Tyndall
National Institute
Institiúid Náisiúnta

Access to Flexible Nanoelectronics Fabrication at Tyndall

ASCENT
Access to European
Nanoelectronics Network

Graeme Maxwell
Tyndall

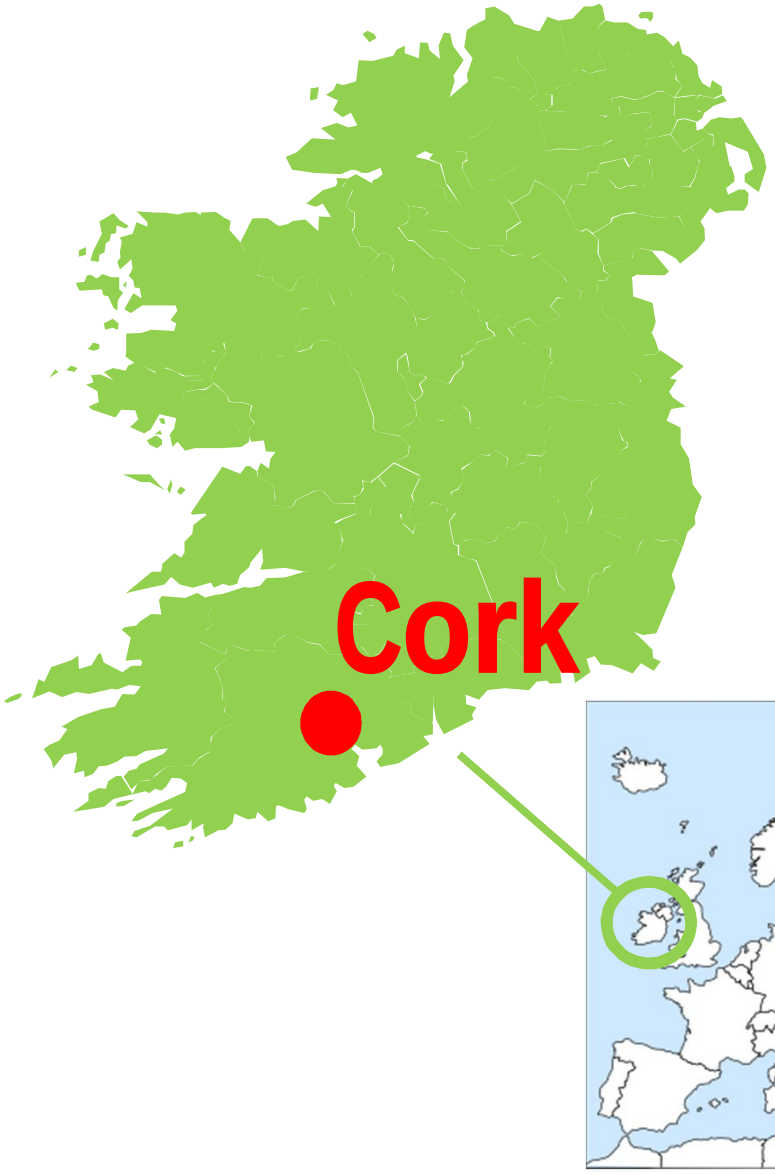
ascent
European Nanoelectronics Access

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional
Development Fund

Tyndall National Institute



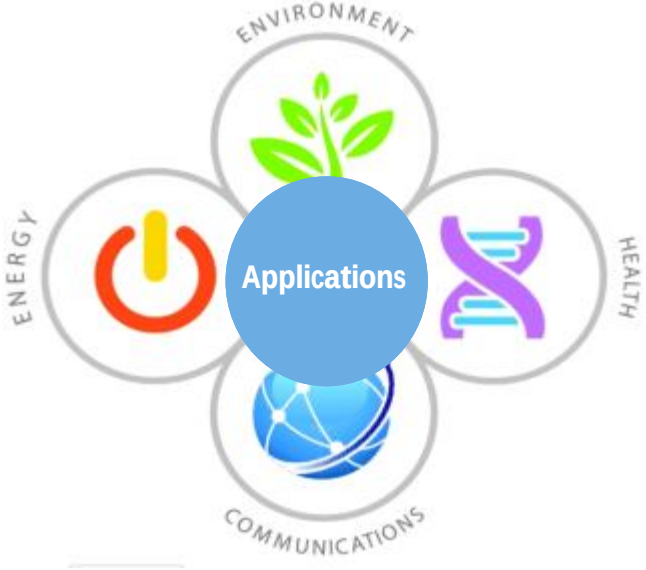
Largest Research Centre in Ireland
based at University College Cork campus

