Si/AlN Epiready substrates for Galium Nitride growth : Application to HEMT and LEDs devices

K. Ait Aissa, J. Camus, S. Bensalem, B. Belkerk, A. Achour, Q. Simon Y. Scudeller et A. Djouadi

JOURNEE DES LABOS 2013, Angers

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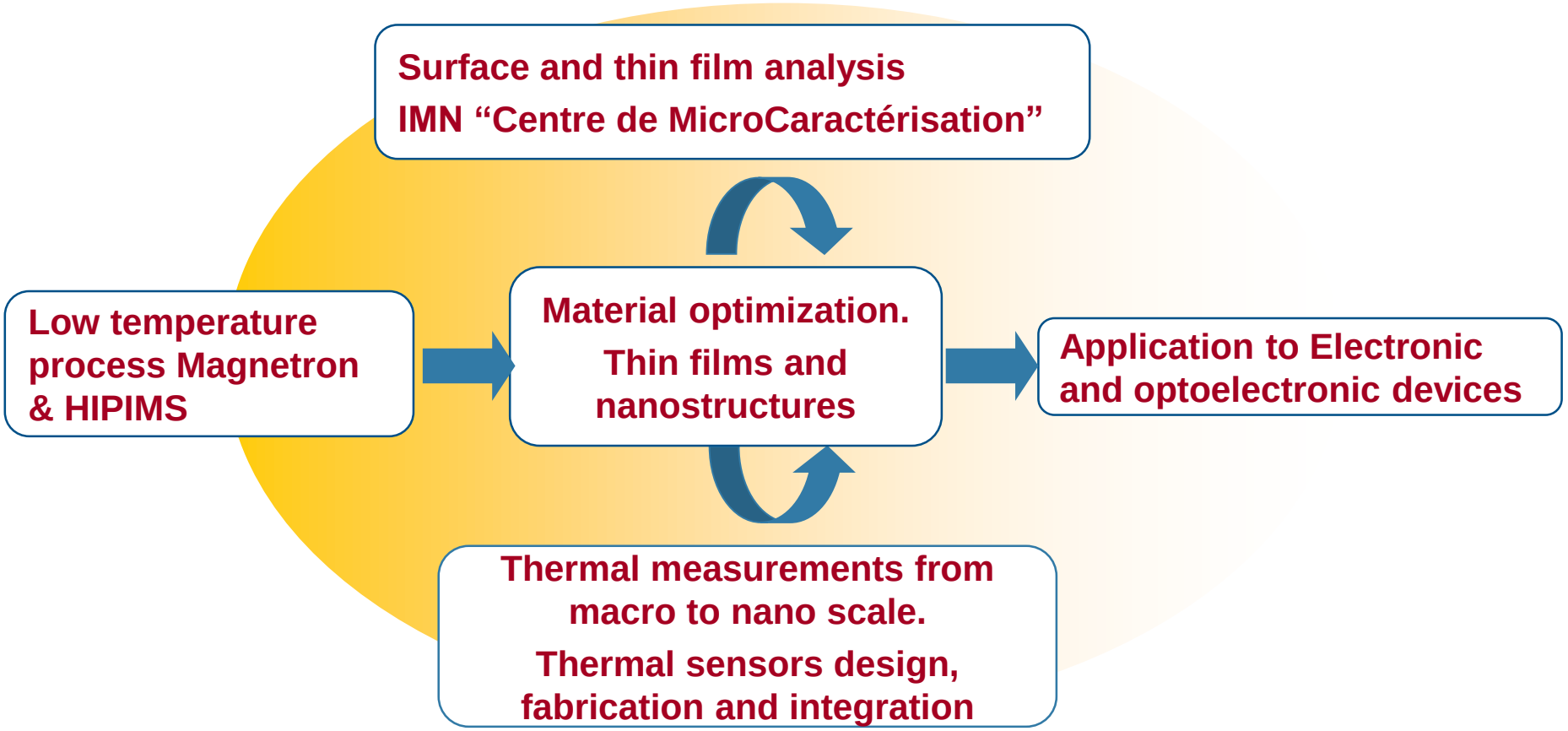
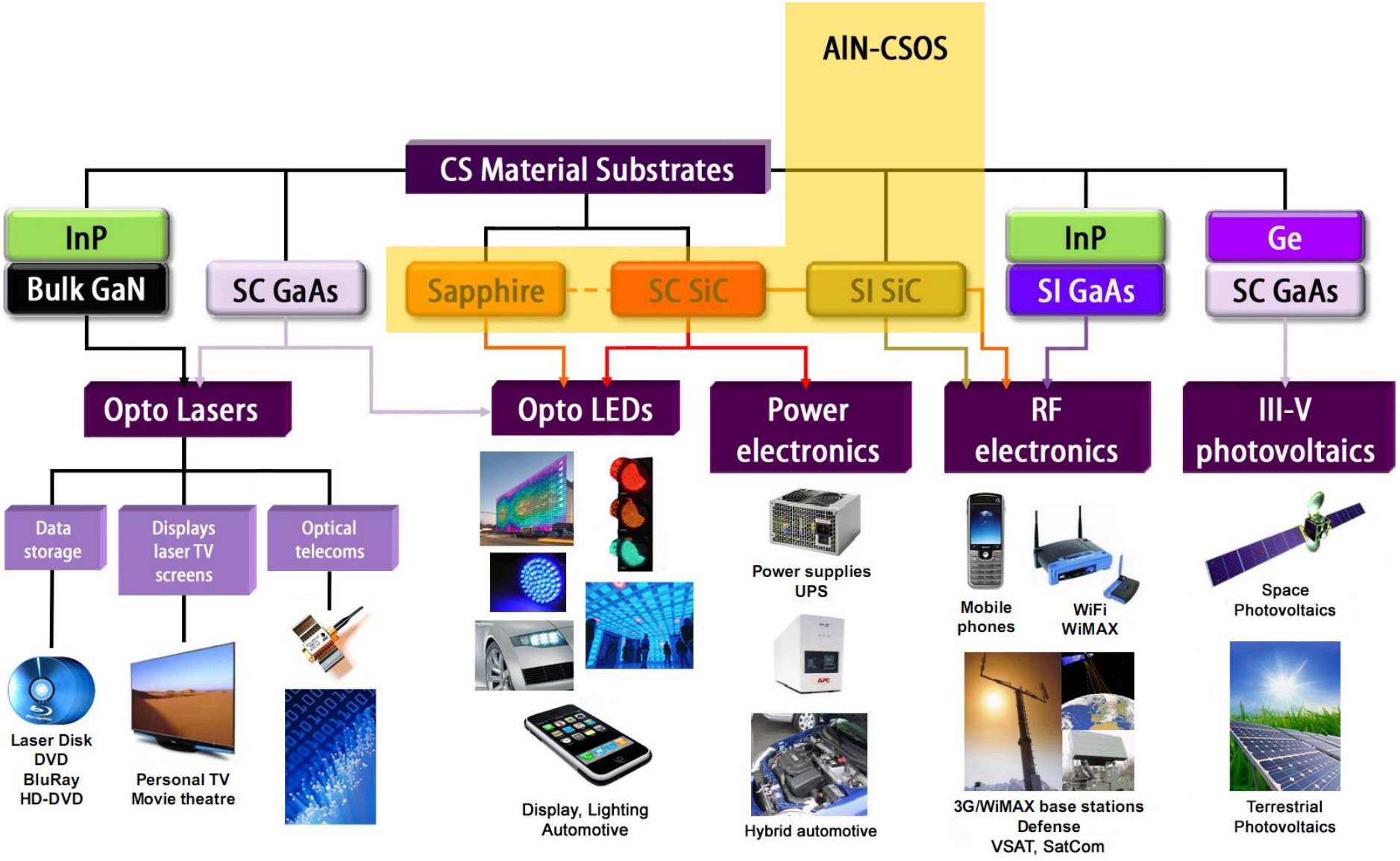
Competences and Research approaches

