

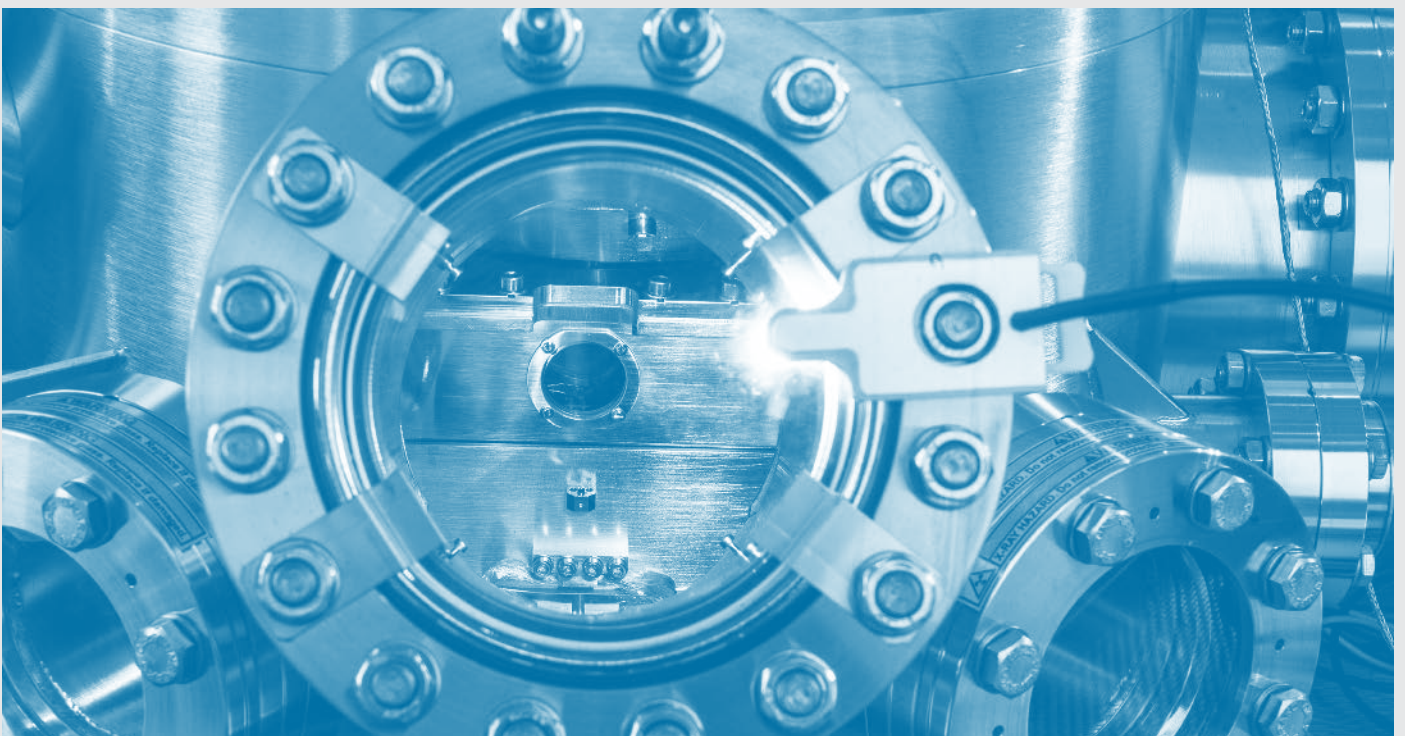


**MINISTRY OF FOREIGN AFFAIRS
OF DENMARK**
Invest in Denmark

2021

QUANTUM TECHNOLOGY OPPORTUNITIES IN DENMARK

www.investindk.com



DENMARK: BEST COUNTRY FOR BUSINESS

AAA-RATING

Denmark maintains its AAA-rating from the credit agency Fitch Ratings (2020). Denmark has addressed the corona-crisis better than equivalent EU countries and cities due to a less restrictive lockdown and a high resilience among Danish export goods. Therefore, the credit rating agency, Fitch, maintains its long-term credit rating of Denmark at "AAA; Outlook Stable":

"Denmark's "AAA" rating reflects a long history of solid political decision-making supported by strong institutions and very strong governance indicators, which Fitch believes will support solid economic recovery as soon as the covid-19 pandemic subsides," writes Fitch Rating agency in its analysis.