Tyndall Overview

- **One of Europe's leading Research Institutes for Information, Communications and Technology (ICT)**
- **Established 35 years ago as part of University College Cork, Ireland**

Our expertise

- Micronanoelectronics
- Microsystems
- Photonics
- Wafer fabrication
- Theory modelling & design



Research from atoms to systems

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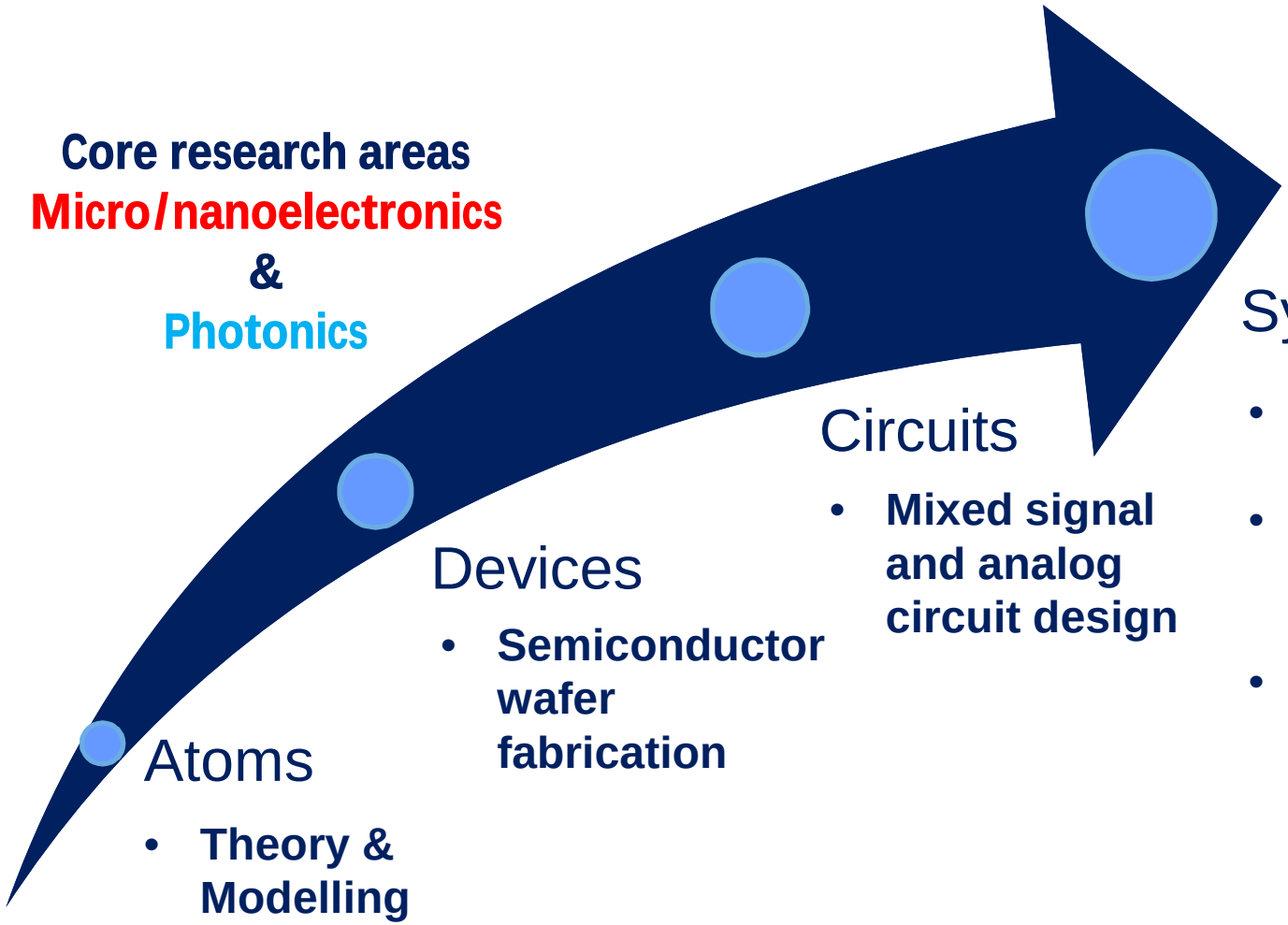
Core research areas
Micro/nanoelectronics
&
Photonics