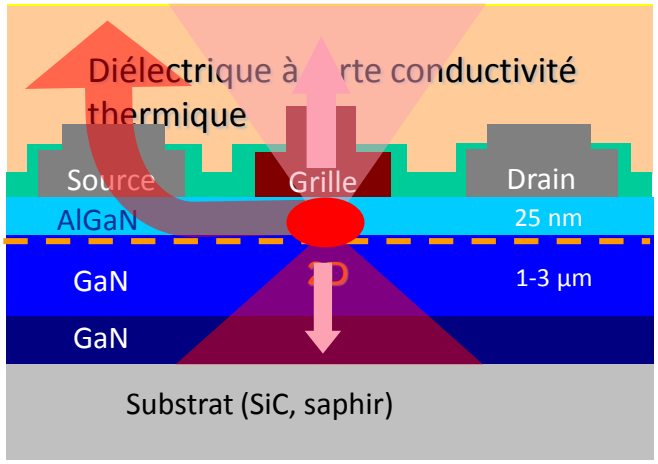


Control and mastery of process and material: Micro and NanoTechnology Applications

GaN material applications



Problematic



1ère Couche de passivation (SiN/SiO_2)

2ème couche de passivation diélectrique

ANR NANOTHERMIC

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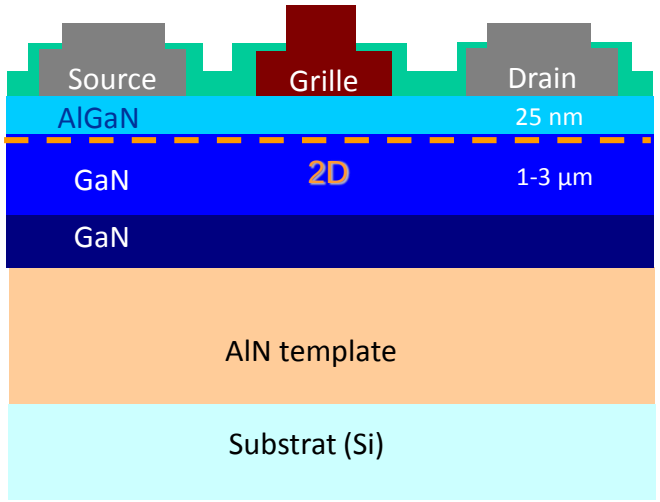
GREMI

III-V lab



ANR CREATIVEPI

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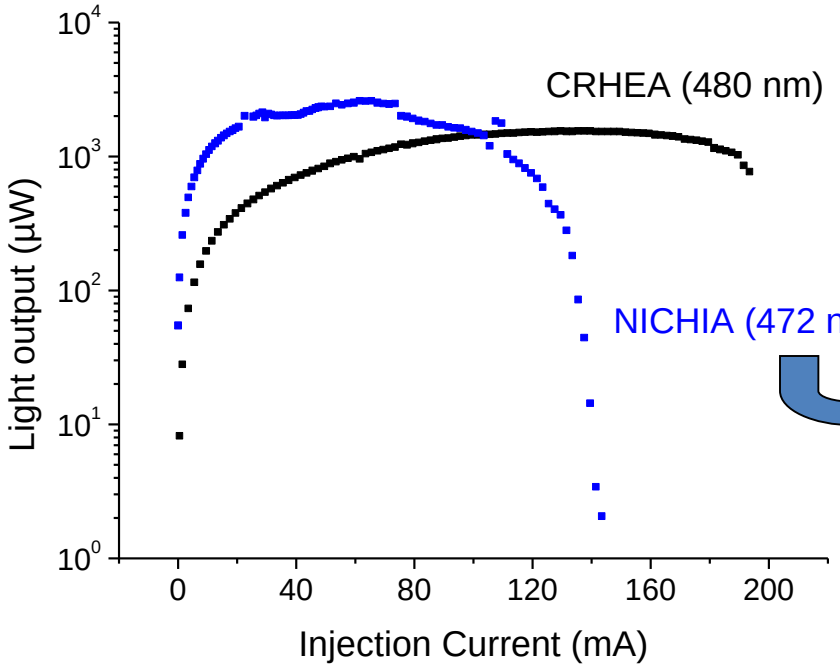
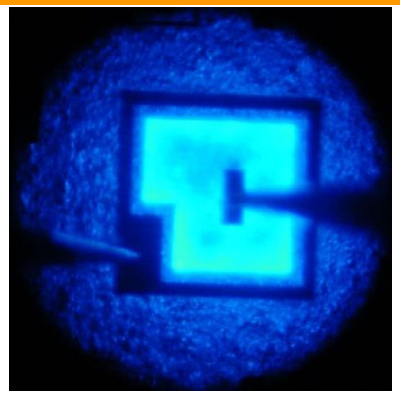
CRHEA

