show that the indium incorporation critically depend on the growth temperature, and the local indium composition may be fluctuating, however within less than +/-2% quite close to the random noise present in the evaluated data. In these QWs of 3-4 nm thickness, when the indium composition is over 20%, defects start to be generated; they may consist of stacking faults and half loop dislocations propagating from the QWs to the layer surface.

References:
1 - Rosenauer, A. et al. Measurement of specimen thickness and composition in AlₓGa₁-xN/GaN using high-angle annular dark field images

Keywords: III-nitrides semi-conductors, Quantum wells, analytical STEM, thin films, LED's
“Nd$^{3+}$ and Lu$^{3+}$ Doped CaF$_2$ Crystals as Novel Amplifier Materials for High-Energy Infrared Lasers”

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Within neodymium-doped laser crystals, the doping of fluorite-type single crystals reveals the unique possibility for broadband, high-energy, short-pulse laser amplification at 1µm [1-3], which makes these materials especially appealing to various fields of physics, in particular for inertial confinement fusion (ICF), which requires very high energy laser pulses with high repetition rates to achieve high efficiency. More precisely, Nd-doped CaF$_2$ crystals exhibit high thermal conductivity [4], and emission bands as wide as the state-of-the-art Nd-doped glasses currently employed in laser amplification for ICF, which they are intended to replace.

In this work, a complete and detailed spectroscopic investigation of CaF$_2$:Nd$^{3+}$ single crystals co-doped with various concentrations of Lu$^{3+}$ ions was performed using various spectroscopy techniques including absorption, fluorescence, excitation spectra, time-resolved emission and excitation spectroscopy and lifetime measurements. The results show that an increase in Lu$^{3+}$ concentration tends to increase the Nd$^{3+}$ transitions’ quantum efficiency, as a consequence of the replacement of Nd-Nd clusters [5,6] by Nd-Lu clusters. By carefully choosing the Lu$^{3+}$ concentration, the time windows used in time-resolved spectroscopy, the excitation and fluorescence wavelengths, it is possible to isolate the absorption and emission spectra of each type of Nd-Lu clusters and to derive absorption and emission cross-sections for each centre. We used Nd-Lu time-resolved excitation spectra to reconstruct the absorption spectra recorded in different samples in which Nd-Nd clusters and the two types of Nd-Lu clusters coexist. We were able to estimate the concentration of each type of Nd$^{3+}$ centres as a function of the Lu$^{3+}$ concentration, showing that above 5%Lu$^{3+}$, all quenched Nd$^{3+}$ clusters have been replaced by emitting Nd-Lu clusters. Laser operational parameters, such as radiative lifetimes and stimulated emission cross sections have been estimated, and the entire set of results has been proved self-consistent by a spectroscopic cross-check procedure [7].

Moreover, mode-mismatched thermal lens and transient-state interferometry measurements have been performed to assess the thermomechanical properties of CaF$_2$:Nd,Lu. The thermal conductivity has been assessed and compared to that of currently employed Nd-doped laser glasses. Its evolution with increasing Lu$^{3+}$ concentration was compared to the predictions of existing models, showing promising results for the application of these materials in high-energy pulsed laser amplifiers.

References:
“Simulation of photo-excited F⁻(H₂O)ₙ and OH⁻(H₂O)ₙ: Toward excited state dynamics in solution”

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¹Université de Caen NORMANDIE, SIMUL

Photo-absorption by anion in gas phase leads to ejection of an electron and formation of a neutral radical. In aqueous phase, solvent molecules perturb the anion and lower the ground state energy. This allows the formation of an excited state supported by surrounded solvent molecules. We refer to it as “charge transfer to solvent” state (CTTS state). We aim to observe the relaxation of fluoride and hydroxide after photo-excitation, when a (radical : electron)ₙaq pair is created. Then the competition between two different dynamical processes occur. The electron get solvated in water (electron solvation) or the electron recombine with it parent radical in a short time (geminate recombination). Experimentally, time-resolved spectroscopy is complex and interpretation of these data are delicate. Theoretically, ab-initio calculations are onerous and potential model from literature are not enough accurate nor transferable.

