A key player in the global tech race

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Nanolab Phase 4: A key player in the global tech race

DTU's planned cleanroom, Nanolab Phase 4, will be a cornerstone in the developing work of Danish technology companies. NIL Technology, a world leader in nanotechnology, is one of the companies ready to use this advanced cleanroom. According to CEO Theodor Nielsen, the new facility will enable the company to maintain and develop its operations in Europe.

DTU is currently planning the details for a long-awaited new cleanroom for nanofabrication. Nanolab Phase 4 expands the existing cleanroom and creates a comprehensively and robustly planned nanotechnology laboratory providing researchers, students, and tech companies with a highly specialized facility. This new cleanroom positions Denmark as a key player in the development of nano components, such as chips and optics—components essential in almost all modern devices and systems.

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>
> – Anders Jørgensen, vicedirektør, DTU Nanolab

An essential facility in the digital age

Nanotechnology is evolving rapidly and has a significant impact on our daily lives. Without chips our payment systems, communication channels, transportation systems, and healthcare systems would collapse. They are increasingly integrated into our daily lives and society. We depend on these small components which are constantly becoming smaller, more efficient and cheaper.

THREE VIEWS OF THE NEW CLEAN ROOM. Companies can use DTU Nanolab's future cleanroom Nanolab Phase 4 (B346A), which Campus Service will build. In the newsletter you will meet Anders Jørgensen (left), who is deputy director of DTU Nanolab, Theodor Nielsen (bottom right), who is director of NILT and Troels Lysgaard-Hansen (top right), who is project manager in Campus Service. Photos: DTU/NILT

"If Denmark is to seize the opportunities that nanotechnology offers, we need to expand our cleanrooms so we can create the chips that the world requires for example in quantum technology, biosensors, and optics. With nanotechnology, we can transmit more information via fiber networks, conduct faster and more accurate diagnostics, make wind turbines more efficient, and contribute to new, more sustainable technologies. Our new cleanroom will serve as a springboard for all of these developments," says Anders Jørgensen, Deputy Director at DTU Nanolab. "Chips are considered one of the most important resources of our time. Our society cannot function without them. That is why the expansion of the cleanroom is so important for Denmark."

New cleanroom keeps leading companies in Denmark

Nanolab Phase 4 is crucial for Danish and international companies, such as NIL Technology (NILT), which develops advanced optical lenses

for applications like facial recognition in mobile phones and sensors in cars. They are among the upcoming users who applaud DTU's investment in the new facility. Their work requires more space and more flexible working environments. When the expansion is complete, they will bring in machines for producing masters for components used in emerging technologies like 3D sensing and eye-tracking in glasses. Their lenses are competitive because they are more compact, precise and cost-effective than traditional lenses.

"We need more space to maintain our development in Denmark. In DTU's new cleanroom, we not only get the space but also the collaboration with researchers and students that we need. It's invaluable to us and supports a growing industry with expertise," says Theodor Nielsen, one of the founders and the CEO of NILT.

The company, which has been a startup to watch since its establishment, made it to the top 50 European tech companies with the most growth potential in 2023. According to Theodor Nielsen, we will soon see a development where Virtual Reality (VR) and Augmented Reality (AR) will gain more prominence. As an example, AR, which integrates digital information with the real world, can be used as a sensor in a car windshield that issues an alert if the driver is not looking at the road. This technology can also be used in educational systems, eliminating the need to physically send a person when employees need training. It can be effective on oil rigs, in healthcare, in manufacturing and more.

Anders Jørgensen also expects a lot from the mix of users and the synergy that will create:

"The companies working here will have direct access to new talent. Here, they can meet bright engineering students, and the students can see how what they learn is directly applicable in the companies," he says.

When NILT occupies space in the new cleanroom in a few years, it will be to create masters that the company uses to manufacture advanced optical lenses, known as metalenses, which will be used in all sorts of sensors, especially in future phones. These masters will also be used to produce AR glasses.

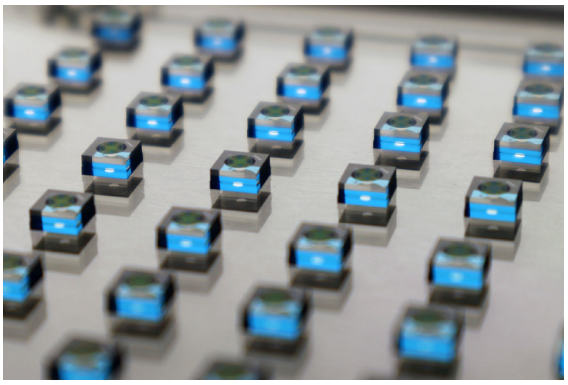
Theodor Nielsen emphasizes the importance of DTU's long-term and ambitious strategy to build and operate a new cleanroom:

