Manifesto

for a GO FAIR Implementation Network on

Nano-Fabrication:

GO NANOFAB

1. Context

In the field of cleanroom nanofabrication (NF), the know-how is in constant evolution under the demand of the user community that is constantly requesting fabrication of new nanodevices to address new research goals. Therefore, NF cleanrooms are constantly developing new NF processes to fulfil the requirements of their users.

However, many cleanrooms are reinventing the wheel everyday by developing new NF processes that have already been developed in other cleanrooms. This considerable waste of resources can be avoided by providing access to NF processes that have already been developed by other cleanrooms.

For this reason, the first difficulty obviously consists in convincing cleanrooms to give access to their know-how, but beyond this difficulty, they face a real technical problem: NF processes are notoriously difficult to export and workflows developed in one cleanroom require new development and significant lead time before they can be deployed and integrated at other sites.

Basically, NF processes consist of: (i) a workflow, (ii) a series of **process steps** described by process parameters, reagents and variables (recipe), (iii) a set of **process rules**. Process parameters are often validated only for a given machine, and will vary according to the model, the history of the machine as well as a variety of uncontrolled parameters such as machine contamination, sample cleaning etc.

Documentation is often based on personal or laboratory notebooks, and operator manipulation can have a significant impact on processes. Currently, there is little standardisation across the NF community, and incomplete data make the exchange and scaling of process flows between sites inefficient and at times impossible.

Furthermore, the NF process data management is different in different cleanrooms. Some of them have in house built systems, some of them share licensed access to servers, some still work on offline tools.

In the perspective of building a distributed cleanroom infrastructure potentially capable to exchange process building blocks, it is necessary to setup a unified framework for NF process description, storage and accessibility that enables interoperability of these process building blocks and their reusability in other

process workflows. This framework can be built in a sustainable manner by using the FAIR data management and stewardship approach.

A major goal of the EuroNanoLab consortium consists in developing process descriptions that are precise enough to be reused by other facilities with minimal development. This is why EuroNanoLab is at the origin of the creation of the GO NANOFAB Implementation Network, which aims to achieve this objective by developing the most accurate description of NF processes, standardised data exchange formats and data management methods using the FAIR approach. The methods used are obviously intended to be extended to all actors of nanofabrication at the international level, which will enable exchanging know-how in the most effective way during any cooperation between these actors.

Besides the possibility to reuse the technology in different cleanrooms, setting a FAIR oriented standard to represent NF steps and workflows generates many other positive « side effects ». By building appropriate interfaces to the ENL e-infrastructure (i) external users will be given the possibility to access process data to feed simulators (ii) it will be easier and faster to find where to obtain a desired process (iii) resource optimisation will be possible, since having the possibility to transfer processes from one cleanroom to others will reduce the impact of equipment downtime.

2. Purpose of this Implementation Network (IN)

The GO NANOFAB Implementation Network (IN) aims to work towards improving capabilities for capturing, storing and making accessible data, parameters and workflows from NF process chains.

The consortium will provide a forum for the Nanofabrication community to agree on metadata content rich enough to enable workflows or modular steps developed in any participating cleanroom to be exportable to the wider community. Specifically GO NANOFAB seeks to:

- **Develop information systems** for cleanroom machines that should be able to harvest, store and export FAIR cleanroom process data with sufficient completeness to enable reusability of the cleanroom processes (e.g. by working with cleanroom equipment makers)
- Reach an **agreement on the standardisation of cleanroom process steps description, data sharing, accessibility** of a large number of available validated processes and promotion of best practice on data management throughout process development.
- The GO NANOFAB vision is to encourage
    - **Developing certified NF data stewardship competence centers** and procedures as recognised data storage repositories
    - **Identification of accessibility conditions for NF data release.** NF data can describe commercially sensitive know-how, and embargoes or licensing restrictions may apply. Data release may be phased, and dialogue and agreement on accepted conventions should be established.
    - **Enabling** the diffusion of best practice and potential solutions towards the implementation of **FAIR** approaches in NF processes.
    - **Opening** a dialogue and pathway for achieving agreement on the implementation of appropriate Persistent Identifiers (PIDs), as well as best practice in data capture.

In the long term GO NANOFAB will work towards **improved interoperability** of data resources, machine parameters, and process steps. For example, we will seek agreement on minimal standards for machine readable metadata, database legal interoperability (licenses), and links with developments or approaches from other INs. This work will allow exchange and interoperability between sectors and across borders, allowing complex process chains to work efficiently across different sites, minimising additional developments and speeding up fabrication services for research.

