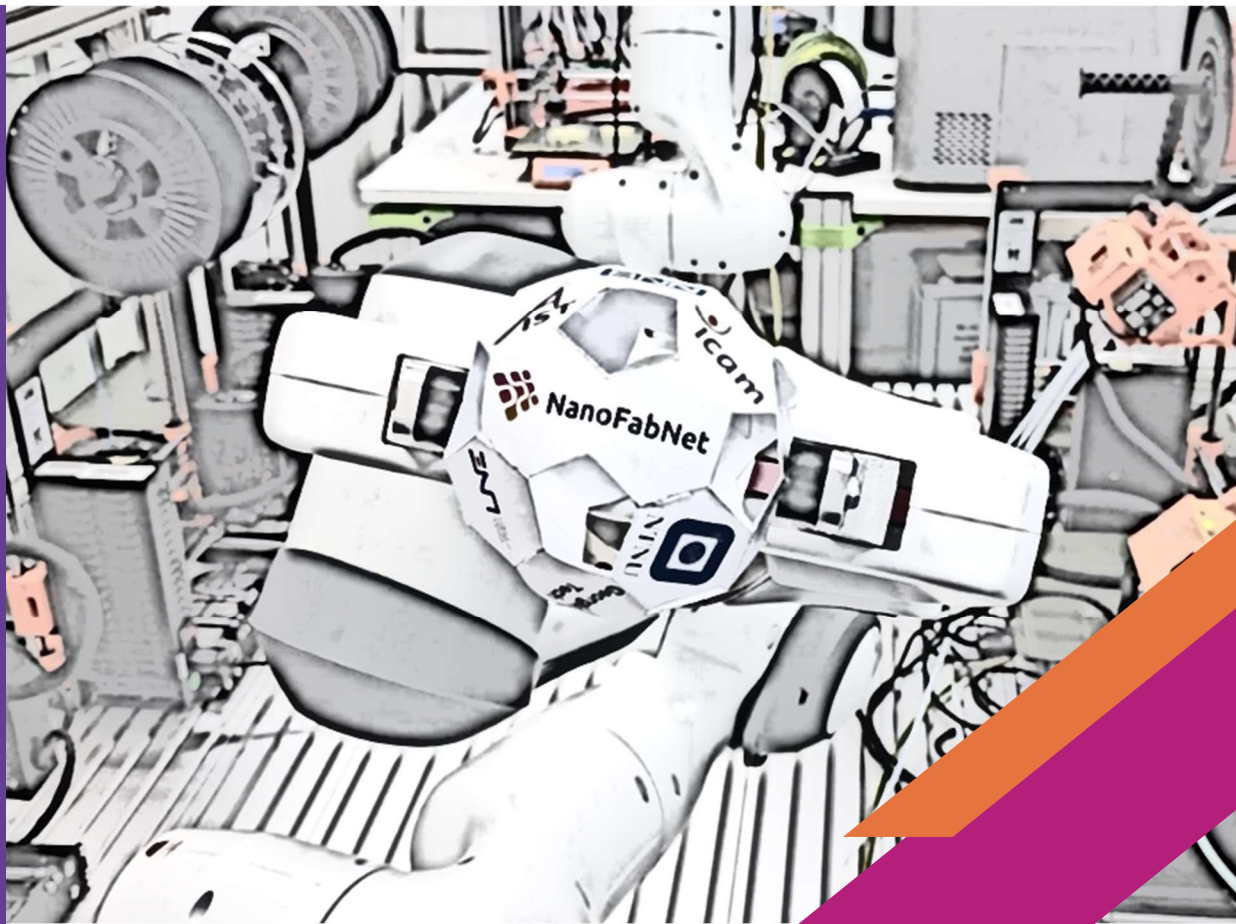
NanoFabNet

international Hub for sustainable industrial-scale Nanofabrication

Nanofabrication Competence Map: Infrastructures, Knowledge & Skills

- Proposal for a new Nanofabrication Taxonomy -



NanoFabNet Report

NanoFabNet

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Acronyms Listed in Document	
2D	Two-Dimensional
DOE	Department of Energy
FIB/SEM	Focused Ion Beam/Scanning Electron Microscope
ISO	International Organization for Standardization
NNCI	National Nanotechnology Coordinated Infrastructure
OECD	Organisation for Economic Cooperation and Development
R&I	Research and Innovation
RTO	Research and Technology Organization
TRL	Technology Readiness Level
US	United States

1. Executive Summary

In this report, we present an analysis of the offer of 66 cleanroom nanofabrication facilities located in 15 countries in Europe and the United States. These facilities advertise more than 3000 pieces of equipment to be used by both internal and external users under an open-access regime. These instruments are typically categorised into three-level structures and are described by various names. We have mapped the entire structure and naming conventions of these facilities. Then we have tried to identify repeating patterns and propose a universal structure under which the facilities' offers can be mapped, categorised and shared for the profit of all stakeholders. We found (weak) patterns in the instrument categorisations and found no patterns in naming convention. After this analysis, we proposed a completely new concept of generic instrument names together with categorisation based on the existing ISO standard. This ISO standard needed to be heavily modified and extended in order to cover all needs of current academic cleanroom nanofabrication centres. The final competence map consists of 5 categories, 21 subcategories and 55 generic instrument names. It covers about 80-90% of nanofabrication tools available in studied nanofabrication facilities, and the map is constructed in a way that other categories can be easily added if needed.

2. Introduction

Nanotechnology is a key enabling technology, which is used by many scientific fields. Nanofabrication knowledge, initially developed by information and communication technology related disciplines, has subsequently spread to many other fields like, among others, life sciences, astronomy, space exploration or environmental monitoring. The global research activity in nanotechnology - now dominated by Asia - continues to increase.[1] Nanofabrication can be done via two main routes: top-down approach which uses lithography to define structure dimensions and bottom-up approach which uses chemical synthesis to connect individual molecules into larger, functional building blocks.[2]

The top-down approach typically requires complex equipment for lithography, etching, deposition, and other auxiliary processes co-located together with characterisation in cleanrooms which require substantial resources to operate. Large initial investment, together with high operational costs of these facilities limits their number to only 1 to 2 in smaller countries and fewer than 10 in large countries. It means that they are typically operated as shared open-access facilities providing services and expertise to researchers form a larger region. They are also often listed on national roadmaps of research infrastructures.

The bottom-up approach on the other hand does not require such complex and expensive equipment and can be typically done in standard chemical laboratories which are available everywhere and in large numbers. Here, the need for shared research infrastructure is typically not so strong (a notable exception to this is the current interest in 2D materials, where the synthesis activity often takes place in cleanroom settings). On the other hand, access to infrastructures providing analytical equipment (e.g. electron microscopes, various types of spectroscopes, etc.) is required also in this branch of nanofabrication.

To keep things manageable, we limited this report and related work by the following constraints:

1. We focus on academic cleanroom nanofabrication facilities, as they represent the core of the nanofabrication research infrastructures. We have consciously omitted big research and technology organisations and companies from the mapping and profiling, as they are more

[1] UNESCO Science Report: towards 2030 (website; accessed: July 2021).

[2] See NanoFabNet deliverable D4.1 *'Report on the Challenges & Opportunities in the Validation, Harmonisation & Standardisation of industrial-scale nanofabrication'* for more detailed description.

single-field focused and also often do not provide detailed publicly available information about their equipment and open access to their infrastructure.[3]

2. During the work on this report, we concluded that it is necessary to focus first on available tools and instruments rather than on processes. As can be seen from the profiling of academic research infrastructures in section 3, the distinction between tools and instruments and processes in the offer of the individual facilities is very blurry and inconsistent. Sometimes the name of the instrument is used, e.g. "electron beam writer" (this term refers to a physical instrument), and sometimes a name of the process, e.g. "nanoimprint lithography" (this term refers to the process) is used. Thus the taxonomy presented in section 6 focuses strictly on tools and instruments.
3. We also exclude a majority of the analytical equipment from the analysis; only those analytical instruments, which offer some nanofabrication capabilities (e.g. lithographic scanning probe microscopes or FIB/SEM systems) are considered.

   The taxonomy presented in section 6 represents is only a starting point, which at this point, is ready to be presented to a broad nanofabrication community for review. However, a good strategy for how to present, promote and spread the proposed taxonomy needs to be developed - it will be done later within the frame of the NanoFabNet Project. If the adoption strategy is successful, it can serve as a role model for other facilities, such as those providing chemical synthesis or analytical services connected with nanofabrication and the competence map and connected taxonomy can substantially grow in the future.

2.1 Nanofabrication Competences – The Landscape

Nanofabrication facilities can be classified into three categories:

- **Academic research centres**, where the research is typically very multidisciplinary, and the access to the equipment and knowledge is very open, especially to academic researchers. The research conducted at the centres may focus on basic research and on lower TRLs (1 – 3), and may - at times - be curiosity-driven. The users of academic facilities often operate the equipment on their own. Examples of such facilities are cleanrooms associated with EuroNanoLab[4] (in Europe) or with NNCI[5] (National Nanotechnology Coordinated Infrastructure, United States). Funding of these facilities is mainly from public resources, and only a small part of research projects (typically up to 20%) is financed from the industry. Into this category we count also government-run user facilities, such as the Department of Energy (DOE) nanolabs in the US.[6] The DOE labs tend to be very basic science, and generally used by the government themselves or academic researchers.
- **Research and technology organisations** (RTOs), where the research may be of an applied research nature, focus more on technology transfer at higher TRLs (e.g. 4-6), building pilot production lines, where the product is tested before a full production line or even a new factory is built. These facilities are typically more specialised (e.g., to semiconductors, photonics etc.) than academic research centres, and access to them and to their knowledge (intellectual property, IP) is much more regulated. Examples of such facilities are IMEC, CEA-LETI and FRAUNHOFER IPMS. In these facilities, the majority of the funding (up to 80%) comes from industry, and a smaller part comes from public funds.

[3] Directorate-General for Research and Innovation, *European charter of access for research infrastructures,* European Comission, 2016 (website; accessed: July 2021).

[4] EuroNanoLab (website; accessed: July 2021).

[5] US NNCI (website; accessed: July 2021).

[6] US DoE Nanolabs (website; accessed; July 2021).

- **Nanofabrication foundries** (fabrication plants) often represent the final step in the research & innovation (R&I) value chain, where the full system development, integration and testing is done, and mass production of the product starts. These facilities are typically 100% privately funded, and all knowledge is heavily protected.

Here, we must note that the boundaries between the categories are not strictly defined, and individual research centres and facilities can (from a small part) operate at different TRLs than is usual for the given facility classification. For example, a start-up company can do their full production in a university cleanroom, or - on the other hand - a company can allow an academic research project to be conducted in their facility. Also, the percentage of public *vs* private funding does not need to be 80% - 20% and some organisations may position themselves at the borderline between RTO and academic research centres. For example, the International Iberian Nanotechnology Laboratory (INL) has many activities as RTO in technology transfer (e.g. building pilot lines) and at the same time provides open access to its infrastructure *via* its EuroNanoLab partnerships. Also, some national networks combine academic cleanrooms together with RTOs (e.g. Italy, Norway, Finland), providing resources for both blue-sky research and technology transfer.

3. Profiling of academic cleanroom nanofabrication infrastructures

In this chapter, we profile 66 nanofabrication facilities in Europe and in the United States. We have selected facilities organised under EuroNanoLab (Europe) and NNCI (United States) networks for the profiling. These facilities represent a substantial part of the transatlantic academic nanofabrication landscape. Both organisations are important NanoFabNet partners and will play an important part in the implementation of the results presented in chapter 6.

For each country, we include a brief description of the local nanofabrication research infrastructure landscape. Then we present a profile of each node (cleanroom facility) in the form of the table summarising the node's offer. The data for this profiling was obtained from publicly available information by analysing the web pages of the individual facilities. We have prepared a three-level table for each facility, and we tried to fit the available information on each facility into this table. As the exact meaning of each level content differs from facility to facility, we decided ona general, number-based naming of the different levels, where Level 1 contains most general groups and Level 3 contains the most specific groups or items.

For the majority of facilities that describe their offer already in a three-level hierarchical form, the allocation and division to the respective table levels was straightforward. However, in some cases, we had to use our best guess when transferring the facility offers into this three-level table or in the case of smaller facilities, the last level 3 had to be omitted.

The table content was directly transferred from the respective websites and only slightly edited for better readability. They truly represent the publicly available information offered by the individual facilities. The aim of this profiling was to collect the data at one place for further analysis (which is presented in chapter 4), not to present the offer of each facility in a consistent and reader-friendly form. Also, some excessively long tables were moved to Annexes 1-4.

3.1 Czech Republic – CzechNanoLab

CzechNanoLab is a national-level research infrastructure in the nanotechnologies field listed on the Czech Roadmap of Research Infrastructures. CzechNanoLab consists of two sites, CEITEC Nano located in Brno and the Laboratory of Nanostructures and Nanomaterials (LNSM), located in Prague. These two nodes provide fast and easy access to cutting-edge equipment and expertise for fabrication and analysis of nanostructures and nanomaterials and access to 1700m^2 of cleanroom space.

Website: www.czechnanolab.cz

3.1.1 CEITEC Nano, Brno

Level 1	Level 2	Level 3
Nanofabrication laboratory	Nanolithography	RAITH, MIRA, DWL, LAURELL, SUSS-MA8, SUSS-RCD8, SUSS-WETBENCH, DEKTAK, DIENER, CPD, NANOCALC, ZEISS-A2
Nanofabrication laboratory	Etching & Deposition	DRIE, PECVD, SCIA, MAGNETRON, MOCVD, APCVD, LPCVD, RIE-F, RIE-Cl, EVAPORATOR, ALD, KAUFMAN, PARYLENE, XeF2
Nanofabrication laboratory	Packaging	WIRE BONDER, LASER DICER, DICING SAW
Nanocharacterisation laboratory	Electrical and magnetic measurements	-
Nanocharacterisation laboratory	Microscopy and nanomanipulation	-
Nanocharacterisation laboratory	Optical measurements	-
Nanocharacterisation laboratory	UHV Technologies	-
Structural analysis laboratory	Electron microscopy	-
Structural analysis laboratory	X-ray diffraction	-
Structural analysis laboratory	Sample Preparation	-
Micro & Nano X-ray CT laboratory	- no info	-

3.1.2 Laboratory of Nanostructures and Nanomaterials (LNSM), Prague

Level 1	Level 2	Level 3
LNSM Structure	Molecular beam epitaxy (MBE)	-
LNSM Structure	Metalorganic vapor phase epitaxy (nanoHET)	-
LNSM Structure	Silicon and carbon nanostructures deposition (nanoCVD)	-
LNSM Structure	Lithographic material structuring (beamLITHO)	-
LNSM Structure	Multimode scanning probe microscopy (multiSPM)	-
LNSM Structure	Atomic resolution microscopy UHV STM / AFM (nanoSURF)	-
LNSM Structure	Laboratory of electron microscopy (LEM)	-
LNSM Structure	Laboratory of optospintronics (LOS)	-
LNSM Structure	Structural analysis (STA)	-
LNSM Structure	Theory group	-

3.3 Estonia – NAMUR+

The University of Tartu and Tartu Science Park, interconnecting the Estonian academic cleanroom infrastructure, encompassing the Institute of Physics (Tartu), Tartu Observatory (Tõravere) and Tartu Science Park (Tartu). The cleanroom infrastructure offers 300 m2 of cleanroom space.