#1 IN EUROPE FOR EASE OF DOING BUSINESS

The World Bank (2008-2020)

USD 60,195

GDP per capita
OECD (2020)



#3 on the OECD Better Life Index
(2020)

#1 IN THE WORLD FUTURE READINESS TO EXPLOIT DIGITAL TRANSFORMATION

IMD (2020)

22%
corporate
tax

#2 IN THE WORLD ON COMPETITIVENESS

IMD Business School ranks Denmark as 2nd best in competitiveness in the world! Denmark stands out with a strong economy, health and education systems, high-class business efficiency and green ambitions. (IMD 2020)

LEAST CORRUPT COUNTRY

Transparency International has released its annual Corruption Perception Index (2019) that measures corruption in regards to bribes and governance of public funding in the public sector. Once more, we can proudly announce that Denmark is the world's least corrupt country.

#1 IN THE WORLD ATTRACTING AND RETAINING TALENTS

IMD (2020)

Language

9 out of 10 people speak English and 5 out of 10 speak German.



Lowest redundancy costs in the world

Shared #1, IMD (2020)

One of the most flexible labour markets in the world

IMD (2020)

#1 IN THE WORLD ON SOCIAL RESPONSIBILITY OF BUSINESS LEADERS

IMD (2020)

WHY DENMARK

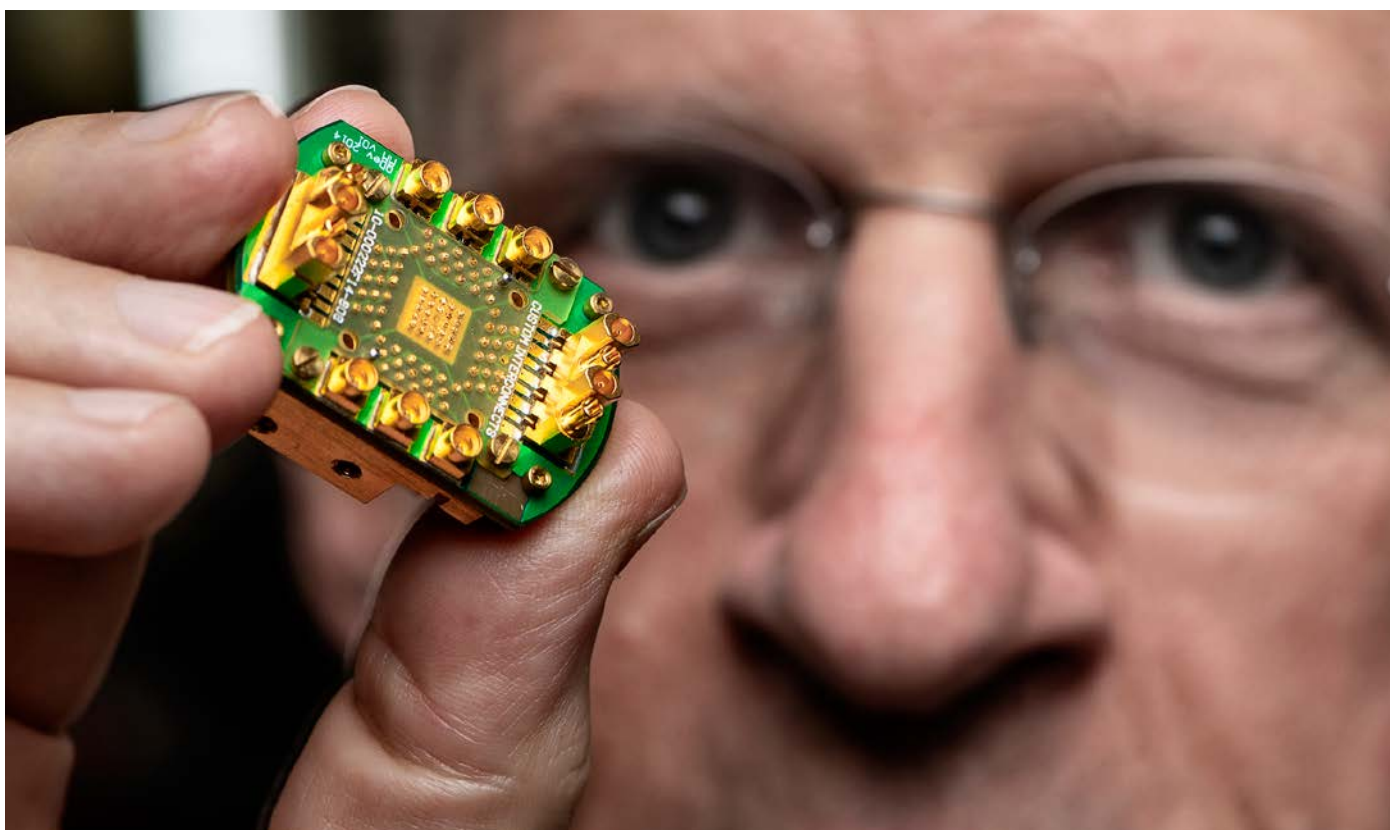
Denmark is one of the strongest hubs for quantum technology in the world and the most innovation-friendly country in Europe. That makes us an attractive location for entering the second quantum era.