The long term goal is to minimise costly site adaptation/process developments (reinventing the wheel) by promoting approaches that facilitates the efficient **reusability** of cleanroom process data, even for other fields of interest.

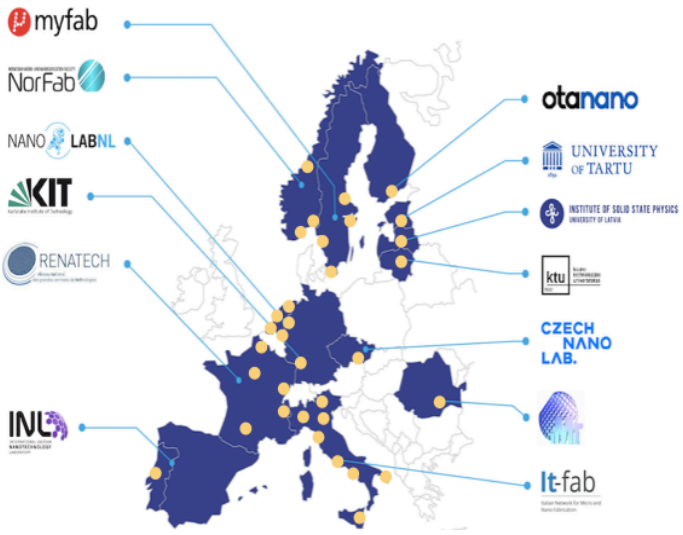
EuroNanoLab has already started this work by identifying families of NF processes (thin films deposition, dry or wet etching, lithography, etc.) and by creating international expert groups that are working on the description of NF processes. **The first international expert group on dry etching processes has met 4 times since 2018**.

3. Overarching Principle of Operation

- The GO NANOFAB IN will **comply with the GO FAIR Rules of Engagement** and will promote exchange on best practice, dialogue on common standards and training resources.
- **Data management**: The ambition of GO NANOFAB is to seek efficiency gains, exchange of data and process expertise, and widely agreed standards in view of process reusability.

4. Membership list

In 2019, the GO NANOFAB consortium includes 44 clean rooms at leading Universities and Research Institutes in 14 European countries (EuroNanoLab: NO, SE, FI, ES, LV, LT, NL, FR, DE, CZ, RO, IT, ES, PT). GO NANOFAB is open to all NF centers worldwide and is actively seeking to engage potential international partners with networks of cleanrooms in the USA (NNCI network), JAPAN (Nanotech Platform), and AUSTRALIA.



- **RENATECH**, www.renatech.org, being the French Nanotechnology National NF facility consortium affiliated to CNRS and encompassing 5 sites: IEMN (Lille), C2N (Paris – Palaiseau), FEMTO-ST (Besançon), LTM (Grenoble) and LAAS (Toulouse).The cleanroom infrastructure has all together about 1000 users and offers 8150 m^2 of cleanroom space. Contact person: Michel de Labachelerie, CNRS
- **CzechNanoLab**, www.czechnanolab.cz, national level research infrastructure in the nanotechnologies filed 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 an expertise for fabrication and analysis of nanostructures and nanomaterials and access to 1700m^2 of cleanroom space. Contact person: Michal Urbánek, Brno University of Technology

