Tyndall
National Institute
Institiúid Náisiúnta

Overview

Tyndall National Institute
Cork, Ireland

May 2021

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Rialtas na hÉireann Government of Ireland
Tionscadal Éireann Project Ireland 2040
Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union
European Union
European Structural and Investment Funds

Deep-Tech Innovation for Ireland

Nanotechnology, electronics, photonics, quantum engineering, wireless & energy

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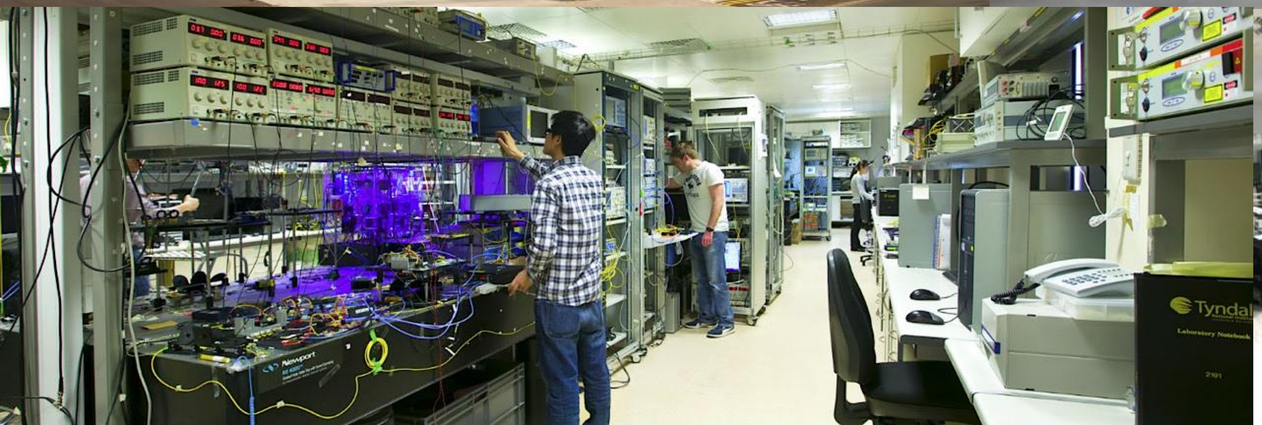

Agritech & Food Security

Health & Life Sciences

Deep technology research at the convergence of micro & nano-electronics, photonics and materials, involving chemists, physicists, engineers and manufacturing personnel

Micro & Macro Energy

Information & Communications

Research landscape in Ireland

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6 National Research Orgs

Tyndall National Institute Institiúid Náisiúnta
Teagasc Agriculture and Food Development Authority
Marine Institute Foras na Mara
nibrt National Institute for Bioprocessing Research and Training
ICHEC Irish Centre for High-End Computing
Health Research Board CRCI Clinical Research Coordination Ireland

Thematic Research Centres funded by Science Foundation Ireland, IDA Ireland and Enterprise Ireland

HQ @ Tyndall

IPIC Bringing Photonics to Life
iERC International Energy Research Centre
MCCI Microelectronic Circuits Centre Ireland

Strong collaboration co-PIs

AMBER
Confirm Smart Manufacturing
CONNECT
VistaMilk
ICHEC Irish Centre for High-End Computing
MaREI Centre for Marine and Renewable Energy
Insight

SSPC Synthesis and Solid State Pharmaceutical Centre Innovation Through Collaboration
iCRAG Irish Centre for Research in Applied Geosciences
lero The Irish Software Research Centre
Infant Irish Centre for Fetal and Neonatal Translational Research
ADAPT Engaging Content Engaging People
CÚRAM SFI Centre for Research in Medical Devices
APC Microbiome Institute Interfacing Food & Medicine

Tyndall – deep tech at scale

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OVERVIEW OF EU PROGRAMMES
(2014 - 2021)

€782 million
Total Project Value

€62 million
Tyndall Grant Value

€53 million
To Irish Partners

€22 million
To Industry based in Ireland

111 Projects
Total # of EU Projects

48 Projects
In ICT

19 Projects
Tyndall Coordinated

Tyndall involved in 10% of the total drawdown in Ireland

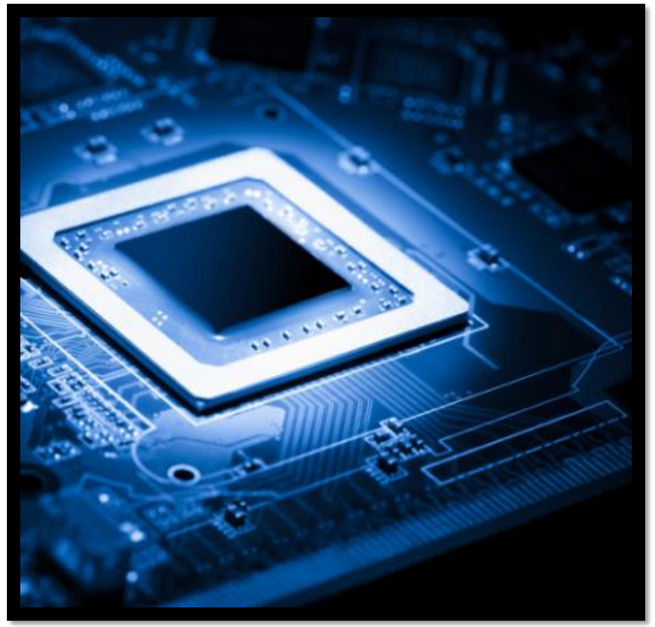
Success rate
>25%
EU average 12%
Ireland 15%

Bridging the "**valley** of death"

