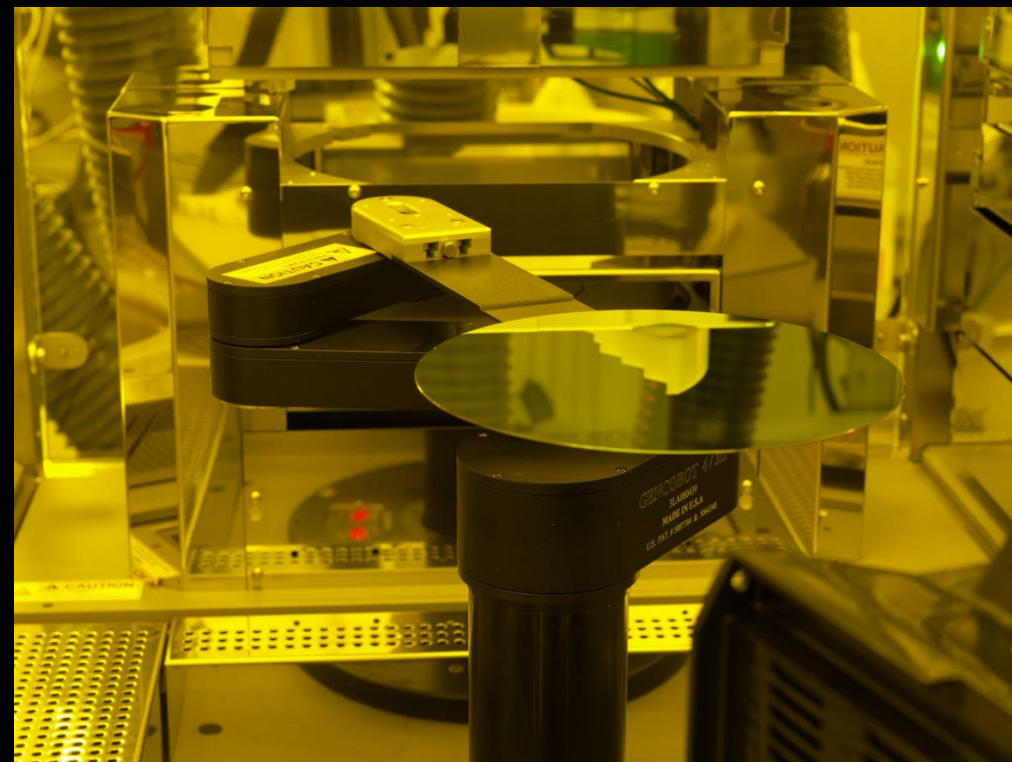


Nano Fabrication at RISE

Martin Berg and Qin Wang

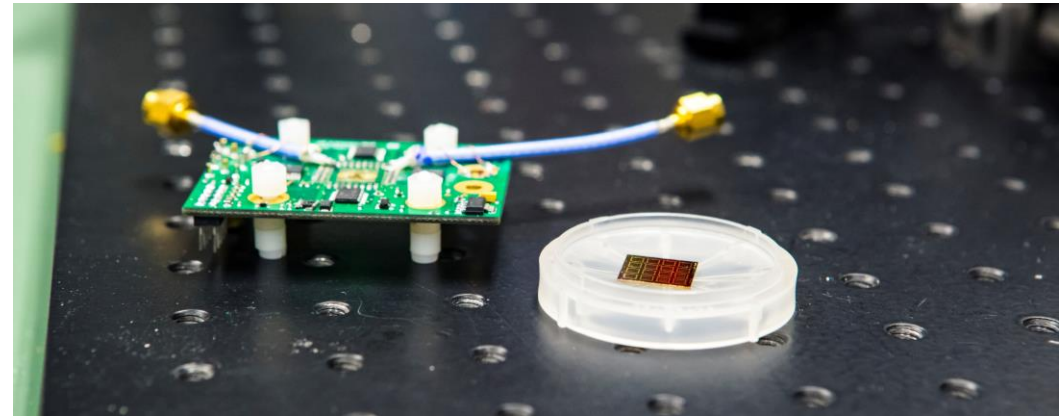
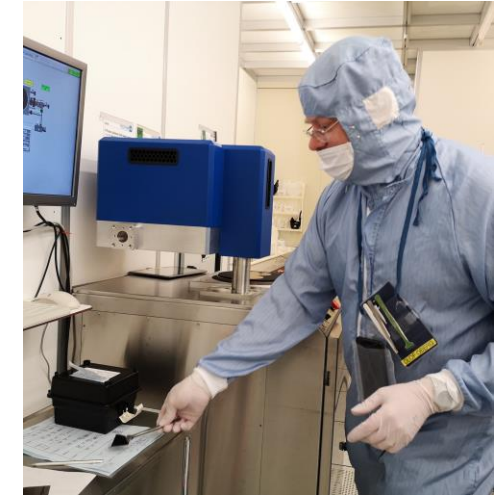
Department of Smart Hardware
Research Institutes of Sweden
RISE AB

www.ri.se



Outline

1. RISE and its testbeds
2. Team Nano
3. Nano fabrication at ProNano, Lund
4. Nano fabrication at Electrum, Kista
5. Offers and collaborations

