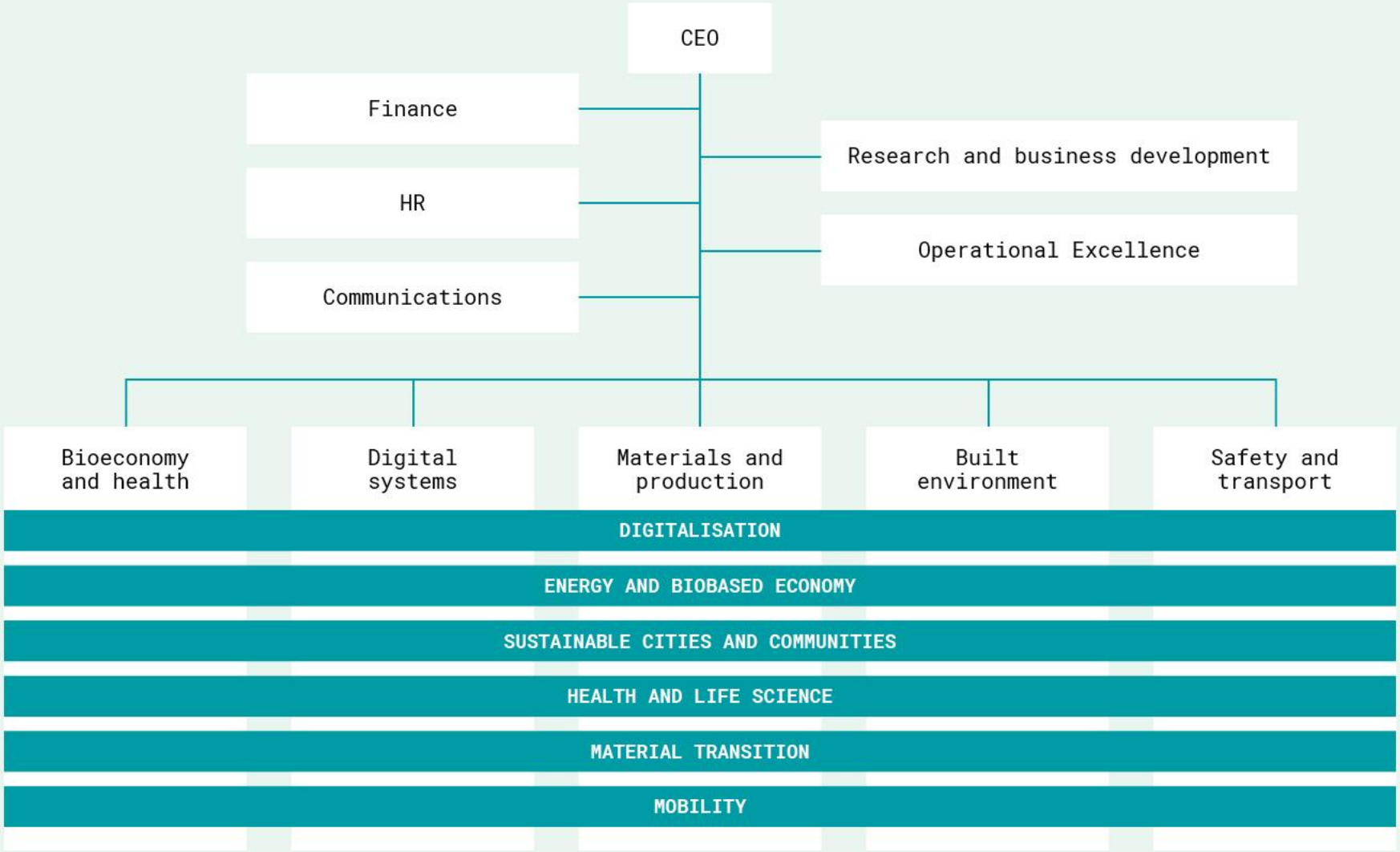
RESEARCH INSTITUTES OF SWEDEN

The Swedish research institution and innovation partner for every part of society

RISE today


CEO
Finance
HR
Communications
Research and business development
Operational Excellence
Bioeconomy and health
Digital systems
Materials and production
Built environment
Safety and transport
DIGITALISATION
ENERGY AND BIOBASED ECONOMY
SUSTAINABLE CITIES AND COMMUNITIES
HEALTH AND LIFE SCIENCE
MATERIAL TRANSITION
MOBILITY