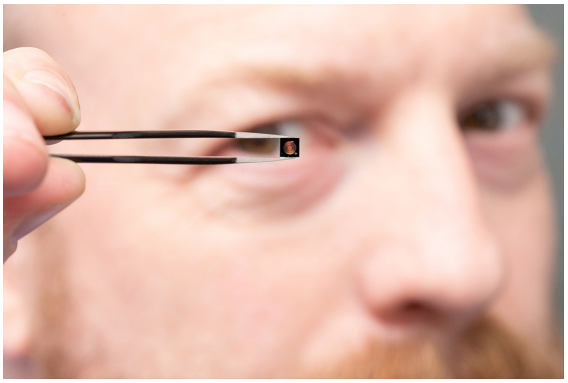
About NIL Technology (NILT)

NILT was founded by Theodor Nielsen and Brian Bilenberg, both of whom are civil engineers from DTU and were pursuing a Ph.D. at DTU when they took a leave of absence and started NILT. They specialize in creating advanced optical lenses, known as metalenses, which are flat instead of curved. Their primary focus is on optical lenses for smartphones, Virtual Reality, Augmented Reality and sensors for cars.

Their solutions are used in applications like facial recognition on mobile phones. These lenses are built using nanostructures and are flat lenses that are more advanced than traditional curved lenses. The fact that the lenses are flat allows for the production of more advanced lens features than curved lenses, where multiple lenses are stacked on top of each other. This technology means that an advanced flat optical lens can replace four curved lenses.

Optical lenses built using nanostructures are compact, simple, and temperature stable. A stable temperature is important in phones that need to work even in high heat or in sensors in car windshields that can get hot in the sun. The market also includes wearables that measure pulse, blood oxygen levels, and AR displays, which NILT expects to gain significant ground in the coming years.





OPTICAL METAL LENSES. NILT manufactures prototypes of optical lenses with electron beam lithography in the clean room at DTU. In order to be able to keep the work on Danish soil, NILT needs more space and a flexible framework. At the top you can see the optical metal lenses, also called Meta Optical Elements. At the bottom, Director of NILT, Theodor Nielsen takes a closer look at a single metal lens. Photos: NILT.

"With the new cleanroom, DTU is creating a significant knowledge-based workplace with the necessary infrastructure, educated employees, and the required technology. It is a strength for our competitiveness and entrepreneurship to have such a facility on Danish soil."

— Theodor Nielsen, Direktør, NILT

"With the new cleanroom, DTU is creating a significant knowledge-based workplace with the necessary infrastructure, educated employees, and the required technology. It is a strength for our competitiveness and entrepreneurship to have such a facility on Danish soil. This means that we keep our development in Denmark instead of seeking it in the East."

New Nanolab supports EU ambitions

According to Theodor Nielsen, Denmark should invest in nanotechnology right now and, most importantly, maintain that investment. Only in this way he believes, can we reap the benefits, namely, becoming a leader in knowledge and technology related to optical lenses and nanotechnology. Developing deep-tech, characterized by long-term and resource-intensive investments in new markets, takes time, but the good news is that jobs will be anchored where the infrastructure is present.

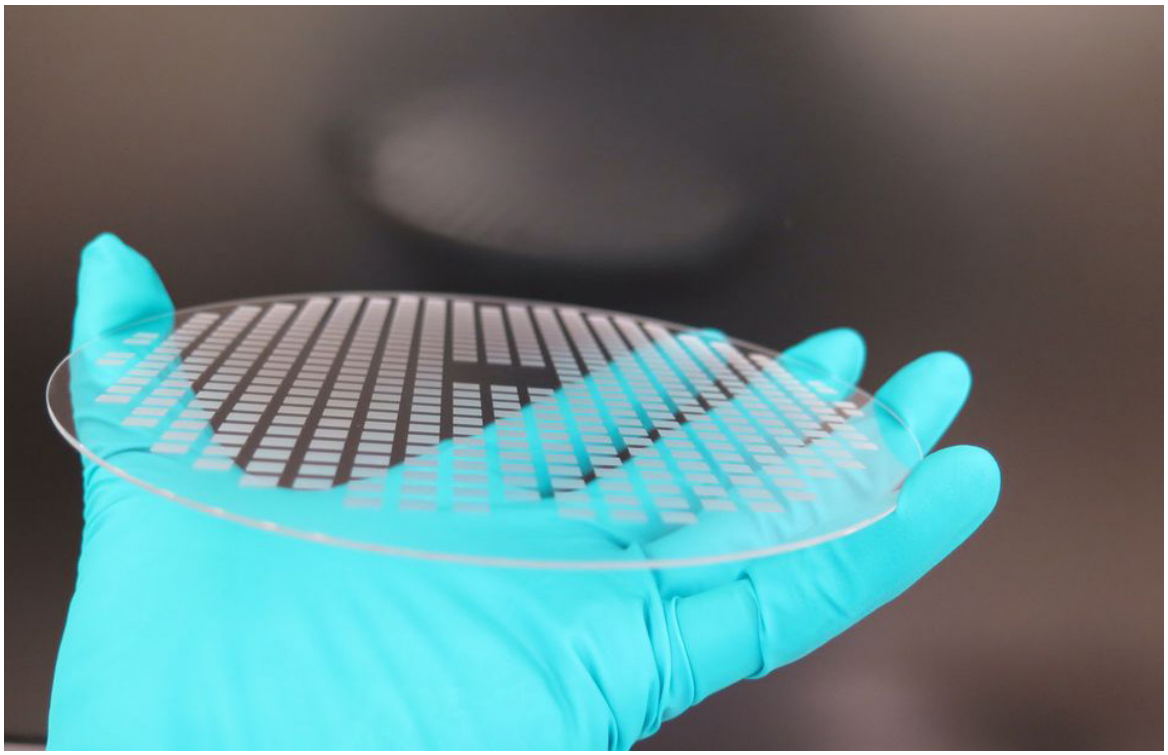
"Follow-up investments are necessary for a field like nanotechnology, and that's why the new facility at DTU is essential for whether we can succeed in keeping an expanding market in Denmark and Europe," says Theodor Nielsen.