Excellent Research

Tyndall research centres – domain focus

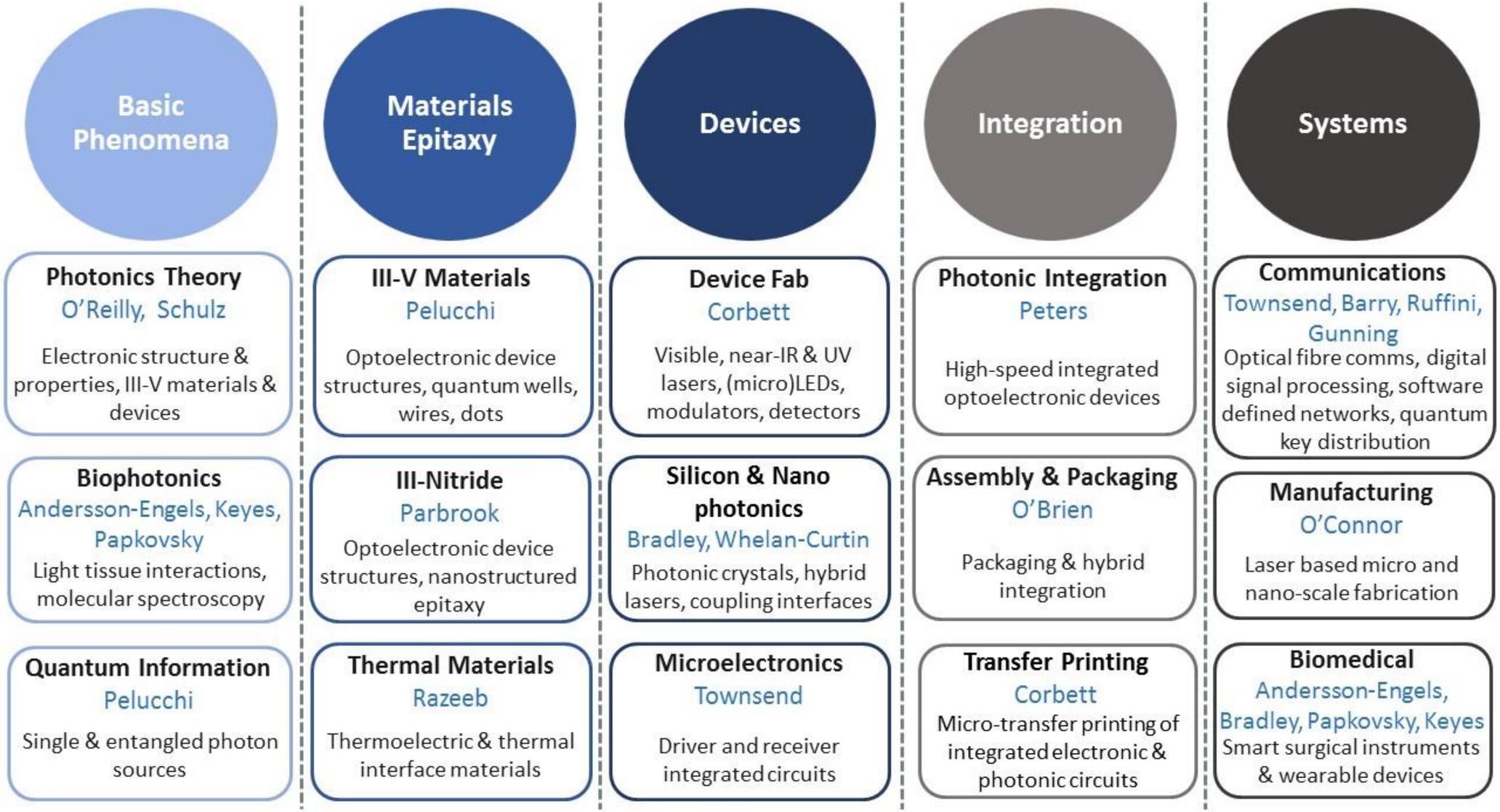
Micro & Nano Systems (MNS)



Photonics

Specialty Products & Services (SP&S)

“Atoms to Systems” Capability Set



Photonics at Tyndall:

- 160 people today
- Plan to grow to 230 under IPIC phase 2

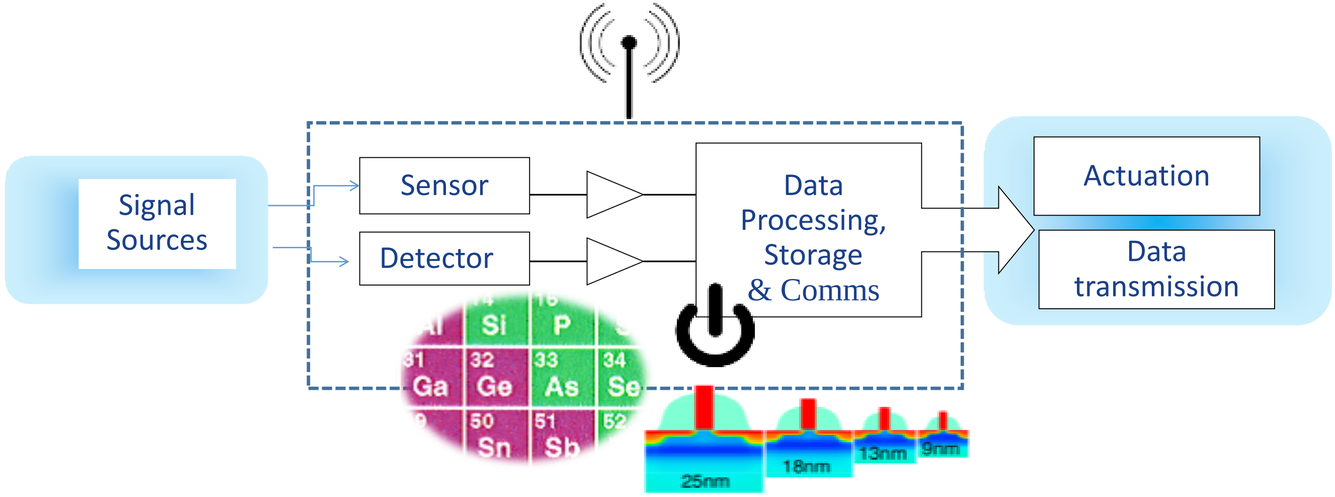
Tyndall MicroNano Systems Centre

Making and Powering Smart Things for the 1 Trillion Sensor Economy

Vision

Undertake world-leading, deeptech research into
a sustainable internet-of-things based on
miniaturised, self-powered, intelligent wireless sensor engines