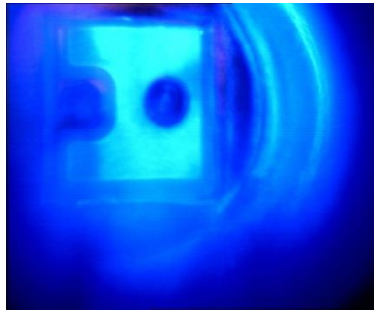
FIST

Problematic



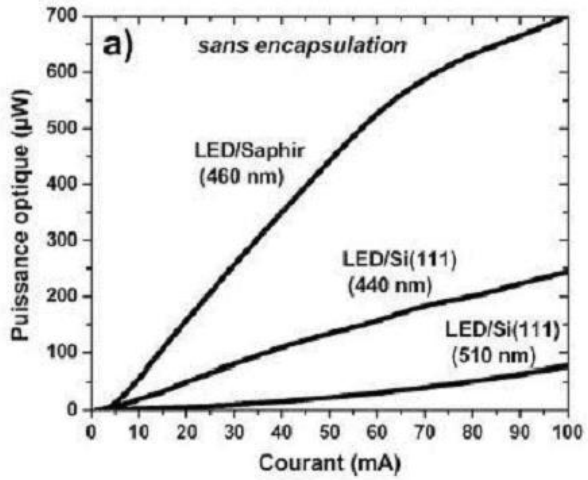


LED

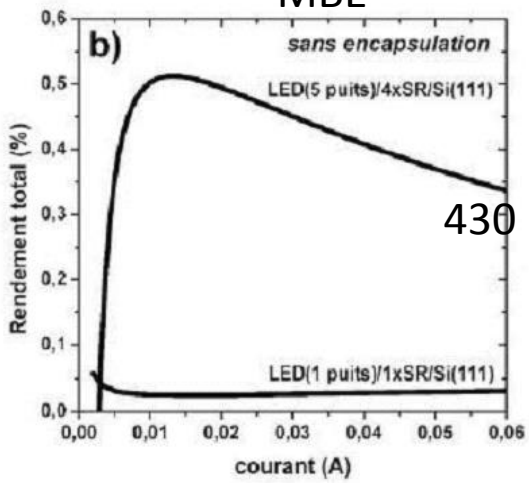


LED
+ epoxy dome

MOCVD



MBE



430 nm

ANR CREATIVEPI Project

WP1
Management & Specifications
All partners

Task 1.1 — IMN-CHREA-IEMN
Project management

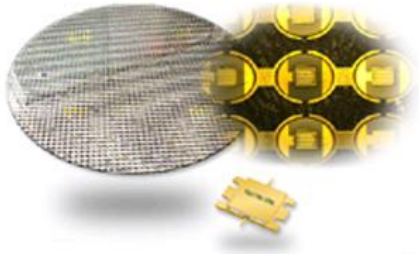
Task 1.2 — IMN-CHREA-IEMN
Specifications
Silicon handle wafer
Composite substrate
HEMT & LED demonstrators

WP2
Composite substrate
All partners

Task 2.1 — IMN
AlN/Si epitaxy by HIPIMS

Task 2.2 — CRHEA
GaN regrowth by MOCVD & MBE

Task 2.3 — IEMN-CRHEA-IMN
Characterization

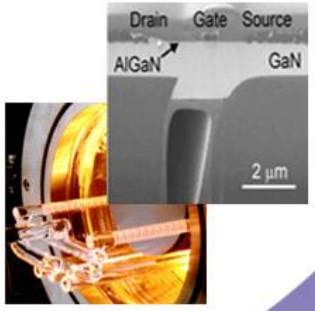


WP4
Evaluation & Dissemination
All partners

Task 4.1 — CHREA-IEMN-IMN
Comparison / State-of-the-Art

Task 4.2 — IMN-FIST
Dissemination of results

Task 4.3 — IMN
Projection towards 6" scale-up



WP3
Demonstrators
All partners

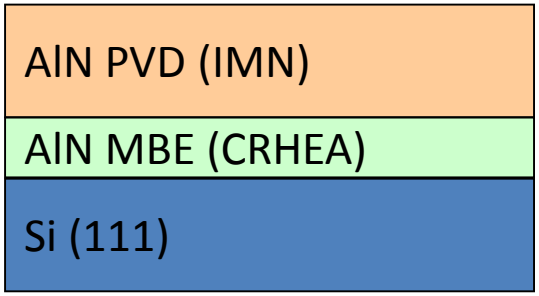
Task 3.1 — CHREA-IMN
GaN epitaxy by MOCVD & MBE

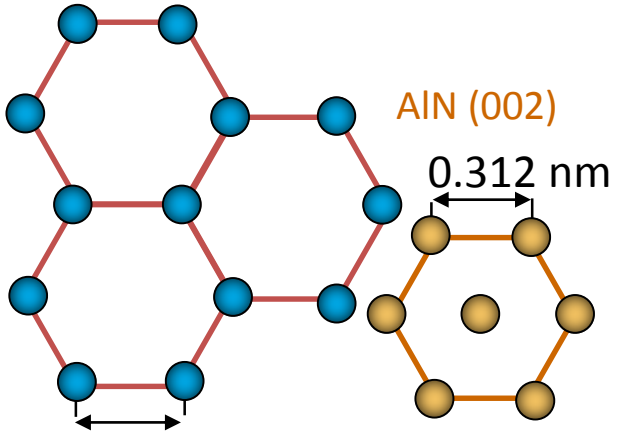
Task 3.2 — IEMN-CRHEA
Technology demonstrators

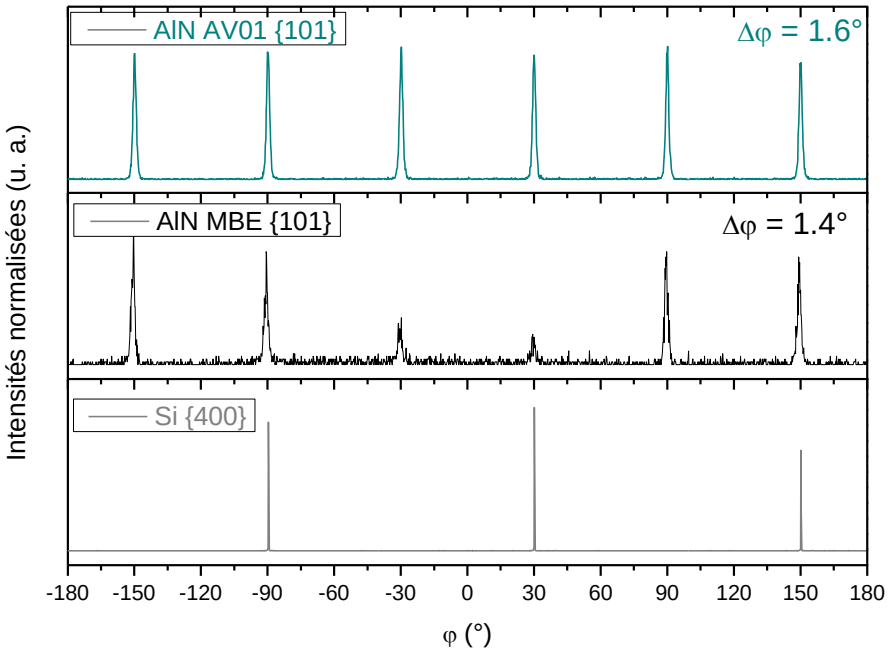
Task 3.3 — IEMN-CRHEA
Characterization demonstrators