The strong interplay between world-renowned researchers and a long tradition for Public Private Partnerships is just part of the reason why Denmark is the perfect incubator for companies developing solutions enabled by quantum technology to solve complex problems.

Another reason is our strong innovation system that can offer access to knowledge and expertise in areas that are key to driving the development of new quantum technology for quantum computing, -communication and -sensing.

Look around, and learn more about Denmark as a quantum hotspot for bringing your quantum solutions to market.

This publication is a short introduction to the reasons why Denmark is a great ecosystem for creating excellence within quantum technology



Professor Charles Marcus holding the heart of a component for future quantum computing.

ALL THE RIGHT CONDITIONS

EXCELLENT R&D OPPORTUNITIES IN A STABLE ECONOMIC ENVIRONMENT

- Strong legacy
- World-renowned research and talent
- One of the strongest economies in Europe, ranked no. 1 for ease of doing business

For over 100 years, Denmark has been at the forefront of ground-breaking discoveries within quantum physics starting with Niels Bohr in 1913 when he formulated his theory about the hydrogen atom. Today, Denmark is still recognized as one of the main hubs in Europe for quantum technology. Offering access to both world-renowned researchers and research groups, a strong talent pipeline and highly qualified labour Denmark is an increasingly attractive location for businesses work to develop quantum technology.

Denmark can not only offer companies an attractive environment to work collaboratively with world-class research institutions to strengthen R&D, commercialization and product pipeline but also state-of-art design, testing and manufacturing competences and facilities relevant to quantum technology development.

Furthermore, Denmark offers a low corporate tax rate, competitive business costs, flexible labour market conditions and simple procedures for establishing a business.

RESEARCH STRENGTH

Research in quantum technology and quantum-enabling technology is conducted at universities across Denmark.

The following areas are strongholds in Danish quantum technology and research positions within quantum technology with a potential to create commercial value for industry in the near term:

QUANTUM SENSING

New approaches to sensing in proof-of-principle demonstrations of magnetic-field detection beyond quantum limits (ultra-precise measurement).

QUANTUM ELECTRONIC COMPUTING

New kind of information processing, in which quantum parallelism is used as a resource to greatly accelerate computational speed.

PHOTONIC QUANTUM TECHNOLOGY

Novel devices based on photons and hardware development for photonic quantum simulators, quantum networks, quantum cryptography, and novel light sources.

QUANTUM COMMUNICATION;

Development of completely new systems for high-rate quantum key distribution (QKD) that efficiently solves all the challenges in a single system for the first time.