Atoms

- **Theory & Modelling**
- **Nano materials and device processing**

Devices

- **Semiconductor wafer fabrication**

Circuits

- **Mixed signal and analog circuit design**

Systems

- **Smart sensors and systems**
- **Optical communication systems**
- **Microelectronic and photonic integration**

Vision

Tyndall Vision

To be the Premier

Information and Communications

Technology research institute

worldwide....

in generating Economic Impact

through Excellence in Research

Tyndall in numbers

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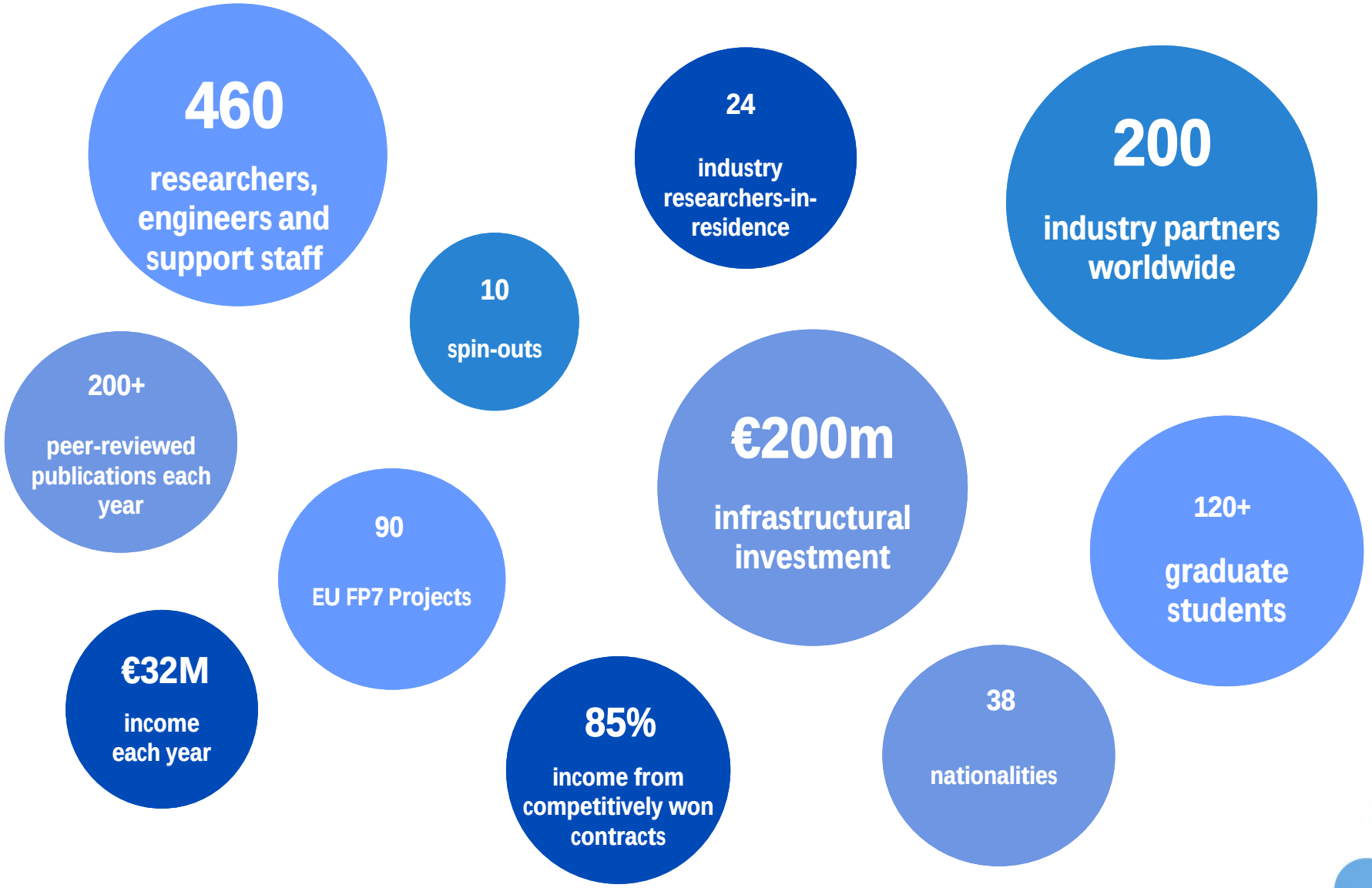