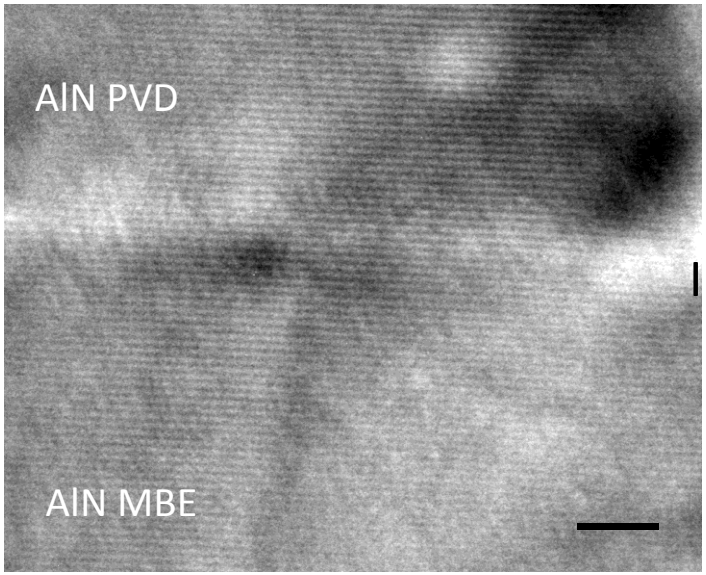
Epiready Substrate AlN(PVD)/AlN(MBE)/Si<111>

XRD: φ-scan









Interface

➢ Signature of epitaxial growth of AlN at low temperature

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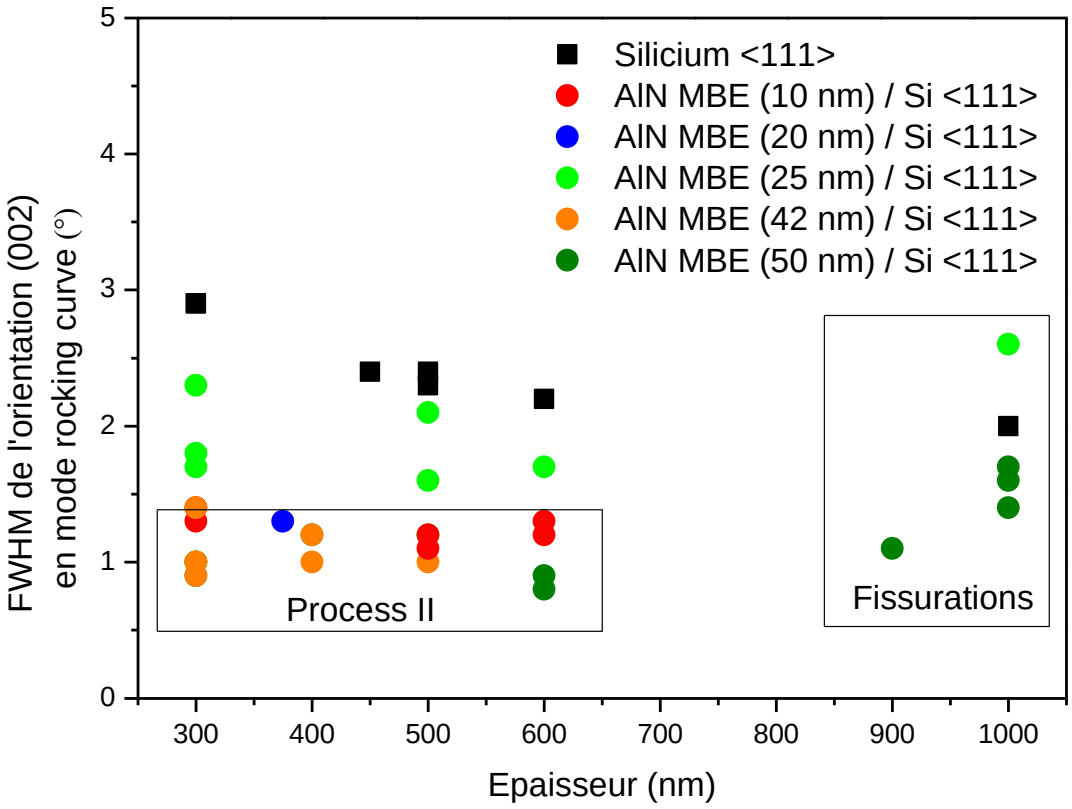
Si et AlN PVD/Si substrate Comparison

DRX: ω-scan (rocking-curve)



$FWHM_{10\ nm}$= 2°

$FWHM_{20\ nm}$= 1.2°

$FWHM_{25\ nm}$= 1.1°

$FWHM_{42\ nm}$= 0.9°

$FWHM_{50\ nm}$= 0.9°

AlN PVD (IMN)

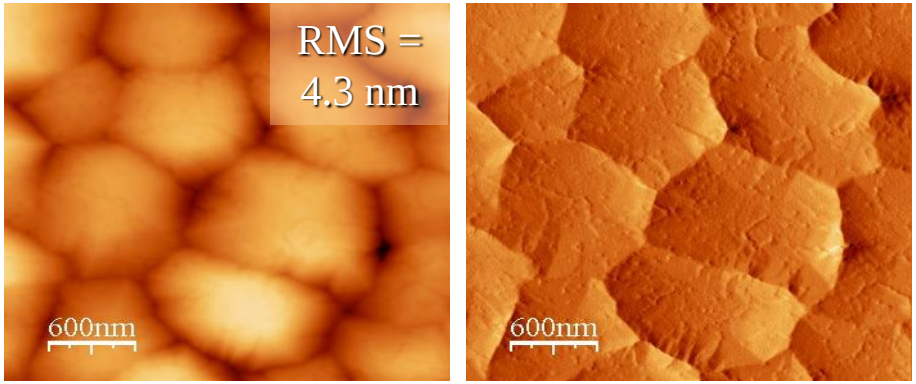
AlN MBE (CRHEA)

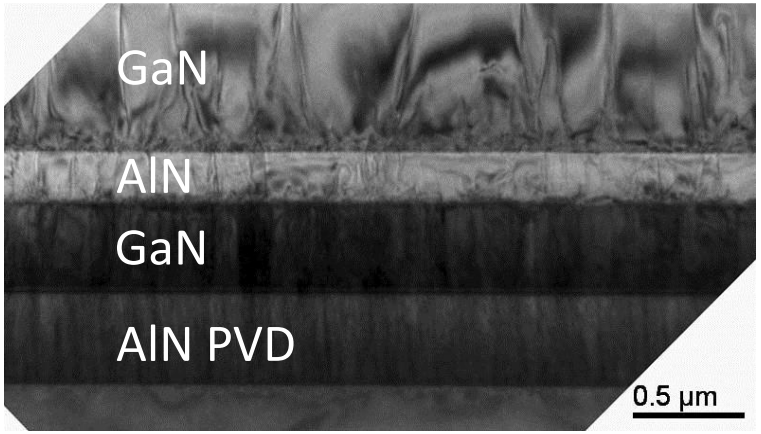
Si (111)