RISE Smart Hardware

120 employees

5 adjunct professors

~ 18MEUR turnover

7 Business Units

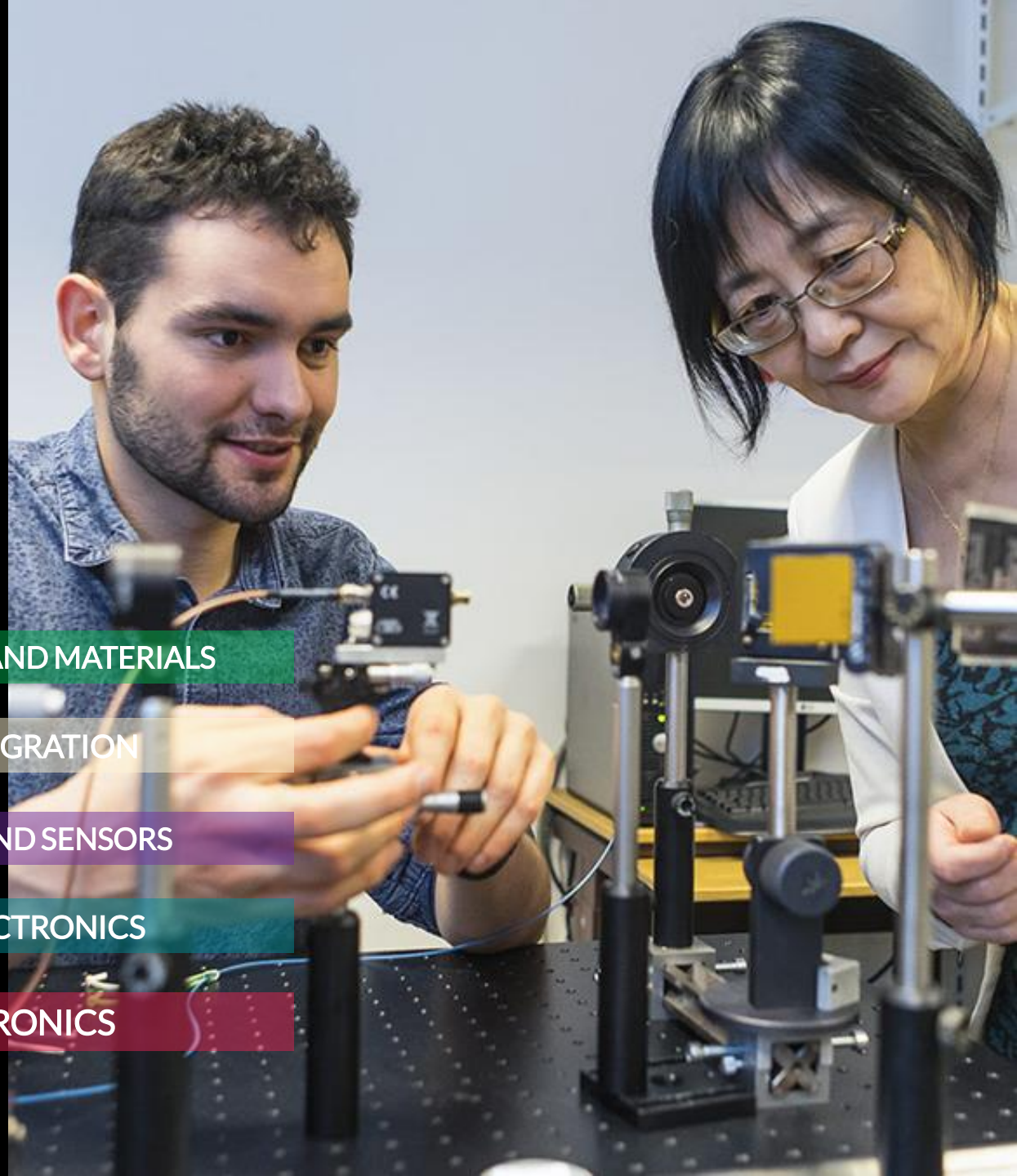
SENSOR SYSTEMS AND MATERIALS

SYSTEM INTEGRATION

FIBER OPTICS AND SENSORS

PRINTED ELECTRONICS

BIOELECTRONICS



Test & demo facilities

ProNano

Electrum Laboratory

Fiberlab

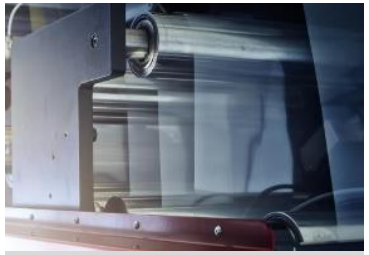
Visualization Table

UAV

DigiCore

Applied Laboratory for Digital Transformation

The Pink



Printed Electronics Arena 4.0

Autonomous shared transport

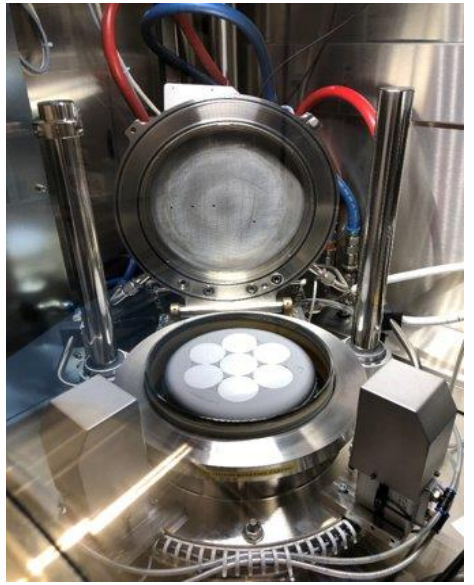
Urban ICT Arena

ICE - Infrastructure and Cloud Environment

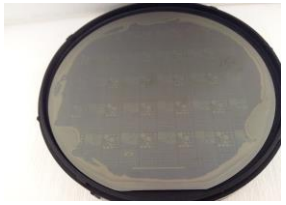
Nano Technology Unit at RISE

- ProNano T&D lab and Electrum for scale-up
- MOCVD processing of material for GaN/AlGaN-based electronic and optical devices
- Hetero-structures of III-N and other wide bandgap materials, SiC, Ga2O3 as well as 2D materials such as graphene
- Electronic/photonic devices and systems based on semiconductor materials including GaN, SiC, Ga_2O_3,
- AlGaN/GaN based High-Electron-Mobility Transistor (HEMT) for Power Electronic and RF Applications

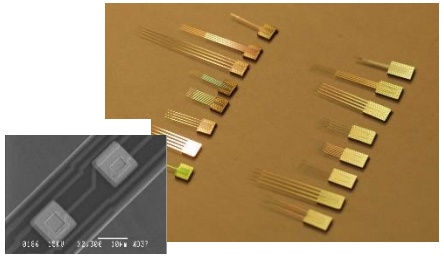
ISO-9001 certificated clean-room facilities and various characterization tools/setups at Kista and Lund