ASCENT @ Tyndall Offerings

Fab Access

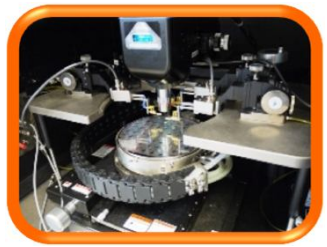
Access to Tyndall Flexifab for non-standard processing

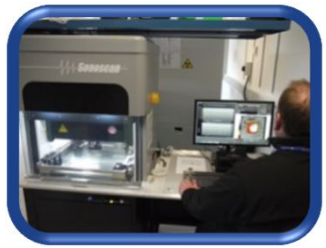
Electrical Characterisation Access

Access to Tyndall electrical test labs

Physical Characterisation Access

Access to Tyndall device characterisation facilities





Tyndall FlexiFab

Range of cleanrooms designed for flexible process & product development

- Silicon MOS Fabrication
- MEMS Fabrication
- Compound Semiconductor Fabrication
- Photonics Fab Training Facility
- e-Beam Lithography
- Non-standard nano-processing

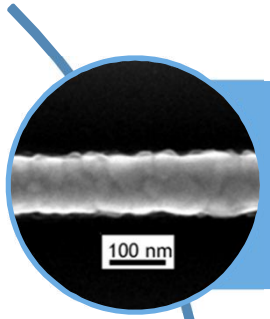
Flexifab Cleanroom

Fab Access

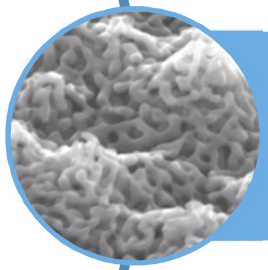
Examples of **nanoelectronic devices and test structures** on offer:

- Integration of new materials, device and subsystem concepts
- Nanoelectronics, nanophotonics, nanobiotechnology
- Tunnelling devices, sensors and NEMS
- e-beam for nanowire patterning - sub 10nm dimensions
- Technologies for 2D contacting to nano-scale structures
- e-beam contacting on flakes
    - Graphene, transition metal dichalcogenides (TMD) monolayers (e.g. MoS2)
- Metal contact tracks enabled using the electron beam or FIB
    - Focused ion beam (FIB) milling – allows customization of nanowire structures at dimensions of 10nm and lower