- Cracking of AlN MBE film with thickness > 150 – 200 nm
- AlN PVD films with no cracking up to 600 nm
- Stress control of the GaN upper film

Growth of epitaxial GaN films

Structure of HEMT device with AlN (PVD) Epiready substrate





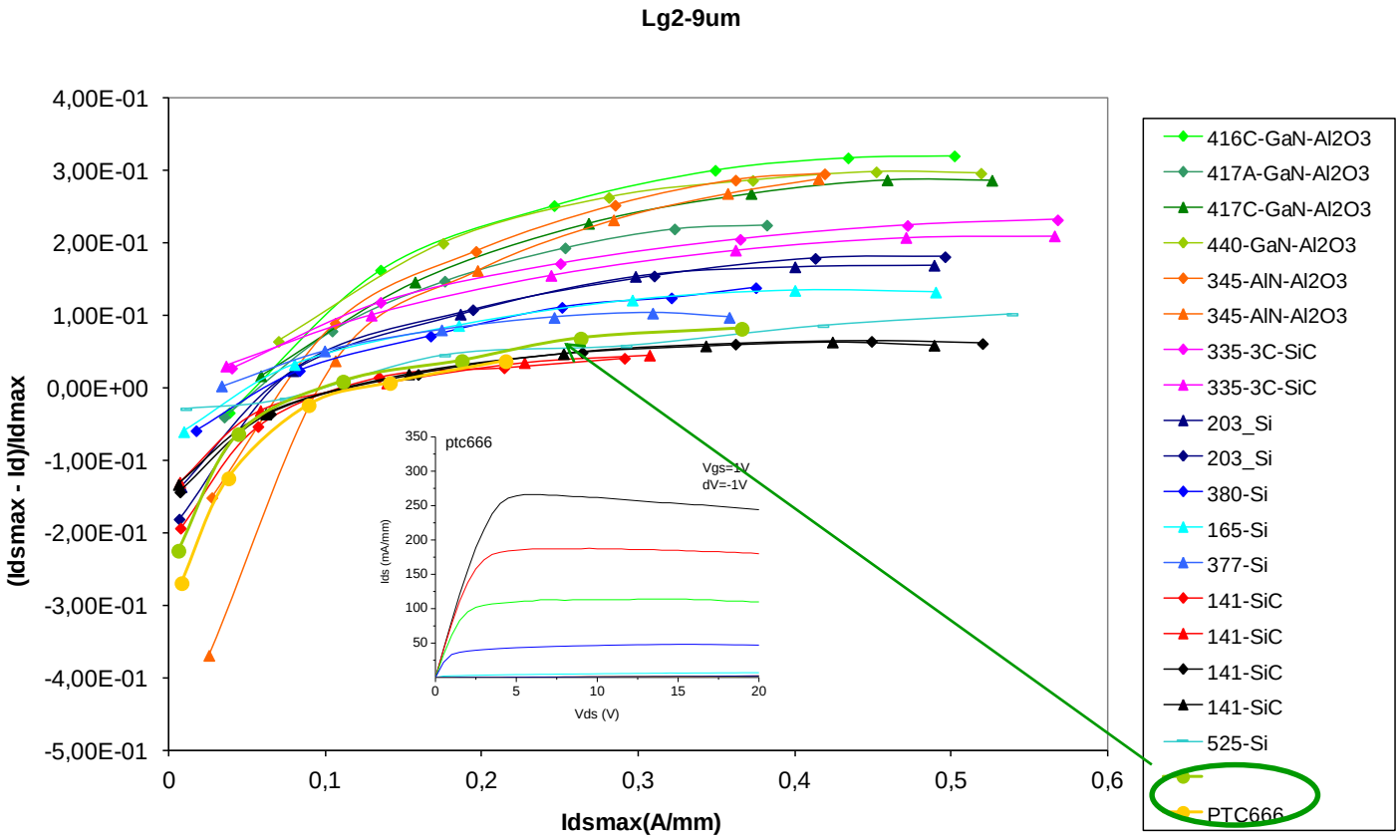
GaN epitaxial growth

Thèse J. Camus (2011-2014)