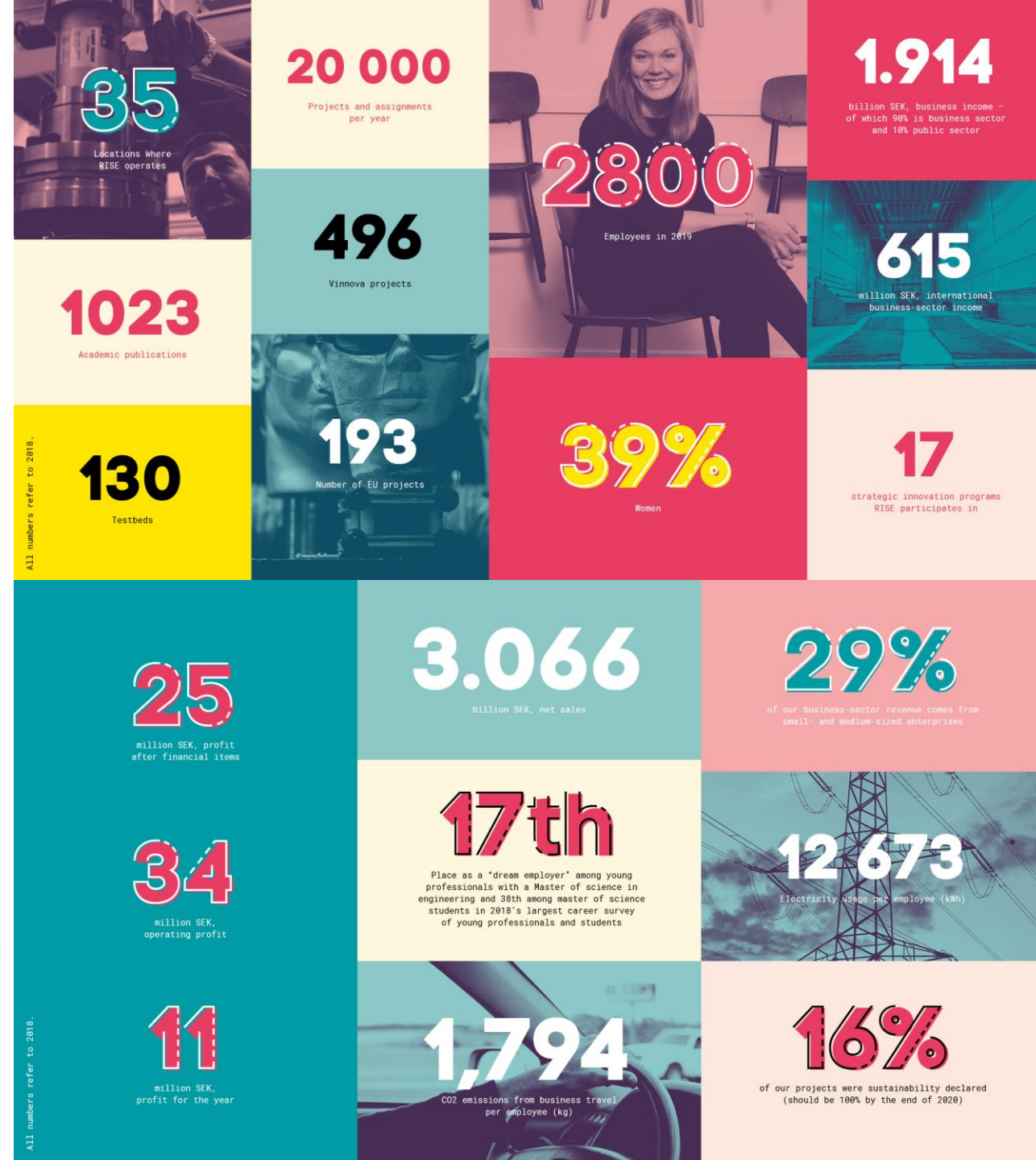


1. RISE in brief www.ri.se

- Across the whole of Sweden and beyond.
- 2,800 employees, 30 % with a PhD.
- Turnover approx. SEK 3.57 billion (2019).
- A large proportion of customers are SME clients, accounting for approx. 30 % industry turnover.
- **Runs >100s of test and demonstration facilities, open for industry, SMEs, universities and institutes**

RISE's Mission

The industrial research institutes shall be internationally competitive and facilitate sustainable growth in Sweden by strengthening competitiveness and renewal in the business community.



Testbeds and Demo facilities at RISE

Testbeds for hardware and pilot production



ProNano & Electrum
Laboratory



RISE Fiberlab



Printed Electronics
Arena 4.0

RISE webinar on April 6

RISE webinar on May 11

Dynamic testbeds



Autonomous shared
transport



The Pink



UX Lab

IT testbeds



DigiCore



ICE - Infrastructure and
Cloud Environment



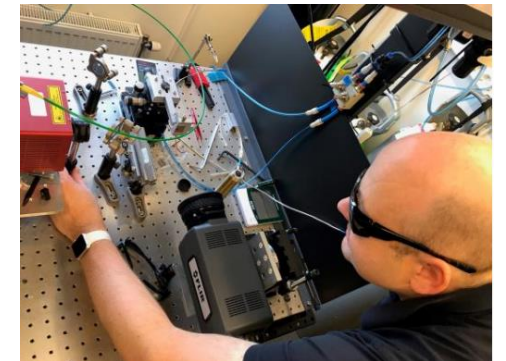
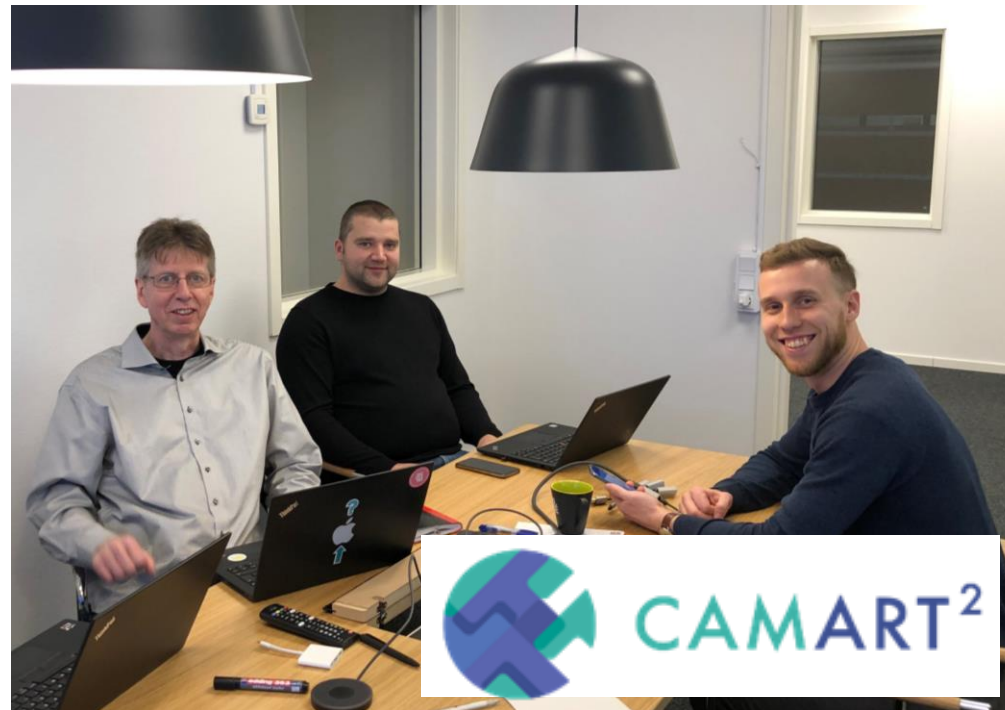
Cyberrange



UAV

2. Team Nano

Colleagues and students involved in the related projects and collaborations in Nano Unit and beyond. International and national funds.



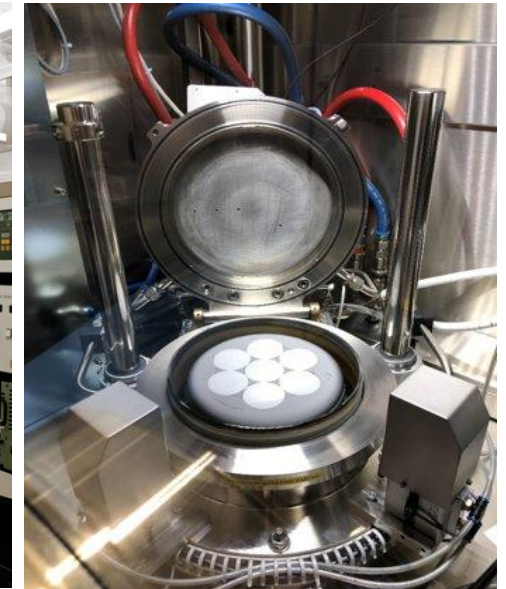
RISE-ISSP joint R&D activities on UVC and Far UVC LEDs

Nano Technology Unit at RISE

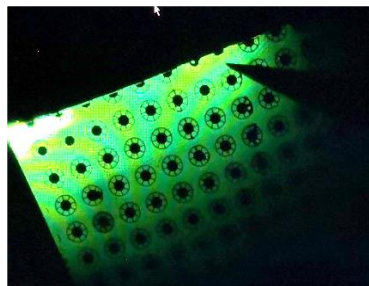
- Focus on electronic/photonic devices and systems based on semiconductor materials including Si, GaAs, InP, GaSb, InSb, GaN, SiC, Ga₂O₃, and ZnO that create new functionalities and allow for further integration and miniaturization giving higher performance at reduced cost.
- Specialize in the areas of nano/micro fabrication, MEMS/NEMS nanoelectronics/ photonics for applications for imaging, bio & life science, sensors & actuators, power electronics and high-speed optical communications.



