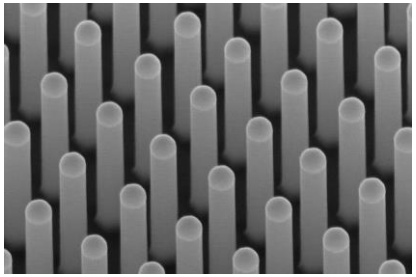
Nanowires for ICT and Energy Applications

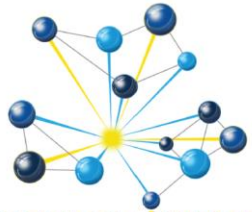
A Demo Case of the Vanguard Initiative
Nano Enabled Products Pilot



Research Institutes of Sweden

VANGUARD INITIATIVE
NEW GROWTH THROUGH SMART SPECIALISATION

The Vanguard Initiative



VANGUARD INITIATIVE

New growth through smart specialisation

The Vanguard Initiative

Regional Cooperation

Smart specialisation

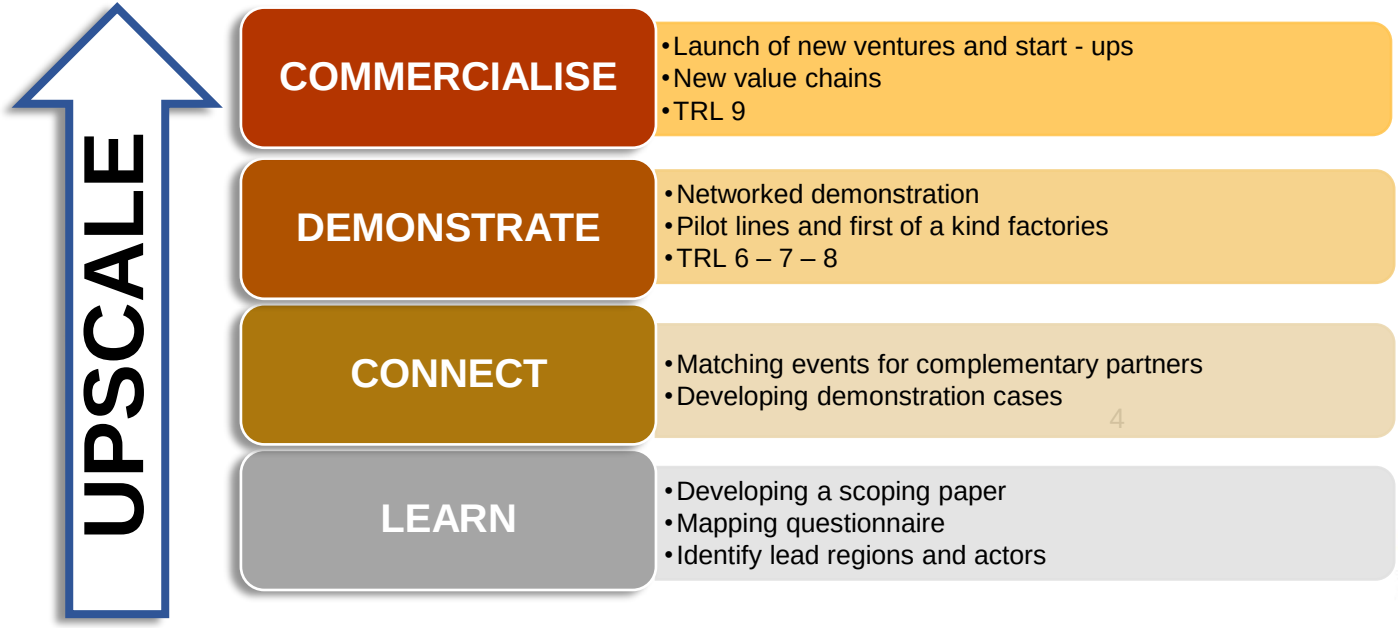
Industrial Innovation, networks of demonstration and pilot infrastructures

