Laboratoire commun CRHEA –RIBER

RIBER GaN Process Technology Center (PTC GaN)

Introduction

The GaN PTC laboratory was established in 2003. It is based in CRHEA facility and benefits from more than 20 years of experience in GaN MBE growth (on Riber MBE 32 and Compact 21 research systems) and structural, optical and electrical characterizations.

Etabli en 2003 dans les locaux du CRHEA, le laboratoire commun s'appuie sur plus de 20 ans d'expérience dans le domaine de la croissance EJM de GaN (systèmes Riber 32 et Compact 21), et de leur caractérisation structurale, optique et électrique).

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RIBER Compact 21T MBE reactor

Objectives / *objectifs* **:**

Development of the molecular beam epitaxy growth technique for GaN and related materials : integration and testing of new equipments and process, publications and Application Notes

Développement de la technologie de croissance par épitaxie sous jets moléculaires des structures à base de GaN : intégration et tests de nouveaux équipements, procédés de croissance, publications et notes d'application

Growth of specific test structures for prospective users

Effectuer des démonstrations à la demande de clients potentiels (Prospects)

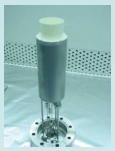
Training courses for RIBER's MBE customers

Former les clients à l'utilisation et la maintenance de réacteurs de croissance (Trainings)

GaN MBE technology

Effusion cells for III-Nitrides

Double filament Ga cells

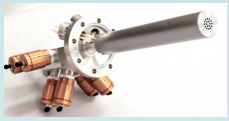


Cold lip Al cell (CL 60/80)

High Temperature substrate heater

Graphite 4 in. heater

Low/High Temperature NH_3 Injector

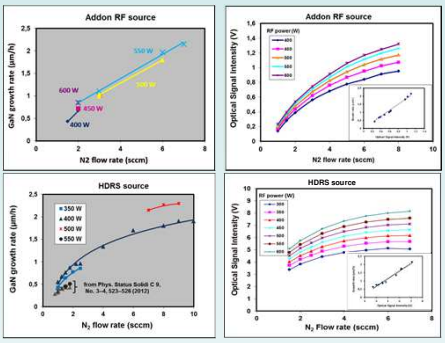


GaN plasma MBE technology

Conventional RF Plasma source: *Addon model RFN50/63*

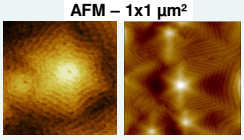
HDRS plasma source: *NU Eco-Engineering Co.*

Effect of nitrogen flow rate and RF power.



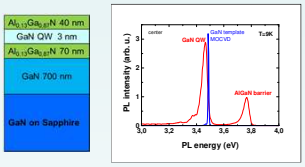
Growth using a nitrogen plasma source (Ga-rich growth regime) T > 700°C

AFM – 1x1 µm²

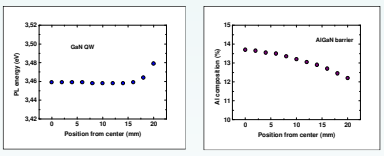


Depending on growth conditions, AFM shows terraces with a mean step height of 1 molecular monolayer (left) and 2 monolayers (right)

Growth of AlGaN/GaN quantum well heterostructures

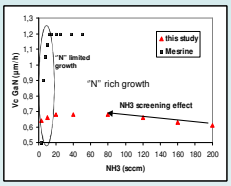


PL uniformity along the radius of a 2'' wafer



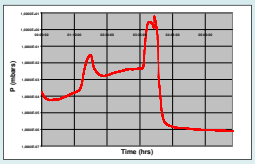
GaN ammonia MBE technology

Influence of the ammonia flow rate



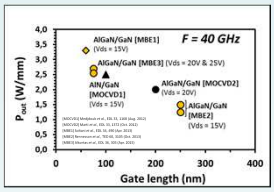
■ **Mesrine et al.** Appl. Phys. Lett. 72 (3) p.350 – 1998). Riber 32 reactor