In this talk, I will come back on the model we developed for the study of these systems. I will speak about the ab-initio study of the structural properties of F⁻(H₂O)ₙ compared to OH⁻(H₂O)ₙ in their ground and first excited states. I will close the discussion with the first results of dynamics of F⁻(H₂O)ₙ and OH⁻(H₂O)ₙ on the first excited states.

Figure  : Excited triplet state geometry structure of F⁻(H₂O)ₙ (left) and OH⁻(H₂O)ₙ (right)
Laser sources emitting around 2 µm raises a great interest over the past few years for numbers of applications like medical surgery, atmospheric monitoring or LIDAR, thanks to the strong absorption of water and human tissues in this spectral range, which is “eye safe”[1]. Various approaches and configurations, based on Tm$^{3+}$ and/or Ho$^{3+}$ doped LiYF$_4$(YLF) as an active medium, are considered to achieve such a device: a bulk single crystal configuration, a waveguide configuration[2] and a thin disk configuration.

Originality and benefits of the thin disk approach will be more particularly discussed in this talk. The Quasi-Continuous-Wave (QCW) laser oscillation at 2 µm has been achieved with a thin disk configuration based on a highly Tm$^{3+}$ doped YLF single crystalline layer homoepitaxially grown on an undoped YLF substrate by Liquide Phase Epitaxy (LPE) [3]. This is a first demonstration of such a MIR laser with an epitaxial layer. These very promising results have been obtained by undoing a technological lock, through the growth of very high optical grade and crack-free epilayers that are few hundreds of microns thick. For this moment, several samples have been tested in a one pass cavity without cooling, for thicknesses of the epilayers varying from 80 µm until 240 µm and using a Ti:Saph laser at 793 nm as a pump. Thus, a slope efficiency of 8.8% in incident pump power and a maximum output power of 305 mW has been reached. These experimental results will be correlated to the theoretical simulations and discussed.

Finally, the next steps and perspectives of this study will be presented.

we report here for the first time on the fabrication of a highly doped Tm:LiYF$_4$ layer and its laser operation around 1.9 µm when the layer is pumped perpendicularly to the surface in one single pass. We also used our samples as one dimensional asymmetrical waveguides exhibiting high gain while keeping good spatial properties. Higher gain can even be obtained when the waveguides are structured as a ridge

“Study on polarity inversion at the <0001> ZnO/GaN heterostructure”

S.Q. Li
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Wurtzite ZnO with a band gap ~3.3 eV at room temperature has attracted a great deal of attention for light emitter application, notwithstanding the lack of stable p-doping. (0001)-GaN/c-sapphire templates have become good candidates for epitaxial ZnO films owning to their moderate lattice mismatch of 1.9%. The polarity control and epitaxial relationship are important for potential application in high mobility transistor by inducing a two-dimensional electron gas (2DEG) in interface. In this work, we succeed to obtain an O-polar ZnO epilayer based on Ga-polar GaN/c-sapphire template by adopting a higher O to Zn flux ratio during the growth nucleation in plasma assisted molecular beam epitaxy. A detailed spherical aberration corrected scanning transmission electron microscopy (Cs-STEM) investigation with HAADF and ABF imaging have demonstrated that this abrupt O-polar ZnO/Ga-GaN heterointerface takes place within one metallic atom lattice plane with the chemical mixtures to most probably occur within the group V and VI elements planes where the polarity appears to be initiated. Along with the experimental investigation, a systematic theoretical modeling of interfacial phenomena is carried out using density-functional theory by considering two types of interfaces: -Zn-O-Ga-N- and -O-Zn-N-Ga- with a special emphasis on the atomic structure, energetic stability of the ZnO/GaN interface. This allows the interfacial chemical bonding character and electronic structure to be determined.
Studying the fragmentation dynamics and possible geometry of Homo and Hetero Molecular Clusters with low energy ion beam