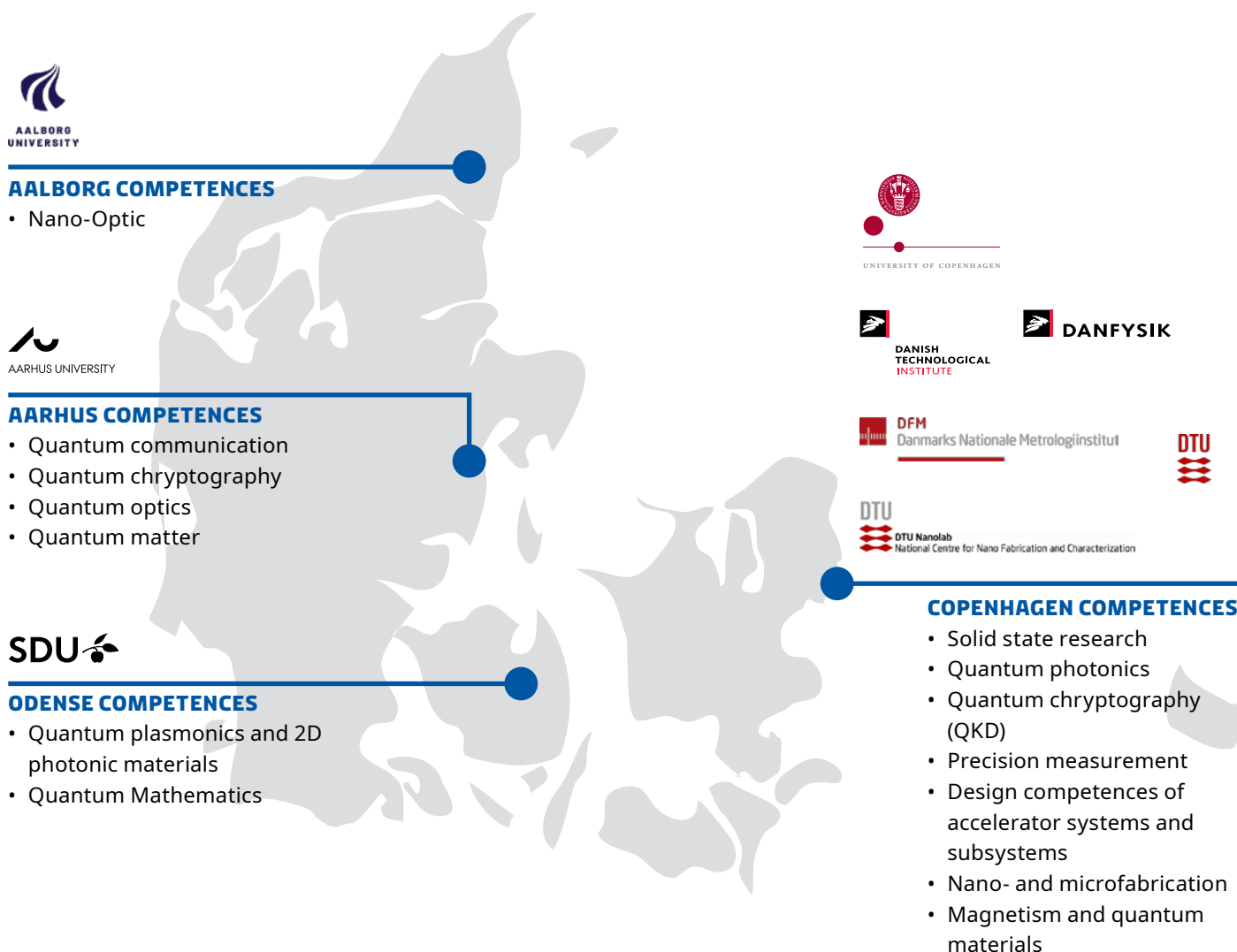
QUANTUM ELECTRONIC MATERIALS

Synthesis and characterization of the essential material platforms.

“The University of Copenhagen ranks 7th in the world on quantum scientific impact measured by the number of unique first-author publications”

Source:
“Economic impact of Quantum in The Netherlands”
(Quantum Delta, 2020)

THE DANISH QUANTUM ECOSYSTEM



RESEARCH HIGHLIGHT I: SECURE COMMUNICATION FOR THE FUTURE

Denmark has world leading research groups in quantum photonics, network technology and cryptography. This makes Denmark a very strong testbed for developing technology to secure communication in the future either through quantum resistant networks or through post-quantum cryptography. If you are considering R&D in the following areas, Denmark offers competences in:

- QKD and Quantum Random Number Generators (QRNGs)
- Ultra-stable lasers sources
- Development of micro-comb generators
- Quantum dot photon-emitter interfaces
- Photonic quantum simulators and quantum networks
- Exploring distributed quantum resources

QUANTUM TECHNOLOGY COMPANIES IN DENMARK

CRYPTOGRAPHY

ZYBERSAFE



CRYPTOMATHIC



LASER AND SINGLE PHOTON SOURCES



INTEGRATED OPTICS



CONSULTANCY



Deloitte.

TRIFORK.