- Nano-Materials: modelling, synthesis, characteristaion, process integration
- Nano-Sensors: CMOS-compatible, design & fabrication
- Circuits: sensor interfacing, data processing & communications
- Embedded intelligence (AI/ Machine Learning) for “Edge of Edge” Computing
- Beyond CMOS: Neuromorphic/in-memory Computing, Quantum Engineering.
- Energy: harvesting, storage & integrated power management
- Smart Systems: heterogeneous integration, deploy & dissolve

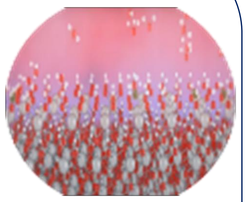


Micro Nano Systems @ Tyndall

Making and Powering
Smart Things
for the
1 Trillion Sensor Economy

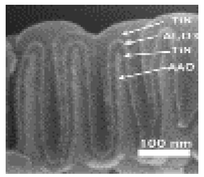
CMOS++

Nano material synthesis & processing



Device modelling & test

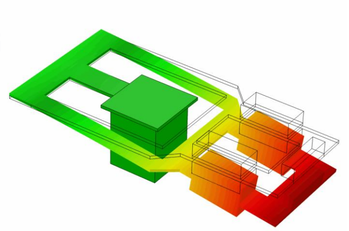
In-memory/ neuromorphic computing



Quantum Engineering Science

Energy for IoT

Micro Energy Generators



Microbatteries, super capacitors & fuel cells

Power Management ICs / Power Supply on Chip

Bio Electronics

Smart bandages

Real-time radiation sensor

Microneedles

Automatic medication

Human Centric Systems for Healthy Living & Work

Physiological Monitoring

Motion Detection / Localisation / Asset Tracking

Wearable Systems for Health, Wellness and Industry 4.0

Sustainable Agri Food Environment (SAFE)

Bio / Chemical / Physical Sensors

Sensor interface circuits

Smart Sensor Systems for Precision Agriculture & the Environment

Photonics - Key Research Themes

‘World’s smallest integrated imaging system for guided surgery’

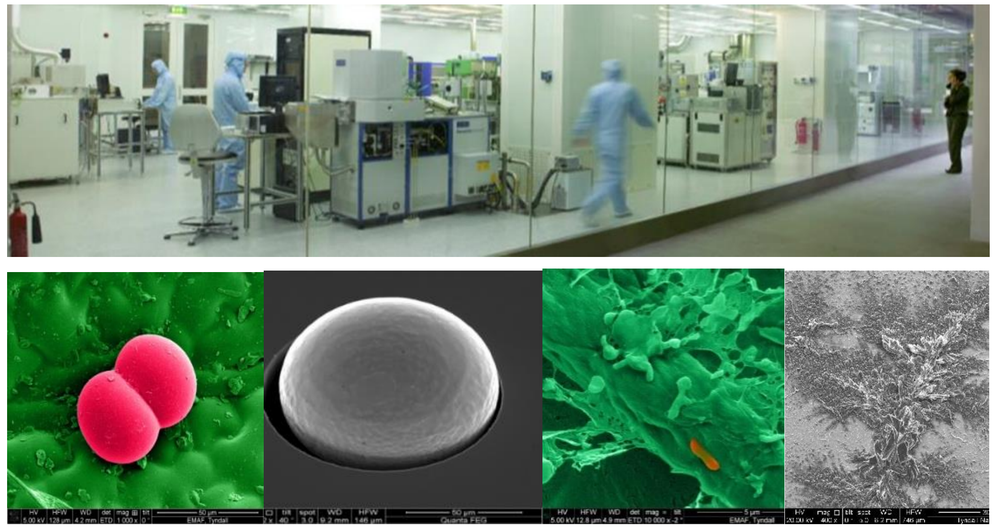
‘Coherent everywhere’ – migration of coherent communications to the network edge

‘Breaking the packaging cost barrier’

‘Printed photonics on anything’

Speciality Products and Services

- Silicon MOS Fabrication
- MEMS Fabrication
- Compound Semiconductor Fabrication
- FlexiFab



- Training Fab Facility
- E-Beam Lithography
- Electronic Packaging & Reliability Analysis
  - Wire/die bond, PCB assembly, uBGA. Environmental testing, failure analysis, burn-in, shock & drop, X-ray analysis.
- Electron Microscopy Analysis Facility
  - (EMAF) – SEM, TEM, FIB, EDAX analysis, cryo-stage enabled SEM for biological sample analysis
- DTE – IC re-engineering, patent infringement, circuit design analysis, analogue, digital & mixed signal diagnostic measurements