Ammonia recovery procedure

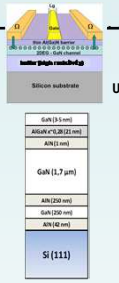


Evolution of the pressure during the recovery of Ammonia

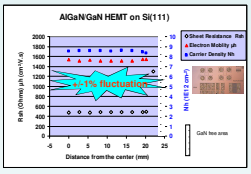
State of the art AlGaN/GaN HEMTs on Silicon



Yvon Cordier, Al(Ga)N/GaN High Electron Mobility Transistors on Silicon, Feature Article, Phys. Status Solidi A 212, n°5, 1049-1058 (2015)



Uniformity along the radius of a 2'' wafer



From research to production

2008: 1st world GaN production MBE

KEY FEATURES

YIELD Excellent crystal quality Excellent uniformity	- Ammonia injector design - Gallium and Aluminium sources - Substrate oven design - Ammonia pumping and recycling
THROUGHPUT High growth rates Multi wafer design Reliability Ammonia handling	- Ammonia precursor growth rate: up to 1.5µm/h - 3x4" scalable to 7x6" - Based on the MBE49 platform Benefit from R&D program: ANISET (E.U community) & DEMONI (ANR)
EFFICIENCY Reduced LN2 consumption Reduced power consumption	- Dedicate cryopanel - Low temperature process

Publications / Applications Notes

PUBLICATIONS

-GaN films and GaN/AlGaN quantum wells grown by plasma assisted molecular beam epitaxy using a high density radical source, Yvon Cordier, Benjamin Damilano, Phannara Aing, Catherine Chaix, Florence Linez, Filip Tuomisto, Philippe Vennéguès, Eric Frayssinet, Denis Lefebvre, Marc Portail, Maud Nemoz, Journal of Crystal Growth (433) 165-171 (2016).

-Influence of nitrogen precursor and its flow rate on the quality and the residual doping in GaN grown by molecular beam epitaxy, Y.Cordier, F.Natali, M.Chmielowska, M.Leroux, C.Chaix, P.Bouchaib, Physica Status Solidi C 9, 523–526 (2012).

-Advances in quality and uniformity of (Al,Ga)N/GaN quantum wells grown by molecular beam epitaxy with plasma source, F.Natali, Y.Cordier, C. Chaix, P.Bouchaib, Journal of Crystal Growth (311) 2029–2032 (2009).

-Signature of monolayer and bilayer fluctuations in the width of (Al,Ga)N/GaN quantum wells, F.Natali, Y.Cordier, J.Massies, S.Vezian, B.Damilano, M.Leroux, Physical Review B 79, 035328 (2009).

-Developments for the production of high quality and high uniformity AlGaN/GaN heterostructures by Ammonia MBE, Y.Cordier, F.Semond, J.Massies, M.Leroux, P.Lorenzini, C.Chaix, Journal of Crystal Growth (301/302) 434-436 (2007).

-Quality and uniformity assessment of AlGaN/GaN Quantum Wells and HEMT heterostructures grown by molecular beam epitaxy with ammonia source, Y.Cordier, F.Pruvost, F.Semond, J.Massies, M.Leroux, P.Lorenzini, C.Chaix, Physica Status Solidi C 3, 2325-2328 (2006).

RIBER Application Notes

- **60825S72 Riber opens new GaN PTC** / *Lancement du Laboratoire Commun*
- **60826N02 GaN on template** / *Croissance de GaN*
- **HLCOF7_Z17G GaN-proces-improvements** / *Améliorations de la croissance GaN*
- **60827M62 GaN uniformity results** / *Uniformités de couches de GaN avec source Ammoniac*
- **INDPHT_E3ZM_60828R92 plasma growth** / *Croissance plasma*
- **60829R42 Preliminary characterization Addon nitrogen source** / *Uniformités de couches de GaN avec source plasma*
- **HMCOF7_6W59_60829p92-AN Highly-doped-GaN** / *Dopage p de GaN*
- **F3AMD6_HMCO Growth-of-GaN-quantum-dots** / *Croissance de boites quantiques GaN dans des couches nitrures très minces*

LAYTEC

- **Newsletter 37 February 2006** / *EpiTT goes GaN MBE !*

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