CRYOTECHNOLOGY



DATA SCIENCE AND MODELLING



NANOFABRICATION AND MATERIALS



DTU

DTU Nanolab
National Centre for Nano Fabrication and Characterization



**DANISH
TECHNOLOGICAL
INSTITUTE**



QUANTUM COMPUTING

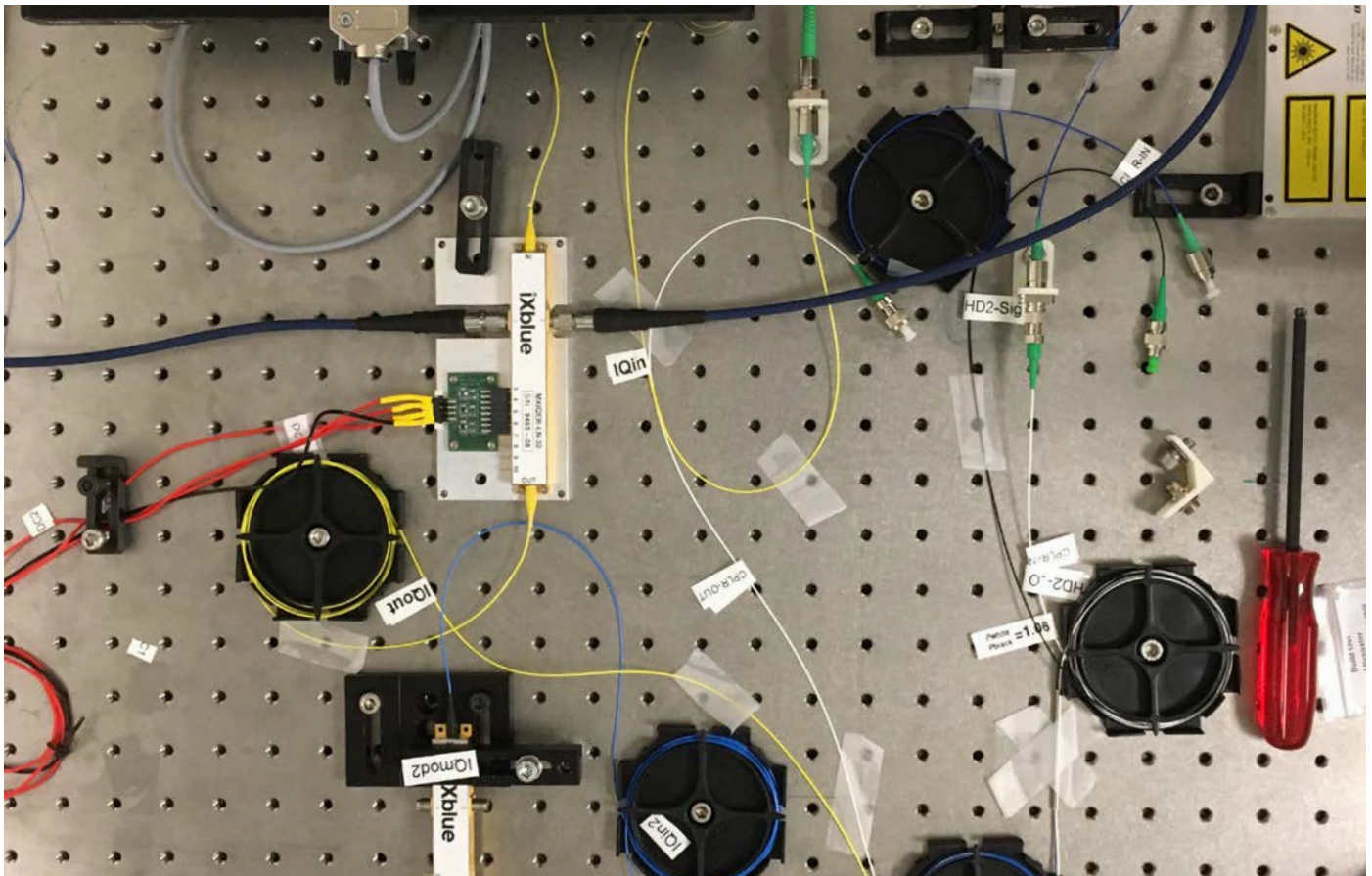


SENSING AND MEASUREMENT TECH



FOSS





DTU researchers have developed a prototype for a quantum key distribution system which is now to be tested in a realistic fibre network

FIRE-Q AND CRYPT-Q

- To new projects starting in 2020 will transform decades of quantum research at the University of Copenhagen and The Technical University of Denmark into commercial products for unhackable encryption and the building blocks of tomorrow's quantum computers.
- One of the objectives is to transport light particles with quantum information via a 10-kilometre fiber-optic network between the Niels Bohr Institute and the Technical University of Denmark and to create an indestructible link (unhackable).
- Together with several companies involved in the project, researchers will build "Plug & Play

RESEARCH HIGHLIGHT II: DRUG DISCOVERY WITH QUANTUM COMPUTING

Home to one of the strongest life sciences clusters in the world, Denmark is a respected international health laboratory – also when it comes to using cutting-edge technology such as quantum computing for driving R&D even further.