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Vision

To realise quantum science

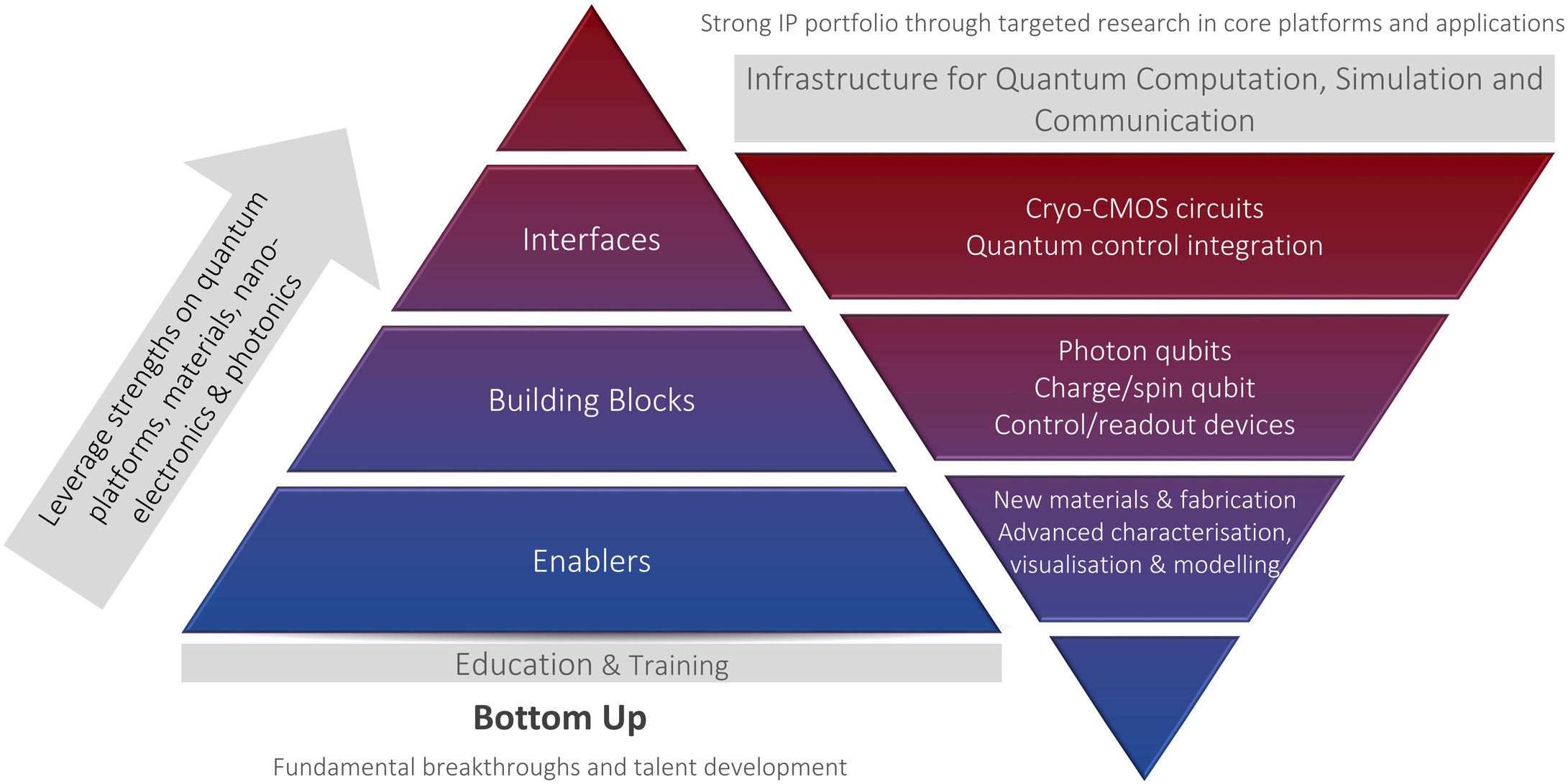
Mission

To lead a global open innovation hub for deep-tech quantum computer engineering, spanning materials to devices to systems and to grow globally competitive quantum engineering talent

QCEC Springboard

Top Down

Strong IP portfolio through targeted research in core platforms and applications



Bottom Up

Fundamental breakthroughs and talent development

Excellent Impact

Industry engagement

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Some clients prefer not to publicize their engagements.

New Ventures Eco-system

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Home-grown spin-outs

ACQUIRED by ONSemi: Low-light measurement & detection (LIDAR)

ACQUIRED by Facebook: MicroLEDs for devices and displays (AR/VR)

ACQUIRED: Integration of low-cost fibre optic solutions

NEW spin-out (2019): Radiation detection & safety solutions

NEW spin-out (2020) Biophotonics phantoms / standards

International spin-ins to Tyndall

2018: NEW VENTURE Gigabit optical comms research team @Tyndall

2019: NEW VENTURE Photonics automated assembly pilot line

2019: NEW VENTURE DTIF & pilot line program teams

Plus 15 SME ESA incubatees across three sites in health, agri-food, transport and ICT markets (50 employed)

Spin-outs – InfiniLED & Facebook

Micro-LED Technology 2008 – 2011

SME Spin-out – InfiniLED 2011

InfiniLED acquired by Facebook 2016

Deeper Tyndall relationship – & expansion of R&D centre (135)

International patent filed

Tyndall Launches InfiniLED Spinout

Facebook's Oculus acquires InfiniLED, an Irish startup that makes low-power LED displays

Oculus to recruit 9 engineers for new Cork office

Facebook-owned virtual reality company expands new LED research base in Cork

World's smallest, brightest, lowest-power LED source

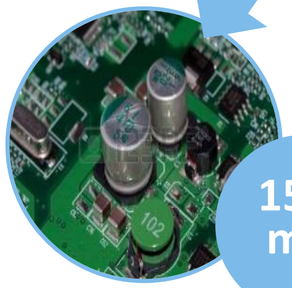
Tyndall continues its ground-breaking research in µLEDS

Technology license

Power supply on chip

Tyndall's leading research on Materials & Chip-level Power

Relentless market pressure for smaller, more power-efficient devices



15x6 mm

1.5 x 1 mm
60 x reduction in area; cost down & longer battery life

Multi-$m licenses of advanced power technology to 2 of the world's Top 5 Consumer Device companies

New license into chip manufacturing partner is embedding the technology in the global power supply chain