Entrepreneurship

Political commitment

VANGUARD INITIATIVE
New growth through smart specialisation

Methodology of the Pilot Projects



VANGUARD INITIATIVE
New growth through smart specialisation

Website: http://www.s3vanguardinitiative.eu

Vanguard Initiative - Current pilot projects and demo cases

New Nano-enabled Products

- Nanowires for ICT and energy applications
- Nano enabled Micro System for Bio Analysis (NeMs4Bio)
- Shapetronics

3D-printing

- 3D-printed hybrid component
- Additive-subtractive platform
- 3D-printed automotive components for large, medium and small complex parts
- Machinery, tooling and complex shapes
- Healthcare case
- Creative industries – mass-customized consumer products
- 3DP in textile

ADMA (Advanced Manufacturing for Energy-Related Applications in Harsh Environments)

- Corrosion
- Manufacture of large-scale components
- Operations and maintenance
- Sensing, instrumentation and remote monitoring

Efficient and Sustainable Manufacturing

- De-and Remanufacturing
- Smart and adaptive assembly and manufacturing systems
- Advanced sustainable surface and material technologies 4 functional polymer components
- Digital and virtual factory integrating planning and stimulation into operative environments
- Energy-flexible and resource-efficient factory operation

Bioeconomy

- Bio-aromatics
- Lignocellulose biorefinery
- Turning (waste)gas into value
- Biogas beyond energy production
- Bio-aviation fuel
- Food & feed ingredients from agrofood waste
- Food & feed ingredients from algae

Nano-Pilot - Member Regions

- **Auvergne-Rhône-Alpes**
- **North Rhine-Westphalia**
- **Baden-Württemberg**
- **Skåne**
- **East Netherlands**
- **South Netherlands**
- **Emilia Romagna**
- **Tampere**
- **Flanders**
- **Wallonia**

New members are welcome!

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Thanks

www.s3vanguardinitiative.eu

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- Els Van de Velde – Pilot Network Manager (Els.VandeVelde@ideaconsult.be)

VANGUARD INITIATIVE
New growth through smart specialisation

PRONANO

NANOPRODUCTS FOR THE FUTURE

The Vision

- European Open Innovation Hub for nanotechnology-based material, process and component industrialization in Lund, Sweden
- NanoPilot Manufacturing Center: Testbed and pilot line infrastructure to help industry with the scale-up of nanotechnology-based products
- Pan-European network for Commercialization of nanotechnology-based research

The Progress

- First customers identified and committed
- Initial investments secured from RISE and Region Skåne
- Phase 1 facility operational Q42020
- Phase 2 facility and business plan under development
- Cross-regional discussions with 2 other EU regions through Vanguard

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NANOLUND
AT THE FOREFRONT OF NANOSCIENCE

REGION SKÅNE

SCIENCE VILLAGE SCANDINAVIA

The ProNano Offer

- Nanomaterial, nanowire and nanostructure processing services
  - Advanced MOVPE for GaN/(Al,Ga,In)N material epitaxy (6x2”, 2x3”, 1x6” wafer)
  - Aixtron CCS Flip Top Reactor for high temperature (1400C) growth
  - Argus thermal mapping and Epicurve curvature measurement
- R&D and Engineering services
  - Nanowire and III-N epitaxy for volume production
  - Process development and control service for reaching volume production
  - Metrology services for material analysis
  - Material, component, packaging and system development
- Advanced facility & infrastructure rental
  - Modular controlled-access environment managed by RISE
    - RISE MOCVD Lab module, expansion ready
    - ISO 5 Cleanroom module, available
    - 2x bio/chemical labs, available

ProNano Development Plan

Phase 1
Pilot
2020-2025

- Test concept first in pre-existing facility
- Develop the inter- and cross-regional business models
- First business case: nano-enabled materials for power and energy applications
- Test the “Nanohouse” Model with co-located startups
- Initial Investment ~3 MEUR by RISE (200 m² clean room)
- Operational Q4 2020

Phase 2
Implementation
2025-

- Implementation: ProNano in Science Village
- Co-location with Nano Lund / Lund University
- Establishment of large-scale Innovation Infrastructure
- 2100 m² modular clean room
- Projected total inv. volume ~50-100 MEUR
- Parallel planning ongoing at national and EU level
- Operational 2025+

Phase 1 Established

ProNano

ProNano is a unique pilot infrastructure for the industrialisation of nanotechnology-based material, processes and components.

