C3N T NEWSLETTER

Swedish Center for III-Nitride Technology

Fall 2022

EVENTS

C3NiT Center Day 10 Nov 2022
More than 80 C3NiT members, affiliates and visitors met and discussed C3NiT research at C3NiT day 2022. The program featured 24 presentations, including 3 invited talks (Enrico Zanoni, Michał Boćkowski and Joana Mendes), 2 industrial, 5 project, 14 PhD and PostDoc presentations.

GRADUATIONS

Hengfang Zhang: “Hot-wall MOCVD of N-polar group-III nitride materials and high electron mobility transistor structures”, **PhD thesis**

Alexis Papamichail: *“P-type and polarization doping of GaN in hot-wall MOCVD”,* **Licentiate thesis**

Rosalia Delgado Carrascon: “Epitaxial strategies for defect reduction in GaN for vertical power devices”, **Licentiate thesis**

Björn Hult: “Design, Fabrication and Characterization of GaN HEMTs for Power Switching Applications”*,* **Licentiate thesis**

Albert Malmros: “Investigation on the Optimization of GaN Etching for FinFET Applications”, **Master thesis**

Shiqui Guo: “AlGaN/GaN HEMTs for high-frequency applications**”, Master thesis**

PUBLICATIONS

D.-Y. Chen et al. *“Impact of the Channel Thickness on Electron Confinement in MOCVD-Grown High Breakdown Buffer-free AlGaN/GaN Heterostructures”*, Phys. Status Solidi A 2200496 (2022) link

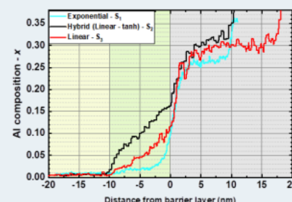
B. Hult et al., *“High Voltage and Low Leakage GaN-on-SiC MISHEMTs on a “Buffer-Free” Heterostructure”*, IEEE Electron Dev. Lett. **43**, 781 (2022)

C3NiT CONTINUATION !

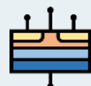
VINNOVA has granted funding for another 5 years of C3NiT! The extension was approved after C3NiT successfully passed the 5-year evaluation and was ranked 2nd among all eight Vinnova competence centers. We are looking forward to another successful 5 years!

PROJECT UPDATES

Epitaxial growth development

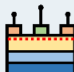


Compositional grading of the channel in AlGaN/GaN high electron mobility transistors (HEMTs) has been developed. The DC performance reveal improved linearity characteristics making our approach highly promising for low-noise RF amplifiers.



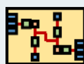
Vertical GaN power devices

Quasi-vertical GaN FinFETs were fabricated on SiC substrates. The devices demonstrate good electrostatic control of the channel and low on-resistance (below 0.05 mΩcm^2). The breakdown voltage of 60 V was obtained. Post gate metallization annealing resulted in reduced threshold voltage, on-resistance, and gate leakage.



HEMT technology

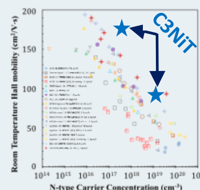
We have demonstrated HEMT devices with 70 nm gate length based on buffer-free epistructures (QuanFINE) without any degradation in structural quality and 2DEG properties. Devices exhibit excellent electrical characteristics such as high breakdown field of 0.95 MV cm^{-1} and DIBL of 20 mV/V at V_{DS} of 25 V. (link)



GaN MMIC

A new batch based on the developed multilayer backend process has recently been finalized. A new feature is an integrated antenna. The circuits await characterization.

Developing the next generation high-power β-Ga_2O_3 material



Successful homoepitaxy of β-Ga_2O_3 (010), with record smooth surface: RMS of 0.8 nm over 10 µm × 10 µm. These epilayers exhibit electron mobility parameters among the best values in the literature $\mu_{a,c}$ = 170 cm^2/(Vs) and μ_b = 12 cm^2/(Vs) for N = 5 × 10^{17} cm^{-3}.

General Assembly Feb 9th 2023

Visit our website: http://www.c3nit.se

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PUBLICATIONS

D.-Y. Chen et al. *"Impact of in situ NH_3 pre-treatment of LPCVD SiN passivation on GaN HEMT performance"*, Semicond. Sci. Technol. **37**, 035011 (2022)

R. Delgado-Carrascon et al., "*Hot-wall MOCVD for high quality GaN homoepitaxy: Understanding nucleation and design of growth strategies*", Cryst. Growth Des. **22**, 7021 (2022)

P. Kühne et al., "*Enhancement of 2DEG effective mass in AlN/$Al_{0.78}Ga_{0.22}N$ high electron mobility transistor structure determined by THz optical Hall effect*", Appl. Phys. Lett. **120**, 253102 (2022) link

D. Gogova et al., "*Epitaxial growth of β-Ga_2O_3 by hot-wall MOCVD*", AIP Advances **12** 055022 (2022) link

H. Zhang et al., *On the polarity determination and polarity inversion in nitrogen-polar group III-nitride layers grown on SiC*, J. Appl. Phys. **131**, 055701 (2022)

A. R. Persson, "*Mg segregation at inclined facets of pyramidal inversion domains in GaN:Mg*", Sci. Reports **12**, 17987 (2022)

D. Q. Tran et al., "*Thermal conductivity of AlxGa1-xN ($0 \le x \le 1$) epitaxial layers*", Phys. Rev. Materials **6**, 104602 (2022).

A. Papamichail et al., "*Mg-doping and free hole properties of GaN grown by hot-wall MOCVD*", J. Appl. Phys **131**, 185704 (2022).

A. Kakanakova et al., "*Incorporation of Magnesium into GaN regulated by intentionally large amounts of Hydrogen during growth by MOCVD*", Phys. Status Solidi B **259**, 2200137 (2022)

M. Schubert et al., "*Terahertz electron paramagnetic resonance generalized spectroscopic ellipsometry: The magnetic response of the nitrogen defect in 4H-SiC*", Appl. Phys. Lett. **120**, 102101 (2022) link

New industrial PhD students!

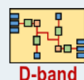
Mado Logotheti
Volvo Cars & Lund Uni
Optimization of WBG technologies for fast and efficient power switching

Pengpeng So
Volvo Cars & Chalmers
Design of compact power modules for propulsion and charging applications

Andreas Divinyi
Saab & Chalmers
Thermal aspects of GaN MMICs

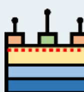
PROJECTS phase 2

Based on the expressed interest and contribution of the industrial partners the following projects during phase 2 of C3NiT are proposed. Project leaders will organize technical discussions in the beginning of 2023 to define the respective project plans, milestones and deliverables.

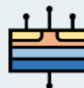


D-band HEMTs and MMIC – Anna Malmros

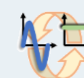
Linear E/W-band HEMTs and MMIC – Mattias Thorsell



High voltage HEMTs & circuits for power and microwave applications – Niklas Rorsman



Vertical devices for power applications
Muhammad Nawaz and Erik Lind



Propulsion/Charger/Converter/Switching applications
Kooros Moabber

Advanced Epitaxial concepts for cost reduction
Vanya Darakchieva and Nerijus Armakavicius

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