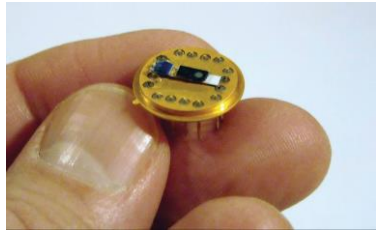
Aixtron Flip Top CCS G-III-Nitride MOCVD System



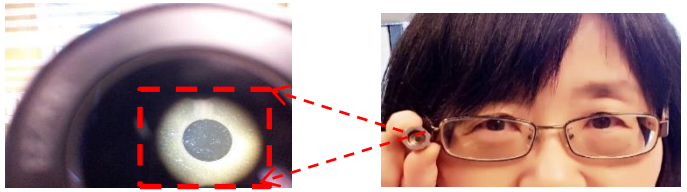
Wafer-scale component design and fabrication



Si based micro needles

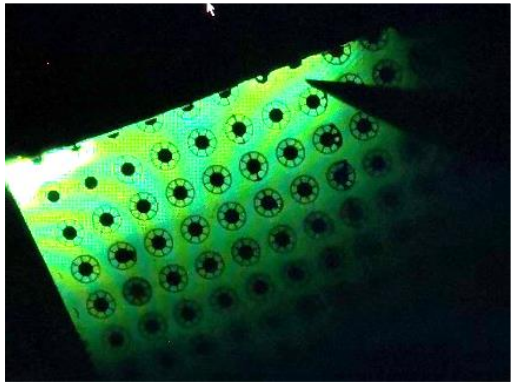


SiC MESFET Gas sensors

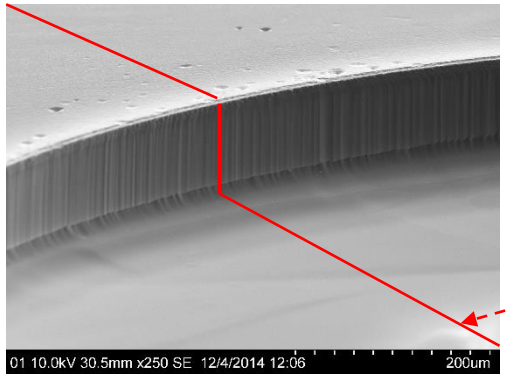


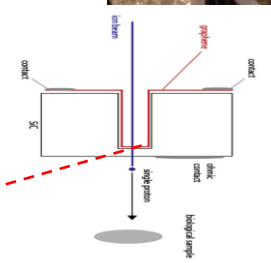
SiC based all-optical high-pressure (350 bar) and high-temperature (1000 °C) sensors for automotive industry and space applications

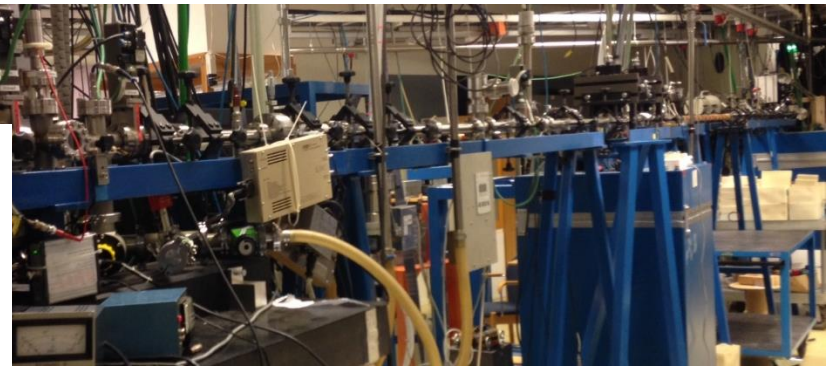
Nano Technology Unit at RISE



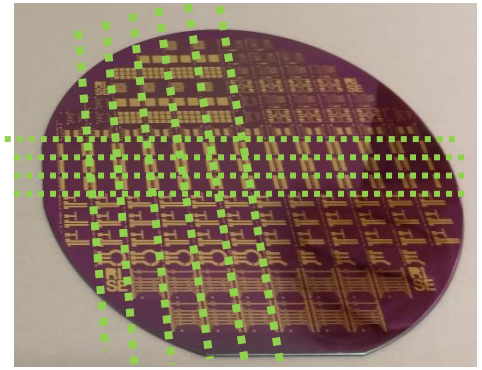
CVD graphene as transparent electrode to operate green LED array