Electrical Tests of GaN HEMT Device

Comparaisons – collapse

$$COLLAPSE = \frac{Id_{knee} - Id_{20V}}{Id_{knee}}$$



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CRHEA

AGENCE NATIONALE DE LA RECHERCHE

ANR

NanoThermIC project

Consortium

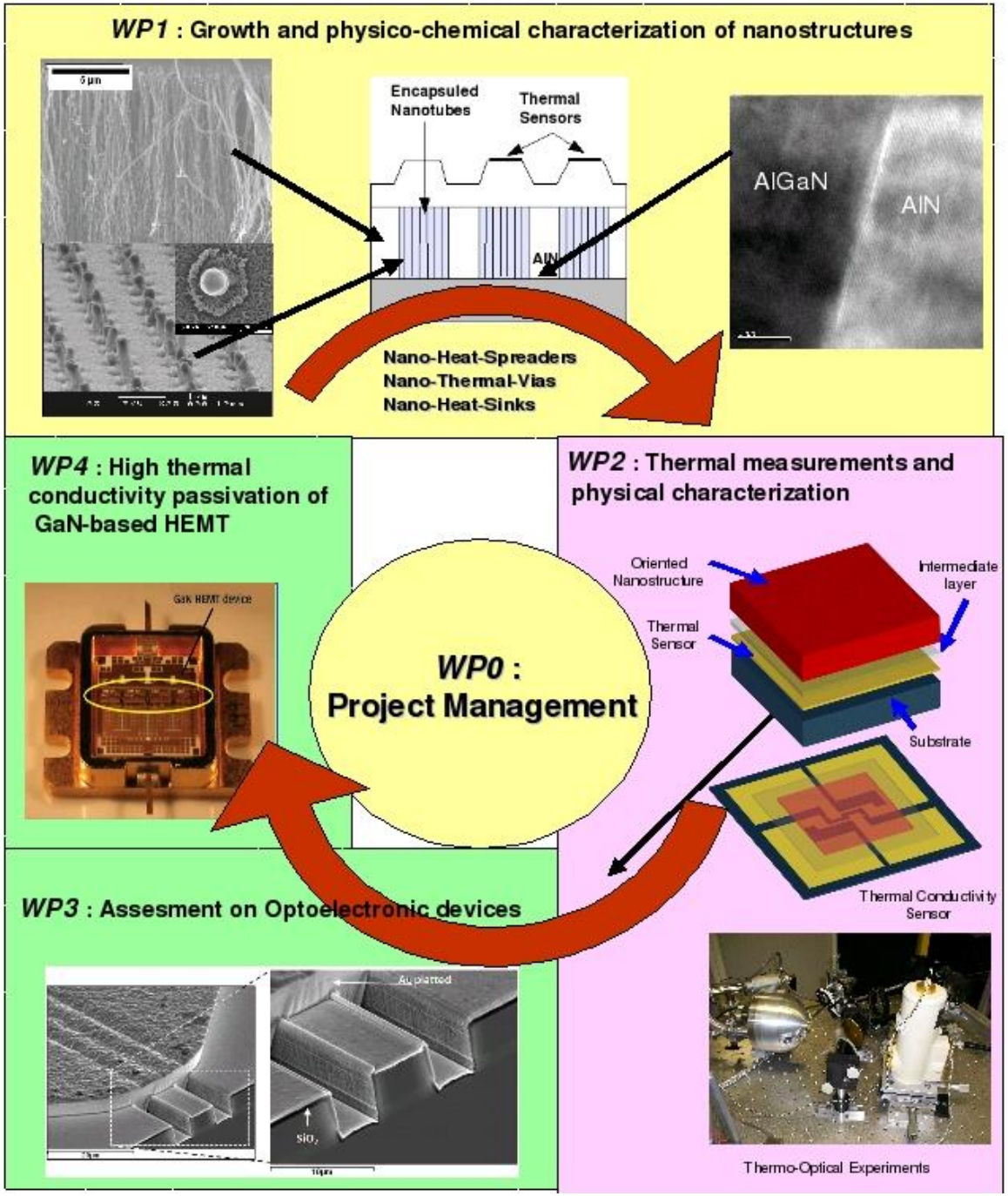
IMN Univ. Nantes

ATL, III-V Lab.

