

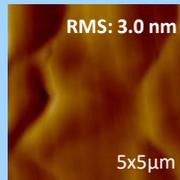
## Swedish Center for III-Nitride Technology

Next Board Meeting September 9<sup>th</sup>, 2021 in Teams

### PROJECT UPDATES

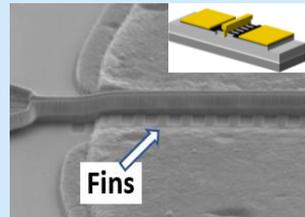
#### Epitaxial growth development:

Two step-growth process of N-polar GaN with low RMS roughness (3 nm) and high growth rate (0.72  $\mu\text{m}/\text{h}$ ) developed. Reduction of contact resistance of ohmic contacts on Mg-doped GaN by four orders of magnitude, when using a combination of aqua regia and HCl pretreatment as compared to contacts fabricated without pretreatment. TCAD simulations for establishing the optimal Mg doping, which will be followed by fabrication of vertical GaN-on-GaN PIN power diodes.



#### HEMT technology:

Development of GaN finFETs for better gate control with reduced short-channel effects and higher transconductance demonstrated. Expected improved linearity from TCAD simulations was not observed.



Initial steps towards self-aligned gates (SAG), where drain-source distance is minimized to reduce parasitic elements. This becomes increasingly important as we target operation at very high frequencies.

#### Vertical GaN power devices:

Interview with PhD student Alexis Papamichail, LiU

**Hej Alexis, what have you been working on recently?**

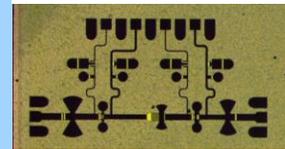
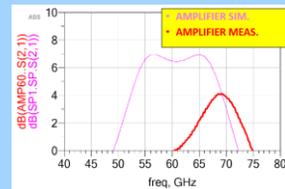
I have been working on the optimization of the Mg acceptors activation in p-GaN layers where we achieved Mg activation efficiencies of  $\sim 4.6\%$ . These values are at the higher end of the state-of-the-art reported results in literature. I am also developing graded AlGaIn channels for highly linear HEMT devices where we have achieved the targeted linear Al profile.



**What would be the next steps?** Next steps include the implementation of the p-GaN layers in PIN power diodes and the growth of the AlGaIn-graded HEMTs.

#### GaN MMIC:

First MMIC run finished and MMICs were delivered. Preliminary characterization indicates expected output current and pinch-off voltage. Gain in targeted frequency range confirmed with 60 GHz 2-stage amplifier, designed by Gotmic. However, modification required due to lower-than-expected gain.



Multilayer integration using BCB: new batch with additional third layer started. On-going work to improve adhesion and surface residues.

#### Developing the next generation high-power $\beta\text{-Ga}_2\text{O}_3$ material:

Epitaxial  $\beta\text{-Ga}_2\text{O}_3$  grown on sapphire from LiU has been evaluated at On Semi demonstrating breakdown voltages of at least 3 kV limited by the measurement capabilities only. Material quality has been further improved and transfer to homoepitaxy is in progress. First THz-EPR- ellipsometry measurements of  $\text{Fe}^{3+}$  defects in  $\beta\text{-Ga}_2\text{O}_3$  are demonstrated.

## RESEARCH HIGHLIGHTS

#### Recent Publications

H.-Y. Lee et al., "Fabrication and Characterization of GaN-Based Fin-Channel Array Metal-Oxide-Semiconductor High-Electron Mobility Transistors With Recessed-Gate and  $\text{Ga}_2\text{O}_3$  Gate Insulator Layer", IEEE J. Electron Dev. B **9**, 393-399 (2021). [link](#)

J.-J. Jian et al., "Investigation of Multiple-Mesa-Nanochannel Array GaN-Based MOSHEMTs with  $\text{Al}_2\text{O}_3$  Gate Dielectric Layer"; ECS J. Solid State Sci. Technol. **10** 055017 (2021). [link](#)

#### Conferences:

V. Darakchieva et. al., "Terahertz optical Hall effect and Terahertz EPR-ellipsometry of ultrawide bandgap and low-dimensional semiconductor systems" (Invited Talk, EXMATEC 2021, June 2021, Bristol, UK)

S. Knight et al., "Fabry-Pérot Enhanced Terahertz Mueller Matrix Ellipsometry for Materials Characterization" (Invited Talk, E-MRS 2021, May 2021)

D.-Y. Chen et. al., "Thin  $\text{Al}_0.5\text{Ga}_{0.5}\text{N}/\text{GaN}$  HEMTs on QuanFINE® Structure" (Talk, CS MANTECH, online)

**Licentiate Thesis:** Tran Quoc Dat (Linköping University), "Thermal conductivity of  $\text{Al}_x\text{Ga}_{1-x}\text{N}$  and  $\beta\text{-Ga}_2\text{O}_3$  semiconductors"

**Licentiate Thesis:** Hengfang Zhang (Linköping University), "Hot-wall MOCVD of N-polar group-III nitride materials"

**Master Thesis:** Kristófer Kristinsson (Chalmers University), "GaN FinFETs"