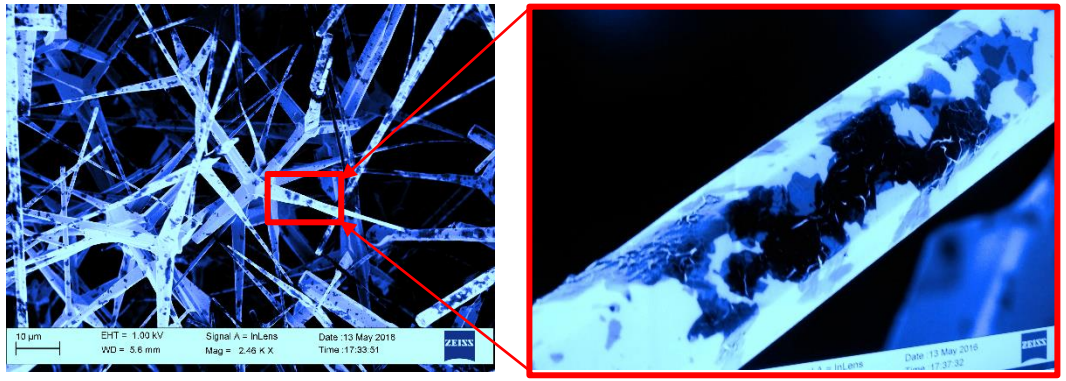


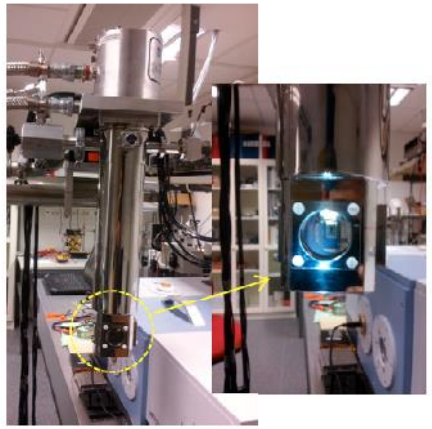


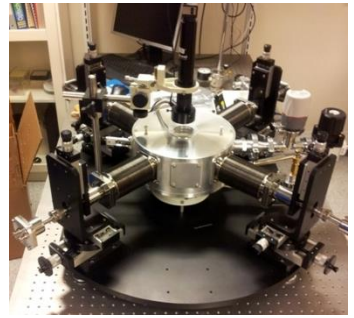


3D graphene on SiC membrane as thin ion transmission detectors that applied in accelerator based systems to study the influence of low-dose particle radiation on living cells



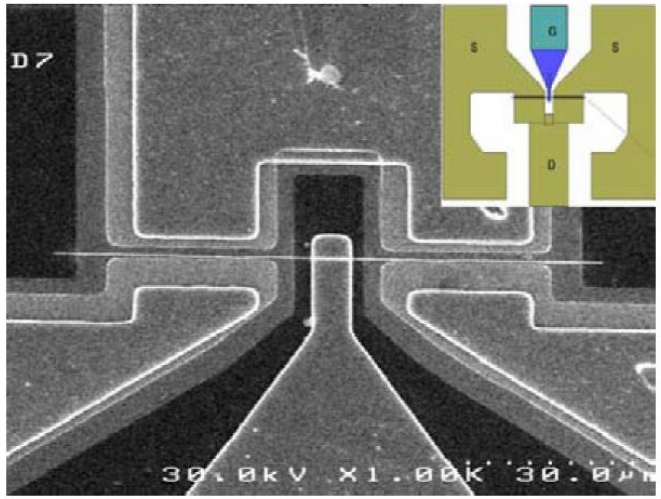


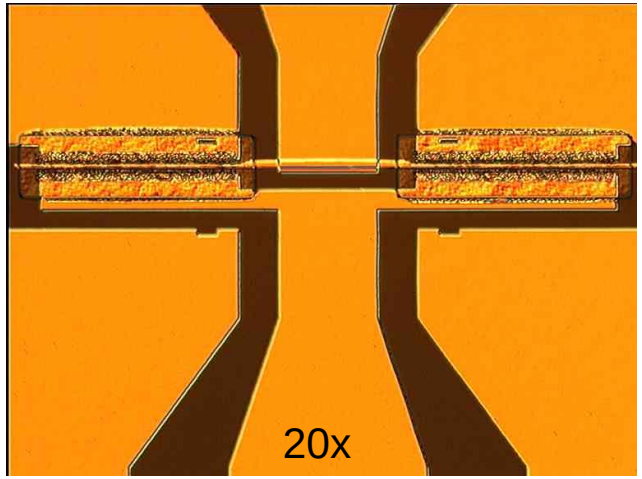


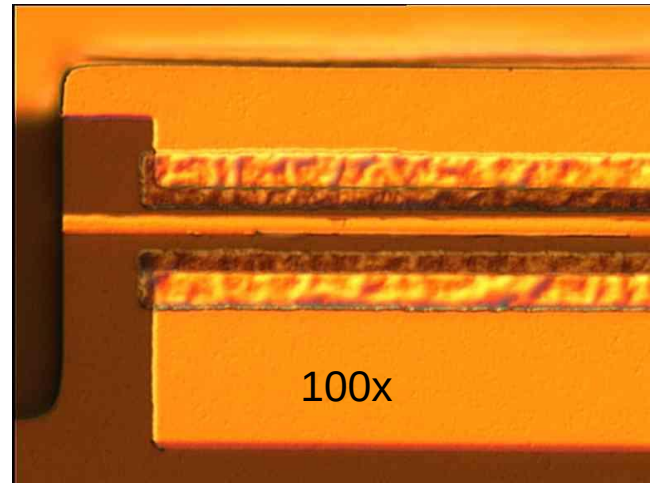


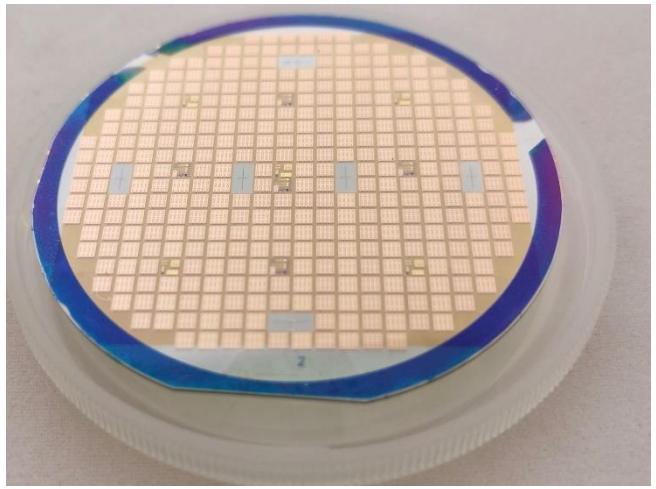
Bio/chemical sensors using large area graphene or graphene/ZnO hybrids for forensic and MedTech applications