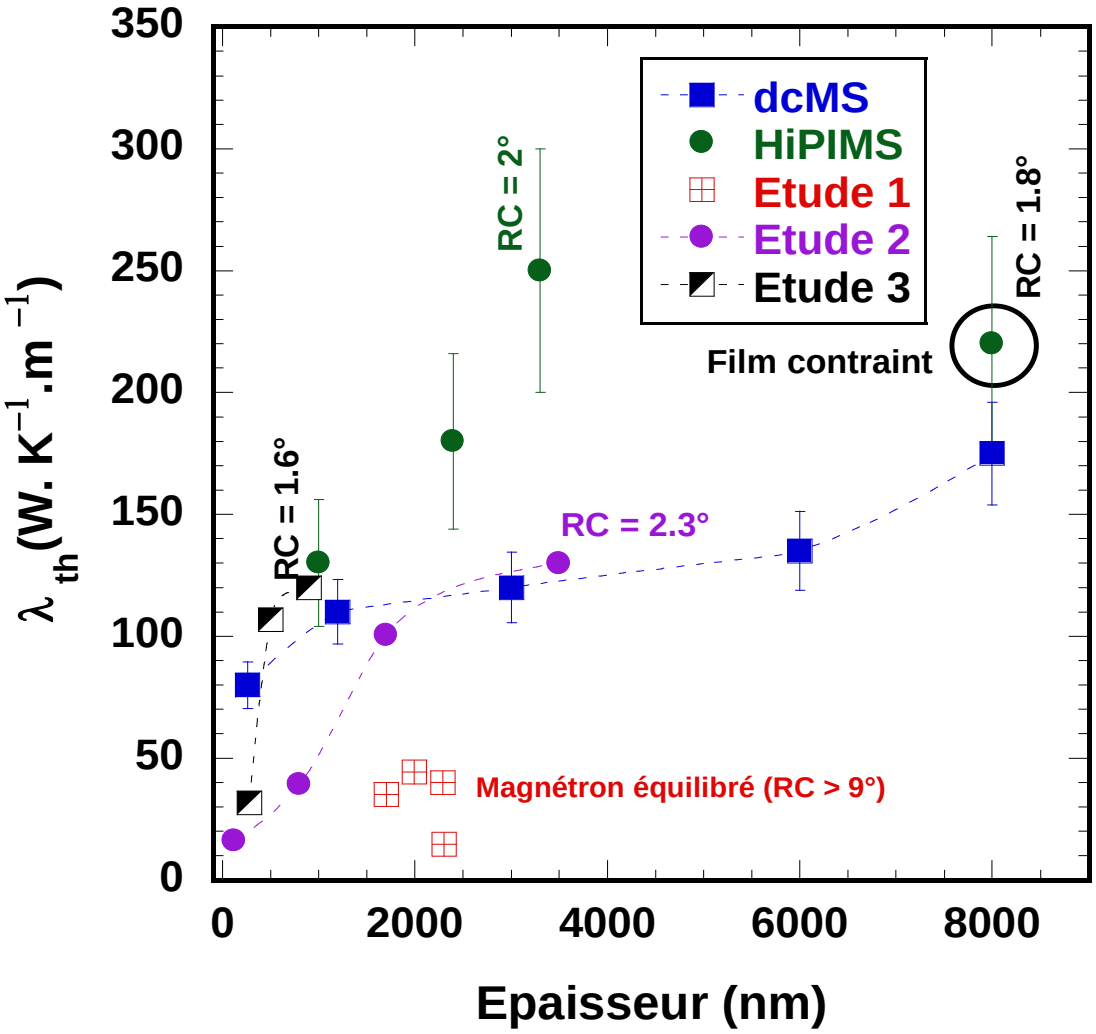
GREMI Polytech Orléans

LGMPA Polytech Nantes
ESPCI Paris

PDI, Univ. Berlin



Thermal Properties



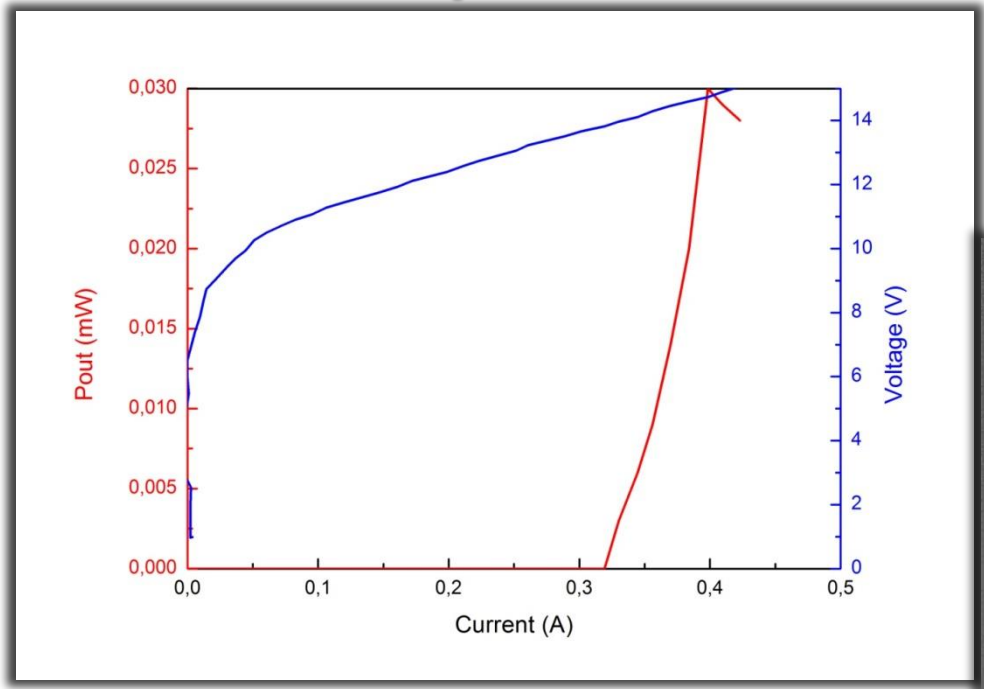
❒ HiPIMS films exhibit thermal conductivity up to 250 ± 50 $W.K^{-1}.m^{-1}$

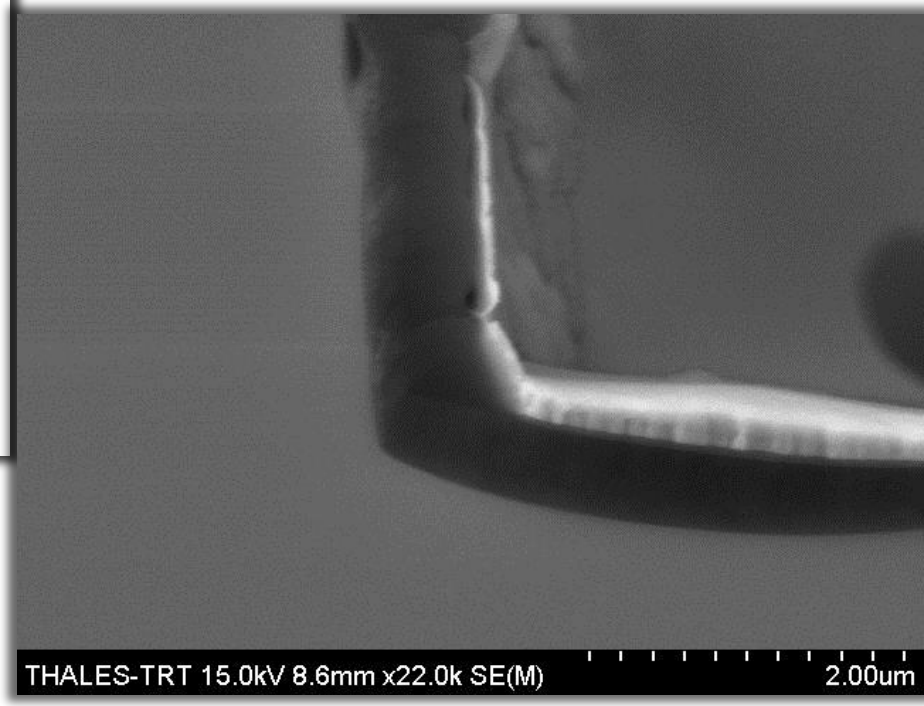
Etude (1) et (2) : C. Duquenne, Thèse de doctorat, Université de Nantes (2008)

Etude (3): A. Soussou, Thèse de doctorat, Université de Nantes (2011).

WP 3. Thermal managment of QCL devices

❖ QCL @3.9µm



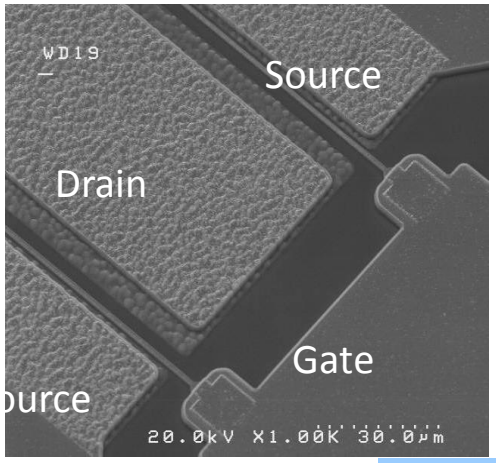


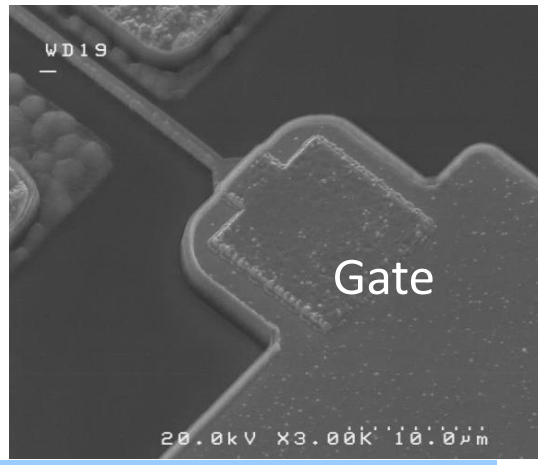
⇨ AlN integration in a real process

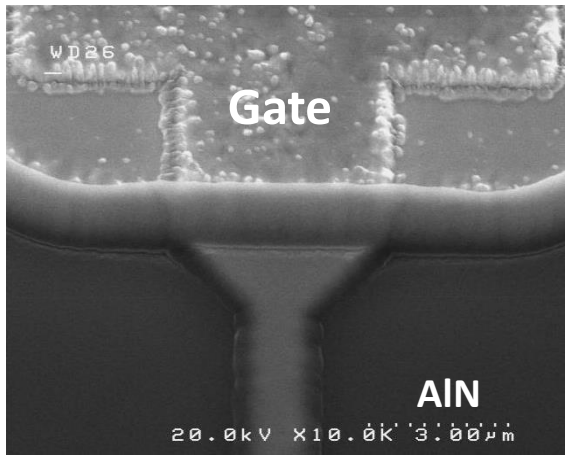
Patent: « Dispositif optique utilisant un dépôt de Nitrure d'Aluminium, non épitaxié, assurant une fonction optique »