Website: https://namurplus.ut.ee/node/19442

Level 1	Level 2	Level 3
Services	Lithography	-
Services	Atomic layer deposition	-

3.4 Finland – OtaNano

OtaNano is the Finnish national research and development centre for micro- and nanotechnology coordinated by Aalto University, and it serves as a state-of-the-art working environment for internationally recognised research fields, such as quantum technology, nanoelectronics, micro- and nanophotonics, and new materials. It provides centralised access to advanced nanofabrication, nanomicroscopy and low-noise measurement facilities. OtaNano provides access to 2600 m^2 of cleanroom space.

Website: www.otanano.fi

3.4.1 Micronova, Aalto

Level 1	Level 2	Level 3
All Tools	Annealing	>10 terms, see Annex A1 for detail
All Tools	Dry etching	>10 terms, see Annex A1 for detail
All Tools	Electrochmical deposition	>10 terms, see Annex A1 for detail
All Tools	Lithography	>10 terms, see Annex A1 for detail
All Tools	Epitaxial growth	>10 terms, see Annex A1 for detail
All Tools	Furnace processes	>10 terms, see Annex A1 for detail
All Tools	Ion Implatation	>10 terms, see Annex A1 for detail
All Tools	Nanostructuring	>10 terms, see Annex A1 for detail
All Tools	Sputtering	>10 terms, see Annex A1 for detail
All Tools	Evaporation	>10 terms, see Annex A1 for detail
All Tools	Wafer bonding	>10 terms, see Annex A1 for detail
All Tools	Wet processes	>10 terms, see Annex A1 for detail
All Tools	Other processes	>10 terms, see Annex A1 for detail
All Tools	CVD & ALD	>10 terms, see Annex A1 for detail
All Tools	Characterisation	>10 terms, see Annex A1 for detail
All Tools	Back-End processes	>10 terms, see Annex A1 for detail

3.5 France - RENATECH

RENATECH, is the French Nanotechnology National Nanofabrication Facility Consortium coordinated by CNRS and encompassing 5 sites: IEMN (Lille), C2N (Paris – Palaiseau), FEMTO-ST (Besançon), LTM (Grenoble) and LAAS (Toulouse). The cleanroom infrastructure has altogether about 1000 users and offers 8150 m^2 of cleanroom space.

Website: www.renatech.org

3.5.1 Institut for Electronics Microelectronics and Nanotechnology (IEMN), Lille

Level 1	Level 2	Level 3
Equipments – Facilities	Materials and advanced characterization	Molecular Beam Epitaxy Ion implantation
Equipments – Facilities	Lithography resource	E-beam writer Mask aligners Substrate bonder Direct Laser writing system
Equipments – Facilities	Etching resource	Dielectric etching Deep silicon etching RIBE (Reactive Ion Beam Etching) III/V etch (Oxford etching)
Equipments – Facilities	Deposition resource	Evaporation resistive (Joule) Electron BEAM evaporation Sputtering Systems Furnaces Multi-Chamber sputtering tool InkJet deposition Electroplating Plasma Enhanced Chemical Vapor Deposition Low Pressure Chemical Vapor Deposition Atomic Layer Deposition
Equipments – Facilities	Process control resource	ESCA Focus Ion Beam Microscope Scanning electronic microscopy Atomic Force Microscope
Equipments – Facilities	Integration Assembly Packaging resource	Polishing Connection Cutting

3.5.2 C2N, Paris

Level 1	Level 2	Level 3
PIMENT PLATFORM	Lithography	Focused Beam Lithography Optic / UV Lithography Alternative and Emerging Lithography
PIMENT PLATFORM	Deposition	Metal Deposition and Electrolytic Growth Dielectric Deposition and Thermal Treatments
PIMENT PLATFORM	Etching	Dry Etching Wet Etching and Chemistry
PIMENT PLATFORM	Analysis/Back-End	Electron and Near-Field Microscopy Back-End Electrical and Physico-Chemical Characterizations

3.5.3 Franche-Comté Electronics Mechanics Thermal Science and Optics – Sciences and Technologies (FEMTO-ST), Besançon

Level 1	Level 2	Level 3
Our cleanroom	Lithography	Optical mask generator Semi automatic cleaning system Spin-coater with integrated hot plate Automatic spin-coater, baking and developer Spray Coater UV Double-side alignment system DUV Double-side alignment system Semi-automatic metrology platform
Our cleanroom	Nanotechnology	Electron beam lithography system Focused Ion Beam system
Our cleanroom	Thin film technology	RF magnetron sputtering system DC magnetron sputtering system DC magnetron sputtering system Electron-beam evaporator Electron-beam evaporator ICPECVD Oxidation and annealing furnace Rapid thermal processing
Our cleanroom	Dry etching	Hydrofluoric Acid Bench Ni Electroplating system Chemical benches
Our cleanroom	Wet chemistry	Megasonic wafer Cleaner & Wafer bonding inspection systems Plasma Surface activation system

Level 1	Level 2	Level 3
Our cleanroom	Integration/Packaging	Multi-wafer bonder Multi-wafer bonder Wafer aligner-bonder 6'' Automatic Flip-chip bonder Pick and Place Die Bonder Semi-Automatic Wire Bonder Mechanical micro bond tester
Our cleanroom	Dicing/Polishing	Precision Dicing Saw 4" High Precision Dicing Saw 8" Precision Lapping & Polishing system CMP system
Our cleanroom	3D laser microfabrication	High resolution 3D printer 3D laser microfabrication system
Our cleanroom	Process characterization	Spectroscopic Ellipsometer Thin layer measurement system Surface Profiler Fizeau Interferometer Wafer surface measurement Contact Angle Metrology Thin film stress measurement system Environmental SEM & EDS systems MEMS Analyser Manual DC probe station Semi automatic RF probe station
Our cleanroom	industrial line	Automatic coating & development tracks DUV Aligner (Contact photolithography machine Stepper (High resolution lithography machine) > Cathode sputtering Evaporation CD SEM (Critical dimension measurement system)

3.5.4 Laboratoire des Technologies de la Microélectronique (LTM), Grenoble

Level 1	Level 2	Level 3
Le Labo/Les Équipes	Equipe Lithographie	Not clear - French
Le Labo/Les Équipes	Equipe Matériaux	Not clear - French
Le Labo/Les Équipes	Equipe Gravure	Not clear - French

3.5.5 Laboratory for Analysis and Architecture of Systems (LAAS), Toulouse

Level 1	Level 2	Level 3
All Tools	Device mounting	>10 terms, see Annex A2 for detail
All Tools	Plasma etching	>10 terms, see Annex A2 for detail
All Tools	Epitaxy	>10 terms, see Annex A2 for detail
All Tools	Photolithography	>10 terms, see Annex A2 for detail
All Tools	Characterization	>10 terms, see Annex A2 for detail
All Tools	PECVD	>10 terms, see Annex A2 for detail
All Tools	Surface treatment	>10 terms, see Annex A2 for detail
All Tools	Annealing	>10 terms, see Annex A2 for detail
All Tools	PVD	>10 terms, see Annex A2 for detail
All Tools	Wet process benches	>10 terms, see Annex A2 for detail
All Tools	Other processes	>10 terms, see Annex A2 for detail
All Tools	Device mounting	>10 terms, see Annex A2 for detail
All Tools	Ebeam lithography	>10 terms, see Annex A2 for detail
All Tools	Laser lithography	>10 terms, see Annex A2 for detail
All Tools	LPCVD	>10 terms, see Annex A2 for detail
All Tools	Oxydation	>10 terms, see Annex A2 for detail
All Tools	Diffusion	>10 terms, see Annex A2 for detail
All Tools	Implantation	>10 terms, see Annex A2 for detail
All Tools	Nanoimprint	>10 terms, see Annex A2 for detail

3.6 Germany – IMN MacroNano

The Institute of Micro- and Nanotechnologies (IMN) MacroNano, is a cross-faculty scientific institute of the Technical University Ilmenau. Internal as well as external users have access to the Centre of Micro- and Nanotechnologies, the core facility of the IMN MacroNano. With 2.000 m^2 laboratory area, the centre combines the know-how and resources of the three cross-application disciplines of Microsystems Technology and Nanotechnology (i.e. micro- and nano-integration, materials for micro- and nanotechnology plus 3D biosystems) for further research on the ranges of application in life sciences, energy efficiency and photonics.

Website: https://www.tu-ilmenau.de/imn/

3.6.1 Institute of Micro- and Nanotechnologies – (IMN) MacroNano, Illmenau

Level 1	Level 2	Level 3
Process classes	Analytics	-
Process classes	Lithography	-
Process classes	Coating	-
Process classes	Erosion	-
Process classes	Assembly and packaging technologies	-
Process classes	Further process classes	-

3.7 International Organisation – International Iberian Nanotechnology Laboratory

The International Iberian Nanotechnology Laboratory (INL) was created under an international legal framework and is the first and only international intergovernmental organisation in the world entirely focused on nanosciences and nanotechnology. Seated in Braga, Portugal, INL offers 700 m² of cleanroom space.

Website: www.inl.int

3.7.1 International Iberian Nanotechnology Laboratory (INL), Braga

Level 1	Level 2	Level 3
Micro and Nanofabrication	Thin Film deposition and Material Growth	
Micro and Nanofabrication	Optical and E-Beam Lithography Area	
Micro and Nanofabrication	Advanced packaging, Annealing and Back-End process Area	
Micro and Nanofabrication	Metrology, Inspection and Eafer-Scale device testing	
ADVANCED ELECTRON MICROSCOPY	TEM	
ADVANCED ELECTRON MICROSCOPY	SEM	
ADVANCED ELECTRON MICROSCOPY	Sample peparation for SEM	
ADVANCED ELECTRON MICROSCOPY	SW for imaging Anaysis	
ADVANCED ELECTRON MICROSCOPY	X-ray Photoeectron Spectroscopy	

3.8 Italy – It-fab

It-fab is interconnecting the Italian cluster of Micro- and Nano-Fabrication research infrastructures encompassing CNR-DSFTM (IMM and Nanotec Institutes), PoliFAB from Politecnico di Milano, FBK-CMM and Fondazione Inphotec. The integrated micro/nanofabrication facilities include more than 400 pieces of equipment in about 4000 m^2 of cleanrooms, located in 11 different facilities.

Website: itfab.bo.imm.cnr.it

3.8.1 Consiglio Nazionale delle Ricerche - Institute for microelectronics and microsystems (CNR-IMM), Catania

Level 1	Level 2	Level 3
Micro/Nano Fabrication at Catania HQ	OPTICAL PHOTOLITHOGRAPHY	Laser beam direct writing lithography
Micro/Nano Fabrication at Catania HQ	NANOLITHOGRAPHY	Electron beam lithography Raith, Nanoimprint lithography
Micro/Nano Fabrication at Catania HQ	GROWTH, DEPOSITION AND THERMAL PROCESSES	The Q300T D Dual Target Sequential Sputtering System from Quorum Technologies, DC magnetron sputtering Kenotec, Inductively Coupled Plasma CVD, PE ALD LL SENTECH Instruments GmbH, EATON Vertical Furnace, Jetfirst150 by Jipelec is a lamp rapid thermal annealing, Carbolite horizontal furnace, Horizontal tube furnace Lenton LTF12/75/750, The vacuum oven A7V10WS0000 Mazzali, Laser Annealing
Micro/Nano Fabrication at Catania HQ	MICROSYSTEM PROCESSES	Micro-Nanomachining and Electrochemical Lab
Micro/Nano Fabrication at Catania HQ	ION IMPLANTATION	Tandem
Micro/Nano Fabrication at Catania HQ	ETCHING EQUIPMENTS	Inductively coupled plasma etching
Micro and nanofabrication facilities at Catania UNIV	Growth, deposition, and thermal processes	Not specified PVD, CVD, annealing
Micro and nanofabrication facilities at Catania UNIV	Optical and laser lithography	Mask Aligner, an automatized coating system, with spin coater and hot plate, and a vertical laminar flow wet bench
Micro and nanofabrication facilities at Catania UNIV	Metrology, control and electrical characterization	Not specified equipment

3.8.2 Consiglio Nazionale delle Ricerche - Institute for microelectronics and microsystems (CNR-IMM), Lecce

Level 1	Level 2	Level 3
Advanced Micro And Nano DEvices laboratory - "AMANDE lab"	Optical lithography bay	semiautomatic maskaligner MA6 (Suss), semiautomatic spinner DELTA 80T (Suss), wet bench equipped with DI H2O and nitrogen
Advanced Micro And Nano DEvices laboratory - "AMANDE lab"	Nanolithography bay	EBL CABL 9000C Crestec, wet benches equipped with DI H2O and nitrogen, FIB NVision 40 Zeiss
Advanced Micro And Nano DEvices laboratory - "AMANDE lab"	Physical Deposition bay	Sputtering SP404 IONVAC, Thermal e-beam Evaporator

3.8.3 *Consiglio Nazionale delle Ricerche - Institute for microelectronics and microsystems (CNR-IMM), Rome*

Level 1	Level 2	Level 3
Micro and nano fabrication - Rome Unit	Optical and laser lithography	Laser write Heidelberg DWL66, Contact mask aligner Karl Suss MA160
Micro and nano fabrication - Rome Unit	Wet and dry etching	Plasma etching and ashing, Oxford plasma technology reactive ion etch, Substrate cleaning and polishing Wet chemical cleaning, KOH etching, Wet etching bench
Micro and nano fabrication - Rome Unit	Growth, deposition and thermal processes	Film growth PECVD, Deposition Pentacene Evaporator, Balzer 510 evaporation system, VS-40 Sistec Sputtering, Printing system Dimatix is a laboratory benchtop digital ink jet printing system, Labratest Gravure printing system, Rapid thermal annealing, Excimer laser annealing

3.8.4 *Consiglio Nazionale delle Ricerche - Institute for microelectronics and microsystems (CNR-IMM), Bologna*

Level 1	Level 2	Level 3
Micro/nano fabrication at Bologna Unit	OPTICAL PHOTOLITHOGRAPHY BAY	CONTACT MASK ALIGNER, PROGRAMMABLE HOT PLATE
Micro/nano fabrication at Bologna Unit	NANOLITHOGRAPHY AND NANOPROCESSING	Dual beam FIB Zeiss CrossBeam 340, UV-IMPRINT LITHOGRAPHY, REPLICATION TOOS FOR SOFT-MASTER NANOIMPRINT, CONTACT DEEP UV PHOTOLITHOGRAPHY
Micro/nano fabrication at Bologna Unit	WET AND DRY ETCHING BAY - PLASMA ETCHING AND ASHING	RIE PLASMALAB u80, RIE SENTECH SI 591, TEPLA PLASMA OXYGEN, DEEP REACTIVE ION ETCHING ALCATEL A601E
Micro/nano fabrication at Bologna Unit	WET AND DRY ETCHING BAY - SUBSTRATE CLEANING AND POLISHING	Piranha, RCA
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - LPCVD SYSTEMS	LOW TEMPERATURE OXIDE DEPOSITION (LTO) , TEOS DEPOSITION - HORIZONTAL LPCVD , SILICON POLYCRISTALLINE UNDOPED, STOICHIOMETRIC SILICON NITRIDE
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - CHEMICAL VAPOR DEPOSITION (CVD)	HOT-WALL CVD SYSTEMS, COLD-WALL CVD SYSTEMS (ELETTRORAVA)
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - PECVD	RF – VHF MULTI-CHAMBER PECVD SYSTEM
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - PVD SYSTEMS - METAL DEPOSITION	DC SPUTTER MAGNETRON MODEL MRC 8603, RF SPUTTER MODEL MCR 8622, E-BEAN VARIAN 3119
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - ANNEALING FURNACE	
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - DOPING	PHOSPHOROUS DIFFUSION DOPING, SPIN-ON-DOPING
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - THERMAL SILICON OXIDE GROWTH	WET AND DRY OXIDATION