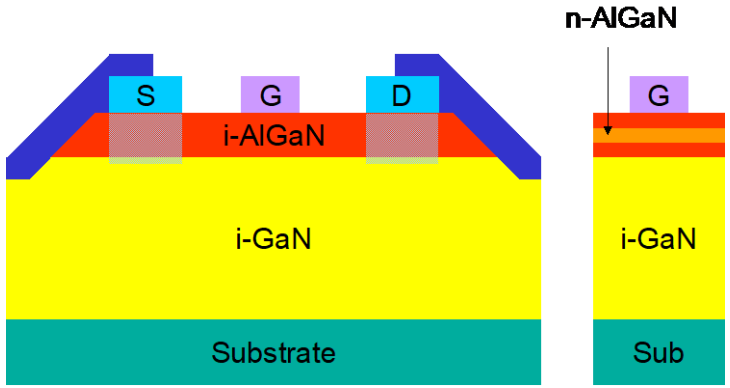
GaN based HEMTs Design, Fabrication & Test

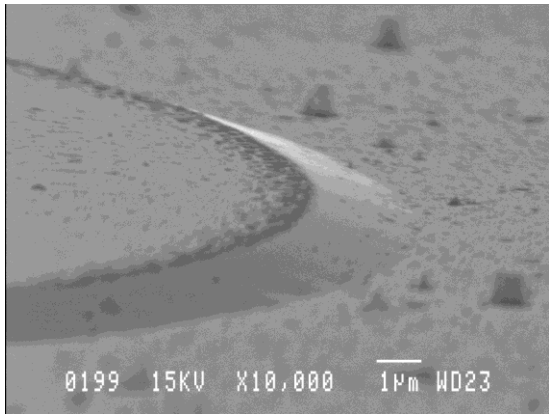












EU DENIS project: Development of low dislocation density Gallium Nitride substrates

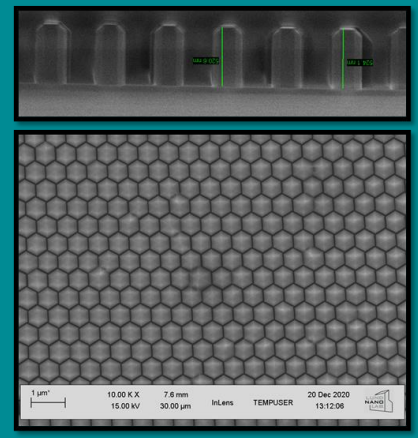
RI. SE

UltimateGaN: Coupling ProNano/Electrum to the European Ecosystem for next generation nanomaterial for Power Electronics

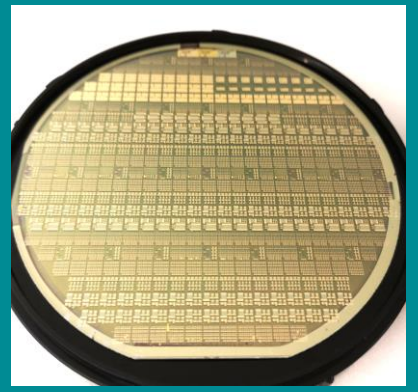
UltimateGaN – Research for GaN technologies, devices and applications to address the challenges of the future GaN roadmap

- Project partners: 26 partners from 9 countries
- Project start: May 2019 for a duration of 3 years
- Total costs: ~ EUR 48 Mio. incl. ~3800 person months
- Full value chain addressed by collaboration of partners from regions all over Europe in the work packages

Technology → Packaging → Reliability → Application



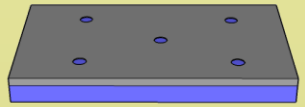
GaN nanowires from RISE ProNano ToD



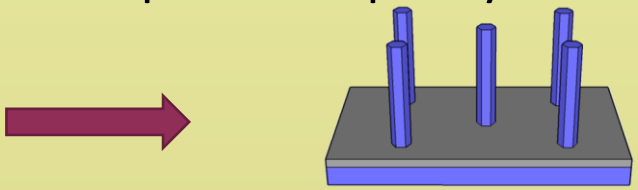
GaN HEMT Power Transistors from RISE Electrum ToD