Facts

TESTBED NAME
ProNano

ESTABLISHED
2020

TESTBED CATEGORY
Isolated testbeds (IT)

INDUSTRY
Manufacturing, Materials

AREA
Digitalisation, Electronics, Material transition, Generic metrology and measurement technology, Production and manufacturing, Sensors and sensor systems

REGION
Region Skåne

The ProNano Network

- Local area network
  - **RISE Research Institute**: r&D for complete nanoscale material, device, system development & prototyping
  - **NanoLund**: World leading R&d center for nanotechnology
  - **MyFab Network**: National research infrastructure for semiconductor processing
  - **ESS and MaxIV**: Large scale European research infrastructures for advanced material research
- Wide area network
  - EPPN
  - ProNano Vanguard Network partners:

	Cross-regional networking & business develoment	Technology develoment and pilot infrastructure	Nanotechnology research pipeline and research infrastructure	Industrial Appications
South Netherlands	Brainport	Holst Centre	TU/E	VDL, Signify
Emilia Romagna	ART-ER		CNR	ST

Inter-regional business models

PRONANO
NANOPRODUCTS FOR THE FUTURE

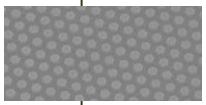
Nanoscale Material
Equipment Mfg
Characterization/Metrology

MOCVD material growth
Aixtron (Germany)
Epiluvac (Sweden)

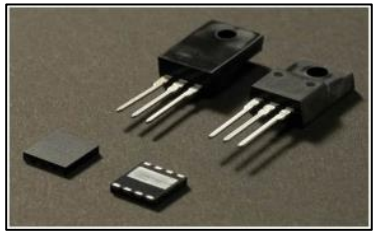
PRONANO
NANOPRODUCTS FOR THE FUTURE

Nanotechnology Cases & Pilot Lines

- **Line 1: III-V (GaN) Nanowire-enhanced materials for high power electronics**
- Line 2: Nanowire solar cells
- Line 3: Nanowire microLEDs
- Line 4: Nanowire biosensors
- Line 5: Nanowire transistors



Power Electronics
Component Companies



GaN Transistors
Infineon (Germany)
ST Microelectronics (Italy)

Sweden:	SME	RTO (RISE)	University (Lund)
Netherlands:	LE	RTO (Holst)	University (TU/E)
Italy	LE	RTO	University (CNR)

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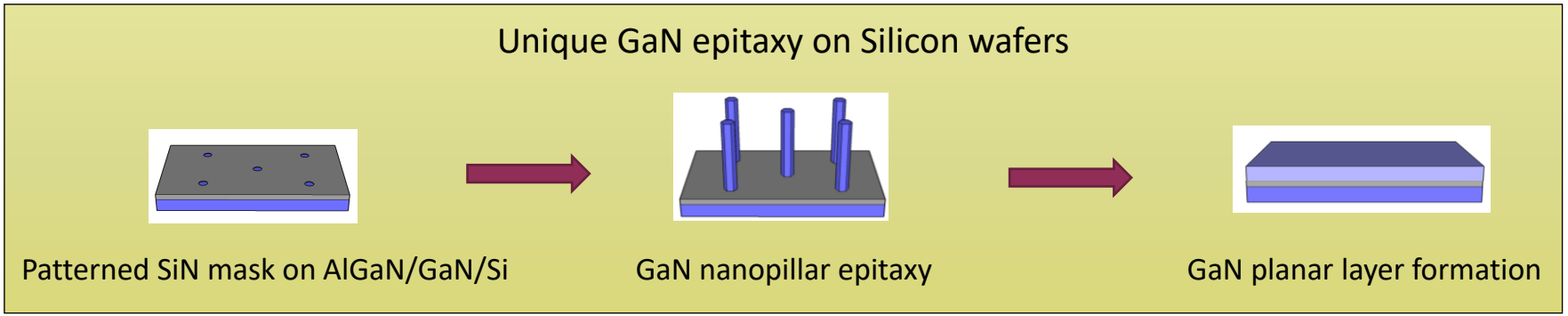
Opportunities for Vanguard Cross-Regional Cooperation