Starting in 2021 two new research centres will be established to work on using quantum simulators to boost drug discovery and developing the medicine of the future.

One centre, Solid-Q, will work on using and integrating two types of quantum simulation hardware to make quantum mechanical calculations of complex biomolecules. The other centre, Quantum for Life, will aim at developing mathematical algorithms that can be used for quantum simulation of biomolecules and thus makes it possible to study biomechanical processes. The two new centres will be placed at Copenhagen University.

“Quantum for Life will develop and use customized quantum algorithms, and in doing so, allow us to open up a new chapter in ‘computational life-sciences’ here in Denmark. With the new centre, I am pleased that the quantum mathematics we work on will be able to be used to solve important issues surrounding fundamental biological processes”

Professor Matthias Christandl,
PI - Quantum for Life

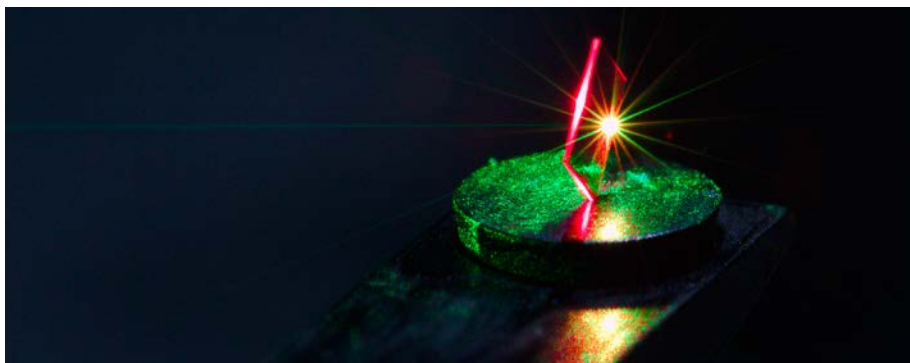
“Today, people are trying very hard to develop new medicines, because with normal methods it is not possible to calculate how proteins and other complex systems react to new medical products. Here, quantum technologies give us new opportunities, as we will be able to develop specialized quantum simulators that are tailored to tackle these processes”

Professor Peter Lodahl
PI – Solid-Q

RESEARCH HIGHLIGHT III: ULTRA PRECISE MEASUREMENT

In Denmark, you will find world-leading research groups working to advance second-generation quantum technology by pushing the limits of sensing to an entirely different level of detailing. Denmark offers competences in:

- **Diamond based 2+1-dimensional magnetometry:** Development of compact magnetic field sensors with unprecedented combination of field sensitivity and spatial resolution for bio-medical sensing.
- **Magnetometer for biomedical applications:** Highly sensitive, practical miniature magnetometer and show a lab demonstration of the magnetometer's capability to detect biologically relevant signals.
- **RF-to-Optical Transducer:** Advancement of MEMS devices with optical sensing in a novel way that is both simple to model and understand whilst being compatible with a general set of electronic circuits that are standard fare in many applications.



SENSING THE BEATING OF AN UNBORN HEART

- Researchers at the Niels Bohr Institute are developing sensors, which can detect extremely small variations in the magnetic fields, and tissue conductivity, which is part of all life processes. This may be used to detect fetal abnormalities e.g. heart anomaly while the fetus rests undisturbed inside the womb. For obvious reasons non-intrusive methods like this will be desirable also when examining delicate parts of the body such as the brain.
- Similar types of quantum sensors may be used for a variety of purposes such detection of gravitational waves helping us to better understand the universe.
















EASY ACCESS TO TALENT

Denmark has the highest number of graduates of quantum relevant studies pr. million inhabitants and new master programs within quantum science underway, which will strengthen the talent pipeline within the next years.

Denmark is also at the forefront when it comes to taking active steps in securing the industry access to necessary competences in order to realize the full potential of quantum technology. A new project at Aarhus University funded by The European Research Council is e.g. mapping future industry need for competences and developing new intuition-based course modules for non-physicists and creating common languages for specialists working with quantum technology e.g. engineers and project managers.