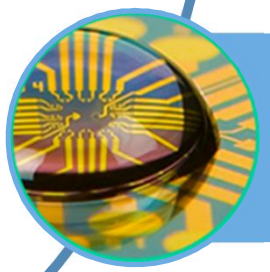
Examples of FlexiFab devices/structures



Nano-patterning of electrodes



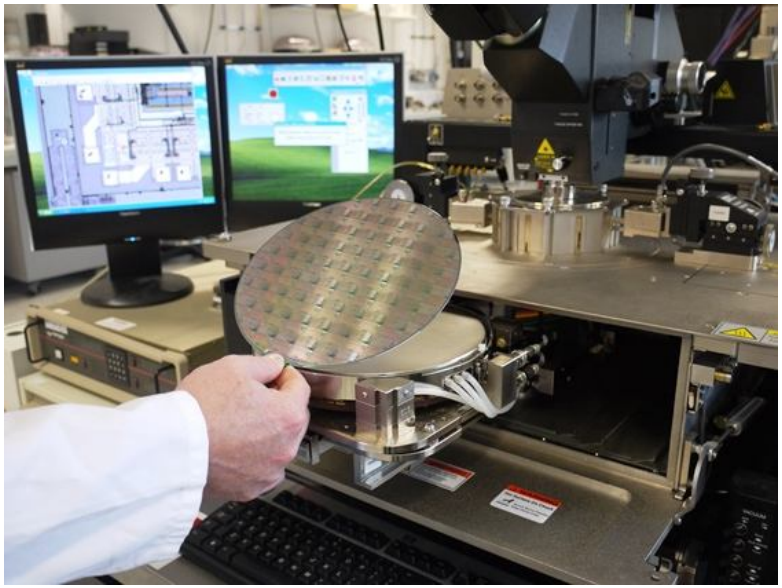
Nanostructured electroplated metals



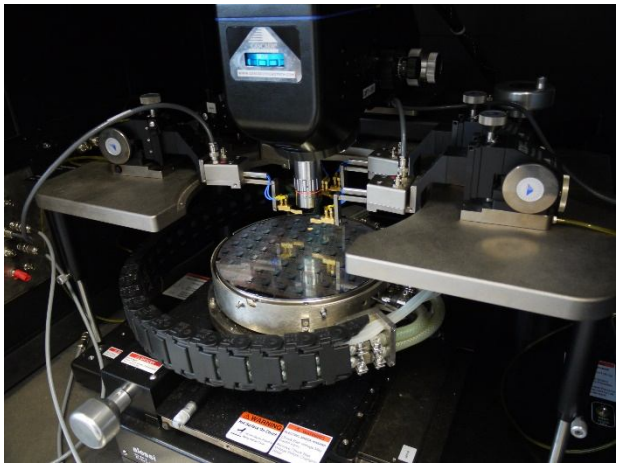
Nanoelectrode sensors

Electrical Characterisation Labs

Open Access Characterisation Lab	Wide range of test equipment for device and wafer testing e.g.: impedance, capacitance, voltage, current, spectrum analysers..
Nanoscale Characterisation Lab	Variable Temperature, Micromanipulator Probe Stations
Reliability Test Lab	Wide range of test equipment for packaged devices



Open Access Test Lab

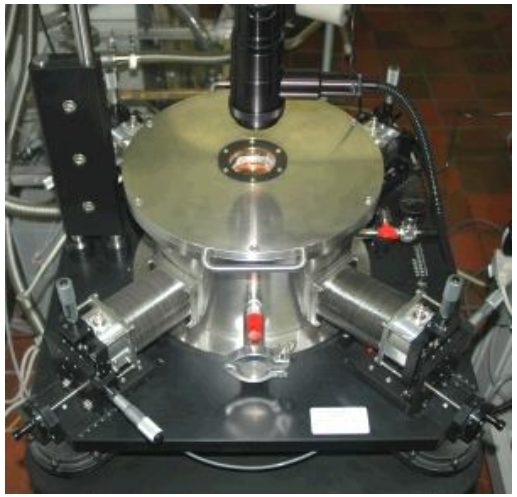


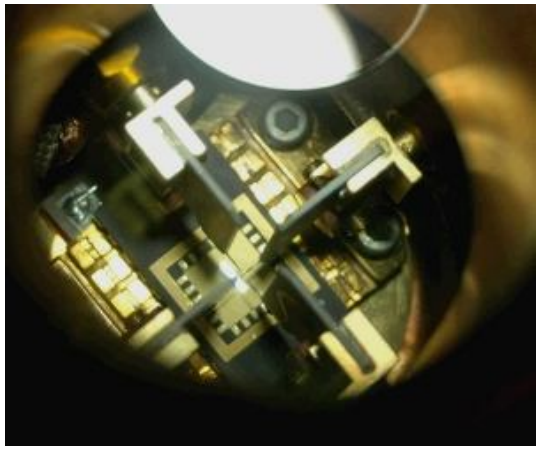
Electrical testing carried out at Tyndall:

- High-k dielectric analysis
- Junctionless InGaAs MOSFETS
- Fully automatic and semi-automatic wafer level tests (-55 to 300°C)
- CV (fF) and IV (fA) characterisation at controlled temperature

Nanoscale Test Lab

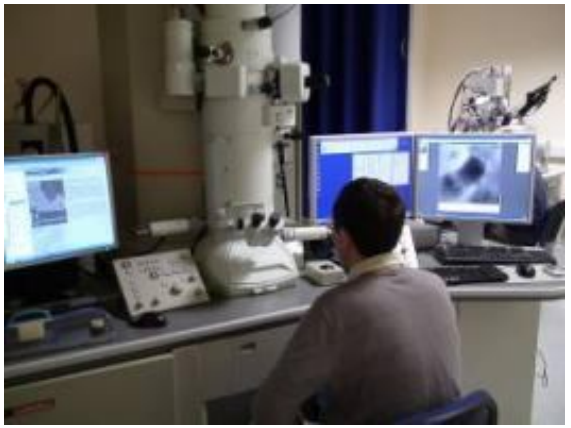
- Parameter analyser for ultra-precise measurements (0.1 fA, 0.5 µV)
- Variable temperature probe stations with micromanipulator
- Cryogenic probe stations: 77 to 400K (±0.1K)