Alcatel·Lucent leti THALES

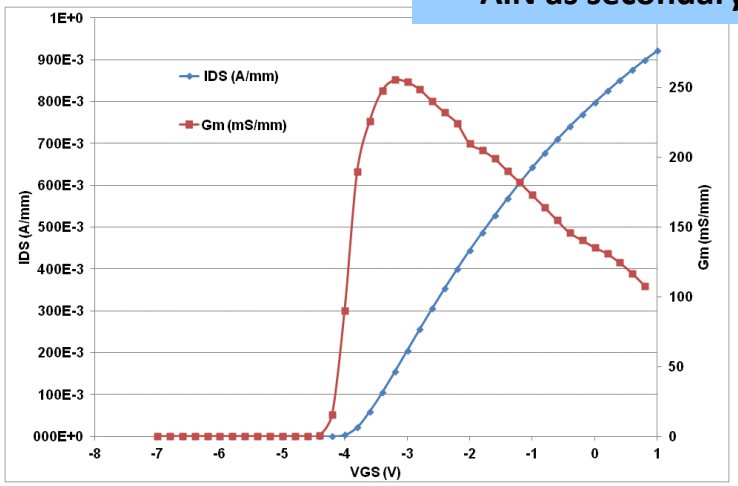
WP 4. High thermal conductivity passivation of GaN-based HEMT





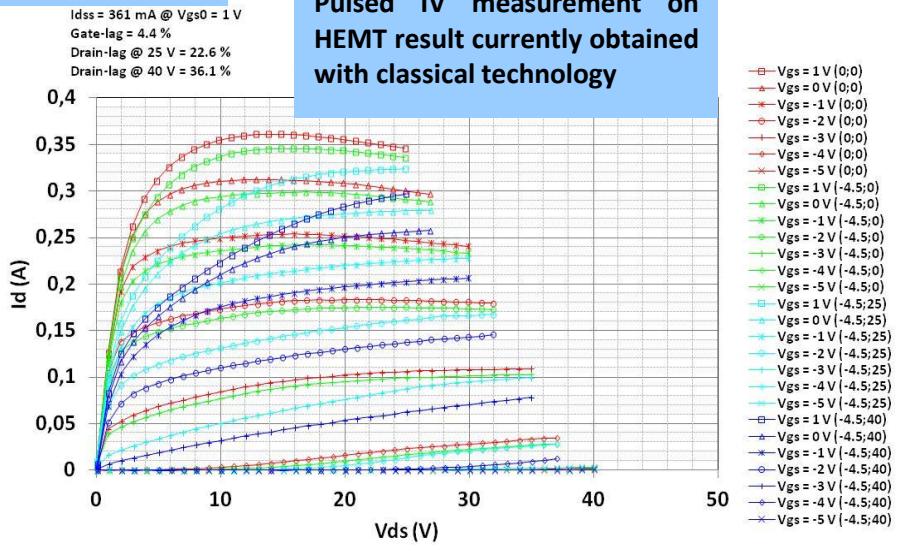


AlN as secondary passivation layer

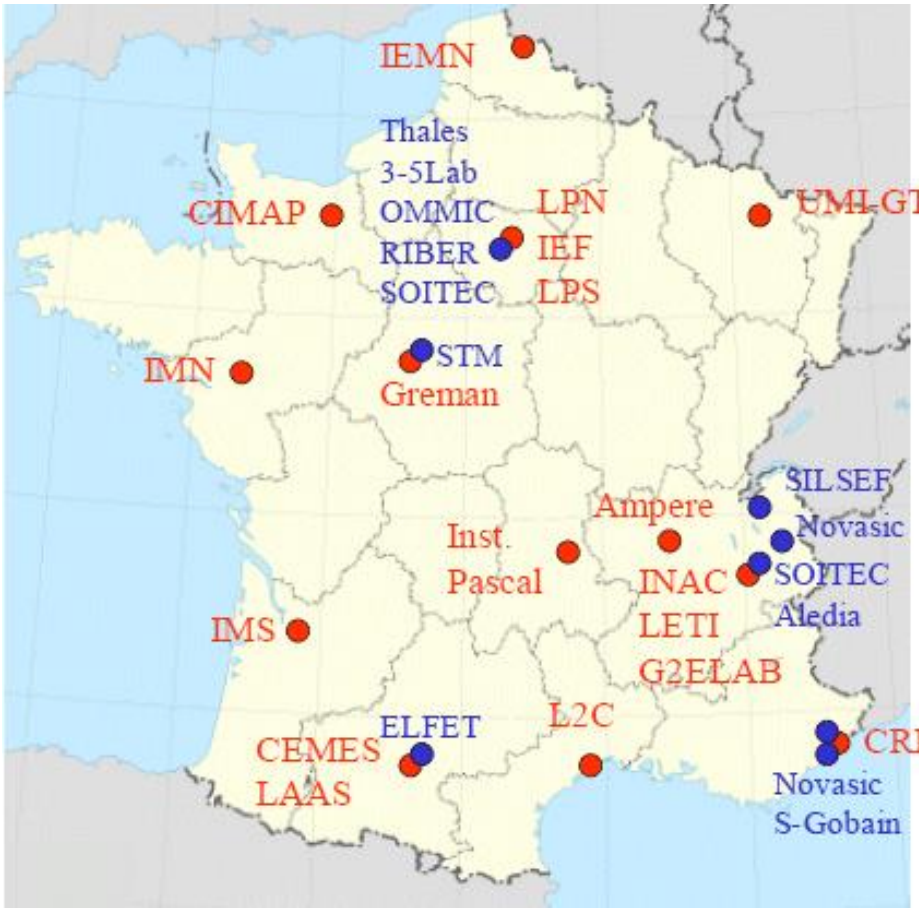


Good Static and pulsed IV measurements
G_m= 250mS/mm, I_{dss}= 880mA/mm, V_p=-4.3V

Pulsed IV measurement on HEMT result currently obtained with classical technology



La synergie entre les aspects thermiques et les procédés couches minces fait de l'IMN un partenaire privilégié non seulement pour réduire la température d'élaboration des composants électroniques mais aussi pour assurer leur management thermique.
Participation au Labex Ganex qui est cordonné par le CRHEA et qui rassemble toute la communauté du GaN en France.



- **Collaboration dans le cadre du Labex Ganex, thèse Ganex et Conseil Régional PdL de Salma Bensalem en collaboration avec l'IEMN à Lille, le CRHEA à Sophia Antipolis et le LAAS à Toulouse (2012-2015).**
- **Collaboration DGA dans le cadre de la thèse de Julien Camus en collaboration avec 3-5 Lab. à Marcoussis (2011-2014).**
- **Thèse CEATech De Sylvain SIM avec le CEA, La Région PdL et ATLANTIC. La thèse est adossée à l'ANR Fichtre en collaboration avec le CEA- LITEN, INP Grenoble et des industriels (Savimes, Polymage, CCIT et Id3) (2013-2016).**