In general, the Danish government has a very strong focus on strengthening industry access to STEM talent and has initiated several initiatives to secure that demand can be met. In 2020, the number of STEM students admitted to Danish Universities was e.g. increased with 9%.

Denmark is the top country in the world on the number of candidates trained in quantum technology relative to population size

Rank by # of graduates of quantum-relevant studies*/mn. inhabitants			Absolute # of graduates	
1		Denmark	645	3,753
2		France	438	29,433
3		United Kingdom	392	26,236
4		Germany	356	29,491
5		Australia	280	7,075
6		Switzerland	280	2,406
7		Netherlands	263	4,539
8		Poland	249	9,427
9		United States	242	79,794
10		India	217	296,601
11		Italy	175	10,540
12		Spain	158	7,364
13		China	157	218,981
14		Russia	137	19,787
15		Korea	116	5,988

Source: Ministry of Higher Education and Science, 2020

NEW EDUCATION

MORE QUANTUM HEROES ARE COMING

In the summer 2022, a new MSc education in Quantum Information Science will commence if approved by the Ministry of Higher Education and Science. The future candidates will be trained in subjects like quantum encryption, quantum-based communication, and applied quantum science. The new education is a collaboration between the University of Copenhagen and The Technical University of Denmark (DTU).

TOP 10 REASONS FOR CHOOSING DENMARK

1. LEGACY

Denmark has a strong legacy of being where it all started and where a new kind of physics gave birth to a new world-view – what we call the first quantum revolution.

2. SCIENTIFIC IMPACT

Denmark is home to some of the world's most excellent researchers and research groups ranking in the absolute global elite in terms of scientific impact and able to attract large-scale private investments.

3. START-UP ECOSYSTEM

Denmark has a vibrant start-up ecosystem and in recent years, several new spinouts developing quantum technology or enabling technology for quantum technology has been spun out from Danish Universities.

4. IDEAL TEST-BED

Denmark offers an ideal test-bed for bringing together top-quality scientists, engineers, students and entrepreneurs in a culture characterized by trust and creativity.

5. TRADITION FOR PUBLIC-PRIVATE PARTNERSHIPS

Denmark has a strong tradition of industry, academia and authorities joining forces to address complex problems by accelerating research and innovation, which involves high risk and a long time horizon.

6. ACCESS TO TALENT

In Denmark, it is easy to recruit staff with the right expertise in quantum technology at the highest international level. Our high living standards also makes us an attractive place to live and work.

7. STATE-OF-THE ART INFRASTRUCTURE

Denmark offers state-of-art infrastructure and top facilities where your company can design, test and manufacture new quantum technology and/or develop/validate use cases.

8. ENABLING TECHNOLOGY AND COMPETENCES

Denmark has strong research communities within photonics, material science, nanotechnology and computer science that is able to drive complex R&D projects, which requires multidisciplinary competences.

9. HIGHEST INVESTMENT POTENTIAL

Greater Copenhagen has the highest investment potential if measured by pro-portion of co-publications with researchers from private companies when compared to key competing regions in Europe.

10. STABILITY AND EASE OF DOING BUSINESS

Denmark is characterised by political, economic and regulatory stability and offers a low corporate tax rate, flexible labour market conditions and simple procedures for establishing a business.



WHAT THE COMPANIES SAY

MICROSOFT

"Copenhagen University is among the leading institutions within the field of quantum research in the world and in Microsoft we have a long tradition of both developing and applying intelligent technology. It's our hope and ambition that by combining our resources we can take quantum computing to the next level, where it will have a great benefit for our society"

Charlotte Mark, Microsoft

KPMG GLOBAL

"For the sake of our clients and society at large we have to take a stand on and deal with both the possibilities and the threats in quantum technology. As an example: If capable quantum computers are ready by 2030 they will be able to read all encrypted data - also data from 2020, such as patient records, bank data and intelligence data. Fortunately, quantum technology is already available today, which can secure our communication against being decrypted. We need to apply that quantum technology now.

In Denmark, we have access to researchers who are among the best in the world. We believe that corporation and joint funding between public and private key players will bring KPMG and Denmark into the forefront in a number of quantum technology areas."

Bent Dalager, Nordic Head of NewTech KPMG

LET US HELP YOUR BUSINESS

Invest in Denmark provides all the support you need for locating your business in Denmark. So, if you are considering setting up or expanding your activities in Denmark, make us your first stop.