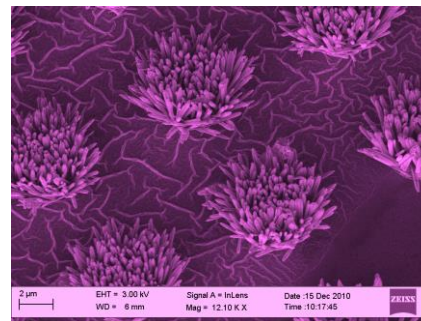
ISO-9001 certificated clean-room facilities and various characterization tools/setups at Kista and Lund



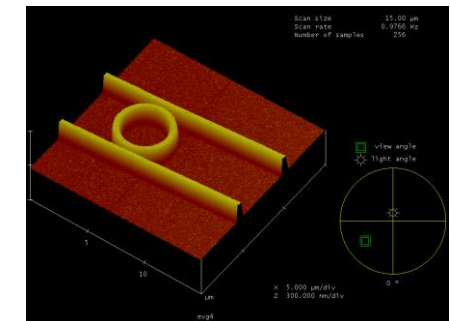
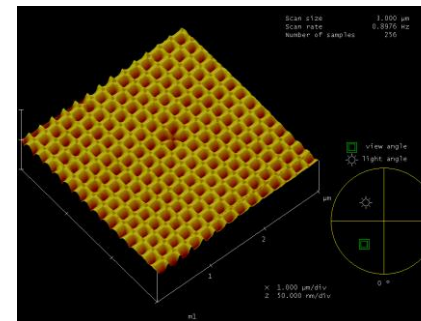
Aixtron Flip Top CCS G-III-Nitride MOCVD System



Wafer-scale component design and fabrication and small-scale products based on quantum structures



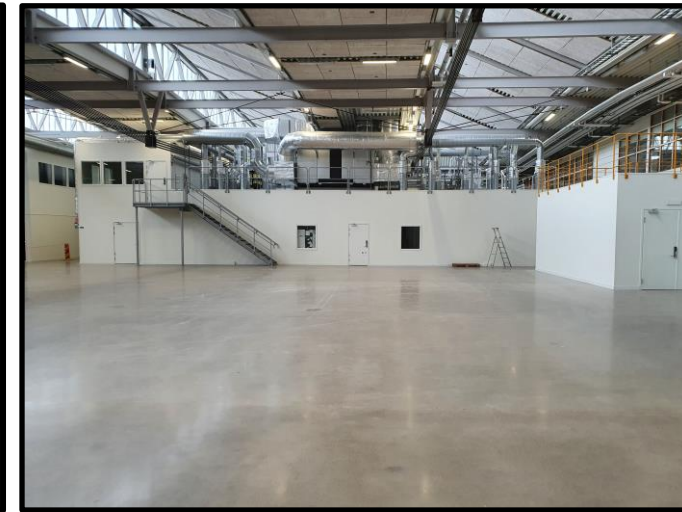
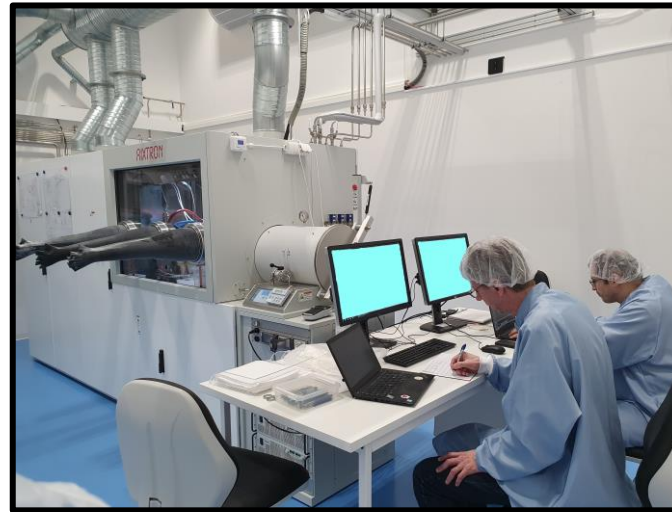
Nano wires/clusters, arrays and particles formed by nanofabrication at RISE and their applications



3. Nano fabrication at RISE PRONANO

The Facility

- 3400 m² facility (2600 m² stabilized floor surface)
- 210 m² ISO5 cleanroom
- 180 m² chem/bio lab
- 250 m² office area



The Equipment

- Advanced MOVPE material epitaxy (6x2", 2x3", 1x6" wafer)
 - Aixtron CCS Flip Top Reactor for high temperature (1400 °C) growth
 - Argus thermal mapping and Epicurve curvature measurement
- Hitachi Regulus SU8230 FE-SEM
 - EDS Bruker FlatQuad Xflash
 - BF STEM Detector

The Team

- Management and facility operations
- Technology and business development
- Research and Engineering

Power electronics

UltimateGaN (2019-ongoing) – Materials for vertical power electronic devices
Customer Hexagem AB – GaN-on-Si wafers by nanowire coalescence

Research projects: GaN and related materials

RGB-LED

Funded by the Swedish Energy Agency (2016-2020) in collaboration with LU μ LED and lighting applications
Commercial commission to aid in the development of nanostructure μ LEDs (2021-ongoing)

Deep UVC-LED

Internal research project (2021-ongoing), collaboration with ISSP UL & KTH.

UltimateGaN: The highly ambitious ECSEL project consists of 26 partners from 9 European countries that strive to achieve significant improvement in digitising the European industry by means of GaN Electronic Components and Systems. The project spans basic research to applications.

Digitalisation: ultra-high speed 5G communication in EU and worldwide.

Efficient usage of energy: efficient energy usage in data centers and power converters in applications like telecommunication and photovoltaic.

Future mobility: electrification of vehicles by innovative battery charging concepts realized with GaN. Next level in autonomous driving through ultra-fast switching sensor applications (LIDAR, RADAR) with GaN based sensor systems.

<http://www.ultimategan.eu/>
<https://www.ri.se/sv/vad-vi-gor/projekt/research-for-gan-technologies-devices-and-applications>



Supports the UN sustainability goals

<p>7 AFFORDABLE AND CLEAN ENERGY</p>	<p>9 INDUSTRY, INNOVATION AND INFRASTRUCTURE</p>	<p>11 SUSTAINABLE CITIES AND COMMUNITIES</p>
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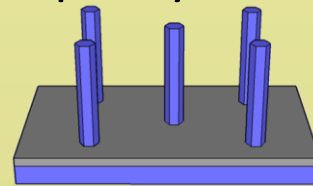


