Verksamhetsbeskrivning / Operational overview for Nanolab Science Village

1 Introduction and summary

Lund University has decided to build a new micro- and nanofabrication facility in Science Village, located at Brunnshög, Lund. The new investment will provide unique opportunities for research and collaboration with industry with the goal of improving conditions for human life and the climate through nanotechnology. It will be an important first step of Lund university's establishment of an active research environment at Science Village in close collaboration with the large research infrastructures MAX IV and ESS. Nanolab Science Village will be the third large, advanced research infrastructure for materials science in the area.

Lund University hosts world-class science based on semiconductor nanostructures. Essential to these activities is the ability to fabricate and manipulate nanostructures with extreme precision and control. The current lab (Lund Nano Lab) is part of the National Research Infrastructure Myfab and is one of the facilities with the highest number of booked hours (40 000 hours/year), but with the smallest working area. The ever-increasing demand for nanofabrication capabilities cannot be satisfied by the current lab as it is limited in both its capacity to meet the facility needs (air handling, cooling, etc) and the space claim for new and additional nanofabrication tools. Building the new Nanolab Science Village (NLSV) will secure the foundation of one of the strongest areas at Lund University and create new opportunities by placing it at Science Village.

Nanoscience and Nanotechnology at Lund University have a 30-year history during which our strategy has been to build on our core competences in semiconductor physics and material growth techniques, such as epitaxy, and to target inter-disciplinary scientific efforts at the highest international standard. NanoLund is Lund University's centre for nanoscience, as well as one of the Swedish government's strategic research areas, and is Sweden's largest research environment for nanoscience and nanotechnology. To stay at the forefront of nanoscience and nanotechnology we are entirely dependent on state-of-the-art facilities for micro- and nanofabrication. To further advance the research and technology transfer to industry, process control and reproducibility must be further improved, which can be achieved in a larger lab with separate process lines that separate incompatible processes and materials. One of the strategic goals of the lab is to serve as the world-class nanofabrication platform for inter- and cross-disciplinary research. As well as serving the academic community, the lab offers charge-based access to start-ups and industry, enabling those users to access state of art capabilities and in doing so, fulfilling an important task of the lab. We contribute to societal and sustainability challenges, for example in health and clean energy, using the tools of nanoscience and nanotechnology.

The existing large research infrastructures in the area, MAX IV and ESS, both provide unique, world-class capabilities for characterization of materials, and one could think of them as huge microscopes with special capabilities for investigating and analysing materials and molecular matter. Nanolab Science Village (NLSV) will complement this by providing a laboratory for the fabrication and synthesis of structures and devices to study at these infrastructures. Together with the leading nanomaterials research environment at Lund University, this will create a highly visible international centre for materials science thus further enabling research in physics, chemistry, and biomedicine. This will contribute to the vision of the Swedish government, to create a world leading research environment within material science and life science in this area.

NLSV will be a world class facility with a cleanroom area of 1400 m^2. This facility will be dependent on a sub-fab beneath the cleanroom to service the equipment needs; a highly sophisticated ventilation system to manage the cleanroom air quality and an extensive distribution network for utilities and process media that will be distributed from a gas tank farm. In addition, areas are needed for a control room, gowning area, workshop and offices for the staff working at the nanolab. The expected total area is about 5700 sqm.