Novel Nanowire based GaN Epitaxy– UltimateGaN

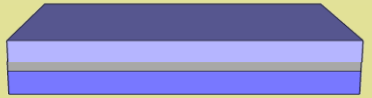
Unique GaN epitaxy on Silicon wafers



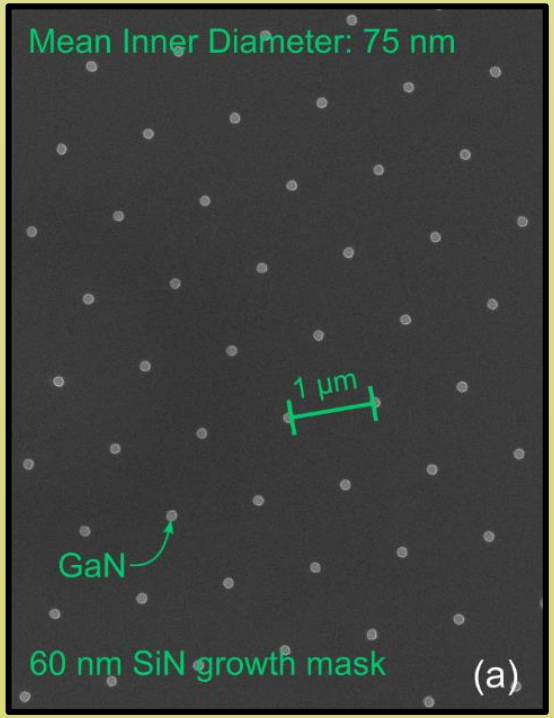
Patterned SiN mask on AlGaN/GaN/Si

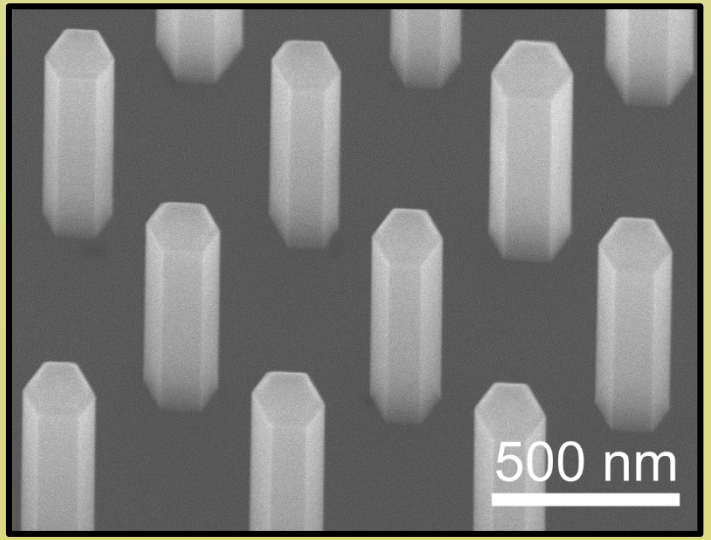


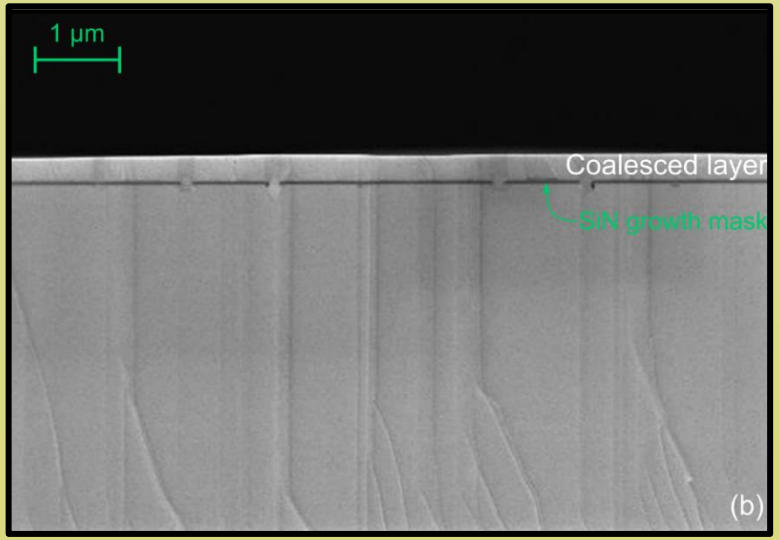
GaN nanopillar epitaxy



GaN planar layer formation

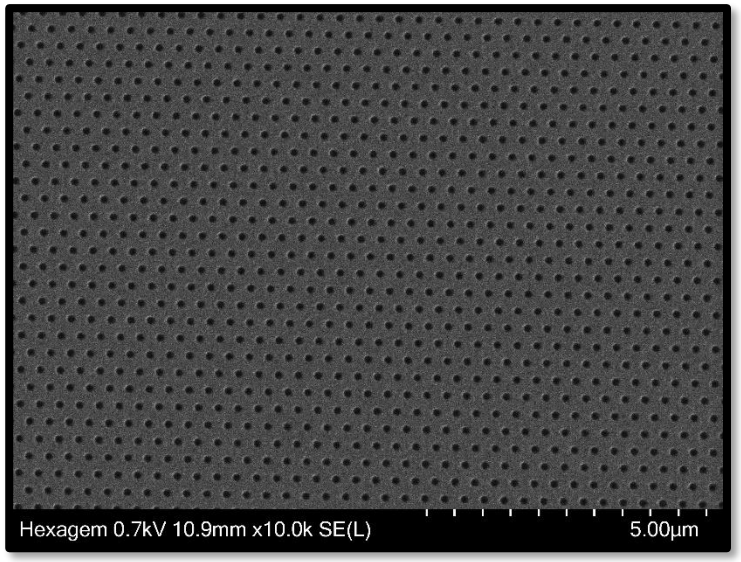


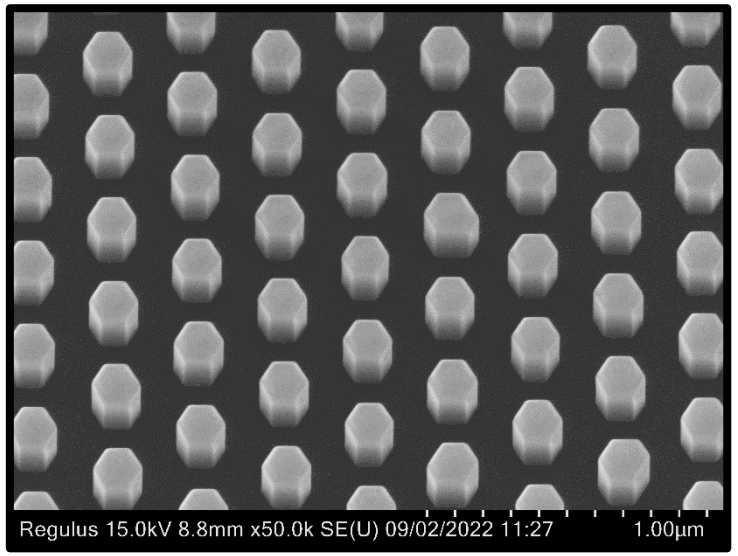