Power electronics

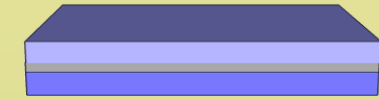
Unique GaN epitaxy on Silicon wafers



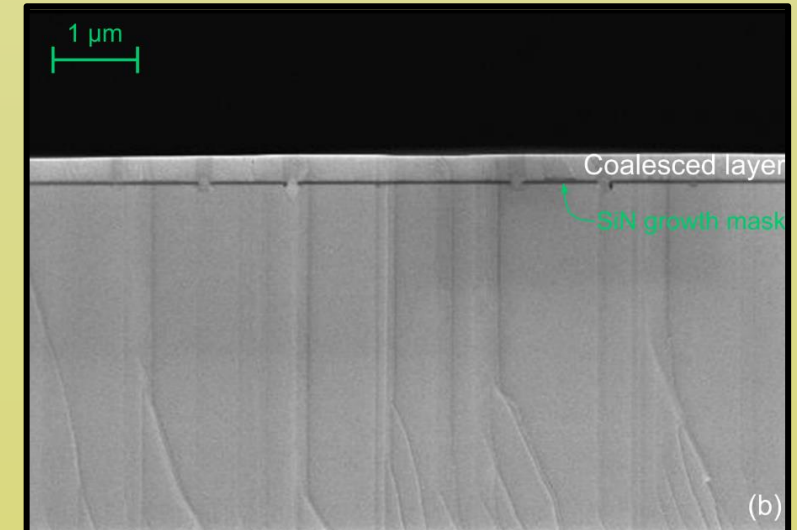
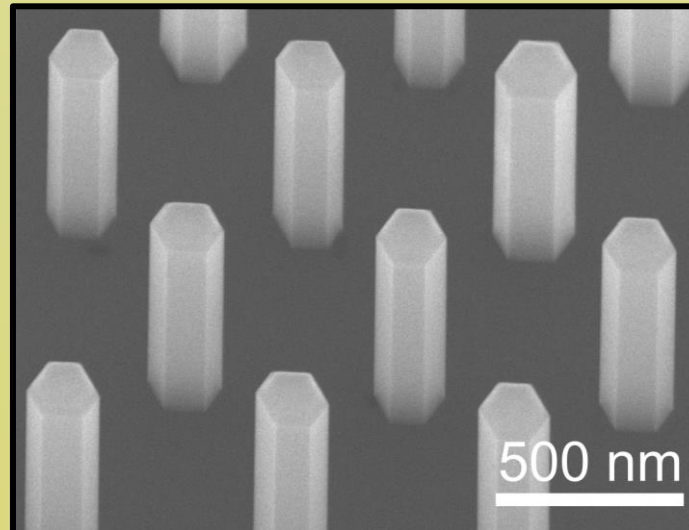
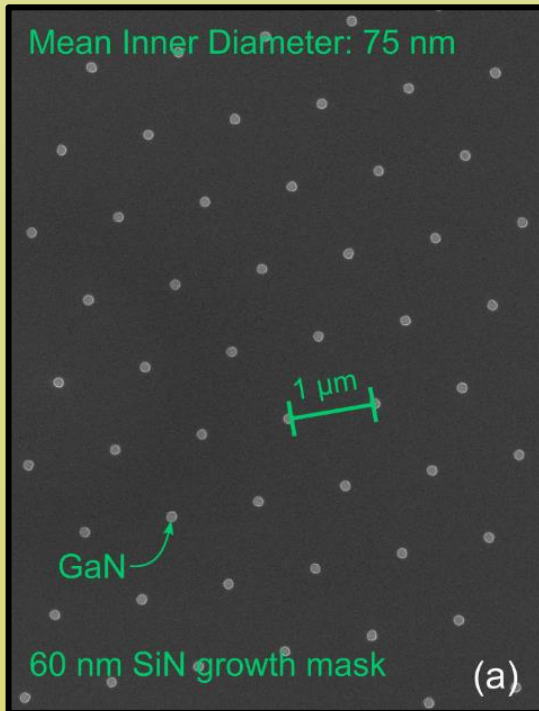
Patterned SiN mask on AlGaN/GaN/Si



GaN nanopillar epitaxy

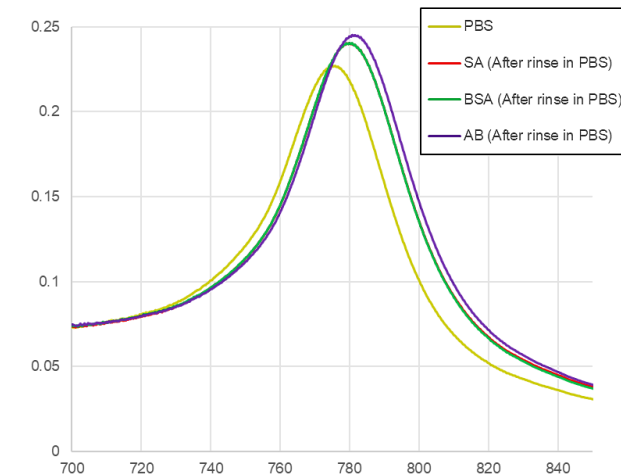
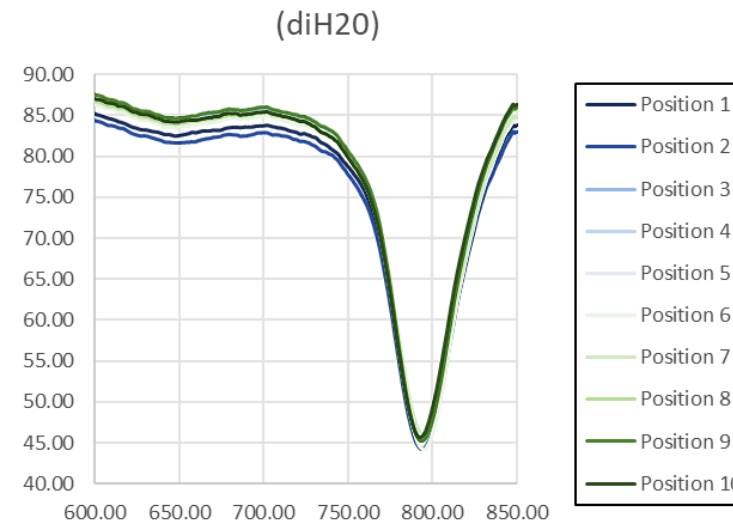
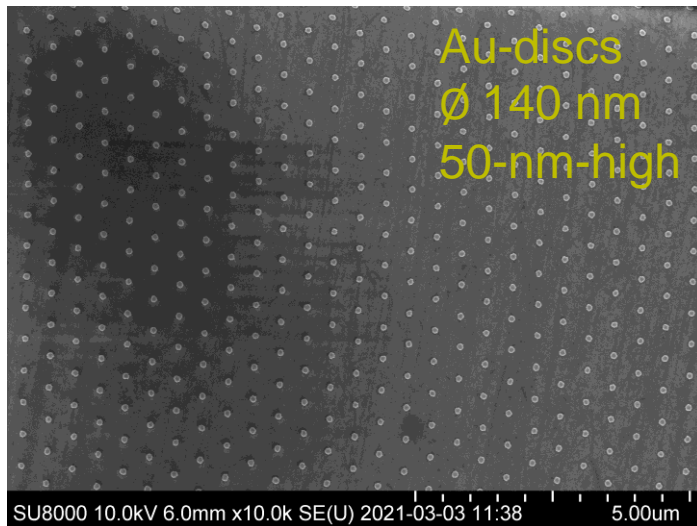