Level 1	Level 2	Level 3
Micro/nano fabrication at Bologna Unit	GROWTH, DEPOSITION AND THERMAL PROCESSES - RAPID THERMAL ANNEALING/PROCESS	ULTRA HT ANNEALING RF FURNACE, RTP TWIN SYSTEM

3.8.5 Consiglio Nazionale delle Ricerche - Institute for microelectronics and microsystems (CNR-IMM), Agrate

Level 1	Level 2	Level 3
Micro/Nano fabrication - Agrate Unit	Optical lithography	Not specified equipment
Micro/Nano fabrication - Agrate Unit	e-beam lithography	Not specified equipment
Micro/Nano fabrication - Agrate Unit	Metal assisted chemical etching (MACE)	Not specified equipment
Micro/Nano fabrication - Agrate Unit	Block Copolymer (BCP) Self-Assembly (SA)	Not specified equipment
Micro/Nano fabrication - Agrate Unit	Sequential Infiltration Synthesis (SIS)	Not specified equipment
Micro/Nano fabrication - Agrate Unit	Monolayer Doping (MLD)	Not specified equipment

3.8.6 Fondazione InPhoTec, Pisa

Level 1	Level 2	Level 3
Processes	Lithography	ELECTRON BEAM VECTOR HB6 HR, KARL SUSS MA6 BA6
Processes	Etching	OMEGA MORI SPTS, TMAH REACTOR
Processes	Deposition - Dielectric materials	STS MAC, OXFORD PLUS PRO 100, SEMCO system and VTR 7000
Processes	Deposition - Metals	TEMESCAL BCD2800 evaporation system

3.8.7 Polifab, Milano

Level 1	Level 2	Level 3
Faclilty/Clean RoomEquipment	Wet Process	Spin Rinser Dryer - Verteq, Wet Bench Lift Off - Robotank, Wet Bench Multi Wafers Etching - SPM, Wet Bench Single Wafers Etching – SPM
Faclilty/Clean RoomEquipment	Yellow Room	Hot Plate - Sawatec HP401, Mask Aligner - Karl Süss MA6/BA8, Maskless Aligner - Heidelberg MLA100, Optical Microscope - Leica INM 200, Plasma Asher - PVA TEPLA 300 AL, SEM with EDX and EBL System - LEO 1525 / Raith Elphy Plus, Spin Coater - Karl Süss RC8, Spin Coater - POLOS SPIN150i, Spin Rinse and Dryer
Faclilty/Clean RoomEquipment	Thin Films Deposition	Ceradrop - CeraPrinter F-Serie, CVD - STS Multiplex, E-beam Evaporator - Evatec BAK 640, RIE ICP - Oxford Plasmalab 100, Sputtering and Ion Beam Etching System - Kenosistec VS80, Sputtering System - Leybold LH Z400, Thermal Evaporator - Moorfield MINILAB-080
Faclilty/Clean RoomEquipment	Magnetic Thin Films	Ion Beam Etching and SiN Sputtering System, LASSE (LAyered Structures for Spin Electronics), Sputtering System - AJA ATC Orion 8, Yamamoto Wafer Electroplating Set

3.8.8 Fondazione Bruno Kessler (FBK), Trento

Level 1	Level 2	Level 3
Infrastructure	Fabrication line class 10-100 cleanroom (560m2)	Magnetron sputtering Metallization: MRC Eclipse, Diffusion: Centrotherm furnace, LPCVD: Centrotherm reactors, CCP PECVD: STS, ICP PECVD, Projection lithography: Suss MA150BSA Single & double side, Stepping i-line lithography: Nikon Mod. NSR-2205i11D, e-beam lithography, Ion Implantation: Varian E220, Dry etching: TEGAL 6510, TEGAL 900, Deep Reactive Ion Etching: Alcatel AMS200, Wet etching

Level 1	Level 2	Level 3
Infrastructure	MEMS class 100-1000 cleanroom (180m2)	Diffusion: Expertech CTR200, Projection lithography: CD 1.5um, accuracy 1um, PVD metallization: Ulvac EBX-16C with e-gun Ferrotec EV S-6, Electroplating: Rena, Dry etching: TEGAL 900, Wet etching

3.9 Latvia – ISSP

The Institute of Solid-State Physics, University of Latvia (ISSP), is the Latvian national research centre for micro and nanofabrication and nano-characterization. ISSP offers 650 m^2 of cleanrooms focused on photonics and bio-medical devices.

Website: www.cfi.lu.lv

3.9.1 Institute of Solid State Physics, University of Latvia, Riga

Level 1	Level 2	Level 3
EQUIPMENT IN CLEANROOMS	-	Glove box in cleanrooms, Electron microscope SEM Lyra, Electron microscope TEM Tecnai, Electron beam lithography system, Multifunctional cluster tool, Optical microscopes in cleanrooms, Profiler, Spin coater, Spin coater for lithography, Thermal evaporator, Wire bonder, UV/Ozone cleaner, Fume hood in cleanrooms

3.10 Lithuania – MNAAPC

The MNAAPC (Open access centre of micro-, nanotechnologies and analysis), at Kaunas University of Technology, is the Lithuanian National Research infrastructure offering analytical and technological services including thin films and coating deposition, optical technologies, nanolithography, reactive ion etching for nano- and microstructures, diffractive optics, nano-photonics, microfluidic devices and biosensors.

Website: www.apcis.ktu.lt

3.10.1 MNAAPC, Kaunas

Level 1	Level 2	Level 3
Equipment	Diagnostic and measurement technologies	Electron beam lithography, electron microscope, energy dispersive spectroscopy

3.11 Netherlands – NanoLabNL

NanoLabNL is interconnecting the Dutch national facilities for nanotechnology research consisting of 7 cleanroom infrastructures at 5 locations: MESA+ NanoLab in Twente, Kavli NanoLab, Else Kooi Lab and TNO NanoLab in Delft, NanoLab@TU/e in Eindhoven, Zernike Nanolab in Groningen and AMOLF NanoLab in Amsterdam.

Website: https://nanolabnl.nl/

3.11.1 MESA+ NanoLab, Twente

Level 1	Level 2	Level 3
Process flow database	-	

3.11.2 Kavli NanoLab, Delft

Level 1	Level 2	Level 3
-	-	-

3.11.3 TNO NanoLab, Delft

Level 1	Level 2	Level 3
-	-	-

3.11.4 Else Kooi Lab, Delft

Level 1	Level 2	Level 3
-	-	-

3.11.5 NanoLab@TU/e, Eindhoven

Level 1	Level 2	Level 3
List of Equipment	Processing Equipment	Temescal FC2000 Electron Beam Evaporator, BVR2008 FC Electron Beam Evaporator, AJA Magnetron Sputtering Tool, Roth & Rau Ion Beam Etcher, Raith EBPG 5150 Electron Beam Lithography, ASML Pass 5500/1100B scanner, ASML Pass 2500/40 stepper, Oxford ICP, Oxford Oxide/Nitride ICP PECVD, Oxford Oxide/Nitride PECVD, Oxford Nitride RIE, Oxford Polymer RIE, Oxford General Purpose RIE, Sentech InP ICP Reactive Ion Etcher, Logitech Chemical Mechanical Polisher (CMP), Semi Automatic Mask Aligner EVG 620NT, Karl Suss MA-6 contact aligner
List of Equipment	Epitaxy Equipment	MBE Createc Metal, MBE Createc II/IV/VI, MBE Createc III/V, MBE Veeco GENxplorer, MOVPE Aixtron Dual Reactor, MOVPE Aixtron Showerhead, MOVPE Aixtron Multiwafer
List of Equipment	ALD Equipment	Oxford Instruments OpAL, Oxford Instruments FlexAL 1, Oxford Istruments FlexAL 2, Oxford Instruments FlexAL 2D
List of Equipment	Characterization Equipment	Hitachi S-9920 CD-SEM, SEM JEOL, SEM ZEISS, SEM / FIB workstation, FEI, X-ray Photo Electron Spectrometer, K-Alpha, X-ray diffractometer (XRD), PanAlytical, Capacitance Voltage (CV) profiler, Tencor Surface profiler, Bruker DekTak XT, Filmetrics, Spectroscopic ellipsometer, Sentech, Optical microscopes
List of Equipment	Small Equipment	Waferbonder, AML, Semi Automatic Wafer Bonder EVG 520IS, Rapid Thermal Annealer 1, Jipelec, Rapid Thermal Annealer 2, Jipelec, Au/Ag Thermal Evaporator, Edwards, Sputtercoater for SEM samples, Emitech, Polymer Plasma stripper, Tepla, Ionwave, Tepla, HMDS-primer deposition, Philips, Critical Point Dryer, Mechanical / chemical polishing, Diamond tool scribers, Karl Suss and Loomis, Brewer Science Equipment, Resist deposition, GYRSET, Silicet Unit, Polymer layer spinning, Ceramic Hotplates, Praezitherm

3.11.6 Zernike NanoLab, Groningen

Level 1	Level 2	Level 3
-	-	-

3.11.7 AMOLF NanoLab, Amsterdam

Level 1	Level 2	Level 3
Equipment info	Cleanroom sample preparation	Wet benches – Organic, anorganic and general purpose wet bench, Spin coater – Suss Delta 80 Spin coater, Critical point dryer – Autosamdri, UV lithography system – Suss MABA6 Mask aligner, E-Beam lithography system – Voyager, 3D direct laser writing lithography – Nanoscribe, Low Pressure Oxygen Plasma System – Sinvacon Diener Pico RIE/ICP Plasma etcher – Oxford Plasmalab 80+, RIE/ICP Plasma etcher – Oxford PlasmaPro100 Cobra, Etching – XeF2 etcher, RTA – Rapid Thermal Anneal, Vacuum oven – General purpose vacuum oven, Tube vacuum furnace (Homebuilt)
Equipment info	Thin film production	Double sputter coater – Leica EM ACE600, E-beam PVD system – E-flex, Sputter PVD system – S-Flex, Deposition system ICPECVD – Oxford PlasmaPro100 ICPECVD, Vacuum coating system – Nanoontje (Homebuilt), Vacuum coating system – Handy Smurf (Homebuilt)
Equipment info	Dedicated equipment	High speed saw – DISCO DAC-2SP/86
Equipment info	Materials Characterization	Optical microscope – Zeiss Axioskop2 mat, Surface profiler – KLA-Tencor alpha-step 500, Atomic Force Microscopy (AFM) – Veeco Dimension 3100 AFM, Scanning Electron Microscope – FEI Verios 460, Scanning Electron Microscope – FEI XL30 SEM, Dualbeam FIB / SEM – FEI Helios nanolab 600, TEM – FEI TecnaiG2 20 X-Twin, Thin film analyzer – Filmetrics F20 UVX, Ellipsometry – Ellipsometer VB-400 J.A. Woollam

3.12 Norway - NorFab

NorFab is the Norwegian National Research infrastructure for nanofabrication encompassing NTNU NanoLab (Trondheim), MiNaLab UoO (Oslo), USN MSTlab (Horten) and SINTEF MiNaLab (Oslo). The cleanroom infrastructure has all together about 550 users and offers 2300 m2 cleanroom space.

Website: www.norfab.no

Level 1	Level 2	Level 3
Technologies	Thermal processes	>10 terms, see Annex A3 for detail
Technologies	Thin film deposition	>10 terms, see Annex A3 for detail
Technologies	Lithography	>10 terms, see Annex A3 for detail
Technologies	Dry Etching	>10 terms, see Annex A3 for detail
Technologies	Characterization	>10 terms, see Annex A3 for detail
Technologies	Bonding and packaging	>10 terms, see Annex A3 for detail
Technologies	Chemical and biological methods	>10 terms, see Annex A3 for detail
Technologies	Sample preparation	>10 terms, see Annex A3 for detail
Technologies	Other	>10 terms, see Annex A3 for detail

Norfab uses united webpage which combines offer of all its nodes under the same categorisation. The table above and its full version contains equipment from the nodes listed below:

3.12.1 Norwegian University of Science and Technology NTNU NanoLab, Trondheim

See the table for the NorFab research infrastructure at the beginning of this section and in annex A1.

3.12.2 University of Oslo MiNaLab UoO, Oslo

See the table for the NorFab research infrastructure at the beginning of this section and in annex A1.

3.12.3 University of South-Eastern Norway USN MSTlab, Horten

See the table for the NorFab research infrastructure at the beginning of this section and in annex A1.

3.12.4 SINTEF MiNaLab, Oslo

See the table for the NorFab research infrastructure at the beginning of this section and in annex A1.

3.13 Portugal – MicroNanoFabs@PT

MicroNanoFabs@PT is interconnecting the national cleanroom at INESC-MN and the international at INL into a Portuguese national infrastructure network. The cleanroom INESC-MN offers 350 m² of cleanroom space.

Website: www.inesc-mn.pt

3.13.1 Instituto de Engenharia de Sistemas e Computadores – Microsistemas e Nanotecnologias (INESC-MN), Lisbon

Level 1	Level 2	Level 3
Facilities	Materials Optimization and Thin Film Deposition	
Facilities	Device Fabrication	
Facilities	Device and Thin Film Characterization	

3.14 Romania – IMT-MINAFAB

Institute for Microtechnologies (IMT-MINAFAB), is the largest cleanroom in Romania, dedicated to micro and nanofabrication for nanoelectronics, MEMS, NEMS, microfluidics and opto-electronic applications. It is acknowledged as a national research infrastructure by the Ministry for Research and Innovation since 2017. MINAFAB consists of more than 1.000 m^2 of class 100 - 100.000 cleanroom with a wide range of equipment from photolithographic mask fabrication to etching, deposition and characterisation.

Website: www.imt.ro/MINAFAB

3.14.1 Institute for Microtechnologies (IMT-MINAFAB), Bucharest

Level 1	Level 2	Level 3
Main Technological and Characterisation Tools	Microlithography tools	DWL66, MA6/B6, DELTA 10 (Wafer spinner), SB6L (Wafer Bonder)
Main Technological and Characterisation Tools	Physical deposition tools	EVAPORATOR
Main Technological and Characterisation Tools	Chemical deposition tools	PECVD, LPCVD
Main Technological and Characterisation Tools	Dry etching tools	RIE, DRIE
Main Technological and Characterisation Tools	Thermal processing tools	
Main Technological and Characterisation Tools	SEM; Electron-beam lithography; Nanoprinting	EBL e-Line, Dip Pen Nanolithography Writer - NSCRIPTOR, PG Elphy Plus

Level 1	Level 2	Level 3
Main Technological and Characterisation Tools	SPM: AFM, STM, LFM, Phase Imaging, Force Modulation, Force Spectroscopy, SNOM, confocal, SECM	-
Main Technological and Characterisation Tools	Nanomechanical characterization tools	-
Main Technological and Characterization Tools	Diffractometry; Interferometry; Spectroscopy; Voltammetry	-
Main Technological and Characterization Tools	Microarrays, Biomolecule research	-
Main Technological and Characterization Tools	Probers, on-wafer; electrical characterization	-
Main Technological and Characterization Tools	Reliability and Testing Tools	-
Main Technological and Characterisation Tools	Wetbenches	-
Main Technological and Characterization Tools	Other tools	-

3.15 Spain - MICRONANOFABS

MICRONANOFABS is the Spanish cleanroom cluster, included in the Map of Unique Scientific and Technical Infrastructures (in Spanish, ICTS) established by the Spanish Ministry of Science, Innovation and Universities (MINCIU) as a Distributed Large-Scale Singular Facility. MICRONANOFABS interconnects three sites, namely Institute of Microelectronics of Barcelona (IMB-CNM) belonging to the Spanish Research Council (CSIC), Institute of Optoelectronic Systems and Microtechnology (ISOM) belonging to the Polytechnic University of Madrid (UPM) and the Nanophotonics Technology Centre of Valencia (NTC) belonging to the Polytechnic University of Valencia (UPV).