Vishant KUMAR

The analysis of ion-molecule collision at low energy ranges like 15 kV beams on the setup COLTRIMS (COLd Target Recoil Ion Mass Spectrometer) helps answering about the physics related to cluster’s dissociation. Experimentally we have found various common phenomena of the physics with the interactions of molecular gas phase clusters of homo or hetero types. In analysis we observed distinguished dissociation mechanism for diatomic clusters. Recently we observed the difference in dissociation of a N2 dimer and CO dimer in 3- body fragmentation. Which leads to the excitation about the trimers in 3 or 4 body fragments. In the past we have observed the mechanism related to effects of the charged neighbour on the fragmenting channel. On the other hand we also answer about the geometrical arrangements of our target cluster using some angular plots. We have already proposed the geometrical structures of Dimers, Trimer and Tetramers shall be soon at disposal. Study of these molecules in gas phase could help people to embark there work on bigger and dense environment like liquid/solid phase. These studies are relevant to atmospheric, stellar and even some biological processes.
Structural modifications induced by swift heavy ions in 
\( \alpha \)-Al\(_2\)O\(_3\) substrate

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Sapphire is a common substrate for nitrides due to its optical transparency and for its hexagonal structure making easy epitaxial growth. Indeed nitride semiconductors are mostly epitaxial films, thick of few microns deposited on insulating substrate for applications in high power and high frequency optoelectronic devices. In real world conditions, these devices can be exposed to ion irradiation as in space or accelerator environment. Thus it is necessary to study under ion irradiation the behaviour of nitride layers and sapphire substrate, of which the evolution of structural properties influence the features of the epitaxial top layer.

In this work, defect formation and structural modifications of \( \alpha \)-Al\(_2\)O\(_3\) induced by swift heavy ion irradiation are investigated. (0001) Al\(_2\)O\(_3\) single crystals have been irradiated along the \( c \)-direction by 92 MeV Xe at room temperature. The irradiation experiments have been performed at GANIL facility (Caen) on IRRSUD beam line. The ion beam energy is 0.7 MeV/A, where along the ion path the electronic stopping power dominates near the surface compared to nuclear stopping power, whereas an inversion of energy deposition processes is observed at the end of the projected range (around 8\( \mu \)m). High resolution X-ray diffraction and in-plane diffraction are used to characterize samples with various sensitivities to surface and to deep thickness. Using different fluences, the mechanisms of structural modifications are investigated.

In the communication, the evolution of the X-Ray patterns recorded in the two configurations for several reflections will be shown, discussed and compared to literature results. A careful study of the reflection characteristics will be detailed to highlight the material damaging through strain and amorphization. The kinetics of these processes with the ion fluence increase will also be discussed. We will show how much the \( c \)-parameter (parallel to ion beam) and the \( a \)-parameter (perpendicular to ion beam) are affected by irradiation in the MeV range. The biaxial and hydrostatic strains, linked to defect formation with fluence increase, are estimated. Finally a depth profile will be purposed as an explanation for the structural behaviour of Al\(_2\)O\(_3\) under 92MeV Xe irradiation. Complementary TEM results will be shown to improve the understanding of the modifications under irradiation.
High efficient infrared quantum cutting in Ce$^{3+}$-Yb$^{3+}$ codoped silicon oxynitride for solar cell applications

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Frequency conversion layers have been investigated to improve the efficiency of commercial Si solar cells, which is limited by the thermalization of high energy photogenerated carriers. To overcome this issue, cheap down converter (DC) layers based on a Ce$^{3+}$-Yb$^{3+}$ co-doped SiO$_x$N$_y$ matrix has been produced with rf co-sputtering technique. The optical properties of DC layers were optimized through variation of deposition and post-annealing parameters.

XPS analysis confirms the presence of optically active Ce$^{3+}$ ions responsible for a wide and bright photoluminescence due to the 5d-4f transition in 400-600 nm spectral range. Ce$^{3+}$ ion 5d band is affected by the SiO$_x$N$_y$ matrix composition resulting in a higher excitation range spanning from 300 nm to 400 nm as compared to the case of Ce$^{3+}$-doped SiO$_2$ matrix. The larger absorption cross section of Ce$^{3+}$ ions (10$^{-19}$ cm$^{-2}$ compared to 10$^{-21}$ for other rare earths) allows a direct excitation without the need of an additional sensitizer. The co-doping of SiO$_x$N$_y$:Ce$^{3+}$ with Yb$^{3+}$ ions exhibits a possible cooperative energy transfer with quantum efficiency (QE) exceeding 150 %. The obtained QE will be discussed and compared to the total efficiency of the system.