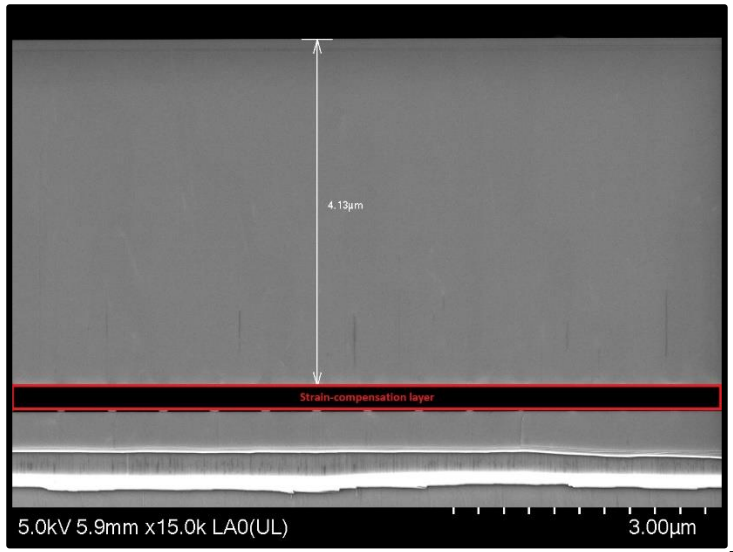


Novel Nanowire based GaN Epitaxy– UltimateGaN

- Talbot Displacement Lithography – Single exposure, full wafer exposure of < 100 nm regular patterns.
- Nanowire growth for single-crystal seeding of device layers for dislocation filtering.
- Nanowire coalescence allows for thick drift layers, enabling high breakdown voltages for vertical power devices.
- Materials characterization by XRD, AFM, SEM, and EDX.