Website: https://micronanofabs.org/en/home-2/

3.15.1 Institute of Microelectronics of Barcelona (IMB-CNM), Barcelona

Level 1	Level 2	Level 3
Technology Offer	Ion Implantation	Two medium current ion implantation systems are available for implanting a number of species: B, P, As, N, Ar, Al, Si, Mg, O, He.
Technology Offer	Dry Etching	Reactive Ion Etching (RIE) systems for aluminium, polysilicon, silicon oxide and silicon nitride materials.
Technology Offer	Dry Etching	Deep reactive Ion Etching (DRIE) systems for deep silicon and silicon dioxide etching.
Technology Offer	Dry Etching	Photoresist ashing.
Technology Offer	Inspection and measurement	Optical Microscopy, Thin film thickness measurement by Spectral Reflectance, Spectral Ellipsometry, 3D optical Profilometry, Mechanical Profilometry, FT-IR spectroscopy, Sheet Resistance measurement, Bow and Thickness measurement, Life Time measurement
Technology Offer	Metallization	Physical Vapor Deposition (PVD): Sputtering and Evaporation.
Technology Offer	Microsystems Processes	Silicon anisotropic wet etching with alkaline solutions, Surface micromachining (sacrificial layer etching), Critical point drying for releasing micromachined structures, Lift-off etching processes

Level 1	Level 2	Level 3
Technology Offer	Nanolithography	Electron beam lithography (EBL)
Technology Offer	Nanolithography	AFM based nanofabrication
Technology Offer	Nanolithography	Nanoimprint lithography
Technology Offer	Nanolithography	Focused Ion Beam (FIB)
Technology Offer	Nanolithography	Scanning Electron Microscopy (SEM)
Technology Offer	Wet Etching and Cleaning Processes	Wet etching processes consisting on isotropic chemical attacks in aqueous solution of a variety of materials. Microelectronic fabrication cleaning processes and photoresist removal
Technology Offer	Photolithography	Automatic coater/developer system
Technology Offer	Photolithography	Contact/proximity and double-side contact/proximity mask aligners
Technology Offer	Photolithography	i-line Stepper
Technology Offer	Photolithography	Mask-Less Laser Lithography (i-line)
Technology Offer	Photolithography	Automatic mask cleaner
Technology Offer	Packaging	Wafer dicing. Die bonding processes, including SMD and flip-chip die assembly. Wire bonding.
Technology Offer	Electrical Characterisation	Device Characterization and parameter extraction. Parametric test of fabricated wafers. Test structure design and characterisation. Development of new measurement techniques.
Technology Offer	Ion Implantation	Two medium current ion implantation systems are available for implanting a number of species: B, P, As, N, Ar, Al, Si, Mg, O, He.

3.15.2 Institute of Optoelectronic Systems and Microtechnology (ISOM), Madrid

Level 1	Level 2	Level 3
MOST RELEVANT EQUIPMENT	GROWTH SYSTEMS	-
MOST RELEVANT EQUIPMENT	PROCESSING SYSTEMS	-
MOST RELEVANT EQUIPMENT	CHARACTERIZATION SYSTEMS	Structural and Surface, Electric and Magnetic, Optics, Of devices

3.15.3 Nanophotonics Technology Centre of Valencia (NTC), Valencia

Level 1	Level 2	Level 3
Processes - Available Processes	Lithography (e-beam & DUV “Mask aligner”)	-
Processes - Available Processes	ICP-RIE etching (Dielectric and Metal etch)	-
Processes - Available Processes	PECVD layer deposition (SiO2, Doped SiO2 - BPTEOS-, SiN, a-Si)	-
Processes - Available Processes	E-beam evaporation (metals, ITO, GST)	-

Level 1	Level 2	Level 3
Processes - Available Processes	Lift-off	-
Processes - Available Processes	Conventional & Rapid thermal annealing	-
Processes - Characterization tools	SEM, AFM, Profilometer, FTIR, Spectroscopic Ellipsometer, RAMAN, SNOM	-
Equipment	Wet Benches and Dry Rinse Spinner: FSI Mercury reactor, SEMITOOOL organic solvent system	-
Equipment	Conventional & Rapid Thermal Annealing	-
Equipment	Deposition of Polysilicon and Dielectric Layers with precise refractive index control: 2 PECVD Applied Materials cluster tools (a-Si:H, Si3N4, TEOS-based B&P doped glasses)	-
Equipment	Resist spinner, develop track and high pressure spray lift-off system	-
Equipment	Lithography	Vistec EBPG5000 (100kV)
Equipment	Lithography	Raith 150 e-Beam direct writing (30kV)
Equipment	Lithography	EVG 620 DUV Mask Aligner systém
Equipment	Lithography	TEL Mk VZ Developer & Coater
Equipment	Dry Etching systems (RIE, ICP): STS and Corial 500 systems.	-
Equipment	Physical Vapor Deposition (PVD): 2 Pfeiffer E-beam evaporation and Emitech DC sputter systems	-
Equipment	Metrology: Hitachi SEM and optical microscopes for x-section analysis of small samples, JEOL FIB for x-section analysis of 6" wafers.	-
Processes - Available Processes	Lithography (e-beam & DUV "Mask aligner")	-
Processes - Available Processes	ICP-RIE etching (Dielectric and Metal etch)	-

3.16 Sweden - Myfab

Myfab is interconnecting the Swedish research infrastructures for micro and nanofabrication encompassing Chalmers MC2 Nanofabrication Laboratory (Gothenburg), KTH Electrum Laboratory (Stockholm), Ångström Microstructure Laboratory (Uppsala) and Lund Nano Lab offering 700 tools in total 5400 m^2 cleanroom space to 850 users from academy (80%) and from industry (100 companies).

Website: www.myfab.se

3.16.1 Chalmers MC2 Nanofabrication Laboratory, Gothenburg

Level 1	Level 2	Level 3
Resources	All tools	>10 terms, see Annex A4 for detail

3.16.2 KTH Electrum Laboratory, Stockholm

Level 1	Level 2	Level 3
Resources	Epitaxy	Epsilon2000 Asterix Obelix Semlan Napoleon LPE 106 Frej
Resources	Thin film deposition	IDP Barbara Indira Pekka IBS KDF AJA Sputter Edvard ALD AJA Sputter Albanova Edwards Auto 306 Albanova Eurovac UHV deposit, Albanova Sputnik Albanova PLD Endura AJA 2 Sputter Albanova Parylene coater
Resources	Lithography	Gamma Bake 7 FH APL-gul Karl Suss Emma Nils Bake 2 Bake 3 Masktvätt Arnold APL-HMDS HMDS 2 FH Gul3 ALS-stepper Bake 4 Bake 6 Maximus Manual spray coater APL spinner Ebeam litho Albanova Karl Suss MJB3 Albanova Albanova Canon Projection Camera NSR Maskless litho Albanova Labspin80 Beamer computer Albanova
Resources	Dry etching	ALOES Advanced Oxide Etcher ICP P5000 Esa Fabio Gallus Tegal Tepla Pamela Plasmatvätt Pico RIE Centura Ariel RIE ICP O2/AR Albanova Cryo RIE Albanova
Resources	Theramal processes	RTA Yes-ugn Peo Bake 5 Activator T1-Oxide 1250C T2-Oxide 1250C T3-Gate ox T4-FGA Rotating Tube Furnace Vacuum Oven B&H Box furnace Annealer, vacuum, Albanova
Resources	Wet processes	Rinser 2 Wetb-Si epi-clean W0607 Wetb Si process Wetb Si strip Wetb APL Wetb MEMS Wetb metal Wetb solvent Wetb Au develop W2631 W3233 W34 FH APL Wetb Solvent clean Wetb APL-gul Rinser 1 R/D double R/D 3 FH III/V R/D Gul1 R/D 2 FH wet chemistry-1 R/D Metals R/D Gold FH wet chemistry-2 (solvent) FH wet chemistry-3 FH wet chemistry-4 FH wet chemistry-5 (solvent) FH wet chemistry-6 Megasonic bath FH epi service Wetb Sabina FH wet chemistry-7 FH wet chemistry-8 SSE Sprayets SSEC FH Service Wetb Al etch Brage Nanna 5175 DS-1 5175 DS-2 5175 DS-3
Resources	Other processes	RoomR Renrum Bläster Läppus Balance Quickseal Kyl & frys Rörtvätt Testtool Lab support Critical Point Dryer Läcksökaren Fiber anneal LIMS TLE lab Fs Laser system 1 Fs Laser system 2 Critical Point Dryer Albanova uFAB Femtosecond Laser Cleanroom Speed mixer Nikon Microphot-FXA CNC-milling machine CMP CO2 Laser Light Soaker CPD Nanoscribe External chemistry lab Sentaurus
Resources	Dice mounting	Bonder Disco-saw Rakel Bertil Disco DAD saw Wire bonder Albanova FH MS Olympus FH MS Nikon Micro Diamond Scriber, Albanova ESEC Automatic Wirebonder Paroteq Bonder Albanova Centrifuge Z 323 HB16-TPT
Resources	Materials and Device Characterization	M07 Olympus/camera LEITZ Dektak M01 Olympus M02 Olympus/camera M03 Leica UVO Cleaner CD SEM 4-Point Tencor P10 M11 Nikon/CD 1 M10 Nikon/auto Manual probstation UVISEL M04 Leitz M05 Nikon/auto HR X-Ray 3D MF Probestation HF Probestation Canon EOS 350D FE-TEM FIB-SEM Gemini Plasma cleaner Gold sputter FNM Diamond saw Grinder-polisher Ultrasonic disc cutter Dimple grinder Electrolyte polishing Ion polishing M20 Microscope Laboratory oven Preparation lab Freeze Dryer Differential scanning calorimetry (DSC) Thermogravimetry Analysis (TGA) UV-Vis-NIR Spectrometer Rotational ViscometerTwo speed grinder-polisher Precision ion polishing system Potentiostat / Galvanostat – ZRA AFM Acreo Probestation 1 Manual Probestation 3 Semi Automatic Probestation 4 High Temp. Cryogenic Probestation FTIR Spectrometer Prometeus manual Prometeus auto Skivthk

3.16.3 Ångström Microstructure Laboratory, Uppsala

Level 1	Level 2	Level 3
No info	No info	No info

3.16.4 Lund Nano Lab, Lund

Level 1	Level 2	Level 3
Resources	All tools	No list of equipment

3.17 United States - National Nanotechnology Coordinated Infrastructure (NNCI)

The National Science Foundation (NSF) supports 69 facilities out of which 24 provide cleanroom nanofabrication (listed below), and a coordinating office as the National Nanotechnology Coordinated Infrastructure (NNCI). The NNCI sites provide researchers from academia, small and large companies, and government with access to university user facilities with leading-edge fabrication and characterisation tools, instrumentation, and expertise within all disciplines of nanoscale science, engineering and technology.

Website: https://www.nnci.net/

NNCI nodes with cleanroom nanofabrication facilities are:

- ***Cornell Nanoscale Science and Technology Facility (CNF)***
- ***Center for Nanoscale Systems (CNS)***
- ***Micro/Nano Technology Center (MNTC) -UofL (KY Multiscale)***
- ***Center for Nanoscale Science and Engineering (CENSE) - UK (KY Multiscale)***
- ***Mid-Atlantic Nanotechnology Hub (MANTH)***
- ***Midwest Nanotechnology Infrastructure Corridor (MiNIC)***
- ***Montana Nanotechnology Facility (MONT)***
- ***Virginia Tech National Center for Earth and Environmental Nanotechnology Infrastructure (NanoEarth)***
- ***ASU NanoFab (NCI-SW)***
- ***Advanced Electronics and Photonics Core Facility (NCI-SW)***
- ***Nebraska Nanoscale Facility (NNF)***
- ***Washington Nanofabrication Facility (WNF) – UW (NNI)***
- ***Advanced Technology and Manufacturing Institute (ATAMI) – OSU (NNI)***
- ***NCSU Nanofabrication Facility (NNF, NCSU) (RTNN)***
- ***Shared Materials Instrumentation Facility (SMIF, Duke) (RTNN)***
- ***Chapel Hill Analytical and Nanofabrication Laboratory (CHANL, UNC)***
- ***San Diego Nanotechnology Infrastructure - Nano3 Cleanroom (SDNI)***
- ***Institute for Electronics and Nanotechnology Micro/Nano Fabrication Facility – GT - (SENIC)***
- ***JSNN Cleanroom and Labs (SENIC)***
- ***Northwestern University Micro/Nano Fabrication Facility (NUFAB) – NU - (SHyNE)***
- ***Pritzker Nanofabrication Facility (PNF) - UC- (SHyNE)***
- ***Stanford Nano Shared Facilities (nano@stanford)***
- ***Stanford Nanofabrication Facility (nano@stanford)***
- ***Microelectronics Research Center (MRC) (TNF)***

NNCI uses a united webpage with a tools database which combines the offers of all its nodes under the same categorisation. They are using a three-level unified taxonomy shown in the table below with level names stated in the second (orange) row of the table.

Level 1	Level 2	Level 3
Tool Area	Tool area sub-field	Tool type
Biological	All Biological	SPR, QCM, Sample Prep, Other
Particle	All Particle	Size, Zeta Potential, Concentration, Other
Metrology/ Characterization	Structure or Device	Profilometry, Electrical, Optical, Mechanical, Other
Metrology/ Characterization	Thin Film	XRD,XRF, XPS, SIMS, EDS/WDS, Spectroscopy (UV-Vis, FTIR, Raman, Other), Mechanical, Contact Angle, Thickness, Other
Metrology/ Characterization	Chemical Analysis	Mass Spec, NMR, TGA, DSC, Chromatography, Spectoscopy (UV-Vis, FTIR, Raman, Other), Other
Imaging	All Imaging	SEM, TEM, FIB, Probe, Optical, Confocal, Sample Prep, Other
Lithography	All Lithography	UV, DUV, EBL, Resist Processing, Mask Making, Soft Lithography, Other
Patterning	All Patterning	Inkjet, NIL, 3D Printing, Laser, Other
Packaging	All Packaging	CMP, Dicing, Bonding, Drilling, Other
Thin Film Processing	Metal	Plating, Evaporation, Sputter, Annealing, ALD, Other
Thin Film Processing	Dielectric	ALD, CVD, Evaporation, Implantation, MBE, PECVD, Oxidation, Annealing, RTA/RTP, Sputter, Doping, Other
Thin Film Processing	Polymer	Spray Coating, Dip Coating, Spin Coating, Other
Thin Film Processing	Other	-
Thin Film Processing	All Thin Film Processing	-
Etching	Dry	RIE, ICP, Ion Mill, Deep Oxide, Deep Silicon (Bosch), FIB, Other
Etching	Wet	Wet Bench, Other
Cleaning	All Cleaning	Wet Bench, Plasma/Stripper, Critical Point Drying, Spin Rinse Drying, Other
Other	All Other	Other

5. Conclusions from the Profiling

The data collected from 66 nanofabrication facilities located in 15 countries in Europe and the US clearly showed that the current situation in presenting the offer of nanofabrication research infrastructures is very inconsistent and confusing. The research field is historically rooted in microelectronics and electrical engineering. However, nowadays nanofabrication is becoming more and more multidisciplinary: the researchers are coming from different fields, such as physics, chemistry, life sciences, mechanical engineering, bioengineering etc. and every research field has a different view on terminology (e.g., a plasma physicist can call one instrument “inductively coupled plasma reactive ion etching system with a heated electrode and He backside cooling”, whereas a biologist would call the same tool a “plasma etcher”). Companies make things even more complicated with their registered trademarks for different technologies (e.g. a combination of electron and ion beam microscope is called “SEM-FIB” by Tescan and Hitachi, DualBeam by Thermo Fischer and “CrossBeam” by Zeiss). A similar problem exists in material classification, where chemists and physicists may have a completely different view on 0D, 1D and 2D materials.