GaN planar layer formation



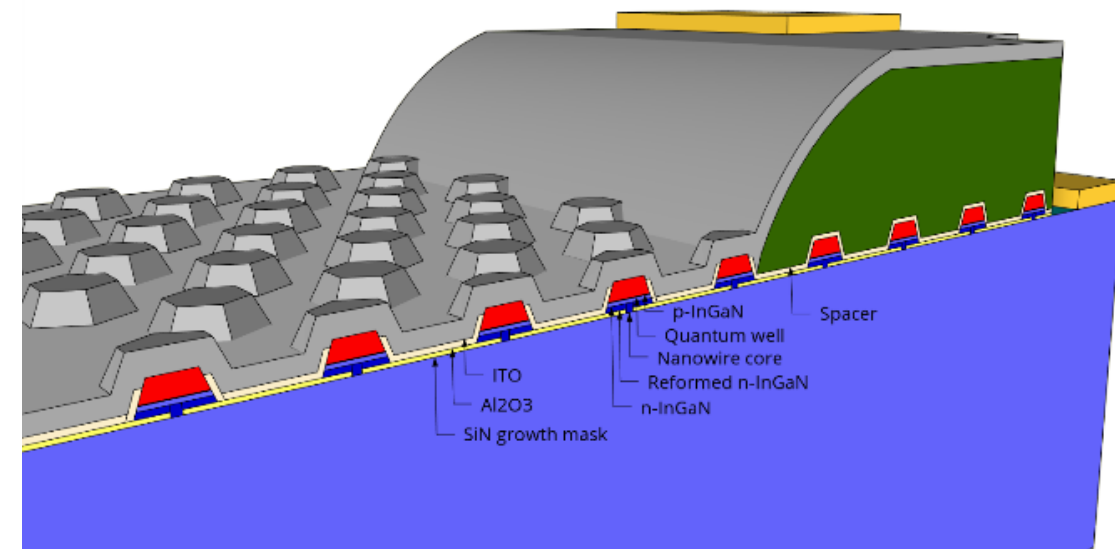
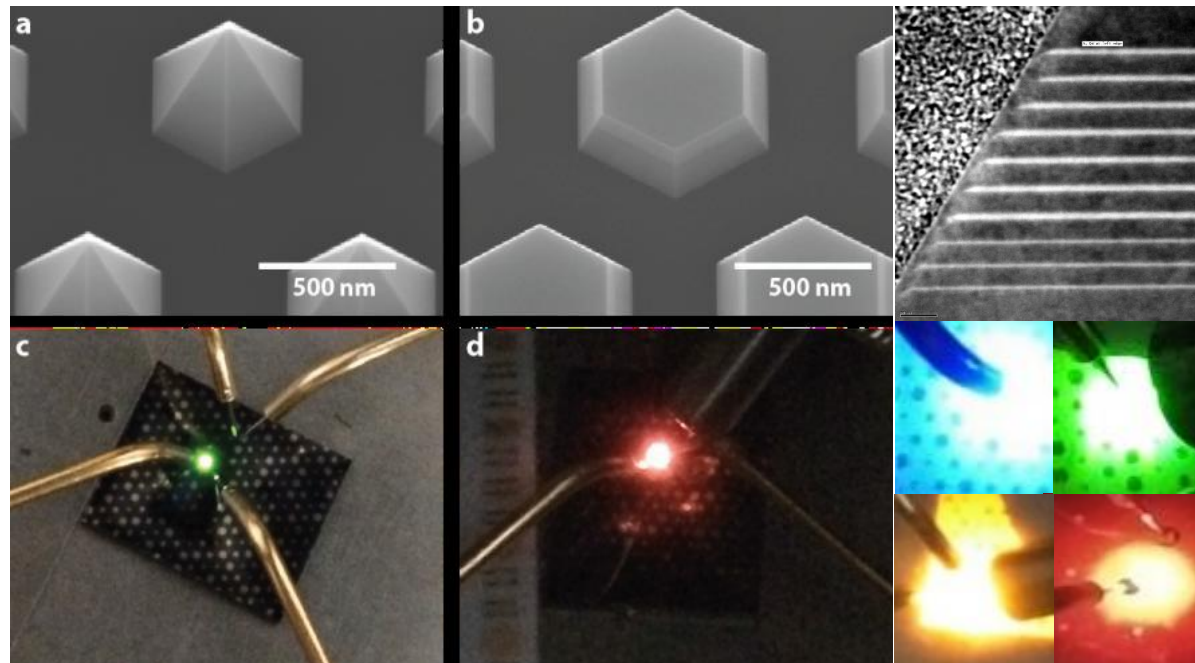
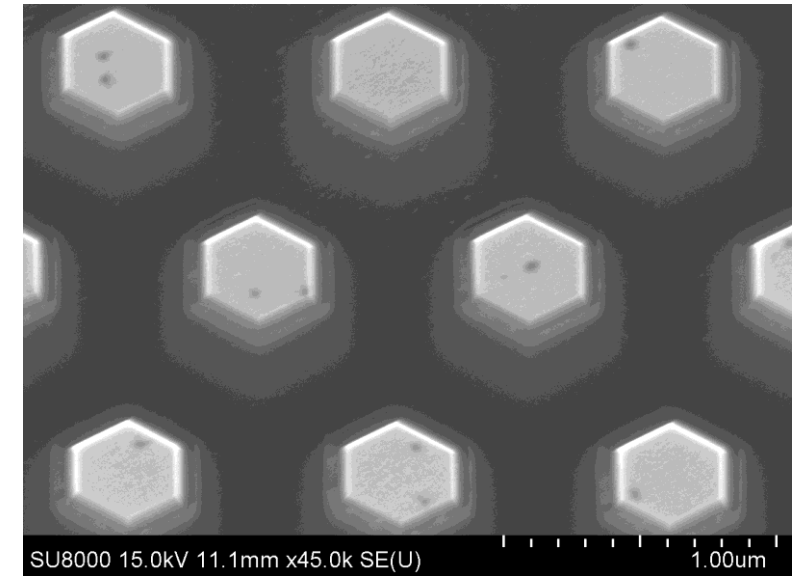
TDL – Cancer diagnostics

- RISE Sensors and Materials
- Talbot Displacement Lithography for deposition of Au islands on 2” Fused Silica for LSPR arrays.
- Could be used for biological sensors of for example cancer exosomes
- Resonance peaks at specific wavelengths dependent on lattice metrics.
- Peak shift upon molecular binding



RGB-LED

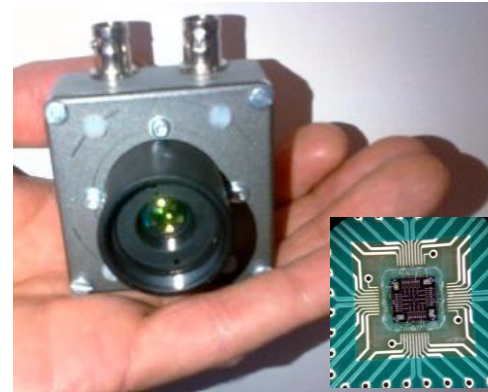
- InGaN pyramids based on LU nanowire technology, grown from holes in SiN_x growth mask
- Tuneable bandgap from blue to red, with no semiconductor etching.
- Precise process control of film thickness etching for p-layer contacting.