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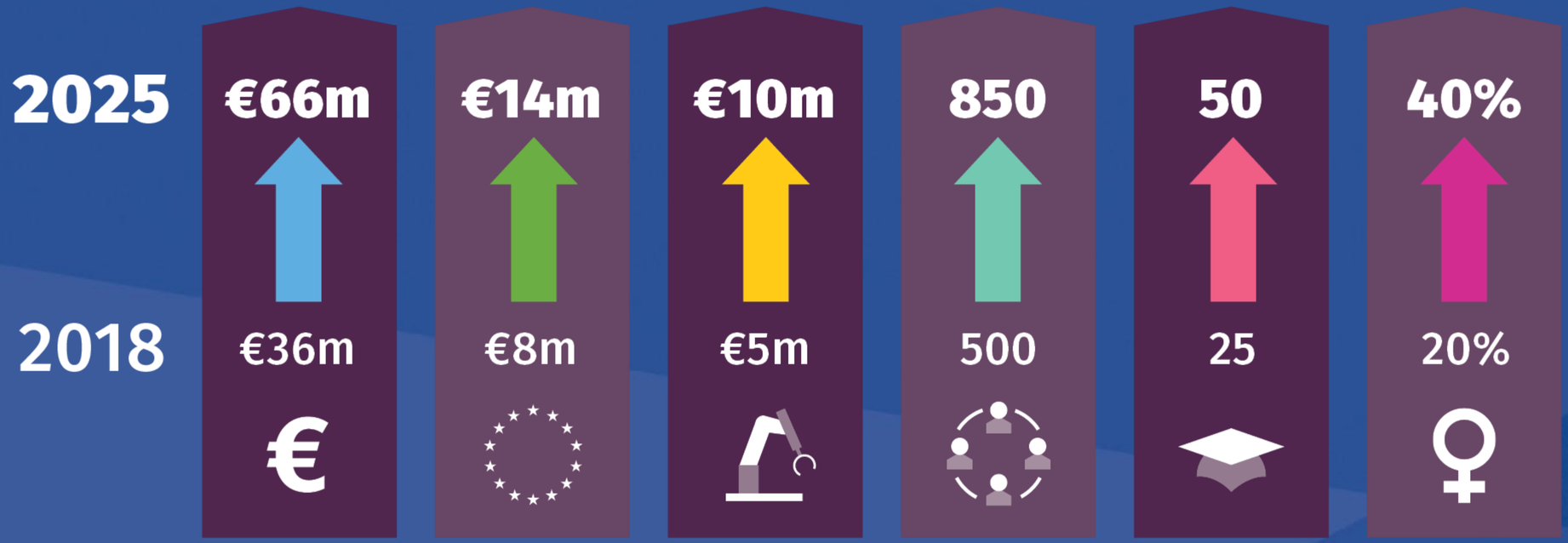
Scaling Tyndall



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Tyndall Development Plan

Major expansion under way

Expansion of research groups, new research themes and physical infrastructure

"We will … upgrade and expand the Tyndall National Institute in Cork to stay at the forefront of new technologies and build on its successful industry engagement model in sectors such as health and life sciences, ICT, energy and agri-tech."

- Government of Ireland, National Develop Plan 2018 - 2027

Expansion Site – North Mall Campus

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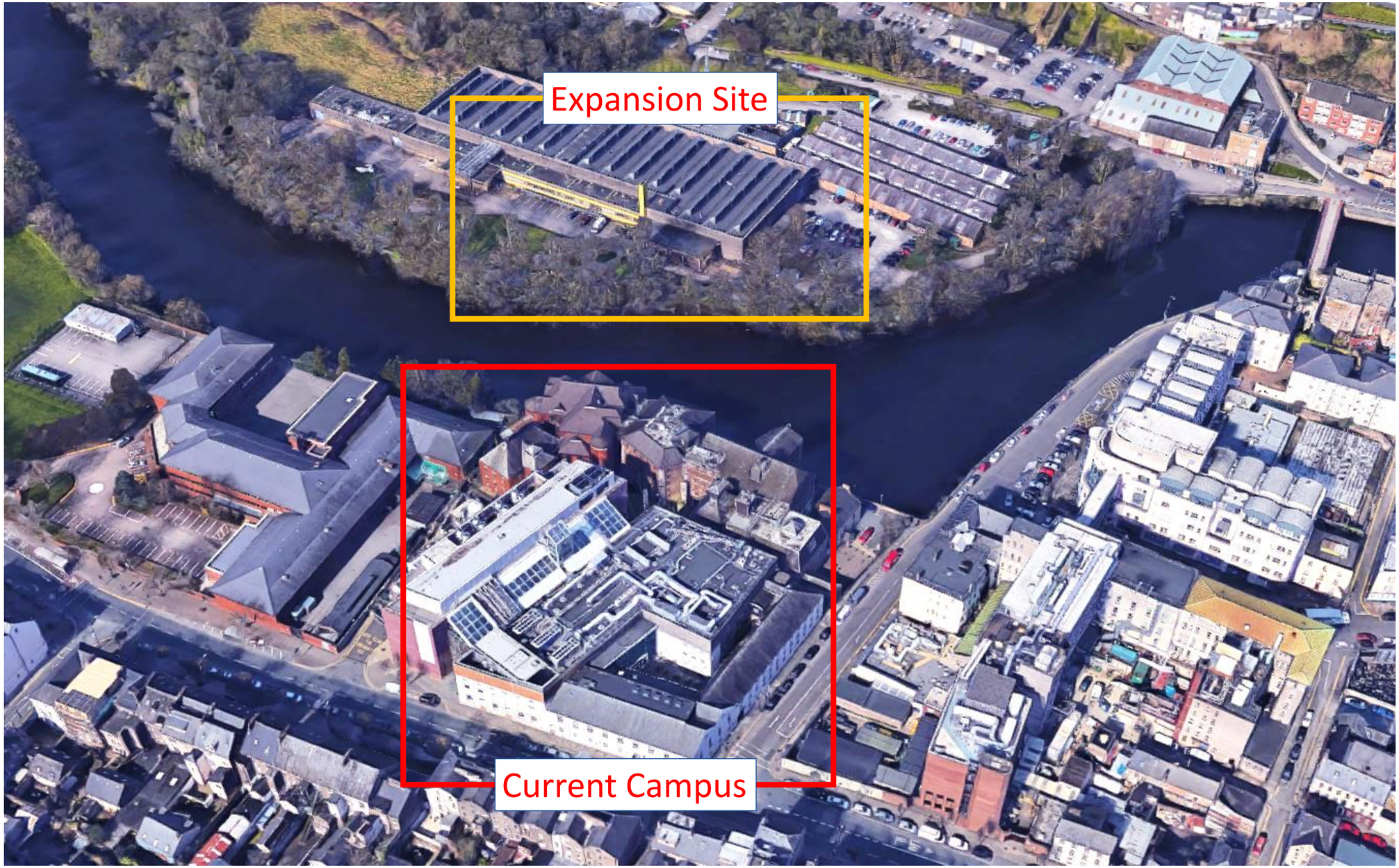