From the previous section 3, it is clearly visible that each nanofabrication laboratory uses its own terminology and categorisation; this may be ok for a local community of researchers. When people are travelling between nano centres or are coming as new users of facilities from different research fields, however, the communication problem may amount to a detrimental barrier to interdisciplinary collaborations. In addition, when organising a broad nanofabrication community, as in the case of EuroNanoLab, NNCI and NanoFabNet, the problem of different languages poses a huge problem.

5.1 Analysing Patterns in Terminology and Taxonomy

Even though, at first sight, the collected data were very difficult to organise in a meaningful way, we have selected two areas for a more in/depth analysis: **lithography** and **dry etching**. These areas were selected because there are expert groups working on these areas within the frame of EuroNanoLab and the experts were readily available for consultations.

We used the collected data presented in the section above (section 3) and tried to find answers to the following questions:

1. *How are the categories "Dry etching" and "Lithography" included in the structure of the individual nanolabs?*

Here we found that “dry etching” (or “plasma etching”) is in most cases (25x) a subcategory of the category “etching”. In nine cases, “dry etching“ (or “plasma “etching“) was at the main category level. In two cases, the “etching” category was used to combine the categories “etching” and “depositions”, and in 17 cleanrooms, the structure was not identified, most probably because small cleanrooms do not need categorisation of equipment.

In the case of “lithography”, the term was found as the main category in 27 cases with no identified structure in a further 26 cases. The names of the subcategories were typically: e.g., beam, optical, UV, laser, direct-write, nanoimprint, alternative and emerging, ion beam, mask aligner NNCI: EBL, Resist processing, UV, DUV, mask making, soft lithography.

2. *Are these two terms a major category, or do they have a parent category?*

We found that the term “dry etching” was, in most cases, a subcategory of “etching”. In contrast, the term “lithography” was used to describe the main category with many subcategories at the next level.

3. *What names are used for these categories?*

The term “lithography” occurs the most frequently, whereas in the case of “dry etching”, the term “plasma etching” is used with the same frequency. It means that lithography, as a category name is well adopted by the community, and it should be well adopted. In the case of dry or plasma etching,

on the other hand, the community is split into two halves, and it might be difficult to push through a common category name to be fully adopted by the whole community.

4. *Should the "dry etching" category be on the same (hierarchical) level as the "lithography" category?*

The conclusion was 'NO, the "dry etching" category should not be on the same level as the "lithography" category' (for reasoning, see the answer to question 2 above), here we note that at this point, it becomes obvious that the organically selected EuroNanoLab working groups on Lithography and Dry etching were actually not at the same level of complexity as the Lithography group covers full category and Dry etching group covers the only subcategory.

5. *Is it appropriate to introduce generic tool/equipment names? >If so, what should these look like?*

Here we concluded that generic equipment names would be a big help; however, no meaningful patterns were identified in the dataset.

6. *Should auxiliary technologies (e.g. CPD, spin coating, wetbenches) be included in the categories? If so, should these, too, have a subcategory?*

Here we concluded that 'probably YES, auxiliary technologies should be included in the categories', and the system should allow placing the same tool/instrument into multiple categories. A subcategory "other" might be a good idea as a place where to collect rare tools.

After this analysis, where we found only very few patterns used across the facilities, we started to prepare a new taxonomy from scratch.

6. Nanofabrication Competence Map – Proposal for a New Taxonomy

The new nanofabrication taxonomy needs to be flexible, expandable, and robust; here, we propose a three-level hierarchical system with Main Category -> Subcategory -> Generic instrument name divisions. The generic instrument name is new and so far an unused construct, which should distinguish an instrument from a process. For example, an "etcher" is a "tool where etching processes are performed". So far, the process terminology and instrument name terminology are liberally mixed as can be seen from mapping data and this is causing big confusion.

We used the ISO standard ISO/TS 80004-8:2020, which describes nanomanufacturing processes,[7] as the main starting point for the newly prepared map; we must note, however, that this standard was able to cover only a small subset of our needs. As a second anchor, used the NNCI terminology,[8] as this terminology is already adopted by 15 US nanofabrication centres and was a subject of a multi-year evolution (see Figure 1).

[7] International Organization for Standardization, Nanotechnologies — Vocabulary — Part 8 — Nanofabrication processes, 2020 (website; accessed: July 2021)

[8] US NNCI Tool Search (website; accessed: July 2021)

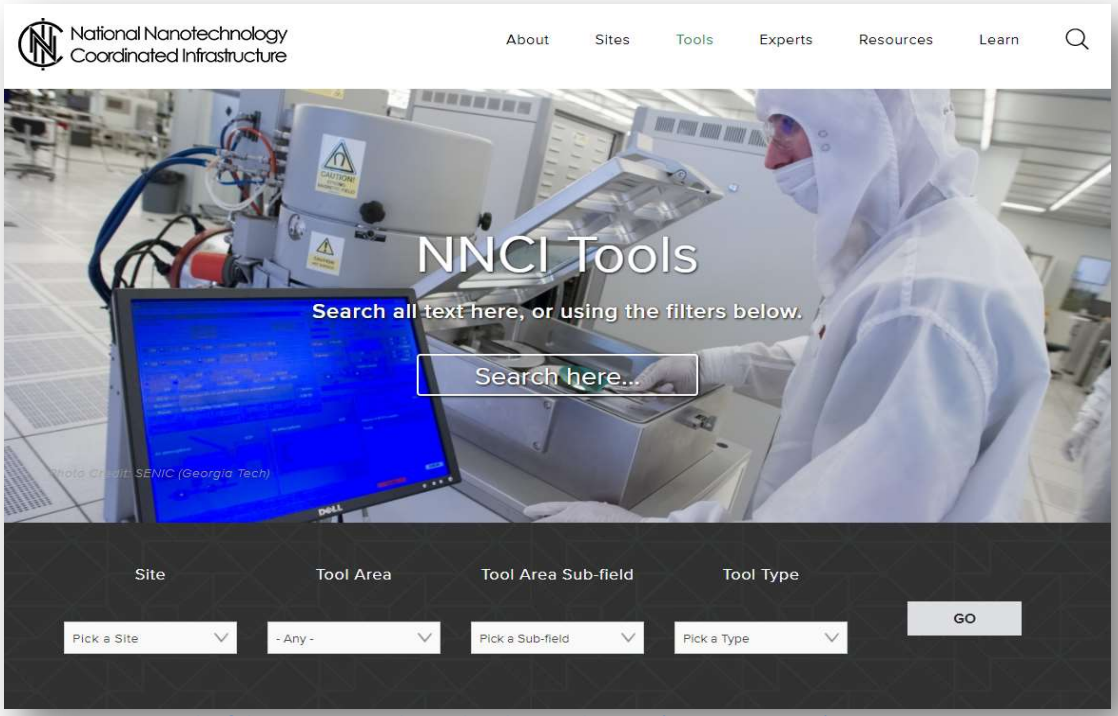

Figure 1: Screengrab of the US NNCI Tool Search online application (source: US NNCI).

However, the NNCI terminology does not have a clear definition added to each category (Tool Area), subcategory (Tool Area Subfield) and generic instrument name (Tool Type). Thus, our work furthermore focussed on finding generic instrument/tool names that would initially cover about 80% of the nanofabrication related equipment from our mapping dataset (NOTE: the list of instrument/tool names would later be extended and refined). We have excluded characterisation equipment to keep the workload realistic. Then we compared the ISO and NNCI terms for generic instrument names, categories and subcategories and either added a modified (we had to convert process names into instrument names) ISO definition to the name, or in case that the definition was not found in ISO standard, we proposed our own definition. This resulted in a list of five categories, 21 subcategories and 55 generic instrument names; each level includes the "other" section, in which rare instruments can be categorised, and in case that later these become less rare, the categories can be expanded.

This is the first proposal of the map, which needs to be reviewed and updated by the community. A strategy on how to disseminate this concept and convince the nanofabrication community about its usefulness will be addressed in the second part of the *NanoFabNet* Project. The actual map can be found below:

Main Categories

	Main Category	Definition
1	Lithography	ISO uses the term "Nanopatterning lithography" as the main category for various lithography techniques
2	Etching	ISO uses the term "Etching processes" as the main category
3	Depositions	ISO uses the term "Deposition processes" as the main category. They have also separate category for Printing and Coating
4	Packaging	No ISO: Packaging provides a means for dicing and connecting chips to the external environment via leads such as lands, balls, or pins.
5	Other	everything which does not fit into previous categories

Subcategories

	Main Category	Subcategory	Definition
1.1	Lithography	Electron-beam lithography	direct write patterning process that uses a focused, concentrated stream of electrons to modify the solubility of a resist layer
1.2	Lithography	Photolithography	process in which electromagnetic radiation is used to transfer a mask through a reticle to create a pattern (not in ISO: also direct wite technique is considered)
1.3	Lithography	Nano-imprint lithography	process in which a pattern is transferred by pressing a nanoscale template (usually called a die, stamp, mask or mould) of the desired pattern in relief into a deformable resist, which is then cured thermally or with light
1.4	Lithography	Focused ion-beam lithography	direct write patterning process that uses a focused ion beam to modify the solubility of a resist layer
1.5	Lithography	Resist processing	no iso definition (NNCI term) processes related to the work with resist, such as coating, developing, baking etc.
1.6	Lithography	Other	everything which does not fit into previous categories (NNCI term)
2.1	Etching	Dry etching	process that makes use of partially ionized gases to remove material from a substrate
2.2	Etching	Dry ashing	dry ashing is aform of dry chemical etching in which surface material is spontaneously etched by a neutral or activated gas and forms volatile etch products
2.3	Etching	Wet etching	chemical removal of a surface material with a liquid etchant
2.3	Etching	Other	everything which does not fit into previous categories (NNCI term)
3.1	Depositions	Chemical vapor deposition	deposition of a solid material onto a substrate by chemical reaction of a gaseous precursor or mixture of precursors, commonly initiated by heat
3.2	Depositions	Physical vapor deposition	process of depositing a coating by vaporizing and subsequently condensing an element or compound, usually in a high vacuum
3.3	Depositions	Atomic layer deposition	process of fabricating uniform conformal films through the cyclic deposition of material through self-terminating surface reactions that enable thickness control at the atomic scale
3.4	Depositions	Coating	Not in ISO: creation of a thin film on a substrate from solution containing the material of interest
3.5	Depositions	Plating	Not in ISO: deposition of material onto a surface from ions in solution
3.6	Depositions	Other	everything which does not fit into previous categories (NNCI term)
4.1	Packaging	Bonding	Not ISO: process by which two materials adhere to each other ensuring a mechanically stable interconnection
4.2	Packaging	Dicing	Not ISO: method to cut a wafer or any other sample to individual dies by mechanical sawing or laser cutting
5.1	Other	Doping	Not ISO: method of implantation of impurities into an intrinsic semiconductor for the purpose of modulating its electrical, optical and structural properties
5.2	Other	Annealing	Not ISO: high-temperature furnace process to relieve stress in structures, activate or move dopants, densify

	Main Category	Subcategory	Definition
			deposited or grown films, and repair implant damage in sample processing
5.3	Other	Cleaning	Not ISO: The removal process of chemical and particle impurities without altering or damaging the surface or substrate

Generic Instrument/Tool Names

	Main Category	Subcategory	Generic instrument name	Definition
1.1.1	Lithography	Electron-beam lithography	electron beam writer	Tool that produces a pattern of a structure with direct writing using the electron beam
1.1.2	Lithography	Electron-beam lithography	scanning electron microscope	A scanning electron microscope with a pattern generator capable of writing patterns using the electron beam
1.2.1	Lithography	Photolithography	stepper	A tool that produces the pattern of structure from the reticule using the photolithography process utilizing deep UV light
1.2.3	Lithography	Photolithography	laser writer	No ISO: The tool that produces the pattern of structure with direct writing record using the laser beam
1.2.4	Lithography	Photolithography	mask aligner	No ISO: The tool that produces the pattern of structure from photo mask using the photolithography process utilizing deep UV light
1.4.1	Lithography	Focused ion-beam lithography	FIB-SEM system	No ISO: The tool combines the observation and the producing the pattern of structure with direct writing record using the ion beam
1.5.1	Lithography	Resist processing	spin coater (also in depositions category)	Creation of a thin film by deposition of a material in solution onto a rotating substrate by utilizing centrifugal force
1.5.2	Lithography	Resist processing	automated spin coater	No ISO: creation of a thin film by deposition of a material in solution onto a rotating substrate by utilizing centrifugal force utilizing automated procedures
1.5.3	Lithography	Resist processing	automated developer	An automated tool for developing of exposed patterns in resists.
1.5.4	Lithography	Resist processing	hot plate	A flat heated surface used for heating of a sample.
1.5.5	Lithography	Resist processing	oven	A tool for preheating or thermal annealing of sample.
1.5.6	Lithography	Resist processing	dry-asher	"A tool for chemical etching in which surface material is spontaneously etched by a neutral or activated gas and forms volatile etch products.
1.5.6	Lithography	Resist processing	fume-hood	A workplace with local ventilation system that is designed to limit exposure to hazardous or toxic fumes, vapours or dust particles

	Main Category	Subcategory	Generic instrument name	Definition
1.5.7	Lithography	Resist processing	wet-bench	Complex equipment with integrated lithographic tools such as hotplates, spincoaters, developers etc.
1.6.1	Lithography	Other	automatic mask cleaner	A tool for removing of chemical and particle impurities without altering or damaging the surface or substrate
1.6.2	Lithography	Other	lithographic scanning probe microscope	A scanning probe microscope with extensions for multiple nanolithography techniques (e.g. Dip-pen nanolithography, Local anodic oxidation...)
1.6.3	Lithography	Other	rinser-dryer	A tool for wet wafer cleaning processes
2.1.1	Etching	Dry etching	reactive ion etcher	A tool for plasma etching in which the wafer is placed on a radio-frequency-driven electrode and the counter electrode has a larger area than the driven electrode
2.1.2	Etching	Dry etching	deep reactive ion etcher	A tool capable of running highly anisotropic etching process used to create high aspect ratio structures
2.1.3	Etching	Dry etching	ion beam etcher	Ion beam milling use of a plasma source to produce a broad ion beam to remove material from a substrate
2.1.4	Etching	Dry etching	ion beam etcher	Ion beam milling use of a plasma source to produce a broad ion beam to remove material from a substrate
2.1.5	Etching	Dry etching	FIB-SEM system	A tool using a beam of ions focused through a set of electrostatic lenses to create a small spot on the substrate.
2.1.6	Etching	Dry etching	vapour etcher	An instrument enabling isotropic chemical etching process using a vaporized liquid etchant.
2.1.7	Etching	Dry etching	gas etcher	A tool that is using neutral gas (e.g. XeF2) for material removal.
2.1.8	Etching	Dry etching	dry asher	A tool utilizing plasma to thin out or remove polymer layers, typically resists.
2.3.1	Etching	Wet etching	wet bench	An instrument for wet etching processes in liquid acid, basis or organic etchers.
2.3.2	Etching	Wet etching	automatic etcher/cleaner	A tool for wafer automated cleaning processes
3.1.1	Depositions	Chemical vapour deposition	metal-organic chemical vapour deposition system (MOCVD)	A tool which produces single- or polycrystalline thin films by a chemical vapour deposition method utilizing ultrapure metalo-organic precursor gases and thermal reaction.