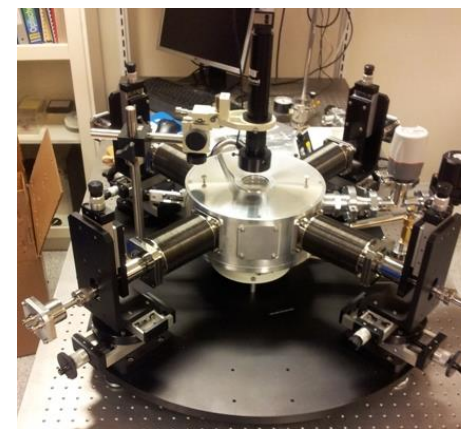
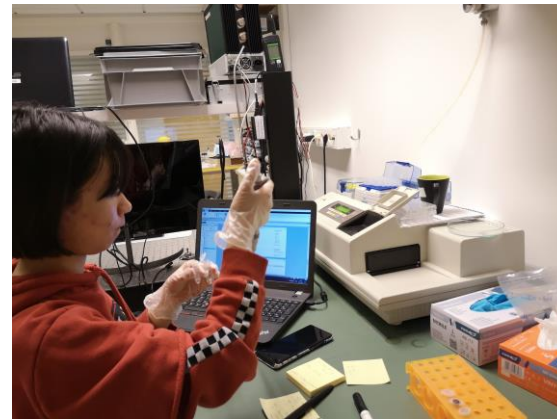
4. Nano fabrications and applications, RISE Kista



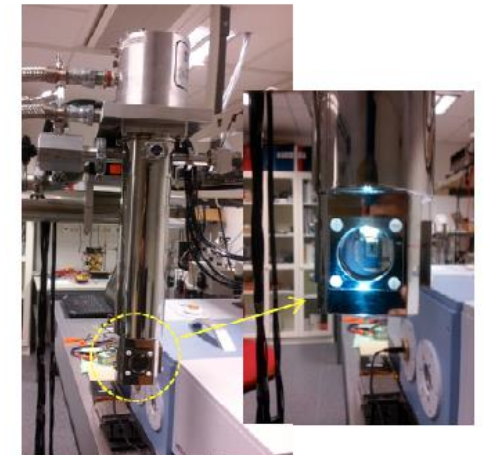
FSO testbed at RISE's Photonics Lab Electrum Kista



Imaging and bio/chem sensors based on quantum wells, wires and dots



Characterization facilities at Nano Unit, Kista



Ongoing GaN and SiC based projects and related nano fabrications

GaN HEMT for power and
RF applications
EU UltimateGaN, 2019-2022
US ONRG, 2021-2024

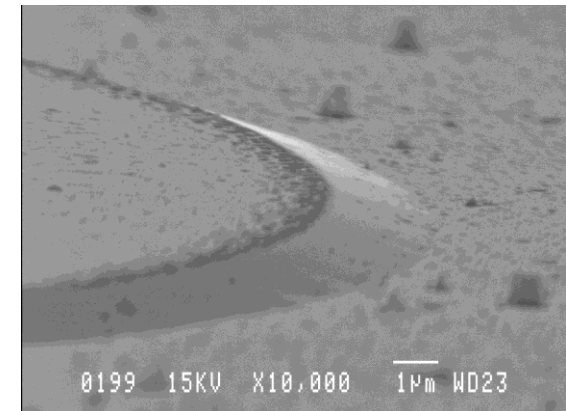
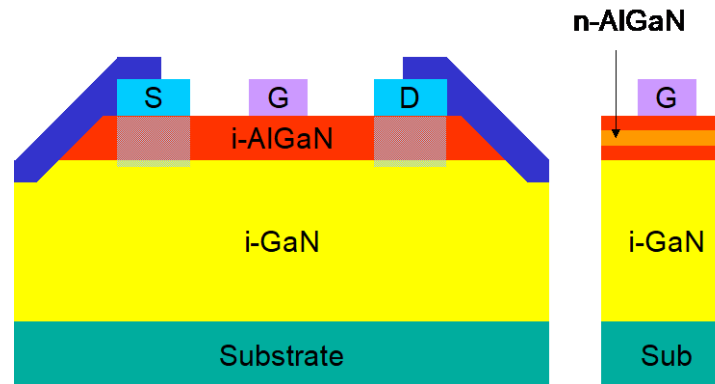
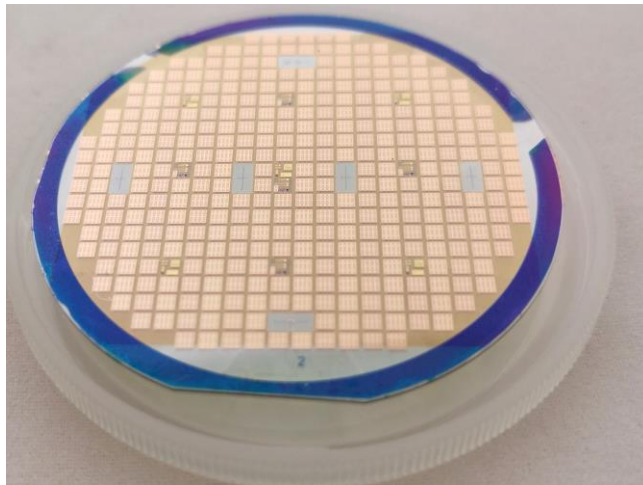
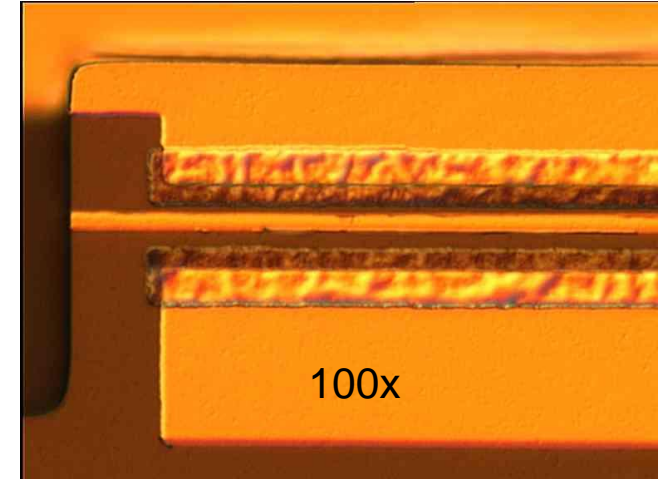
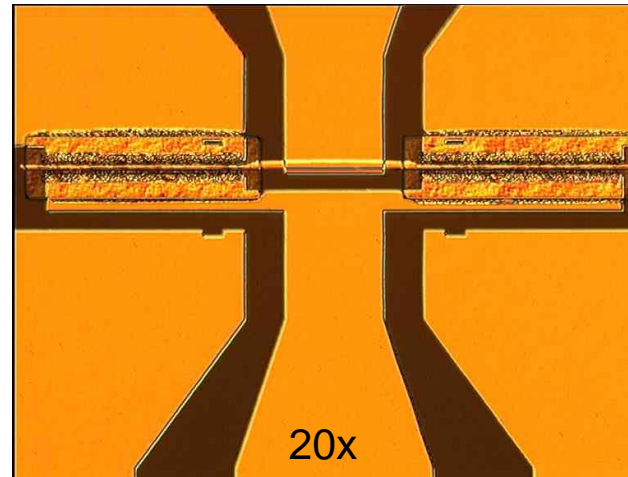
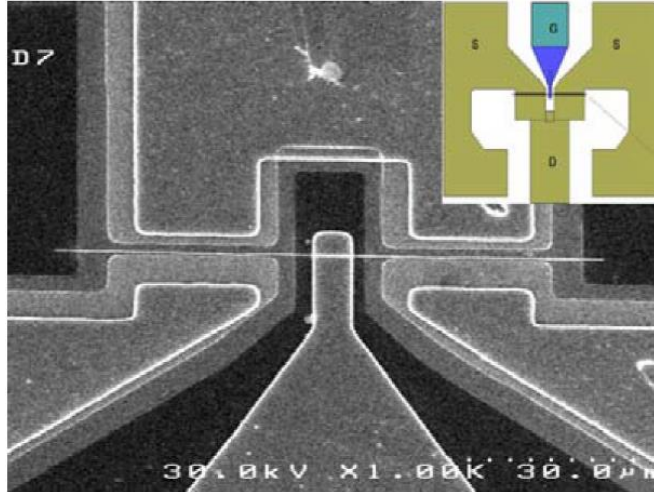
SiC based high-temperature and
high-pressure sensors
Swedish Energy Agency
2021-2022