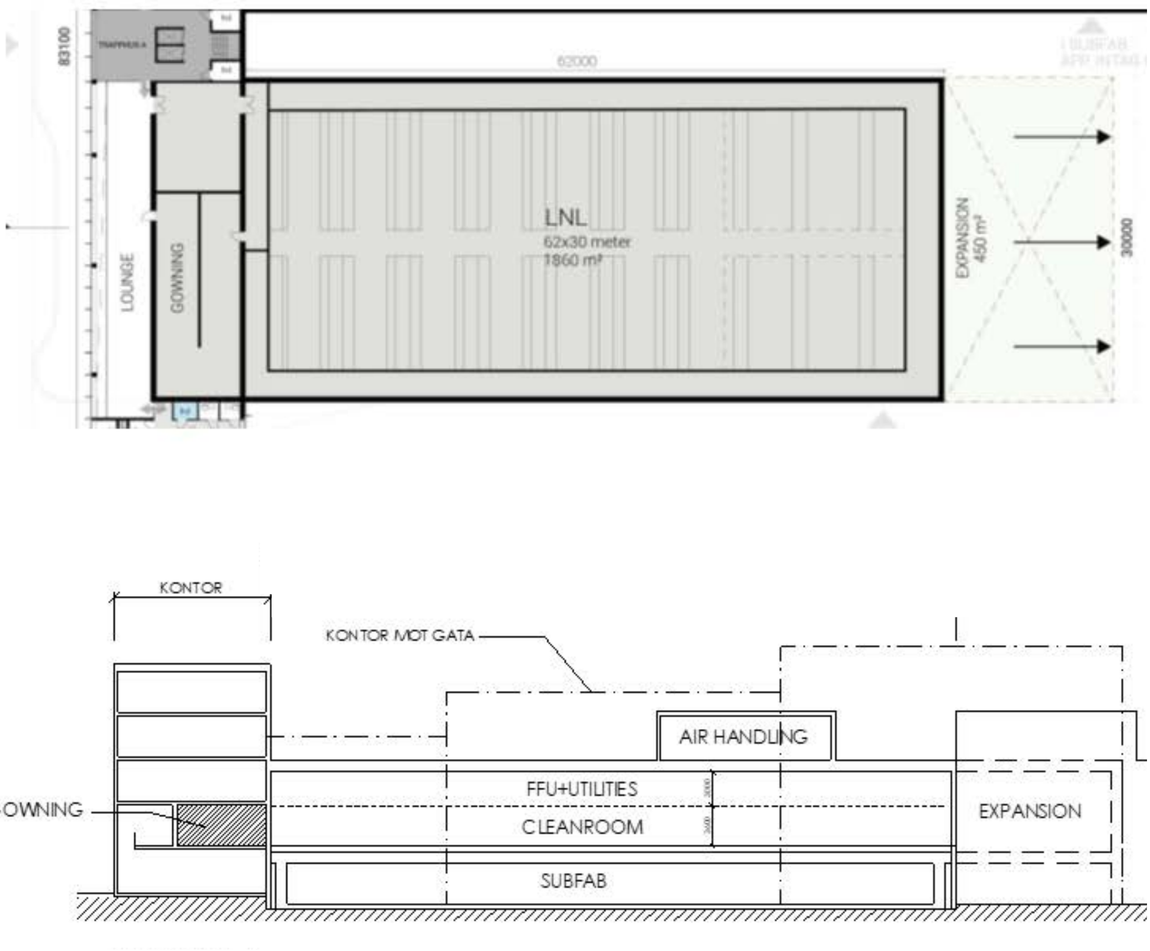

Fig 1. Above: Plan view of level 2. The actual cleanroom area is the inner rectangle with the text LNL. Below: Side elevation.

Technically, the building has many specific and advanced requirements, including those for vibration control, for a controlled atmosphere (particles, temperature, and humidity) and for minimal magnetic field variations. The facility will require a significant electricity supply, cooling water capacity and be prepared for handling chemicals and process gases, including highly toxic, flammable, and corrosive gases. It is important that the building will be designed with inbuilt flexibility, enabling us to add, move and remove equipment and dependent accessories and allow for expansion or modification of all installations/infrastructure. The main contractor needs to have specific expertise in and experience of advanced technical buildings and will need to partner with an experienced cleanroom subcontractor for designing the cleanroom itself.

2 Description of the activities

Nanolab Science Village will be an open research infrastructure for micro- and nanofabrication in a semiconductor cleanroom environment. The facility will be integrated in the national infrastructure, Myfab (the other nodes are found at Chalmers, KTH and Uppsala University), just like our current nanofabrication facility. We plan to host up to 70-80 simultaneous users and expect to have more than 200 active users. This could be compared to our current facility which was used by 135 active users during 2022 from Engineering, Natural Science and Medical Faculties of Lund University, as well as from other universities and five commercial companies. The majority of the users will most likely still be researchers within Lund University, but we will also have users from other universities (national and international), as well as external users from companies or other organizations. We give several undergraduate courses in the clean-room and every year we expect to have about 100 students gaining practical, hands-on experience in the clean-room.

The processing of structures and devices on the nanoscale requires a highly controlled environment. The dimension of the nanostructures is in the order of 10-100 nm, i.e. down to one hundredth of a micrometer or one thousandth of the diameter of a hair. In addition, we need very good control of surface areas, down to atom level control. This means any dust or particles from the environment or the operator’s skin will destroy the devices fabricated in the nanofabrication facility. The cleanroom suits serve to keep the environment clean, not to protect the people who are working in the laboratory.

Fig 3. Main methods used in the micro- and nanofabrication facility.

To operate the facility, we estimate a staff of 25-30 people. Mainly research engineers and technicians. The lab is open 24-7 for the users so it is important that disturbances to operations are kept to a minimum through planned services and preventative maintenance. To minimize the impact to the users, planned shut-down of operations are to be kept as short as possible and at times when the workload is lighter, which typically is the case at weekends. Planned maintenance must be discussed and agreed well in advance. Annual service should be coordinated and combined to as large extent as is possible – the number of planned shut-downs per year should be kept to a minimum. Unplanned maintenance (failures or acute problems with facility and central utilities including ventilation, electricity, cooling water and DI water) will force us to close the lab and stop the operation with little or no warning. It is required to have an agreed action plan to manage these cases.

Overarching aims to the new facility are:

- Provide state-of-the-art resources in nano and micro fabrication for its users to achieve the highest excellence in research and development.
- Design and deliver a sufficiently large and flexible lab space for the continued growth and dynamic developments in the research areas related to the lab.
- Provide a world class teaching environment for education programs such as ‘Processing and Device Technology’ and ‘Advanced Processing of Nanostructures’.
- Be at the forefront within the area of compound materials for semiconductor devices.
- Be able to offer stable processes and high reproducibility, which is especially needed for applied research, but also for fundamental research at the absolute forefront.
- Be a strong partner with MAX IV and ESS.
- Enable a significant utilization and collaboration with industry.
- Create easy accessibility for researchers, students, and external users.
- By design, to have inherently improved and safer infrastructure and logistics (devices, gases, chemicals, consumables).