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Goal 1: Research Excellence

We will be known for excellence and distinction in our research and for people who are world leaders in their field

Grand challenges: we will address significant technological challenges by developing new themes within Tyndall and by harnessing the collective efforts of our researchers and their collaborators

Research leadership: we will enable many of our researchers to achieve landmark discoveries or innovations, opening major new possibilities in their field

Future research leaders: We will ensure a world-leading environment in which to develop students and early stage researchers while constantly raising their ambitions

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Smaller, Denser Data Storage

Ferroelectric behavior in exfoliated 2d aurivillius oxide flakes of sub-unit cell thickness

Adv. Electron. Mater. 6, 1901264 (2020); https://doi.org/10.1002/aelm.201901264 Lynette Keeney (Tyndall National Institute), Ronan J Smith (Trinity College Dublin), Meghdad Palizdar (University of Leeds), Michael Schmidt (Tyndall National Institute), Andrew J Bell (University of Leeds), Jonathan N Coleman (Trinity College Dublin) and Roger W Whatmore (Imperial College London)

Background

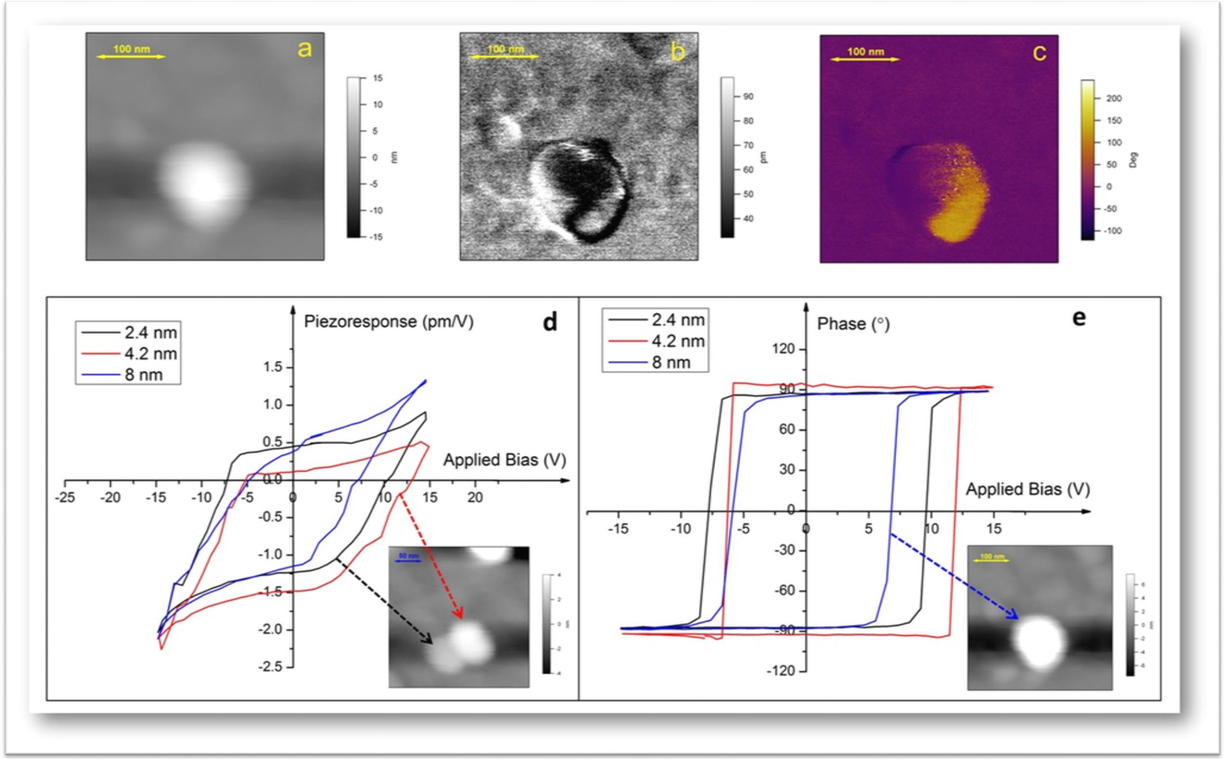
As miniaturisation of electronic devices continues, a crucial requirement for materials in data storage applications is the enhancement of their functional properties at very small dimensions. This is challenging for ferroelectric materials because ferroelectricity is a collective phenomenon and spontaneous electrical polarisation is expected only to be sustained above a certain critical thickness, previously thought to be above 20 nm. However, there has been significant progress in piezoresponse force microscopy (PFM) instrumentation over the past two decades that has provided experimental evidence for the persistence of ferroelectricity down to two-unit cell thicknesses.

Approach

In this work, ceramics of an Aurivillius phase ferroelectric were ultrasonically exfoliated into thin (120 nm down to 2.4 nm) 2D flakes. At Tyndall, we performed detailed PFM studies to overcome the challenges involved in measuring ferroelectric properties at such small dimensions. Measurements demonstrated that these very thin flakes exhibit piezoelectric effects.

Outcome & Impacts

We have shown that ferroelectricity can exist and switch in flakes with thicknesses of only 2.4 nm, which equals one-half of the normal crystal unit cell. This work constitutes the first evidence for ferroelectricity in a 2D oxide material.



Representative a) topography, b) vertical DART-PFM amplitude, and c) vertical DART-PFM phase images of a single 15 nm high flake of exfoliated B5TFCO. Vertical DART-PFM switching spectroscopy d) piezoresponse and e) phase loops of exfoliated B5TFCO nanoflakes at room temperature after removal of an applied DC bias.