ProNano UVC and far UVC
LEDs
ProNano
EU Camart2

Empowering 3D graphene-on-SiC
sensors utilizing X-ray based
techniques at the Max IV Laboratory
Vinnova
2021-2023 (18 months)

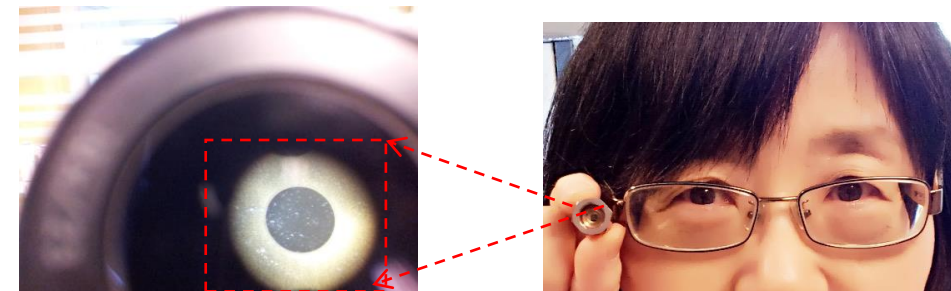
GaN based RF HEMTs fabrication



High P/T SiC-based sensors, national fund with industrial partners such as Volvo AB and Scania AB

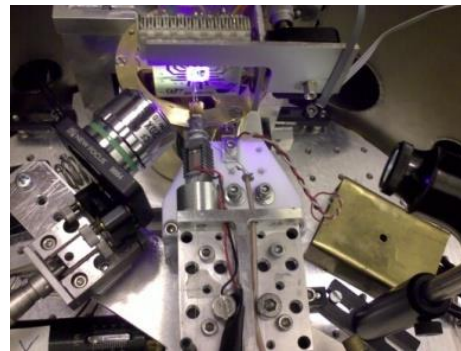
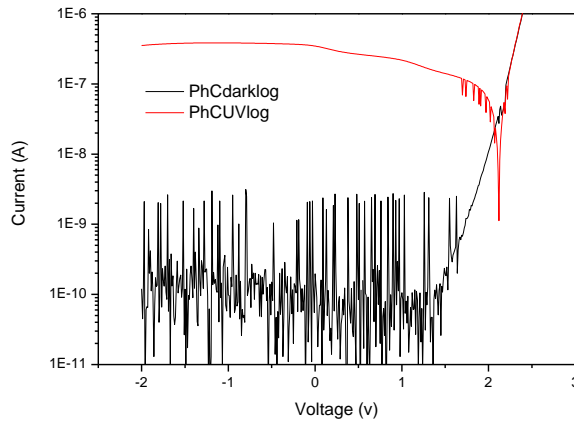
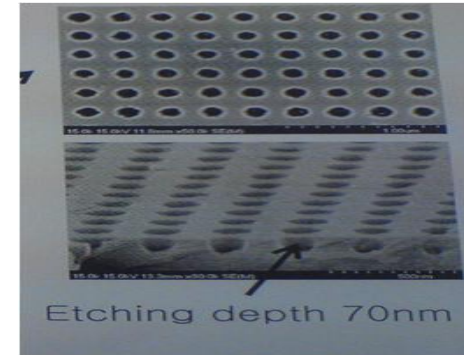
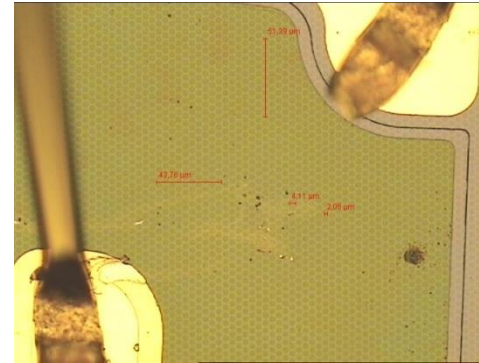
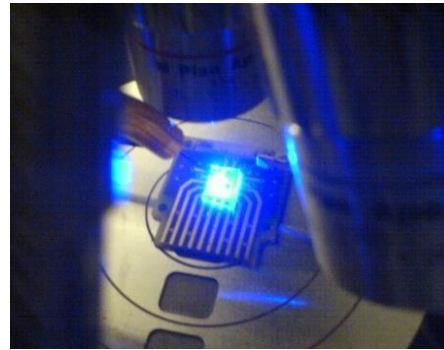
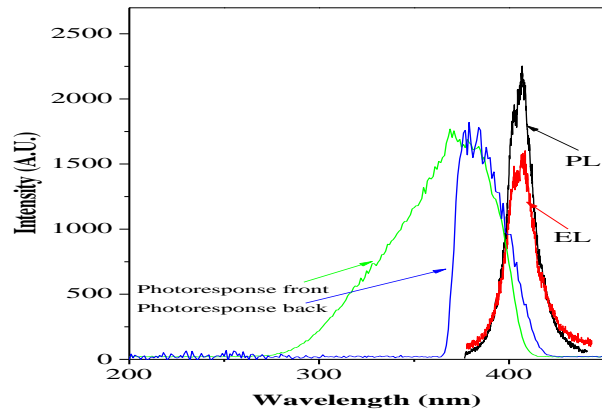
- Diaphragm-based extrinsic Fabry-Perot interferometer (EFPI) pressure sensors can be used widely for healthcare, automotive, and aerospace applications utilizing polymers, metals, silica, silicon, and other ceramics as diaphragm materials
- SiC-based piezoresistive and capacitive detection mechanisms are available in the 350–600 °C
- The silicon-based sensors and electrical wirings limit their sensing performances at elevated temperatures. Moreover, most of them are sensitive to temperature variations and electromagnetic interference (EMI)

- SiC based the pressure sensors offer at RISE
 - High temperature capability up to 1000 °C
 - EMI immunity
 - High fundamental resonance frequency
 - Corrosion and oxidation resistance
 - Low internal stress
 - High mechanical reliability
 - Small and light-weight