In July 2023, the European Council adopted The European Chips Act, which aims to boost digital innovation in the EU and give Europe a share in the supply chain for major tech manufacturers—a share that currently only constitutes 10% of the global microchip market. The goal is to achieve a 20% market share by 2030, reducing Europe's dependence on the USA and Asia—a challenge that became particularly evident during the COVID-19 crisis when many tech manufacturers had to increase prices for products such as phones and washing machines because chips became a scarce commodity due to production shutdowns worldwide.

Nanolab Phase 4 is expected to become a national hub for researchers, companies, and students when complete.

How to build with many constraints

How do you build an ultra-clean, stable and controlled environment for research and production in a highly technological field that is evolving rapidly?
Troels Lysgaard-Hansen, the project manager for the construction at DTU Campus Service, has the answers. And it's not a simple process. It requires



WAFER. The optical elements are seen here on a so-called wafer, which is a thin slice of semiconductor. Photo: NILT.

Chips - the components we can't live without

Chips are a coveted building block that is found in virtually all high-tech products from traditional digital microchips in computers and mobile phones to chips made using the same technologies but with entirely different materials. They are an essential part of the development and production of items like sensors, pumps, solar cells, hearing aids, and optical lenses for facial recognition in mobile phones. They are also the foundation of DNA screening, drug discovery, chemical analysis and quantum computers. Chips are made through nanofabrication, a technology we are already dependent on and whose demand is increasing.

There is geopolitics involved in chips. The EU is working to be able to supply chips to European companies themselves to lessen the dependence on countries such as China, Taiwan, and South Korea, which are major players globally. The EU is working to implement The European Chips Act, which aims, among other things, to increase the market share of all types of chips in EU countries, both digital and those based on new materials.

Europe and Denmark can become important suppliers, ensuring that the EU can provide the chips needed for our development and security. This requires the right facilities, and they are being built at DTU.

great precision and thoroughness in the design phase and the involvement of users, such as Nanolab itself, DTU Campus Service, students, and external companies like NILT.

Super-controlled space in a busy environment

The fact that the building is being constructed on DTU's Lyngby Campus, adjacent to the existing cleanroom, is challenging. It's a densely occupied area with daily traffic, elevators, tunnel systems, and more. Additionally, a light rail is being built right next door. Vibrations and electromagnetic influences can pose challenges when working with nanotechnology because even the smallest disruptions can affect the work in the cleanroom. The advanced processes the new building will host must be able to function under all conditions.

"When developing and manufacturing electronic components in the nanoscale, it requires that we build in a way that eliminates any vibrations in the cleanroom," explains Troels Lysgaard-Hansen.

To support the advanced research and technology being developed at DTU Nanolab extreme demands are placed on vibrations, air quality, temperature, and humidity. Even the slightest fluctuations in indoor climate can affect the results of the processes being carried out. The cleanroom and its associated technical systems must be executed with meticulous attention to detail, which places significant demands on design, planning, and execution.

B346A IS BEING BUILT AT ØRSTEDS PLADS. Nanolab Phase 4 will be built on Ørsteds Plads on the DTU Lyngby Campus and will be connected with the existing clean room, so that a unified facility is created. Photo: DTU

A physical framework for future technology
Science is constantly changing, and nanotechnology is no exception. To put the development into perspective, experts from DTU Nanolab say that if cars had progressed as much as digital chips have, we could buy a car for less than 10 DKK today and drive 20 million kilometers on one liter of fuel.

