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The World's Best Location for Materials Research

By
Copenhagen Capacity

Table of contents

Preface

For many people **research into photon and neutron sources** is still closely linked to fundamental research in physics, chemistry and other sciences. However, with the emergence of new high-power sources, advances in equipment and advances in computing power and data processing, these methods are no longer only of interest in the sphere of fundamental physics but are also increasingly being used in industrial applications.

The aim of this brochure is to provide a closer look at the new facilities being developed in the Öresund Region of Copenhagen and the southern part of Sweden. What makes this region particularly suitable and of interest to a wide range of researchers and industries is the current construction of the **MAX IV plant and the European Spallation Source (ESS**) together with the existing **3D Imaging Center of the Technical University of Denmark (DTU)**. These facilities combined will form a world-class infrastructure for research into a variety of materials and create an outstanding research landscape characterised in particular by complementarities between the different facilities.

Numerous projects and partnerships already exist between companies and the local universities in Copenhagen in the field of **X-ray and neutron scattering**, based on the existing technologies at both the DTU and the University of Copenhagen. Long-term contracts with the emerging ESS and MAX IV institutions mean that the resident universities can also ensure access to the most advanced research facilities in neighbouring Lund. This is supported by funding from the Structural Fund and a private industry portal, and this targeted cooperation with the DTU and the University of Copenhagen is also available to your company to mutual benefit. The data management facilities and the ESS Software Center further emphasise **the attractiveness of Copenhagen as a location for a research & development facility**. Together the DTU and the University of Copenhagen form a strong partnership in the industry, which can function both as a first point of contact for your company as well as a link to the emerging world-class research facilities.

On the following pages we will outline the leading modern systems in the field of **materials research and product development** for you and describe how these are relevant to many companies within the industry. Starting with an introduction to the research facilities, the brochure contains examples of important innovations that have been created with the help of fundamental research. This will give you an insight into how this excellent infrastructure could provide your company with a key competitive advantage.

General facts

MAX IV

Image:
MAX LAB – Fojab Arkitekter Snøhetta

Information:
The facility will enable researchers to explore different materials and substances more quickly and at higher resolutions than ever before.

Timeline:
The facility will be finished in 2016.

European Spallation Source (ESS)

Image:
© Henning Larsen Architects:
European Spallation Source
– bird's eye view

Information:
The European Spallation Source aims to be the world's leading center for materials research and life science based on neutron sources.

Timeline:
The facility will be finished in 2025.

3D Imaging Center

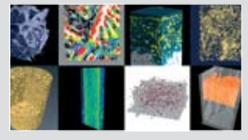

Image:
DTU Imaging – 3D Imaging Center

Information:
The 3D Imaging Center is a center of excellence for the 3D imaging of materials using x-rays and neutrons.

Facts:
The center is already up and running. It has Xradia VersaXRM-410 micro-CT equipment with a resolution of 1-50 µm of tests sized 1-50 mm.

Introduction to the facilities

Max IV

The MAX IV consists of two facilities, the MAX IV facility, which is currently under construction and will open in 2016, and the MAX-Lab. The Max-Lab was opened in 1987 for scientists to use the MAX I, II and III rings. The MAX IV facility, which is currently being built on the outskirts of Lund in Sweden, will be the world's best synchrotron light source. The facility will enable researchers to explore different materials and substances more quickly and at higher resolutions than ever before. This could lead to a significant improvement in the quality of a product or the development of a new or better solution to an existing product line.[1] The technology revolves around x-rays and is especially used for recording changes that occur in materials under operating conditions. Furthermore, the technology can be used for microscopic studies of materials at very high spatial resolutions (down to 10 nanometres).

> "ESS will be around 30 times brighter than today's leading facilities.[2]

European Spallation Source (ESS)

The European Spallation Source is a new European research facility that is aiming to become the world's leading facility for research using neutrons.[3] Neutrons can help determine the composition of a given material or the properties of an object. Furthermore, the ESS instruments can help create still and moving images of the hidden structures and the atomic processes within an object.[4] ESS will provide new opportunities for researchers in the fields of life sciences, energy, environmental technology, cultural heritage and fundamental physics. The planned facility will be finished in 2025 and will cost about €1,843 billion.[5] ESS is a European project with Sweden and Denmark as host nations. In Denmark, the Data Management and Software Centre (DMSC) will be built in Copenhagen.[6]

[1] http://www.lightsources.org/facility/maxiv
[2] http://europeanspallationsource.se/european-spallation-source-0
[3] ESS activity report 2011-12 – page 6
[4] 3D Imaging Center – En portal for industriel anvendelse af ESS og MAX IV
[5] http://europeanspallationsource.se/faq-funding-and-costs
[6] http://europeanspallationsource.se/ess-organisation

Below is a map of the Öresund region. Copenhagen and Malmö are connected by the Öresund Bridge, making travel between Denmark and Sweden very easy.