	Main Category	Subcategory	Generic instrument name	Definition
3.1.2	Depositions	Chemical vapour deposition	plasma enhanced chemical vapour deposition system (PECVD)	A tool which produces single- or polycrystalline thin films by a chemical vapour deposition method utilizing ultrapure precursor gases and plasma.
3.1.3	Depositions	Chemical vapour deposition	low pressure chemical vapour deposition system (LPCVD)	A tool which produces single- or polycrystalline thin films by a chemical vapour deposition method utilizing ultrapure precursor gases, thermal reaction and sub-atmospheric pressure.
3.1.4	Depositions	Chemical vapour deposition	atmospheric pressure chemical vapour deposition system (APCVD)	A tool produces single- or polycrystalline thin films by a chemical vapour deposition method utilizing ultrapure precursor gases, thermal reaction at atmospheric pressure.
3.2.1	Depositions	Physical vapour deposition	electron beam evaporator	A tool in which a material is vaporized by incidence of high energy electrons in high or ultra-high vacuum conditions for subsequent deposition onto a substrate
3.2.2	Depositions	Physical vapour deposition	ion beam sputtering system	The tool employing a beam of highly energetic ions generated by ion source to transfer atoms from a target material to a substrate
3.2.3	Depositions	Physical vapour deposition	magnetron sputtering system	The tool employing a strong electric and magnetic fields to confine charged plasma particles (ions) to transfer atoms from a target material to a substrate
3.2.4	Depositions	Physical vapour deposition	"pulsed laser deposition system	The tool employing a high-power pulsed laser beam to evaporate a target material for subsequent deposition onto a substrate
3.2.5	Depositions	Physical vapour deposition	"molecular beam epitaxy system	A tool for growing single crystals in which beams of atoms or molecules are deposited on a single-crystal substrate in vacuum, giving rise to crystals whose crystallographic orientation is in registry with that of the substrate
3.2.6	Depositions	Physical vapour deposition	thermal evaporator	A tool in which a material is vaporized by heating in the "boat" cavity for subsequent deposition onto a substrate
3.2.7	Depositions	Physical vapour deposition	thermal evaporator - organic	The tool in which an organic material is vaporized at low temperature by heating in the "boat" cavity for subsequent deposition onto a substrate
3.3.1	Depositions	Atomic layer deposition	atomic layer deposition system (ALD)	A tool for fabricating uniform conformal films through the cyclic deposition of material through self-terminating surface reactions that enable thickness control at the atomic scale

	Main Category	Subcategory	Generic instrument name	Definition
3.4.1	Depositions	Coating	dip coater	A tool for creation of a thin film by dipping a substrate into a solution containing the material of interest
3.4.2	Depositions	Coating	spin coater	A tool for creation of a thin film by deposition of a material in solution onto a rotating substrate by utilizing centrifugal force
3.4.3	Depositions	Coating	electroless deposition system	A tool for autocatalytic deposition of material onto a solid surface from ions in solution in the presence of a soluble reducing agent
3.4.4	Depositions	Coating	spray deposition system	A tool for material deposition onto the outside or uppermost layer of substrate by pressurization of a liquid through a nozzle to create droplets or aerosols
3.5.1	Depositions	Plating	electroplating system	A tool for deposition of material onto an electrode surface from ions in solution by electrochemical reduction
4.1.1	Packaging	Bonding	wafer bonder	A tool by which two wafers of any materials are bonded together ensuring a mechanically stable and hermetically sealed encapsulation
4.1.2	Packaging	Bonding	wire bonder	The instrument for making an electrical interconnections between an integrated circuit or other semiconductor device and its package using metallic microwires
4.2.1	Packaging	Dicing	diamond saw dicer	A tool which employs a high-speed spindle fitted with an extremely thin diamond blade or diamond wire to dice, cut, or groove wafers
4.2.2	Packaging	Dicing	laser dicer	A tool which employs a laser to dice, cut, drill or groove wafers
5.1.1	Other	Doping	ion implanter	A tool that uses incident flux of high energy ions to modify structural, chemical or electrical properties of a material.
5.1.2	Other	Doping	diffusion owen	An instrument for thermal processing with a cylindrical heating chamber for the vapor-phase to diffuse into the solid state semiconductor without introducing undesirable impurities.
5.1.3	Other	Doping	wet bench	A tool used to carry out wet cleaning and etching operations in semiconductor manufacturing or other technology processes
5.2.1	Other	Annealing	annealing owen	The tool for high-temperature process to relieve stress in structures, activate or move dopants, densify deposited or grown films, and repair implant damage in wafer processing

	Main Category	Subcategory	Generic instrument name	Definition
5.2.3	Other	Annealing	rapid annealing owen	A tool that heats wafers to high temperatures over 1000 degC on a timescale of seconds.
5.3.1	Other	Cleaning	critical point dryer	A tool for removing liquid from samples in a precise and controlled way
5.3.2	Other	Cleaning	automatic mask cleaner	A tool for controlled removing of any residue left on a glass mask before and after lithographic processes
5.3.3	Other	Cleaning	rinser dryer	A tool for removing particles and loose debris left over a wafer from a previous process step in a semiconductor fabrication line

NanoFabNet

ANNEX – A1: OtaNano, Finland

The table below lists the offer of OtaNano research infrastructure sorted in the three-level structure.

Level 1	Level 2	Level 3
All Tools	Annealing	Annealing Annealing furnace PEO-603 Hot Plate Pia Oven Despatch Oven Memmert Oven1 Oven2 Oven3 Reflow oven ATV RTA RTP Jipelec Vacuum Furnace Vacuum Furnace Webb Vacuum Oven
	Dry etching	Annealing furnace PEO-603HF vapor etcher MEMS-CET ICP-RIE Plasmalab 100 Ion Beam Etcher Ion Beam Trimmer Metal etcher LAM TCP9600 Oxide etcher LAM4520 Oxide Etcher LAM4520XL Oxide ICP etcher STS AOE Plasma Stripper Q240 Polysilicon etcher LAM4420 RIE Oxford 80Plus RIE Plasmalab F10 Silicon ICP etcher (Aviza) Silicon ICP etcher (STS) XeF2 Etcher
	Electrochmical deposition	Au plating module Electroplating Cu Electroplating Ni Electroplating Sn Fumehood PLATING In plating module Ni plating module bump Plating work bench Rena Cu plating A Rena Ni plating RENA Sn plating Rena SnPb plating SnAg plating module
	Lithography	Coater Developer EVG120 Developer Spinner LabSpin Developer track Convac EBL Pattern Generator

Level 1	Level 2	Level 3
		EBL Vistec
		Fumehood Litho
		HMDS Desiccator
		Hot Plate
		Hot plate BLE
		Hot plate duo
		Hot Plate Matti
		Hot Plate Mervi
		Hotplate OPTIHOT HB20
		Hotplate small
		Laserwriter
		Manual Spinner Duo
		Manual spinner LARGE
		Manual spinner LSM200
		Manual spinner SCS
		Manual spinner SMALL
		Mask aligner - Mauri Antero
		Mask aligner MA150
		Mask Aligner MA200
		Mask Aligner MA6
		Oven 120
		Oven 90
		Oven Adjustable
		Prime Oven HMDS
		Primer oven YES-3
		Primer oven YES-5
		Resist oven 1
		Resist oven 2
		Resist oven 3
		Resist oven LOWER (5)
		Resist oven UPPER (4)
		Resist Spinner LabSpin
		Resist Station Gamma4
		Resist track
		Resist/developer track AIO
		Spinner BLE
		Spinner I
		Spinner II
		Spinner Laurell
		Spinner Lithography
		UV-NIL (accessory for Mauri Antero)
		Vacuum Oven
		Wafer spinner POLOS
		Wafer Stepper FPA 3000-i4
		Wet bench Hot plates
		Wet Bench spinner
	Epitaxial growth	Black Magic
		MOVPE I / Asterix
		MOVPE II
		MOVPE III
	Furnace processes	CVD Furnace

Level 1	Level 2	Level 3
		ATV furnace Mörkö Diffusion furnace, A1 anneal Diffusion furnace, A2 oxidation Diffusion furnace, A3 oxidation Diffusion furnace, A4 oxidation Furnace MiniBrute Lower Furnace MiniBrute Upper Furnace PEO LPCVD furnace, B1 LTO LPCVD furnace, B2 TEOS LPCVD furnace, B3 POLY LPCVD furnace, B4 Nitride Oxidation 3 Oxidation 1 Oxidation 2 Oxidation 4 Oxidation furnace PEO-603
	Ion Implatation	Ion Implanter Eaton Ion implanter Eaton 8200
	Nanostructuring	Oven3FIB Helios /SEM/EDX Nanoimprinting tool NPS300 Test_tool_Mko
	Sputtering	AlN Sputtering System DCA Sputtering System OEM Sputtering System Sputter Chromium Sputter Gold Sputter Plasmalab F10 Sputter Sloan Sputtering system Mark IV Sputtering system 1 PV-LLS801 Sputtering system CLN 200 Sputtering system MRC Sputtering system VA
	Evaporation	Evaporator e-gun Edwards Evaporator e-gun Varian Evaporator LISA Evaporator MASA SQUID-evaporator
	Wafer bonding	Bond Aligner Bond aligner EVG620 Wafer Bonder AML Wafer Bonder EVG 510 Wafer bonder EVG5201S
	Wet processes	Aluminium Etch Dual Spin Rinse Drier 16 and 17 Dual SRD 14 (150mm) and 15 (200 mm) Dual SRD 3 (100 mm) and 4 (150 mm) Dual SRD 6 (150 mm) and 10 (200mm) Dual SRD 7 (100 mm) and 8 (150 mm)

Level 1	Level 2	Level 3
		Electrochemical Etching Cell
		Fume Hood HF etch
		Fume hood Metal etch
		Fume Hood TMAH
		Fume Hood A
		Fume Hood Acid work
		Fume Hood Acid work 1
		Fume Hood Acid work 2
		Fume Hood ALD
		Fume Hood Cu Contamination
		Fume Hood Electroplating
		Fume Hood KOH
		Fume Hood Lift off
		Fume Hood Lithography
		Fume Hood Salo
		Fume Hood Solvents
		Fume Hood Solvents
		Fume Hood Spinner
		Fumehood
		Fumehood
		Fumehood ACID
		Fumehood BOAT CLEAN
		Fumehood DEVELOP
		Fumehood for anodization
		Fumehood IMPLANT
		Fumehood KULTA
		Fumehood LIFT-OFF
		Fumehood MASK CLEAN
		Fumehood SCALE&CUT
		Fumehood SERVICE ACIDS
		Fumehood SERVICE SOLVENTS
		Fumehood solvents for cleaning parts
		Fumehood TMAH
		Fumehood VESSEL
		Fumehood WET SERVICE
		Heating Bath IKA
		KOH setup
		Microscope 3
		RCA 2
		Rinse Dryer 100
		Rinse Dryer 150
		Rinse Dryer Verteq 100
		Rinse Dryer Verteq 150
		Single Wafer Dryer
		Sink Neutralization
		Sink Solvent
		Spin Etcher
		Spin rinse drier 1 (150 mm)
		Spin Rinse Drier 18 (150 mm)
		Spin rinse drier 2 (150 mm)
		Spin Rinse Drier 20

Level 1	Level 2	Level 3
		Spin rinse drier 5 (100 mm)
		Spin rinse drier 6 (150 mm)
		Spin/Rinse Dryer 11 (100 mm)
		Spin/Rinse Dryer 12 (150 mm)
		Spin/Rinse Dryer 13 (100 mm)
		Spinner 8 inch
		Spinner Cu
		TMAH etch
		Ultrasonic Bath
		Wafer Cleaner Batchspray Acid
		Wet Bench F11A
		Wet Bench MIXED ETCHANTS
		Wet Bench PRE-CLEAN
		Wet Bench RCA 1-2
		Wet bench D CLEAN 1
		Wet bench D CLEAN 2
		Wet Bench DCLEAN 3
		Wet bench DEVELOP 2
		Wet Bench Development
		Wet bench HF 1
		Wet bench HF 2
		Wet Bench KOH
		Wet Bench MASK CLEAN
		Wet bench METAL ETCH
		Wet Bench Oxide Etch
		Wet bench PIRANHA
		Wet bench Piranha
		Wet Bench POLYMERS
		Wet bench POSISTRIP 1
		Wet bench POSISTRIP 2
		Wet bench POST CMP
		Wet bench Resist Removal
		Wet bench RINSE
		Wet bench RINSE 1
		Wet bench RINSE 2
		Wet bench SOLVENTS
		Wet bench STANDARD ETCHANTS
	Other processes	2D Heterostructure Transfer System
		Air Plasma Treater
		Anodization Cell
		Cassette washing machine
		Cleanroom A
		Cleanroom B
		Cleanroom C
		Cleanroom D
		Cleanroom E
		Cleanroom F
		Cleanroom G
		Cleanroom H
		Cleanroom I
		Cleanroom J

Level 1	Level 2	Level 3
		Cleanroom K
		Cleanroom L
		CO2-dryer BalTec CPD408
		Die Sorter IC 1200
		Electrostatic Carrier
		Glove Box ALD old
		Lab 4142 N1
		Lab 4142 N2
		Lab 4142 N3
		Lab 4142 N4
		Lab 4165
		Lab 4166 A
		Lab 4166 B
		Lab 4168 A
		Lab 4168 B
		Lab 4169 A
		Lab 4169 B
		Lab 4196
		Lab 4197
		Laser marking station Trumpf
		Laser Micromachining System
		Laser Wafer Marker
		Logitech PM6 Lapping system
		MBE Lab A
		MBE Lab B
		MBE Lab C
		Microscope 5
		Microwave asher Aura1000
		MOVPE Lab A
		MOVPE Lab B
		MOVPE Lab C
		Parylene spray deposition tool
		Plasma stripper 1 PRS801
		Plasma stripper PRS900
		Rinse Dryer 4-6
		Rinse Dryer 4-6
		Rinse Dryer Square
		Rinse Dryer Square
		TePla 400
		Thin Film Lab A
		Thin Film Lab B
		Thin Film Lab C
		UV photostabilizer
		UV-Lamp Visual Inspection
		Wafer Taper
		Workshop 1177A
		Workshop 1177B
	CVD & ALD	ALD Reactor ALD-1
		ALD Reactor ALD-2
		ALD Reactor ALD-3
		ALD reactor SUNALE R-150B