So, it takes something special to build a cleanroom, including the construction process itself. The project cannot be viewed as an optimized machine for a specific process or production here and now. Instead, as Troels Lysgaard-Hansen explains, we should see the project as a physical framework for activities that will unfold over the next 20 to 30 years. The big and challenging question is how to do that. Because who knows how science will evolve?

According to Troels Lysgaard-Hansen, the team at CAS is constantly asking questions to the users in a way that does not limit but opens up new ideas and provides insight into the larger goals and possibilities that can be achieved with the facility and its design.

"An important task for us at CAS has been to make decisions that do not limit. We need to dimension areas, facilities, and routes to a technological future that we may not necessarily be able to define today," says Troels Lysgaard-Hansen, emphasizing that CAS must always be curious about the technology and have respect for the users' expertise and experiences. Thorough dialogue is crucial not only to make the facility usable but also for the financials. It should always be clear when decisions that affect the result are made, and these decisions should be communicated and aligned with the users.

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Spontaneous encounters between researchers, students, and companies
In the cleanroom, companies should be able to rent workspace and shape the facility according to their specific needs and requirements. In some cases, there may be a need to create nanostructures in glass, while in other setups, silicon structures may be required. Etching may be necessary one day and not the next. The building is designed to allow quick adaptation to the users' demands. Input from

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— Troels Lysgaard-Hansen, projektleder, CAS

user representatives is continuously considered and developed. The users have also highlighted the need for more flexible common areas. Why great importance has been placed on creating an inspiring environment:

"We are building a facility with common areas that promote spontaneous knowledge sharing. A place that encourages an open culture, where you can find a suitable space to talk to others during a visit to Phase 4. We are creating open staircases, café areas, and places where people can sit down and talk," says Troels Lysgaard-Hansen, explaining that the building should also be inspiring and have ongoing exhibitions that convey nanotechnology.

The cleanroom will be a flexible research facility that supports the needs of all users, from basic research to small-scale production.

State-of-the-art: As sustainable as a cleanroom can be
DTU focuses on reducing energy consumption and long-term operating costs in all construction projects. The new cleanroom is demanding – the air in the cleanest rooms alone is recirculated several hundred times per hour. Nevertheless, the building will serve as an example of how to construct as sustainably as possible within this type of facility.

"We focus on a significant reduction in process energy and the consumption of resources, such as chemicals, water, and gas, etc. We do everything possible to reuse energy within the building. We want to show how to make this type of facility as sustainable as possible," says Troels Lysgaard-Hansen.

With the new facility, DTU is expanding what is already Denmark's largest semiconductor cleanroom. The building is expected to be ready by the end of 2026 at Ørsteds Plads on DTU's Lyngby Campus.

CLEAN ROOM IN B346. A look into DTU's existing clean room, which is now being expanded with Nanolab Phase 4. Photo: DTU

What is a cleanroom?

There are different types of cleanrooms. The common denominator is the control of contamination in the form of particulates. In semiconductor cleanrooms (like Nanolab Phase 4), there is positive pressure in the laboratory, ensuring that particles from the outside are kept away from the laboratory. In cleanrooms for the pharmaceutical industry, negative pressure is typically maintained to prevent contamination of the surroundings.

A ballroom, which will be Nanolab Phase 4's primary cleanroom, is a large, open and flexible cleanroom with an underlying deep basement (subfab) and an open plenum. The cleanroom is executed in ISO Class 4-6 as a flexible laboratory, with the supply of ventilation, gases, clean dry air, ultrapure water, etc., prepared for various machines and equipment. The new cleanroom includes rooms that are ISO 4 classified from the start. ISO 4 means that the air in the room circulates regularly and is filtered several hundred times per hour. This high air change rate is required when working at the nanoscale as it ensures the passage of particle-free air that keeps the facility clean.

What is a semiconductor, conductor, and insulator?

Materials behave differently when subjected to an electric field. Some materials easily allow a current to pass through, and these are called conductors. We encounter them in everyday life, like the copper inside many electrical wires.

Other materials do not allow any current to pass through, and these are called insulators. We are also familiar with them from regular electrical wires, where the plastic covering ensures that we can safely touch the wires without getting shocked or causing a short circuit.

There is also a special group of materials that exhibit some of the properties of both conductors and insulators. The behavior of these materials can be controlled by adding specific impurities or through other external physical/chemical influences. These materials are called semiconductors. The most well-known of them is silicon, which has been used in semiconductor technology for 70 years. Silicon technology is the dominant platform for digital chips worldwide.

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