Use case: III-V (GaN) Nanowire-enhanced materials for high power electronics



- **Collaboration to solve challenges in preprocessing steps**
  - Highly oriented AlN layers on Si or AlN/GaN layers on Si (2”, 4”, and 6”)
  - Lithography for sub-100-nm circular hole arrays (hexagonal pattern) on 2”, 4”, and 6”
  - Anisotropic reactive ion etching of SiN with good selectivity to photoresist mask
  - Characterization/Metrology

Hexagem
Perfect GaN

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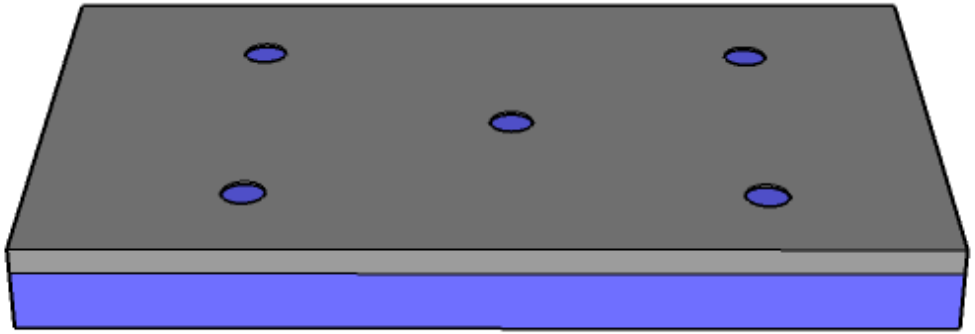
III-V (GaN) Nanowire-enhanced materials for high power electronics

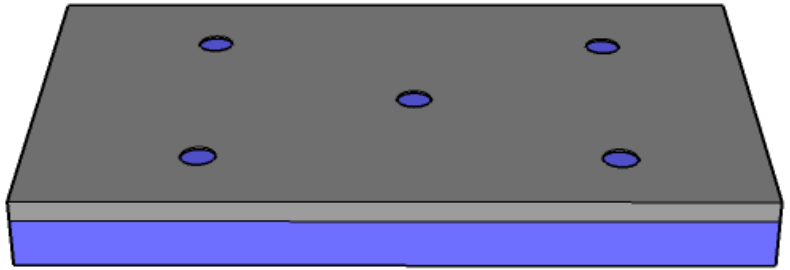
Substrate challenges



- Wafer size: 2” up to 6”
- Material:
  - 100nm AlN on Silicon (111)
  - 100 nm + 10 nm GaN on Silicon (111)
- Supply of high quality, highly oriented AlN on Si

III-V (GaN) Nanowire-enhanced materials for high power electronics

Lithography challenges



- Wafer size: 2” up to 6”
- Material: 100nm AlN on Silicon or GaN on Silicon

- Mask material: 50nm Stoichiometric SiN

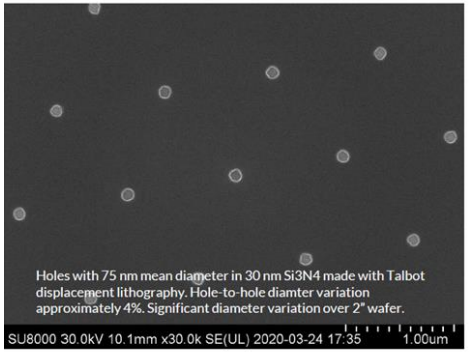
- Pattern: Hexagonal
- Pitch: 0,5-1µm
- Average hole diameter: 60-80nm
- Uniformity: < 10nm (6σ)