World’s brightest LED

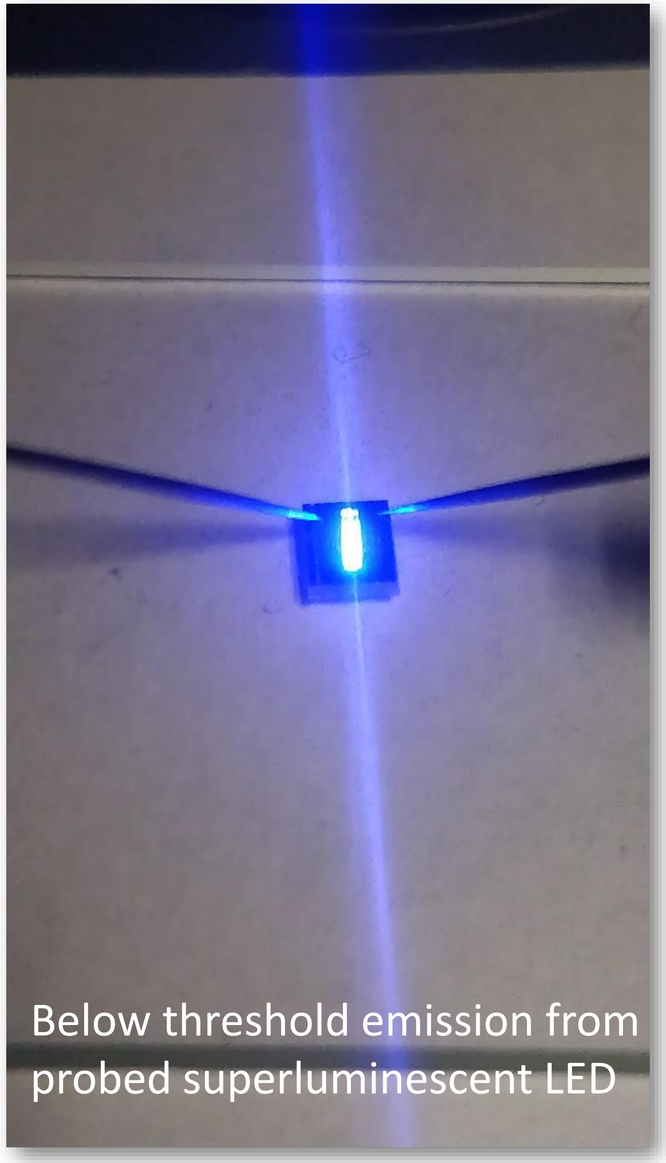
High power surface emitting InGaN superluminescent light-emitting diodes

Appl. Phys. Lett. 115, 171102 (2019); https:// doi.org/10.1063/1.5118953 Rory Cahill, Pleun Maaskant, Mahbub Akhter and Brian Corbett

Background
Established photonic technologies such as lasers and light-emitting diodes can respectively provide high power in a beam and a broad emission spectrum, but not both. This has led to increasing interest in the super-luminescent light-emitting diode (SLED), which can, in principle, achieve both properties in a single device. However, current SLEDs are limited in the power that they can deliver, restricting their potential as light sources for pico-projection, optical coherence tomography, machine vision or LiDAR.

Approach
To address this issue, we developed our patented substrate-emitting arrangement using high-quality blue emitting gallium nitride materials. Our approach uses a unique etching technology to create ultra-smooth angled facets that direct in-plane amplified light downwards and out through the transparent substrate.

Outcome & Impacts
In the work published in Applied Physics Letters, we demonstrate the world record optical power from a SLED (of any colour) while maintaining a broad emission spectrum. The experiments revealed the high levels of gain that can be achieved in these materials. The surface-emitting design reduces production costs by allowing for on-wafer testing, allows for integration of different functions and has the potential to be adapted for many applications in the future.



Below threshold emission from probed superluminescent LED

Goal 2: Impact

We will deliver impactful IP to industry, create high-value new ventures and grow a diverse talent pipeline

Technology transfer: we will work with SME and MNC industry partners to commercialise Tyndall's breakthrough technologies with a market value-based approach, targeting market needs and global societal challenges

High-value start-ups: we will develop our entrepreneurship culture to encourage the creation of new business ventures supported by a class leading commercial, research and service ecosystem

Talent pipeline: we will support MNCs and SMEs across all relevant technology sectors by training Ireland's future deep-tech leaders, equipped with a wide range of transferrable skills and cutting-edge research and development expertise

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Industry Researchers-in-Residence

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X-Celeprint

LAKE REGIONAL HEALTH SYSTEM
www.lakeregional.com

intel

Boston Scientific

InfiniLED
Next Generation Display Technology

APPLIED MATERIALS®

Rockley™ PHOTONICS

~60 industry staff with industry suites and lab/clean-room access

Goal 3: International Reach

We will be the partner of choice, internationally recognised for driving research and innovation to address global challenges

Thought leader: We will develop our global presence and influence through working on research policy, industry road-mapping and grand research challenges

Strategic partner: We want to expand our international network of strategic partnerships with leading tech brands, research and technology providers and academic institutions

Large-scale initiatives: We will enhance our international leadership by establishing new multi-party programmes with international significance and with global impact