Level 1	Level 2	Level 3
		ASM LPCVD Nitride
		ASM LPCVD Poly
		ASM LPCVD TEOS
		Glovebox ALD Precursors
		LPCVD PolySi
		LPCVD SiN
		PECVD Oxford Plasmalab100
		PECVD Oxford PlasmaPro System 100
		PECVD Plasmalab F10
	Characterization	Mechanical testing system MTS
		240 LED lamp
		AFM DI3100
		AFM Dimension Icon
		AFM NT-MDT Ntegra
		Aiolos Probing Station
		Alignment verification system DSM8
		CD MT3000
		Contact Angle Meter THETA
		DLTS
		Ellipsometer Plasmos
		Field emission SEM
		Film stress measurement tool
		Flash Light
		Flatness meter ADE
		Four Point Probe Old
		Four-point Probe Loresta
		Goniometer
		Hall Measurement System Ecopia
		Halogen lamp
		Hot plate - Tmax 250C
		Hot plate - Tmax 250C
		Hot plate - Tmax 350C
		Impedance Analyzer
		IR-Inspector
		Lifetime Scanner PV-2000
		Linear Corona Charger
		Manual prober
		Mapping sheet resistance tool
		Mask Inspection Station
		Micro-Raman
		Microscope 1
		Microscope 10
		Microscope 11
		Microscope 12
		Microscope 2
		Microscope 4
		Microscope 5
		Microscope 8
		Microscope 9
		Microscope A
		Microscope DIC

Level 1	Level 2	Level 3
		Microscope F13B
		Microscope Opton
		Microscope with camera
		Microscope Zeiss
		Microscope Zeiss Axiotron
		mPCD scanner
		Needle corona charger
		Non destructive X-Ray inspection
		Non-contact sheet resistivity tool
		Optical characterization tool FilmTek4000
		Optical Profilometer Contour
		Optical Profilometer Filmetrics
		Optical transmission analyzer
		Probe station Cascade
		Probe Station PA-150
		Profilometer Bruker DektakXT
		Profilometer Dektak/XT
		Profilometer Veeco Dektak M6
		Profilometer Veeco Dektak V200Si
		QuickSun
		Reflectometer 2000M-NIR
		Reflectometer FilmTek 2000M
		Reflectometer Nanospec
		Reflectometer Opton
		SAM Acoustic microscope
		SEM EBL Zeiss Supra 40
		SEM Tabletop
		SEM Zeiss Supra 35
		SEM/EDX/e-beam
		Semiconductor Parameter Analyzer
		Sinton Lifetime
		Small LED lamp
		SNOM/NSOM WITec alpha300
		Spectroscopic Ellipsometer SE-2000
		SPV Scanner
		Stereo Microscope F10B
		Suns-Voc
		Suntest XLS
		Temperature dependent Sinton Lifetime
		UV Lamp System
		Wafer Defect Inspection System
		Vector Network Analyzer
		Vibrometer Lynceetec
		Xenon lamp
		XRD Panalytical
	Back-End processes	CMP 6DSSP
		CMP Strasbaugh 6EC
		Dicing Saw DFD6341
		Dicing saw Disco
		Disco DADdy - Dicing saw
		Flip-chip bonder B

Level 1	Level 2	Level 3
		Manual spinner apogee
		Manual wafer taper
		Manual Wafer Taper
		Metal Backgrinder
		Probestation
		Struers Grinding LaboPol-21
		Struers Polishing RotoPol-22
		Wafer backgrinder 7AF
		Wire bonder
		Wire bonder
		Wire Bonder Bondtec 5330
		Wire bonder Delvotec 53
		Wire Bonder Delvotec 53XX

ANNEX – A2: LAAS Toulouse, France

The table below lists the offer of LAAS Toulouse cleanroom sorted in the three-level structure.

Level 1	Level 2	Level 3
All Tools	Device mounting	carotteuse ultra sonique (A-MONT) Découpe Graphtec (A-MONT) Etuve Horo (A-MONT) étuve MEMMERT (A-MONT) Etuve TETHYS (A-MONT) étuve Thermox (F-FRAI) Fer à souder Weller (F-FRAI) Film monter UH-115 (A-MONT) Form 3 (L- 3D) Grinder G&N (A-POLI) hotte montage (F-FRAI) Hotte polissage (F-FRAI) Jauge de mesure d'épaisseur (A-POLI) Mesure planéité (A-POLI) Micro Injecteur (A-MONT) Micro-soudeuse Delvotec 5430 (A-MONT) Micro-soudeuse KnS 4526 (A-MONT) Micro-soudeuse KnS 4700 (A-MONT) Micro-soudeuse KnS 484 (A-MONT) Micro-soudeuse KnS 484x (A-MONT) Micro-soudeuse TPT HB-16 5 (A-MONT) Nettoyage wafers UH-117 (A-MONT) oscilloscope (F-FRAI) polisseuse CDP41 (A-POLI) polisseuse ESCIL (A-POLI) Polisseuse PM5 (A-POLI) Pull shear testeur (A-MONT) Report Eutectique (A-MONT) Report eutectique KnS 6482 (A-MONT) Report/Collage Tresky T3000 (A-MONT) Report/Collage Tresky T4907 (A-MONT) Scie diamanté DAD-321 (A-MONT) Scriber JFP-S100 (A-MONT) Scriber Karl-SUSS RH-100 (A-MONT) Scriber SET (A-MONT) Wafer Substrate Bonding (A-POLI)
	Plasma etching	ALCATEL P1 (G-DRIE) ALCATEL P4 (G-DRIE) DIENER plasma O2 (F-FRAI) Etchlab 200 (G- ICP) ICP2 III-V et NoMos (G- ICP) ICP3 NoMos (G- ICP) SI500 (G- ICP) SI500-DRIE (G-DRIE) TEPLA plasma O2 (F-FRAI)
	Epitaxy	D8-Discover (M- DRX) MBE2300 (M- EJM)

Level 1	Level 2	Level 3
		MBE32P (M- EJM) MBE412 (M- EJM) Paillasse Chime EJM - Solvants - III/V (F-FRAI) Paillasse Chime EJM- Acides - III/V (F-FRAI) Paillasse Chime EJM-1 (F-FRAI)
	Photolithography	étuve HMDS auto (F-FRAI) étuve HMDS manuel (F-FRAI) étuve polymères (F-FRAI) EVG120 (P-PHOT) EVG620 (P-PHOT) GenISys lab (LOGICI) HMDS Obducat (F-FRAI) MA6 Gen4 (P-PHOT) microscope leica photo auto (F-FRAI) microscope leica photo manuel (F-FRAI) paillasse photo 1 : poste de développement (F-FRAI) paillasse photo 1 : tournette 1 (F-FRAI) paillasse photo 2 :procédés spécifiques (F-FRAI) paillasse photo 2 :procédés spécifiques (F-FRAI) paillasse photo 3 :procédés MOS (F-FRAI) paillasse photo 3 :procédés MOS (F-FRAI) plaque chauffante SU8 n°1 (F-FRAI) plaque chauffante SU8 n°2x (F-FRAI) Stepper Canon (P-PHOT) Suss MA150 (P-PHOT) Suss MA6 (P-PHOT) Suss MJB3 GaAs (P-PHOT) Suss MJB3 Si (P-PHOT) Suss SprayCoater (P-PHOT) WAFERS / SUBSTRATS (FOURN)
	Characterization	AFM DIMENSION (C- AFM) AFM ICON (C- AFM) balance (F-FRAI) Differential Scanning Calorimetry (C- DSC) Digidrop (F-FRAI) Ellipsomètre HJY (C-SPEC) FIB Dual Beam (C- FIB) FTIR (C-SPEC) MEB S-3700N (C- MEB) MEB S-4800 (C- MEB) Microscope optique Leica (F-FRAI) Olympus MX50 (F-FRAI) optical microscope NIKON (F-FRAI) Profilomètre mécanique Tencor P16+ (F-FRAI) Profilomètre mécanique Tencor P17 (F-FRAI) Profilomètre optique LEXT (F-FRAI) Profilomètre optique Wyko (F-FRAI) Résistivimètre automatique (F-FRAI) Résistivimètre manuel (F-FRAI) Spectromètre UV-VIS (C-SPEC) Testeur sous pointes (F-FRAI)

Level 1	Level 2	Level 3
		viscosimètre(F-FRAI)
	PECVD	ICPECVD (T- CVD) PECVD 100 ApSy (T- CVD)
	Surface treatment	SFD (J-TRAI) SPD (J-TRAI) spectroline 248nm (F-FRAI) Tousimis (J-TRAI) UV -ozone (F-FRAI) UV Ozone (F-FRAI)
	Annealing	Four RECUIT6 (T-FOUR) Recuit Au et Cu sur Si (T-FOUR) Recuit ferrite 6" (T-FOUR) Recuit métaux divers sauf Au et Cu sur Si (T-FOUR) Recuit métaux lourds 6" (T-FOUR) Recuit métaux sur substrats verre (T-FOUR) Recuit Polyimide (T-FOUR) Recuit verre 6" (T-FOUR) RTP As-Master (T-FOUR) RTP As-One (T-FOUR)
	PVD	AC450CT Pulvérisation (D-PRST) ApSy E100 (D-PRST) EVA 600 Evaporation (D-PRST) Parylene C30S (D-PARY) PECS (D-PRST) Plassys nano (D-PRST) Plassys Organiques (D-OLED) Riber degas (D-PRST) TFE 644 Pulvérisation (D-PRST) Univex 450 Pulvérisation (D-PRST) Varian Evaporation (D-PRST)
	Wet process benches	Batch Buffer Oxide Etching 1-7 MOS (F-FRAI) left organic solvents fume hood with lowerable window (F-FRAI) wet bench for harmless chemistry (F-FRAI) acid wet bench for multicleaning and etching (F-FRAI) clean wet bench organic solvents (F-FRAI) fume hood exploratory chemistry (F-FRAI) Glove box for HF based chemistry (F-FRAI) Gravure KOH (E-ANIS) Gravure TMAH (E-ANIS) MOS wet bench (F-FRAI) NanoMOS wet bench (F-FRAI) Paillasse de Développement & Stripping (F-FRAI) Paillasse de Développement & Ultrason (F-FRAI) paillasse electroless (E-MANU) paillasse jet d'encre (F-FRAI) RCA/Piranha cleaning MOS (F-FRAI) right organic solvents fume hood with lowerable window (F-FRAI) semitool Spin Rinse Dryer Main Chem (F-FRAI)

Level 1	Level 2	Level 3
		wet batch photoresist stripping by AZ100 remover (F-FRAI) wet bench III-V (F-FRAI) wet bench metal etching (F-FRAI) wet bench organic solvents PDMS and outgasing (F-FRAI)
	Other processes	Sonication cabin (F-FRAI)
	Device mounting	Aligneur Suss (A-INTE) encolleuse (A-MONT) Etuve vieillissement thermique (A-MONT) Four de refusion (A-INTE) hotte solvants (F-FRAI) Hotte Wafer Bonder (F-FRAI) microscope Leica (F-FRAI) plaque chauffante 300°Cx (A-INTE) Report flip chip (A-INTE) sérigraphie (A-INTE) Shipley 3024 (A-INTE) Shipley 360 (A-INTE) Wafer bonder AML (A-INTE) Wafer bonder SUSS (A-INTE) viscosimètre (F-FRAI)
	Ebeam lithography	RAITH150 (N-RAIT)
	Laser lithography	DILASE 3D HR (L- 3D), DILASE 3D MR (L- 3D), DILASE 650 (L- 2D), DILASE 650, DILASE 750 (L- 2D)m , DWL 200 (L- DWL), HMP 90 (L- DWL), Hotte Litho laser (F-FRAI), PHOTONIC PROFESSIONAL (L- 3D)
	LPCVD	Four AET Reve (T- CVD) Four OXYNIT6 (T- CVD) Four SI3N46 (T- CVD) Four SIPOLY6 (T- CVD) Four Tempress Si-poly (T- CVD)
	Oxydation	Four AET Bore (T-FOUR) Four AET Phosphorex (T-FOUR) Four AET Propre (T-FOUR) Four Alox (T-FOUR) Four OXYBORE6 (T-FOUR) Four OXYPHOS6 (T-FOUR) Four OXYPROP6 (T-FOUR)
	Diffusion	Four DIFPHOS6 (T-FOUR)
	Implantation	Hotte implanteur (F-FRAI) Implanteur ionique IMC 200 (I-IMPL)
	Nanoimprint	Hotte nano (F-FRAI) Nano-imprint equipment (N-NEX)

ANNEX – A3: NorFab, Norway

The table below lists the offer of NorFab research infrastructure sorted in the three-level structure.

Level 1	Level 2	Level 3
Technologies	Thermal processes	Climate Cabinet (Weiss) Climate test chamber CNT-reactor Cryofreezer High temperature furnace Oven Binder MB6 Oxidation Oven Harmbridge HiTech furnace Post Cure Chamber Temp chamber Heraeus Kendro Temp Chamber Heraeus Kendro Temp chamber Lenton 202 Temperature Shock chamber Thermal Chamber Heraeus T6200 Thermal Chamber Lenton WHT6/30 Thermal Chamber Thermaks TS4115 Thermal Chamber, Heraeus Wötsch Thermoshaker TS-100 Tube furnace 2" (new), For Annealing only ! Tube Furnace High Temperature 2" Calcination (gold) Furnace Drying Oven 1 Drying Oven 2 Drying Oven 3 (Small) Microwave Oven Rapid Thermal Processing (RTP) Oven RTP Allwin 1 Organic RTP Allwin 2 Inorganic Vacuum Oven 1 Vacuum Oven 3 3-zone furnace Big blue tube furnace Birkeland Tube furnace Flextura - Annealing chamber Lindberg Tube furnace Rapid Thermal Processing - Micro Rapid Thermal Processing - One Small blue tube furnace Tube 1 - 4-stack furnace Tube 2 - 4-stack furnace Tube 3 - 4-stack furnace Tube 4 - 4-stack furnace Warm cabinet Diffusion Furnaces Gas phase doping LPCVD of Si3N4 and polySi

Level 1	Level 2	Level 3
		Rapid thermal processing
Technologies	Thin film deposition	Au sputter VG Microtech SC500 Electroplating Ni Electroplating of Cu and Sn Fume Hood 6- Au electroplating, Ti etch Laminar flow bench 4 Metal finger Plasma Cleaner Addax Profilometer DEKTAK 150 Sputter AJA Thermal Evaporator Moorfield MiniLab T25M ALD Carbon Coater for SEM Sample Prep. CVD Dip Coater E Beam evaporator & Sputter AJA E Beam Evaporator - K.J. Lesker E-Beam Evaporator - Pfeiffer Electroplating System PECVD Sputter Coater and Thermal Evaporator Sputter Coater for SEM Sample Prep. Angstrom - E-beam and thermal PVD Atomic layer deposition (ALD) DC Magnetron sputtering Flextura - Magnetron sputtering chamber Flextura - Remote plasma chamber Leybold E-beam evaporation Moorfield - DC/RF Magnetron sputter MOVPE / MOCVD NanoPVD - DC/RF Magnetron sputter PECVD Semicore - DC/RF Magnetron sputter Thermal evaporator Automatic CSD PZT deposition PECVD Pulsed laser deposition Sputter for Al Ti TiN and W Sputter for Au, NiCr, TiW, Al, Ti, and Pt
Technologies	Lithography	Fume Hood 4 for General Solvents Fume Hood 5 for corrosive chemicals Fume hood 7 - Corrosive Mask Aligner - Karl Suss MA56 (new) Mask Aligner EVG 620 Maskless aligner Rinse and dry STI Semitool Spinner 1 Semitool 1 Spinner 2 AB Plast Spin 150 Wet Etching AB Plast