Physical Characterisation Labs

Electron Microscopy Facility	High Resolution TEM, SEM and FIB, EDAX capability
Nanoscale Characterisation	AFM, SEM and electrical characterisation
Optical Spectroscopy Labs	Raman & optical Spectroscopy, fluorescence microscopy
Magnetic Characterisation	SQUID magnetometer for nano magnetic materials
Package Characterisation	Scanning Acoustic microscope, X-ray analysis



Electron Microscopy Facility / Nanovisualisation

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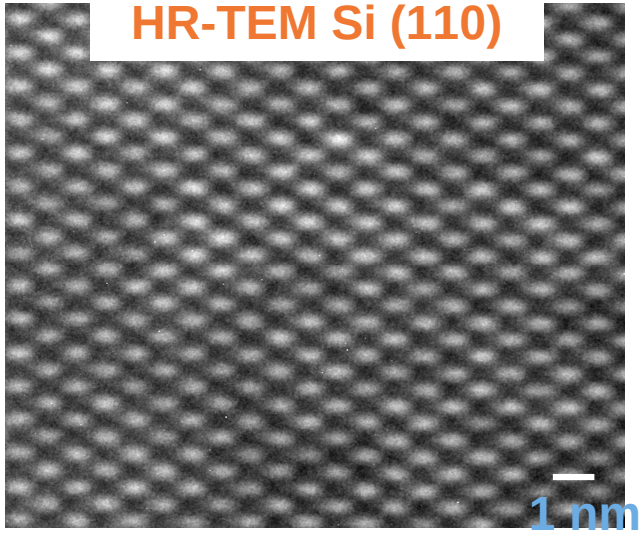
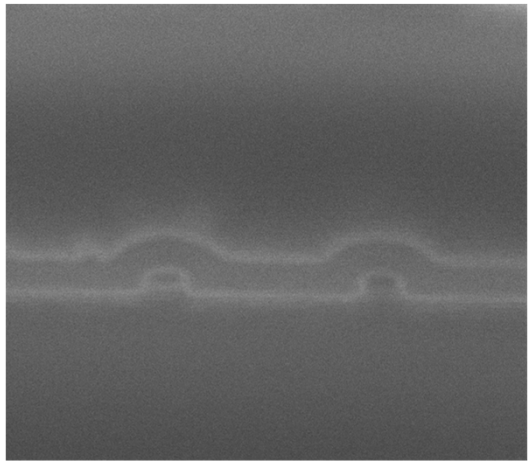
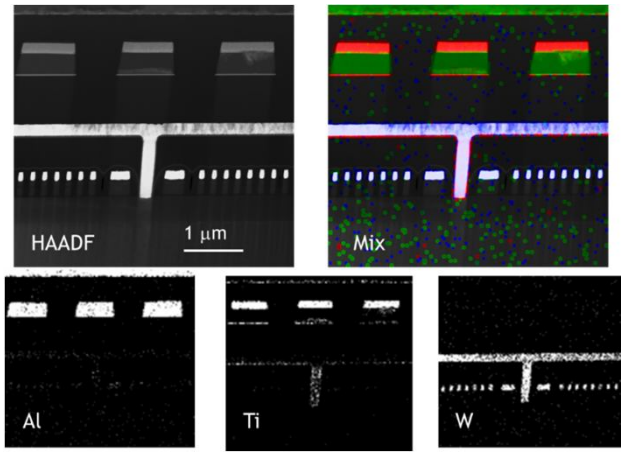
Standard Imaging and Elemental Analysis
from crystal lattices, nanostructures, surfaces, layers to full devices and systems

- High Resolution Transmission Electron Microscopy HR-TEM
- Ultra High Resolution Scanning Electron Microscopy UHR-SEM
- Nano-analytical Energy Dispersive X-Ray Spectroscopy EDX
- Scanning probe microscope (AFM): 4 nm (lateral res.) , 0.1 nm (vertical)





UHR-SEM of
Si nanowires as part of
junction-less transistors



Compositional maps through nano-analytical EDX of a device

Focussed Ion Beam (FIB)

Complete nanotechnology lab in one tool

- High resolution pole piece – point-to-point resolution of 0.21 nm
- EDS, Oxford instruments, INCA 250, site-lock drift correction system for high resolution elemental mapping
- In-situ STM-TEM holders, high temperature TEM holders
- STEM mode with BF and HAADF detectors (0.8 nm resolution)
- Oxford Instruments X-MAX 80 for high productivity EDS analysis
- Cryo preparation for liquid and gel-like materials