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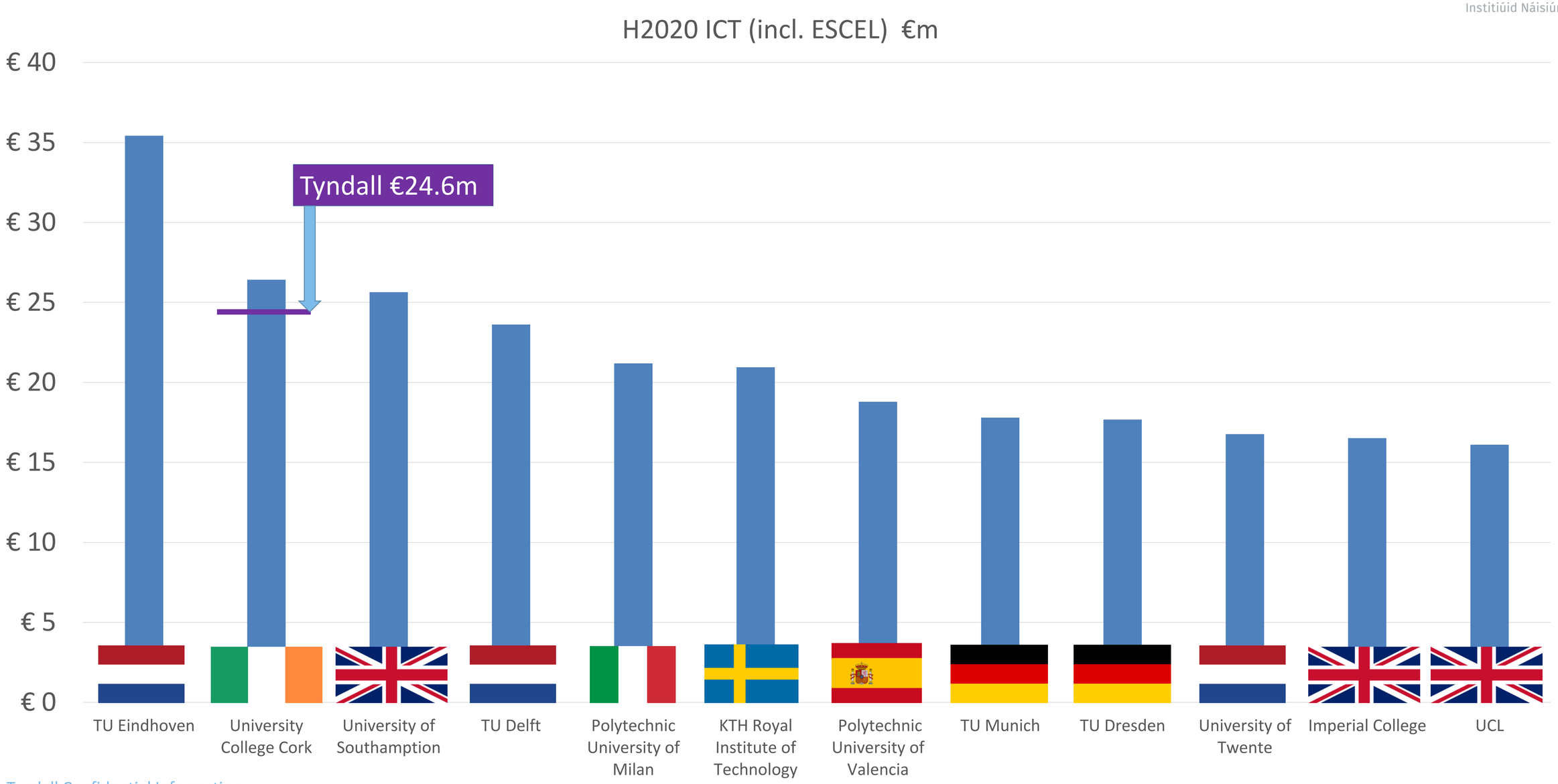
Leading in EU ICT Research



Goal 4: People and Culture

Tyndall will attract, nurture and enable people to fulfill their potential within a culture of inclusivity, creativity and entrepreneurship.

Attract the best talent: To double in size we will need to attract the very best talent to Tyndall.

Career development: We will establish career and developments programmes that empower the next generation of leaders and entrepreneurs.

Integration and Collaboration: We will foster integration and collaboration between functions and disciplines.

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Tyndall Wireless Communications Lab Dublin Opens

- Headed by Dr Holger Clausen – Formerly of Nokia Bell Labs

- Winner of the prestigious **World Technology Award 2014** in the individual category Communications Technology for innovative work of **"the greatest likely long-term significance".**

- Previous winners were **Elon Musk, Mark Zuckerberg, Gordon Moore & Paige**

Areas of Research

- Future RF/Antenna design
- Future Radio Access Networks/ Protocols
- Future AI
- Future Quantum Systems

Professor of RF Microwave Communication

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- Headed by Prof Dimitra Psychogiou

- A global expert in RF front-end technologies
- Will lead a team of researchers at Tyndall in developing ground-breaking

Areas of Research

- RF Front End Technologies
- RF Microwave/Millimeterwave Communications
- RF MEMS
- Reconfigurable Circuits
- Tunable Filters

Goal 5: Infrastructure

Tyndall will considerably expand its internationally competitive state-of-the-art infrastructure to enable excellent research and provide support to industry

State-of-the art infrastructure:

Deliver the NDP-enabled Tyndall Development plan to significantly upgrade research infrastructure and capital development

Strategic alignment:

Establish new infrastructure to support emerging technologies, aligned with national and international roadmaps

Internationally competitive:

Recognised internationally as a key European Research and Technology Infrastructure with streamlined access routes for internal and external users

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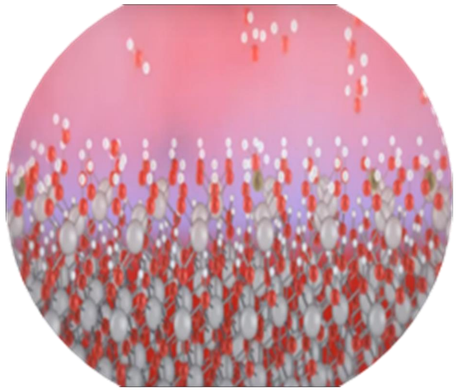
Unique research environment

Atoms

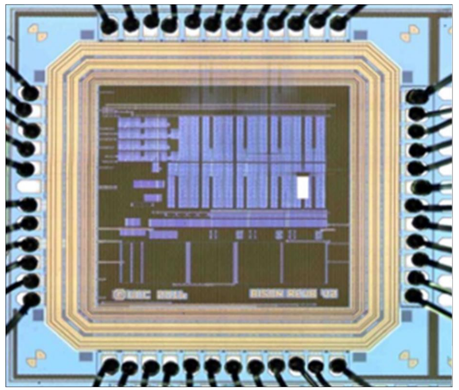


- Materials Research & ALD
- Atomistic Modelling & Simulation
- Synthesis & Processing

Devices

- Semiconductor wafer fabrication
- Nano materials and device processing

Circuits



- High performance RF & mixed-signal circuits
  - Data converters
  - Ultra wideband radar
  - RF circuit design
- Photonic light sources & detectors
- Power supply on Chip

Systems

- Smart sensors and systems
- Optical communication systems
- Microelectronic and photonic integration
- Application-specific Packaging

Atoms to systems – conceive, produce, characterise, deploy