3D Imaging Center – Assisting you with your research

Although the potential exists for extraordinary and revolutionary research to be carried out at the two facilities in Lund, there is a problem in terms of access and availability. Companies may have limited knowledge or expertise to conduct the research themselves, or they may simply not have the means to do so. Therefore, an industrial portal has been established as part of the Structural Funding Project in Copenhagen known as "ESS og MAX IV som vækstmotorer I hovedstadsregionen", which has been set up with the Technical University of Denmark (DTU).

3D imaging will make it possible to depict materials and the internal structure of their components in order to see how these change over time, for example under stress and operational conditions. This could prove beneficial for a wide range of companies operating within different industries, such as energy, cleantech, nanotech, transportation, mechanics, construction and the environment. The tool will help companies to better understand their products, develop new and innovative products, or improve the quality of their current products. DTU has already signed a long-term contract with MAX IV ensuring close collaboration in the future.[7]

[7] 3D Imaging Center – En portal for industriel anvendelse af ESS og MAX IV – page 9

Getting to Denmark for Materials Research

Copenhagen Airport - Scandinavia's hub airport

Copenhagen airport is Scandinavia's hub airport, i.e. the transfer airport for air traffic between other parts of the world and the many national and regional airports in Scandinavia and the area south of the Baltic Sea. Over the next couple of years, the airport will be expanded to be able to handle 40 million passengers a year.[8]

> "There is a train connection between Copenhagen and Lund every 12 minutes.

Distance between Copenhagen and Lund

The distance from Copenhagen to Lund is 50 km. The train from Copenhagen Central Station to Lund Central Station leaves every 12 minutes.

[8] http://www.cph.dk/en/about-cph/profile/Facts-about-CPH/A-quick-overview/

Examples of new innovations

The number of new innovations that have resulted from research at similar facilities such as CERN in Geneva and Oak Ridge National Laboratory (ORNL) in the United States is extraordinary. Some of the most interesting research or innovations are listed below.

Capacitive touch-screen

In the 1970s, when the Super Proton Synchrotron (SPS) in CERN was being built, Frank Beck and Bent Stumpe were given the task of developing a user-friendly and intelligent system that would replace the conventional buttons in the central hub. In 1973, the world's first capacitive touch-screen prototype was built. Today, capacitive touch-screens are used in a vast array of different devices including iPhones and iPads.[9]

Tetra Pak Packaging Solutions

Tetra Pak is a global supplier of food processing and packaging solutions which is constantly looking to improve its products. The company therefore approached the MAX IV Laboratory. The researchers at Tetra Pak used Small Angle X-ray Scattering techniques to understand the materials they were using and develop ways to improve them.[10]

Residual stress-testing by Volkswagen

Volkswagen, one of the largest automotive companies in the world, sent engineers to Science Link in Lund to investigate residual stresses in the test castings of aluminium based alloys. The simulations created by the engineers helped predict the stresses and increase the reliability and the durability predictions of the aluminium alloys.[11]

Product development by Novo Nordisk

Novo Nordisk, one of largest diabetes care providers in the world, used the Molecular Crystallography facilities at the MAX-Lab to determine the 3D structure of a molecule when bonded to its receptor in order to further understand bodily functions and to develop the company's products.[12]

[9] http://www.pcpro.co.uk/realworld/357325/capacitive-or-resistive-whats-the-best-type-of-touchscreen
[10] http://redit.skane.com/sites/default/files/media/document/case_tetra_pak_science_link.pdf
[11] http://redit.skane.com/sites/default/files/media/document/volkswagen_science_link.pdf
[12] http://redit.skane.com/sites/default/files/media/document/case_novo_nordisk_science_link.pdf

Why establish a research department in Copenhagen?

According to the Economist Intelligence Unit's business ranking model, **Denmark is the world's easiest place to do business**.

The labour market

Denmark has the most flexible hire/fire legislation in the EU. This means that **starting and running a company in Denmark is low risk.**

Taxes

In Denmark, the tax paid by expats and researchers is only **26% for 5 years**, while corporation tax will only be **22% in 2016.**

Policy towards private enterprise and competition

Social security contributions paid by Danish employees are **the lowest in Europe.**

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Contact

This report has been created by Copenhagen Capacity, which works to promote marketing and business in the capital region.

Copenhagen Capacity can put you in touch with the right people for the projects that are relevant to your company.

Copenhagen Capacity can help all companies considering locating or expanding their operations in Copenhagen to succeed in achieving their business goals.

Our services are available to all foreign-owned companies and are provided free of charge.

Copenhagen Capacity is the Danish capital city region's official organization for investment promotion, business development and cluster growth. Founded as a non-profit organization with the mission to grow business capacity in the Copenhagen region, Copenhagen Capacity is working to:

- **strengthen the region's** international competitiveness
- **market its strongholds internationally**
- **improve framework and factor conditions** for businesses, cluster organizations and international talent

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