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3 Facility and Utility Requirements

3.1 Utility requirements overview

This document provides the 'operational overview' for Nanolab Science Village (NLSV), and the intention is to give a good picture of the vision, mission, operation, size and broad overview of the most important technical needs for the new facility. In step 2 of the procurement, the full set of procurement documents with much more information and details will be provided.

3.2 Facility requirements

An estimate of the facilities planned is given below.

	Area (sqm)
Requirements within the vibration damped construction (main lab)	
Cleanroom	1 400
Perimeter corridor for visitors / service	400
Subfab / basement including shipping and receiving	1 620
Chemical storage	125
Ventilation / air handling	280
Total lab area	*3 825*
Requirements within the "office" building – "lab related"	
Gowning area and transfer areas	215
Process control room	30
Mechanical and electrical systems centrals	200
Facility workshops	300
Other areas	60
Sum lab-related in "office" house	*805*
Within the office building – "non-lab related"	
Entrance, user lounge and lunch area	350
Offices	345
Meeting rooms	90
Other areas	110
Sum of normal in "office" house	*895*
Outside the main building	
Tank farm and gas bunker	150
Back-up power	30
Waste room	20
Sum outside	*200*
Total	5 725

As mentioned above, this is a facility with many technical requirements. We give an overview of some aspects in the table below presenting the order of magnitude needed. More details will be provided in step 2. When calculating the quantity and maximum flow of different utilities, it is already considered a level of redundancy (the need to install new and different equipment in the future) and that not all equipment will be running simultaneously.

Utility	**Total**
Power, Amps (400V)	1 500
Power, Amps (240V)	500
Heat to Ambient from equipment, kW	200
Compressed Dry Air, flow (l/min)	700
Compressed Dry Air, quantity, M3/day	450
N2 utility, flow, l/min	1 100
N2 utility, quantity, M3/day	500
Process cooling, l/min	500
DI water, M3/day	100
Acid exhaust, M3/hr	20 000
Solvent exhaust, M3/hr	50 000
Scrubbed exhaust gases, M3/hr	10 000

To work with micro and nano fabrication, the equipment installed in the cleanroom must be isolated from vibrations from the office building, central utilities, goods receiving and the wider environment at Science Village. The cleanroom floor on which the equipment is installed will be specially designed to achieve vibrational control according to Vibration Criterion 'VC-E'. A detailed investigation must be made to assess the requirements and the structural design for this part of the building.

The particle level in the cleanroom air will typically be required to be controlled according to ISO 14644-1, to the equivalent level of ISO 5-7. In some areas, by actively utilizing minienvironments, even higher cleanliness levels will be required. Excellent climate control of temperature and humidity will also be required.

3.3 Energy efficiency

It is extremely important to consider that cleanroom operation requires a considerable amount of energy in the form of electricity, cooling and heating water capacity: it is estimated that the facility and equipment combined will require 0,9 GWh/year district heating; 1,5 GWh/year cooling water and 2,0 GWh/year electricity. The majority of this energy is needed for the air handling: excellent humidity and temperature control is required throughout the cleanroom. Finding energy efficient solutions, including innovative energy recovery, are critical for the project and to maintaining low operation costs and impact to the environment.

3.4 Overarching principle for the cleanroom design: Flexibility

The cleanroom is to be designed for maximum flexibility with regards to:

- Establishing different air quality in different areas (particle level, temperature and humidity) and flexibility to change over time.

- The use of partitions to separate different functional areas.
- The accessibility of utility supplies to be able to install equipment.
- The possibility for installation of new and alternative process equipment.

The plan is to have central plants with distribution of media (i.e., gas, water, power) that will be routed to all service areas of the cleanroom. In the service areas media connection points will be evenly distributed to allow a flexibility when connecting the individual equipment to the utilities. This will give an acceptable degree of freedom in tool selection and a layout flexibility during design and installation of the cleanroom facility and, perhaps more important, to maintain a high degree of flexibility throughout the lifetime of the facility. The tenant will, of course, consult the landlord before new equipment is installed to be able to check that the supporting systems and distribution of the different media are in balance.

3.5 Additional requirements

Some additional requirements are summarized below:

- All corridors, doors, etc., need to be wide enough and tall enough to transport equipment and goods into and out of the cleanroom.
- Occasionally, there will be a need to install or remove larger equipment that cannot be delivered via the elevator and perimeter corridor. Crane access will be needed to the locality to be able to deliver equipment directly to the 2nd floor.
- The required height of the chimney for some toxic exhaust gases will depend on the height of the surrounding buildings.
- Plan for expansion area for future addition to the lab.
- Transportation of chemicals, gases, waste with trucks shall be considered in the design of the surrounding area.

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