JEOL 2100 HR-(S)TEM / FEI Helios NanoLab DB-FIB

ASCENT Access Mechanism

Sign Up

- Free sign up as member
- Discuss with Co-ordinator (Paul) & Technical PoC (Nicolas)

Apply

- Apply for access to Fab, Test or Characterisation
- Selection Panel decides on access

Access

- Visit Tyndall
- Share your results

Some ASCENT Users of Tyndall Facilities

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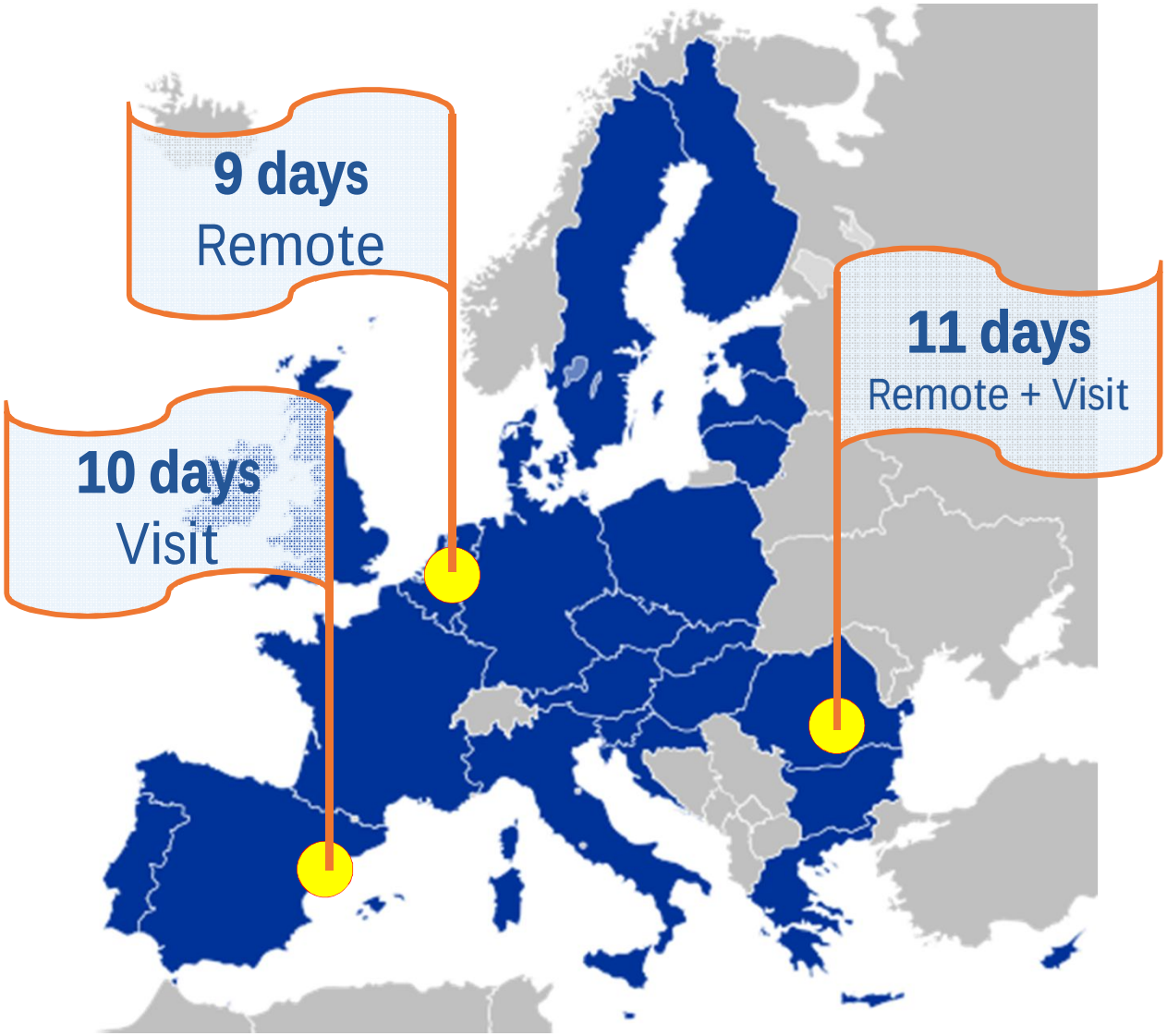
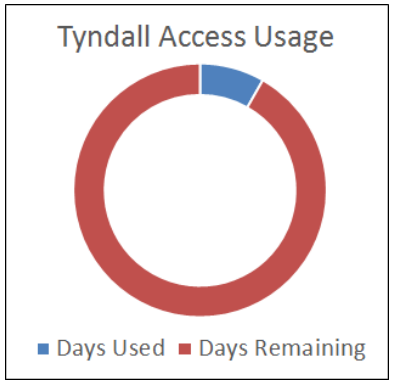