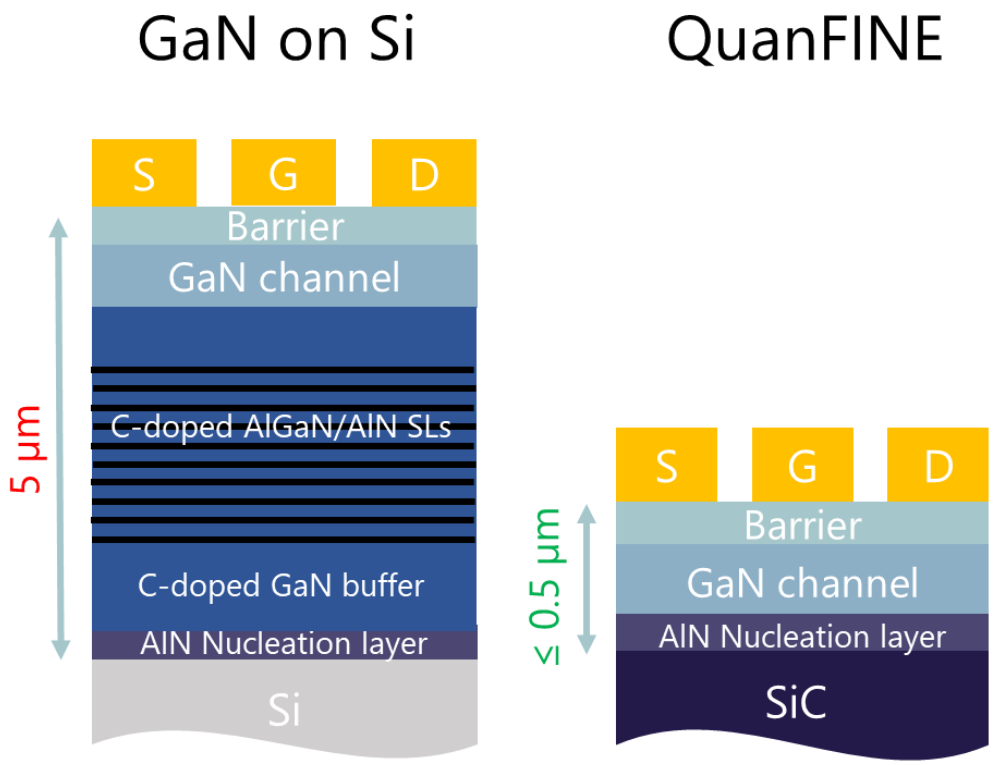


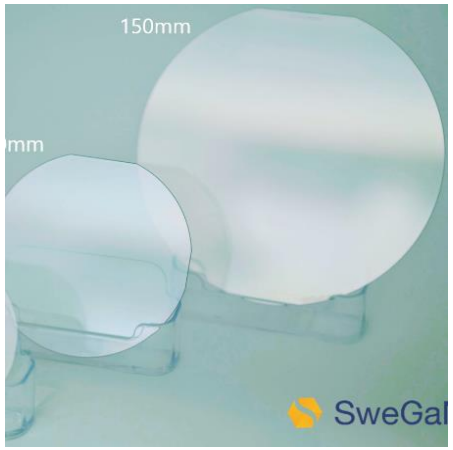




T2.3.2: Cost competitive alternative substrates

- **QuanFINE®, buffer-free GaN-on-SiC epitaxy**



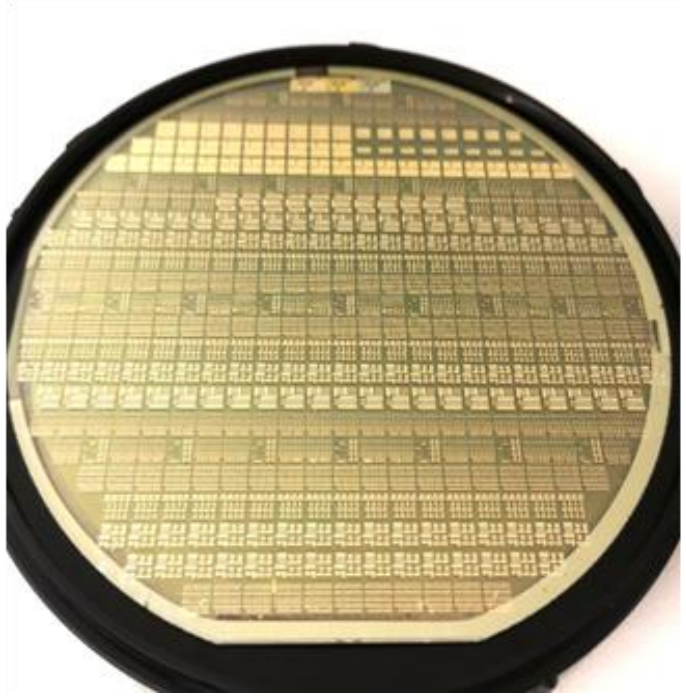


- The buffer-free GaN-on-SiC epitaxy is successfully scaled to 6” and mass produced in a high-throughput reactor.

- The dislocation density in QuanFINE® epiwafers is around mid 10^8 cm^{-2}
- >1000x better than GaN-on-Si for lateral ≤ 600/650V devices in the first 300nm GaN layer.

T2.3.2: Cost competitive alternative substrates

- **Power HEMTs based on QuanFINE wafers**



- 6” processed QuanFINE epiwafer fabricated by RISE using GaN power HEMT technology developed in UltimateGaN


Michael Salter


Prof. Bakowski


Prof. Q. Wang

➢ Benchmarking HEMTs on different substrates

HEMTs based on QuanFINE (buffer free GaN-on-SiC) and GaN-on-Si substrate were fabricated by the same process run. The QuanFINE epi wafers were more robust during the fabrication, which may enable higher yields.

➢ Low gate leakage and high I_{on}/I_{off} ratio

Low gate leakage in pA scale and I_{on}/I_{off} to 10^{11} were achieved for both material systems. Such the state-of-the-art figure of merit of the devices demonstrates good process control and throughout.

➢ High breakdown voltage

Breakdown electric field performance was verified to be beyond state of the art for the QuanFINE HEMT devices, achieving 1.1 MV/cm with 10 um gate-drain length with low leakage current in nA scale.

➢ High output current

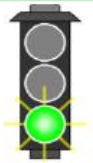
The output current of 27A was demonstrated for a QuanFINE multiple-finger HEMT that assembled in a ceramic packaging with integrated heatsink at RISE.

T4.1.3 Package development for power GaNs

Fully-printed package for power GaNs

- Both dielectric and conducing parts were fabricated using multi-material printing.
- Dielectric ink (DI): polyimide. Conductive ink (CI): silver.
- First characterization results promising.

- Task Lead: SAL
- Partner: RISE

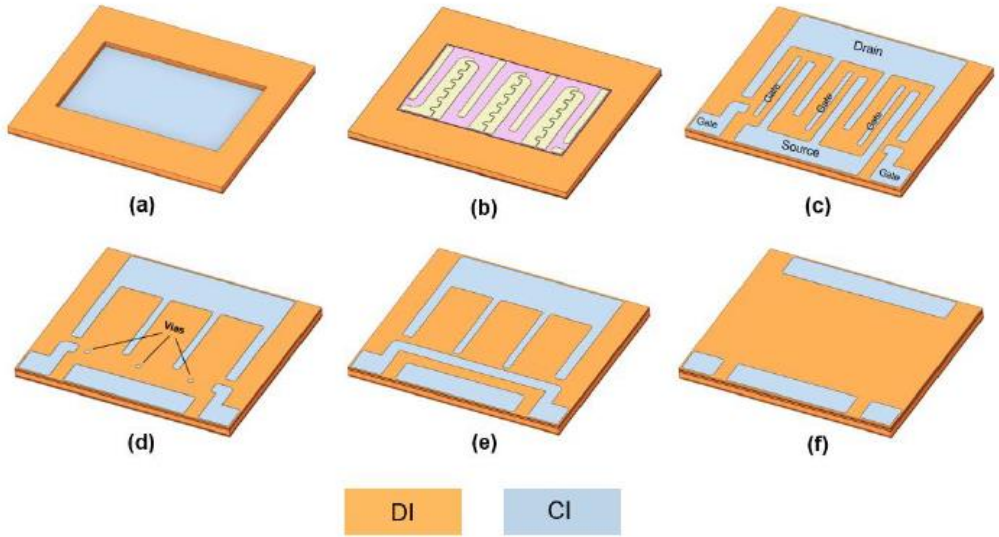


Top Side

Bottom Side

Commercial Package from GaN Systems

Printed Package



Thank you!

Michael Salter

michael.salter@ri.se