Furthermore, to improve the Ce$^{3+}$-Yb$^{3+}$ coupling rate, Bragg mirrors have been designed on the doped SiO$_x$N$_y$ and the experimental results will be compared to the simulations for finding a maximum density of UV photons trapped as well as a density of IR photons redirected to the solar cell.
The compressive strain release in In$_x$Ga$_{1-x}$N/GaN heterostructures

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The direct band gap of In$_x$Ga$_{1-x}$N alloys could allow emission and absorption of light from UV to near IR with optimal efficiency. However, due to the physical properties of its alloy constituents (InN, GaN), phenomena such as compositional ordering [1] or In composition pulling [2] and phase separation [3] may take place upon growth. They contribute to material quality deterioration with formation of pinholes for releasing the increasing strain even for moderate indium content [2]. It should be noticed that the wurtzite structure has a smaller symmetry than the III-V compounds that crystallize in the cubic zinc blende, with reduced possibilities for dislocation glide within the conventional growth geometries. Original reports on strain relaxation have already been proposed, such as the punch-out process [4], and that which proposed an explanation for the formation of V-defects [5].

In this work, we have investigated the structural properties of MOVPE (metalorganic vapor phase epitaxy) single InGaN/GaN layers of 50-100 nm thick over a range of In-content (4% to 25%). The growth has been carried out using self-supported GaN as well as sapphire substrates. The study has been carried out first by a detailed AFM analysis of the generated surfaces, then XRD analysis of the residual strain, and finally we have carried out TEM of the interfacial dislocations that form versus the indium content. Our results show that for lowest indium content, the interface exhibit a networks of a type screw dislocations, however even at 15% indium, coexistence of edge and screw dislocations is observed. Within the highest content all the interface dislocations are of a edge type with their line along <10-10> directions. For highest content, above 20%, the formation of stacking faults appears to constitute an additional strain relaxation mechanism.

References:
Experimental study of the interaction of ions with metal nano-particles for sizes up to 10 nm

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Nanoparticles are objects of multiple studies because of their unique size-related physico-chemical properties and their potential to impact fields like electronics, communication, medical or energy technologies. From another point of view, there are many open questions concerning the interaction of nano-dust with energetic particles and their influence on the formation of stars, planets and the role they can play in the formation of atmospheres. However, there are not many experimental studies of collisions between slow/fast ions with sub-10 nm nanoparticles, especially for the case of metallic and fullerene clusters, although theoretical approaches do exist [1]. Recently, this topic got its "renaissance" in the context of radiobiology and future hadrontherapy treatment plans, where metallic nanoparticle-based drugs are planned to be used as radio-sensitizing agents [2].

This communication concerns the development of the experimental set-up COLIMACON DUO built with the aim to study the interaction of ions and metallic nanoparticles in the gas-phase. First results will be communicated. The set-up is equipped with a magnetron based cluster source, capable to deliver intense molecular beams of metallic nanoparticles with a wide size distribution (from below 1 nm up to even 10 nm). Projectile ions are formed in an ECR ion source in charge states between 2 and 25 at an acceleration voltage of 15 kV. After the collision the positively charged products are analyzed with respect to their mass/charge ratio by ToF mass spectrometry. Different mechanisms like electron capture, evaporation and sputtering will be discussed both for the case of silver and bismuth nanoparticles. For bismuth clusters because of their small size the interaction is dominated due to peripheric collisions and electron capture into projectile. On the other hand silver clusters are much bigger (few nm) therefore the cross-section for penetrating collisions is larger. The above figure shows the region of small-sized Ag clusters produced after collisions of 255 keV Xe\textsuperscript{17+} projectiles with Ag\textsubscript{n} particles with diameters between 2 and 10 nm. The intensity distribution clearly shows the shell closure effects at n=3 and 9.

Figure 1: Part of the mass/charge spectrum produced in collisions between highly charged Xe ions (17+, 255keV) and Ag\textsubscript{n} particles with diameters between 2 and 10 nm. The intensity distribution clearly shows the shell closure effects at n=3 and 9.

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