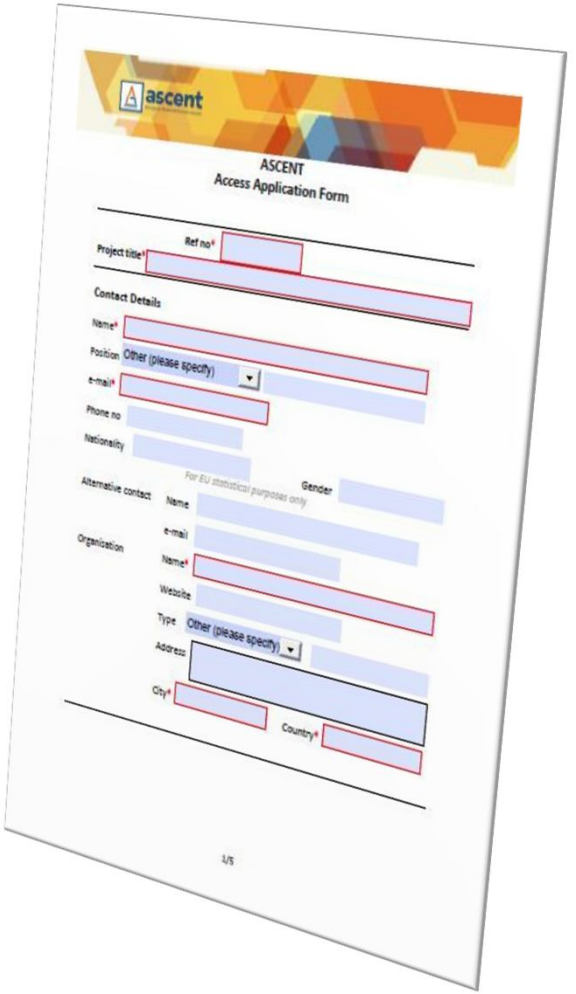
How to access

- Access through Tyndall's ASCENT technical contact point (**TPoC**)
  - TPOC reviews the **User** access request
  - TPOC supports user to prepare application
  - Output and deliverables agreed by TPoC and User at the outset
  - Approved requests directed to the Tyndall technical expert
  - Translated into a fabrication or packaging (electrical contacting) process in consultation with the User
- Test and characterisation: Both user and ASCENT samples
- TPoC is responsible for estimation of the required time and schedule for the work.
  - Typical visit: 5-10 days
  - Units of access based on the number of person-days required for the work and material costs

- Open Research Data → User makes data available to research community

Application

- **Simple:** 5-page electronic form
- **Fast:** 1 week evaluation
- ASCENT provides:
  - Facilities: fully funded access
  - Travel and accommodation



More Info …

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www.ascent.network

What's Next?

We will follow up with all registered attendees after the Workshop and invite you to sign up as members of ASCENT

www.ascent.network

or email or phone
Paul Roseingrave: +353-21-2346168

and join with us in this exciting opportunity for nanoelectronics research

Follow us on Twitter: **@ascenteu**

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UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh
Ireland's European Structural and Investment Funds Programmes 2014-2020 Co-funded by the Irish Government and the European Union
European Union
European Regional Development Fund

Users

- RefNo 023
  - Prof Dragoman, IMT Bucharest, Romania
  - Thin/smooth metal deposition for MIM devices
  - Status: Phase I completed
  - Facilities: Metal deposition + AFM
  - Phase I: **Remote**, Phase II: Transnational
  - Effort/usage: 11 person.day
- RefNo 029
  - Ling Ye, MESA, Univ. Twente, Netherlands
  - Nanowires for monolayer doping
  - Status: Ongoing
  - Facilities: e-beam lithography, elec. Characterisation
  - **Remote Access**
  - Effort/usage: 9 p.d
- RefNo 030
  - Prof Miranda, Univ. Aut. Barcelona (Spain)
  - Characterisation of 2D MESFETs (high-k under electrical s
  - Status: Application submitted
  - Facilities: Electrical testing
  - **Transnational access**
  - Effort/usage: 10 p.d