Our specialised, international staff can advise you on every aspect of locating a tech business in Denmark whether you want to set up or scale your business.

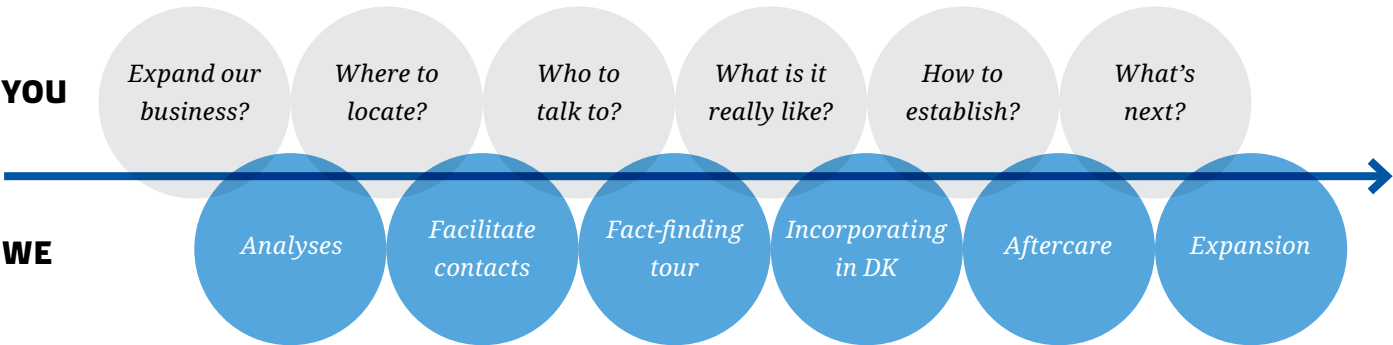
Our tailor-made solutions include connecting companies with key local stakeholders, arranging fact-finding tours and providing comprehensive benchmark analyses. We make sense of local legislation and the advantages of locating in Denmark – all free of charge and fully confidential.

WE START WHERE YOU ARE

The process of expanding a business takes many forms – depending on the type of business, organisational structures, resources and more – all unique to each company.

Whether your company is considering relocating, consolidating, setting up new production facilities, establishing R&D facilities or is looking for new innovative partners, Invest in Denmark is the place to start.

Invest in Denmark starts where you are – and assists you all the way to an establishment in Denmark and beyond.



DENMARK: THE GREEN FACTS



#1 IN THE WORLD
on climate change action

Environmental Performance Index, Yale University, 2020

**PRODUCED RENEWABLE
POWER BY 2019:**

47%
WIND

3%
SOLAR

0%
Greenhouse Gas
Emissions by
2050

100%
GREEN ELECTRICITY BY
2027

**#1 OECD
RENEWABLE
ENERGY TRENDS**

*World Economic
Forum 2020*

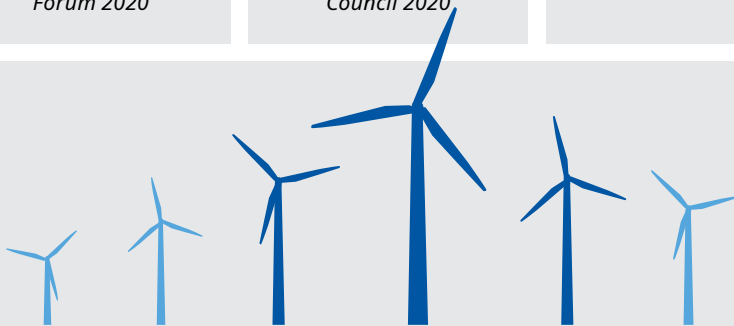
**#3 WORLD
BEST ENERGY
SYSTEM**

*World Energy
Council 2020*



64%

**DANISH HOUSEHOLDS
HEATED BY DISTRICT
HEATING**



**DENMARK AIMS TO BE POWERED ENTIRELY BY
RENEWABLE SOURCES BY 2050**

#2 IN ACHIEVING THE SDGS

SDG Index 2020

**#1: ORSTED
#2: CHR. HANSEN
#6: NOVOZYMES**

**Danish corporates receive top
rankings on sustainability**

Corporate Knights 2020

**GOVERNMENT
CLIMATE ACT TARGET:**

70%
reduction of CO₂ by 2030

HEADQUARTERS

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OUR GLOBAL PRESENCE



WE LOOK FORWARD TO WELCOMING YOU TO DENMARK

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