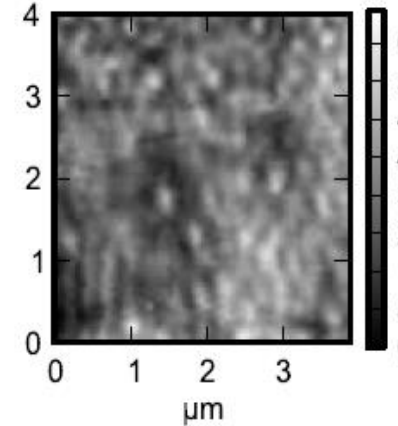


Advantages of the SiC based Pressure Sensors

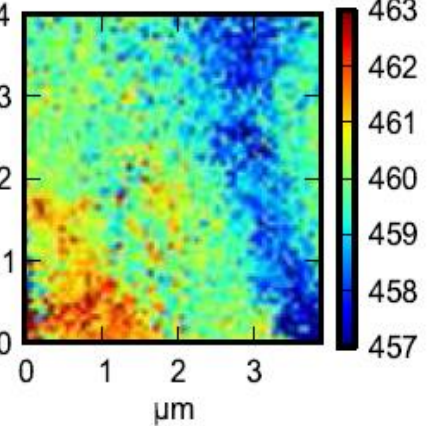
III-N and SiC based photodetectors and LEDs



Peak intensity (% of far field)

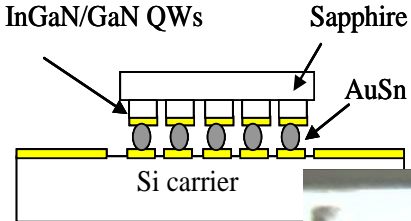
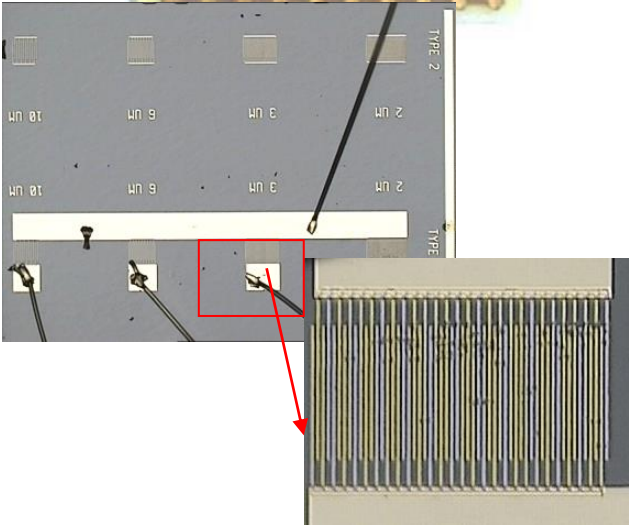
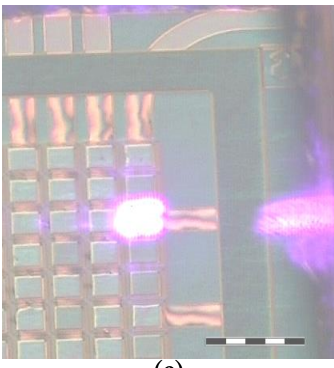
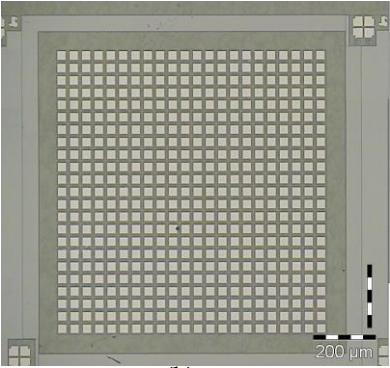
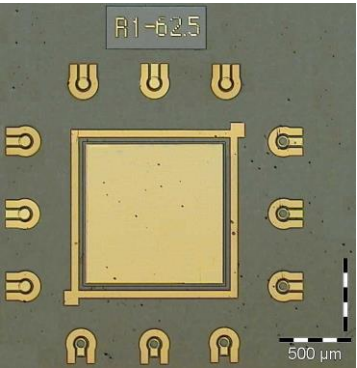
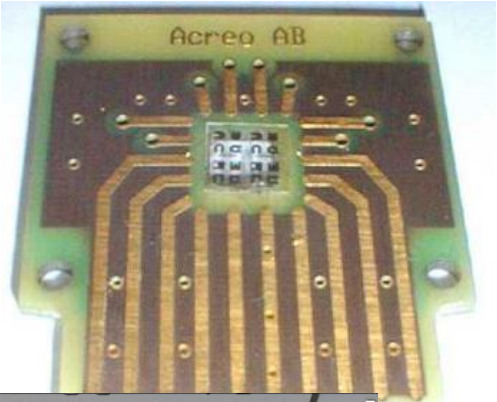


Peak wavelength (nm)

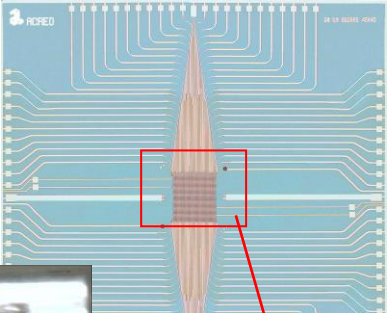


Nanophotonic integration, III-Nitride detectors/emitters

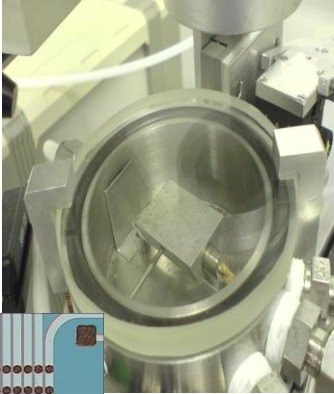
Package and assembly



(d)



(e)



(f)

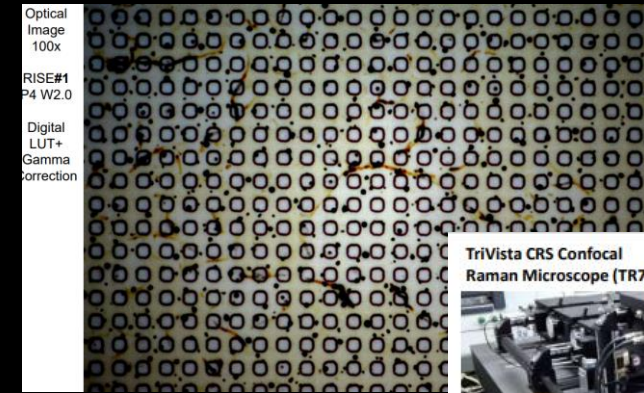
4. Offers

- Competence/expertise and Lab service based on nano/micro technology platform: from design, processing, packaging to system integrations.
- Joint EU applications, Sweden-Latvia bilateral call(s).
- Networks: Swedish academic and industrial partners, EU partners/funds through our ongoing EU projects, such as Opera on advanced epi, Lightcoce on property enhancement for concrete and ceramics by addition of nanoparticles to formulations (e.g. Al_2O_3 , TiO_2 , SiC, CNT) for constructions and infrastructures, as well as for the aerospace, automotive and defense industry.
- Joint workshops/conferences/events, IEEE Photonics Society, Women-in-STEM.
- ...



5. Discussions with the webinar's participants on collaborations

- (1) Could our offers be interesting in your R&D areas?
- (2) Could you see any possibilities to collaborate with us through regional joint technology platform?
- (3) Would you consider to perform an internship or a Master thesis project in nano fabrication by a seed project within our team?
- (4) Do you need any contributions from us to your conferences, workshops, webinars and events?
- (5) More needs and questions?



Plasmonic arrays fabricated at RISE and Raman characterizations at ISSP



Charlotte Karlsson, vice president of RISE, invited speaker in Women-in-STEM event during IEEE NMDC 2019

Welcome collaborations



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martin.berg@ri.se



teresita.gvarnstrom@ri.se