Level 1	Level 2	Level 3
		Chemical stations in lito area EBL Elionix Mask Aligner MJB3 Maskaligner MA6 MLA 100 MLA 150 Nanoimprinter SCIL Ovens for Lithography Processes SCIL Replication tool Yellow Light Microscope Mask aligner 2 Resist spinner Tabletop Maskless Litography/Aligner System Coater, Gyrset RC8 Mask Aligner MA150 KWS Mask Aligners MA150e Plasma Cleaners Resist Coater ACS200 Resist Coater Maximus
Technologies	Dry Etching	DRIE Deep Si etcher Plasma Cleaner PPS CAIBE ICP-RIE Chiller ICP-RIE Cryo Plasma Cleaner TePla plasma asher Reactive Ion Etch Reactive Ion Etch (RIE) tool 1 Reactive Ion Etch (RIE) tool 2 Reactive Ion Etch (RIE) tool 3
Technologies	Characterization	Acoustic material characterisation Acoustic Pulse-Echo measurements AFM XE-200 Elipsometer Gas chromatograph,Shimadzu Hall Instrument He- Leak Detector Impedance measurement Interferometer Wyko NT9100 Optical Microscope I Leica DM4000M Optical Microscope II Neophot 32 Optical microscope Leica DM3 XL Optical Microscope Olympus IX51/TH4-200 Optical Microscope Olympus MVX10 Probe Station PWS Probe II Probe station RF Probe Station, Pasific Western

Level 1	Level 2	Level 3
		Probestation Cryo, Lakeshore
		SAM 300, PVA TePLA
		Scanning tank, Onda
		SEM Hitachi SU 3500
		SEM Hitachi SU 8230
		Spectrofluorometer FS5
		XRD
		3D Optical Profiler
		AFM Dimension Icon
		AFM, NanoSurf
		AFM, Nanosurf Flex
		AFM, Veeco
		DIC microscope
		FIB G4 (Advanced level)
		Fluorescence microscope
		Focused Ion Beam (FIB G2)
		JEOL SEM
		MiBots (micromanipulators)
		Micro-Raman Spectroscopy
		NanoDrop UV vis spectrophotometer
		Nanosight Nanoparticle Analysis System
		Particle size analyser
		Profilometer (Stylus)
		Reflectometer
		S(T)EM
		SECM
		SEM (Table Top)
		SEM APREO
		Stereomicroscope
		STM 1, Nanosurf
		STM 2, Nanosurf
		STM 3, Nanosurf
		4-point probe
		Ellipsometer
		Flextura - Analysis chamber
		FT-IR
		High-temperature Hall (MEMS room)
		IT-300 SEM
		Low-temperature Hall (Cleanroom)
		Probe station
		QSSPC
		RBS
		Room-temperature Hall (Cleanroom)
		Room-temperature Hall (MEMS room)
		Solar simulator
		Spectrophotometer
		Stylus profilometer
		XRD

Level 1	Level 2	Level 3
		4-point Probe Automatic Inspection Automatic Probe Station TSK Ellipsometer Interferometer Profilometer SEM
Technologies	Bonding and packaging	Wire Bonder Ball bonder - TPT HB100 Bond pull tester Micropull Critical Point Dryer Die Attach Laurier Inc. Die Bonder, TPT Flip-chip bonder FinePlacer Pico (Automatic Force 2-700 N) Flip-chip bonder FinePlacer Pico (Manual Force 1-40 N) IR-Camera Pixelink PL-B74EF Optical Microscope, Zeiss V12 Shear tester Delvotec 5600 Ultrasonic bath FB15051 Ultrasonic Cleaning Brandson Vacuum packer Vacuum welder, Budatec Wafer Bonding System EVG 501 Wire bonder (Ball) Wire Bonder (Ball) Delvotec 5610 Wire bonder(wedge), TPT Wirebonder (Ball) manual Delvotek5410 Bond Aligner, EVG Bond Aligner, Suss Wafer Bonder, EVG Wafer Bonder, SB6e Wafer Dicing Saw Wire Bonder
Technologies	Chemical and bioogical methods	Autoclave Biological Safety Cabinet 2 BIO Biological Safety Cabinet 3 BIO Centrifuge Eppendorf 5702R Centrifuge MiniSpin Cleaner BioTek ELX50 Consort Multi-parameter analyser Dispencer Chemyx Micro Syringe pump 1 Edvocycler Edvocycler Electrochemical workstation Elektro Chemical workstation Elektro Phoresis Elektro Phoresis Fume Hood 1- BIO Fume Hood 2 -BIO Fume Hood 3- BIO

Level 1	Level 2	Level 3
		Fumehood nr 8 for Gold etching Incubator Binder CB150 Incubator Labnet Incubator, Orbital shaker Laminar flow bench 1 BIO Reader 1 Tecan Spectra Fluor Reader 2 Bio Tek Synergy2 StepOnePlus real-time PCR UV Photospectrometer, Shimadzu Analytical Balances Autoclave Centrifuge (Table top) Fume Hood 4 Fume Hood 5 Fume Hood 6 Glove Box Nitrogen HF buddy HF fume hood LAF Safety Bench Laminar Flow Bench 1 Laminar Flow Bench 2 Laminar Flow Bench 3 Langmuir Blodgett trough Microscope Microscope Microscope PDMS Area pH-meter Rotary evaporators Shaking platform (orbital) Spin coater Syringe Pump Fusion Syringe pump KDS Syringe Pump Nexus Table Top Centrifuge Ultracentrifuge Ultrasonic Disintegrator 1 Ultrasonic Disintegrator 2 UV Ozone Cleaner Acid Wet bench Lithography Wet bench RCA Wet bench Solvent Wet bench
Technologies	Sample preparation	Grinding Struers Knuth rotor ION MILLING IM4000 MultiPrep system for grinding/polishing Allied Polishing Equipment 1 Struers DP10 Polishing Equipment 2 Struers DP20 Polishing Equipment, Logitech PM5

Level 1	Level 2	Level 3
		PC-room K1-148 Scriber
Technologies	Other	Glovebox Laser Cutting Machine Optical Lab Vacuum Chamber 3D printer Titan 1 3D printer Ultimaker 2 Chemical area course Lithography Course Spin Coater Corrosive Fumehood Wafer saw Disco 3220 Wet Etch Course Cross Section Polisher Ion implanter Laser Cutter Optical Microscope Line for Non-CMOS compatible materials

NanoFabNet

ANNEX A4: Chalmers MC2 Nanofabrication Laboratory, Gothenburg, Sweden

The table below lists the offer of Chalmers MC2 Nanofabrication Laboratory sorted in the three-level structure.

Level 1	Level 2	Level 3
Resources	All tools	Wet Bench - Solvent - Ultrasonic bath - Microwave line
		Wet Bench - Solvent - Ultrasonic bath
		Wet Bench - Solvent - Ultrasonic bath
		Wet Bench - Solvent - Ultrasonic bath
		Wet Bench - Solvent - Remover Bath
		Wet Bench - Solvent - Megasonic bath
		Wet Bench - Solvent - Mask cleaning
		Wet Bench - Solvent - Liftoff Bath
		Wet Bench - Solvent - Development work & Hot Plate
		Wet Bench - Solvent - Developer Work
		Wet Bench - Solvent - Chemical preparation
		Wet Bench - Solvent
		Wet Bench - Solvent
		Wet Bench - Hotplate & HMDS & Oven
		Wet Bench - Acid & Base - Standard Clean baths (SC1/SC2)
		Wet Bench - Acid & Base - Piranha Cleaning Bath
		Wet Bench - Acid & Base - KOH bath & NaOH work
		Wet Bench - Acid & Base - Electroplating
		Wet Bench - Acid & Base - Developer Work - Microwave line
		Wet Bench - Acid & Base - Developer Work
		Wet Bench - Acid & Base - Developer Work
		Wet Bench - Acid & Base - Developer Spinner - Osiris
		Wet Bench - Acid & Base - Developer Spinner - Delta22
		Wet Bench - Acid & Base - Developer Bath - Microwave line
		Wet Bench - Acid & Base - Chemical preparation
		Wet Bench - Acid & Base - BOE bath
		Wet Bench - Acid & Base - Al-etch bath
		Wet Bench - Acid & Base
		Wet Bench - Acid & Base
		Wet Bench - Acid & Base
		Wet Bench - Acid & Base
		Wafer Inspection System - IR
		Wafer Expander - Dynatex
		Vacuum sealer
		Vacuum packer - LCD line
		Vacuum oven - Hereaus
		Vacuum oven - Fisher Scientific -Block Copolymer processing
		UV illumination box
		Toxic gases
		Tool installations
		Surface profiler - Wyko NT 1100 - Optical
		Surface profiler - Tencor P15
		Surface profiler - Tencor AS500 #2
		Surface profiler - Tencor AS500 #1
		Surface Profiler - Dektak

Level 1	Level 2	Level 3
		Substrate bonder - Suss SB6
		Steam boiler #2
		Steam boiler #1
		Sputter - Pfeiffer
		Sputter - NORDIKO
		Sputter - FHR
		Sputter - DCA Cluster - Oxides
		Sputter - DCA Cluster - Metals
		Sputter - DCA - Ferroelectrics
		Sputter - Balzers
		Sputter - AJA
		Spinner - Suss RCD8
		Spinner - Suss LabSpin6 & Low temp hotplates
		Spinner - Suss LabSpin6 & High temp hotplates
		Spinner - Suss LabSpin6
		Spinner - Suss LabSpin6
		Spinner - Polos & hotplates - Unconventional resists
		Spinner - Headway
		Spinner - BLE & Oven
		Spinner - BLE & HMDS hotplate - Microwave line
		Spinner - BLE
		Spectrometer EDX - IXRF
		Software - SPM/AutoCAD
		Software - Proxecco proximity correction
		Software - GenISys LAB
		Software - GenISys BEAMER
		Smoltek CVD
		Scrubbers
		Scriber breaker - Loomis
		Scriber - Suss - Soft wafers
		Scriber - Suss - Hard wafers
		SPM - Bruker Dimension ICON
		SPM - Bruker Dimension 3100
		SEM - Zeiss Supra 60 VP - EDX
		SEM - Zeiss Supra 55 - EDX
		SEM - JEOL JSM 6301F
		Raman microscope - Horiba
		RTP - STEAG
		RTP - JIPELEC JetFirst 200
		RTP - JIPELEC JetFirst 100
		RTP - AccuThermo AW610 - Wide bandgap
		RTP - AccuThermo AW610 - InP
		Process cooling system
		Parameter Analyzer - Keithley 4200SCS
		PPMS - Quantum Design
		PLD - Twin System
		PLD - Small System
		PLD - RHEED System
		PLD - DCA Cluster
		PLD - Compex Pro 110 Laser
		PLD - Compex 205 Laser

Level 1	Level 2	Level 3
		PLD - Carbon System
		PLD - Calas System
		PECVD - Smoltek - Remote plasma
		PECVD - STS
		Ozone Cleaning - Novascan
		Ozone Cleaning - FHR
		Nanoimprint - CNI v2
		Nanoimprint - CNI v1
		Microscope stereo - Olympus SZX-9 - PL2
		Microscope stereo - Olympus SZX-9 - PL1
		Microscope stereo - Olympus SZX-12
		Microscope stereo - Olympus SZH-11
		Microscope Automatic - Nikon L200ND
		Microscope - Olympus MX50 - Nano area
		Microscope - Olympus MX50 - Nano area
		Microscope - Olympus MX50 - Metrology area
		Microscope - Olympus MX50 - III/V area
		Microscope - Olympus MX40 - Silicon area
		Microscope - Olympus MX40 - III/V area
		Microscope - Olympus MX40
		Microscope - Olympus BX52
		Maskless lithography - SmartPrint
		Mask aligner - Suss MJB3 UV 400 #2
		Mask aligner - Suss MJB3 UV 400 #1
		Mask aligner - Suss MJB3 DUV
		Mask aligner - Suss MJB2
		Mask aligner - Suss MA/BA 6 #1
		Mask aligner - Suss MA 6 #2
		Mask aligner - Canon PPC-210
		MBE - Riber C21
		MBE - EPI 930
		Laser writer - Heidelberg Instruments DWL 2000
		Inert gases
		House vacuum system
		Hotplate - Wenesco - SU8/BCB
		Hotplate - Solar-semi & BLE - Microwave line
		Hotplate - Solar-semi
		Glue Dispensing System - LCD line
		Furnace - Wet oxidation
		Furnace - Thermolyne - Open Tube/1600°C
		Furnace - Thermolyne - BCB cure
		Furnace - Lenton
		Furnace - Graphene SiC
		Furnace - Centrotherm #4-4 LP-Polysilicon
		Furnace - Centrotherm #4-3 LPCVD - SiN
		Furnace - Centrotherm #4-2 LP-TEOS
		Furnace - Centrotherm #3-3 Hi temp anneal
		Furnace - Centrotherm #3-2 Au anneal
		Furnace - Centrotherm #3-1 Al anneal
		Furnace - Centrotherm #1-3 Wet & dry oxidation
		Furnace - Centrotherm #1-2 Wet & dry oxidation (public)

Level 1	Level 2	Level 3
		Furnace - Centrotherm #1-1 Oxidation (restricted)
		Fume hood - Solvent - Dicing preparation
		Fume Hood - Solvent - Polishing preparation
		Fume Hood - Solvent
		Fume Hood - Acid & Base - Wash-up
		Fume Hood - Acid & Base - PLD target polishing
		Fume Hood - Acid & Base - Hot Acid Work
		Fume Hood - Acid & Base - HF & BOE Work
		Flood exposure - Bachur & Associates - DUV
		Flammable gases
		Evaporator - Varian
		Evaporator - Plassys
		Evaporator - Lesker Spectros
		Evaporator - Lesker PVD 225 #2
		Evaporator - Lesker PVD 225 #1
		Evaporator - Lesker Nano Cr
		Evaporator - Edwards
		Evaporator - AVAC
		Ellipsometer - J.A. Woollam M2000
		EBL Sample pre-aligner
		EBL - Raith EBPG 5200
		EBL - JEOL JBX 9300FS
		Dry etch Stripper - TePla
		Dry etch RIE - Plasma-Therm - Oxygen
		Dry etch RIE - Plasma-Therm
		Dry etch RIE - Advanced Vacuum
		Dry etch RIBE - Oxford Ionfab 300
		Dry etch RIBE - NILT
		Dry etch ICP - STS - Deep Silicon etch
		Dry etch ICP - STS
		Dry etch ICP - Oxford Plasmalab 100 - Two chambers
		Dry etch ICP - Oxford PlasmaPro 100
		Dry etch IBE - Oxford Ionfab 300 Plus
		Dry etch IBE - Oxford Ionfab 300
		Diffractometer Xray - Panalytical X'Pert
		Dicing saw - Loadpoint Microace 3+
		Dicing saw - Disco DAD3350
		DI Water system
		Critical Point Dryer - Bal-Tec
		Corrosive gases
		Compressed Dry Air
		Chemicals
		CVD - Parylene
		CVD - MgB2 - PVD hybrid
		CVD - MTI - Graphene
		CVD - MTI - CNT
		CVD - Aixtron - Graphene
		CVD - Aixtron - CNT
		CMP Polishing & Lapping tool - Logitech PM5 #2
		CMP Polishing & Lapping tool - Logitech PM5 #1
		Buffing tool - LCtec - LCD line

Level 1	Level 2	Level 3
		Aligner & Assembler - Ciposa - LCD line
		ALD - Oxford FlexAl
		4-point probe - CMT SR2000N

NanoFabNet

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