- Note: Commercial wafers may have substantial bow (>50µm)

III-V (GaN) Nanowire-enhanced materials for high power electronics

Lithography challenges

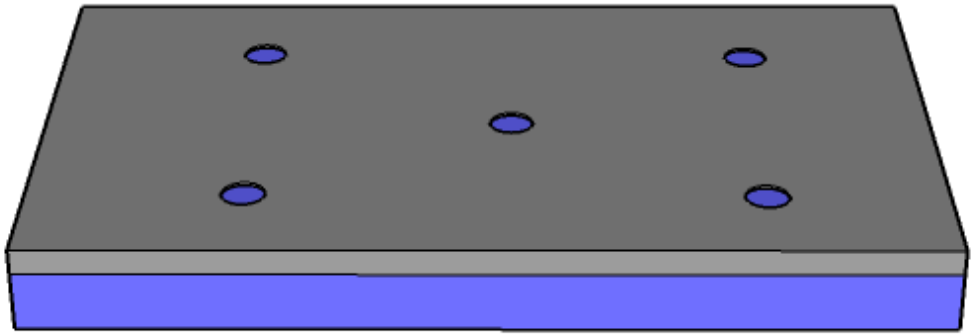
- Currently using Talbot Displacement Lithography
- Process similar to: https://iopscience.iop.org/article/10.1088/1361-6528/ab8764/meta
- 75 nm holes have been achieved, but it is challenging to get small enough variation at these dimensions
- Thin resists put high requirements on Si3N4 etch selectivity. This is an obstacle to moving to 90nm Si3N4.



- Variation over wafer at least partly due to variations in Talbot mask

III-V (GaN) Nanowire-enhanced materials for high power electronics

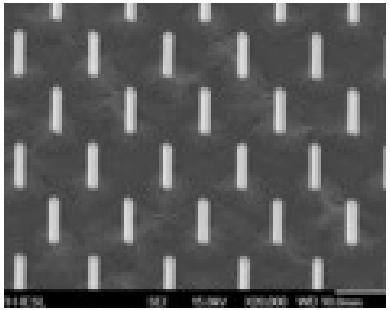
Etching challenges

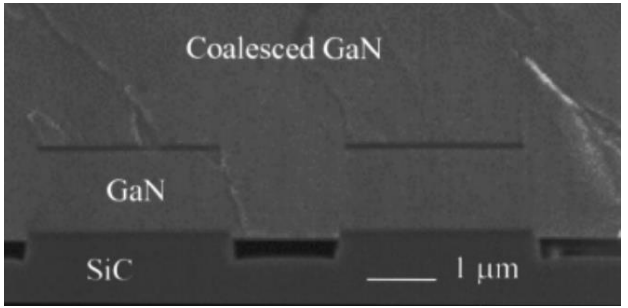


- Wafer size: 2” up to 6”
- Material: 100nm AlN on Silicon or GaN on Silicon
- Etch material: 50nm Stoichiometric SiN
- Need anisotropic etch to prevent widening hole size and distribution
- Need selectivity between photoresist and SiN high enough (>2) that resist is not etched through and the SiN surface is etched

III-V (GaN) Nanowire-enhanced materials for high power electronics

Characterization challenges





- Quantification of material defect density with high quality material (< 10^6 / cm^2)
- Development of new methodologies for electrical, XRD, SEM characterization
- Doping characterization methods (resistivity, mobility)
- Mechanical (bowing, thickness, surface uniformity, roughness)
- Advanced Optical (PL mapping)
- Automation of characterization for high volume material quality control

THANK YOU

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Digital Systems/Smart Hardware