- **University of Tartu and Tartu Science Park**, being the Estonian academic clean rooms infrastructure, encompassing Institute of Physics (Tartu), Tartu Observatory (Tõravere) and Tartu Science Park (Tartu). The cleanroom infrastructure offers 300 m2 cleanroom space. Contact person: Toomas Plank, University of Tartu
- **OtaNano**, www.otanano.fi, is the national research and development center for micro- and nanotechnology, and it serves as a state-of-the-art working environment for internationally recognized research fields, such as quantum technology, nanoelectronics, micro- and nanophotonics, and new materials. It provides centralized access to advanced nanofabrication, nanomicroscopy and low-noise measurement facilities. OtaNano provides access to 2600 m^2 of cleanroom space. Contact person: Sorin Paraoanu, Aalto University
- **Karlsruhe Nano Micro Facility (KNMF),** www.knmf.kit.edu, is run at Karlsruhe Institute of Technology (KIT). KNMF offers user access to a uniquely complete set of nano and micro fabrication and characterization technologies. External users from academia and industry, either national or international, can apply for open and – if the results are published and where in accordance with EU State Aid Law: – free access. The highly qualified KNMF staff guide users through the relevant processes and techniques to address their processing goals and characterization needs. Contact persons: Jürgen Brandner and Susan Anson, Karlsruhe Institute of Technology
- **INL** infrastructure, located in Braga - Portugal, 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. INL offers 700 m^2 of cleanroom space. Contact persons: Dmitri Petrovykh, INL
- **It-fab**, itfab.bo.imm.cnr.it, being 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 equipment in about 4000 m^2 of clean-rooms, located in 11 different facilities. Contact person: Vittorio Morandi, CNR, Italy
- **Institute of Solid State Physics (ISSP)**, www.cfi.lu.lv, being the Latvian national research centre for micro and nano fabrication and nanocharacterisation. ISSP offers 650 m^2 of clean-rooms focused on photonics and bio-medical devices. Contact person: Andris Anspoks, University of Latvia
- **MNAAPC** (Open access centre of micro-, nanotechnologies and analysis), apcis.ktu.lt, being 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, nanophotonics, microfluidic devices and biosensors. Contact person: Sigitas Tamulevičius, Kaunas University of Technology
- **NanoLabNL** www.nanolab.nl, being the Dutch national facility for nanotechnological 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). Contact person: Frank Dirne, Delft University of Technology
- **NORFAB**, norfab.no, being the Norwegian National Research infrastructure for nanofabrication encompassing NTNU NanoLab (Trondheim), MiNaLab UoO (Oslo), HSN MSTlab (Horten) and SINTEF MiNaLab (Oslo). The cleanroom infrastructure has all together about 550 users and offers 2300 m^2 cleanroom space. Contact person: Peter Köllensperger, Norwegian University of Science and Technology
- **MicroNanoFabs@PT**, www.inesc-mn.pt, being the portuguese infrastructure network for micro and nanofabrication including 1 national cleanroom (INESC-MN) and 1 international (INL). The clean room INESC-MN offers 350 m^2 of cleanroom space. Contact persons: Susana Cardoso de Freitas, INESC-MN
- **IMT-MINAFAB**, www.imt.ro/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 1.700 m^2 of class 100 - 100.000 cleanroom with a wide range of equipment from photolithographic mask fabrication to etching, deposition and characterization. Contact person: Andrei Avram, IMT Bucharest
- **MICRONANOFABS** is the Spanish Cleanroom Network, 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 consists of three sites 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), Nanophotonics Technology Center of Valencia (NTC) belonging to the Polytechnic University of Valencia (UPV). Contact person: Manuel Lozano, IMB-CNM Barcelona
- **Myfab,** myfab.se, being the Swedish National Research Infrastructure 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). Contact person: Thomas Swahn, Chalmers University of Technology

At the international level, the participation of several cleanroom networks will be sought:
- In USA, the National Nanotechnology Coordinated Infrastructure (NNCI). It is the national academic nanofabrication network of USA.
- In Japan, the Nanotech Platform? It is the national academic Nanofabrication network of Japan.
- In Australia, the Australian National Fabrication Facility network (ANFF). It is the Australian academic Nanofabrication network.

Signatures

(with the agreement of all the consortium members)

Name	Signature
Michel de Labachelerie, Coordinator of EuroNanoLab, CNRS, Paris, France	
Peter Köllensperger, Vice-coordinator of EuroNanoLab, NTNU, Trondheim, Norway	
Vittorio Morandi, Vice-coordinator of EuroNanoLab, IMM/CNR, Bologna, Italy	

APPENDIX: Rules of Engagement to GO FAIR initiative

(to be acknowledged by all participants of implementation networks under the responsibility of the coordinator(s))

To join a GO FAIR Implementation Network, each partner should:

Answer to the FAIR Data Principles: The GO FAIR implementation plan for the Internet of FAIR Data and Services (IFDS) as a whole will answer to the FAIR Guiding Principles. This means that data resources, services, and training materials will be developed according to these principles and will be adorned with rich, machine-readable metadata, and that they will thus be Findable, Accessible, Interoperable, and Reusable under well-defined conditions, by machines and humans.

Abide by the Governance Principles: A GO FAIR partner should formally acknowledge and endorse the general Governance principles of the GO FAIR initiative.

Accept to be stakeholder-governed: The GO FAIR implementation approach for the IFDS is stakeholder-governed. A self-coordinating, board-governed organisation drawn from the stakeholder Implementation Network community creates trust that the organisation will take decisions driven by community consensus, considering different interests.

Accept non-discriminatory membership: When willing to sign the Rules of Engagement, any stakeholder may express an interest in and should be welcome to join GO FAIR.

Conduct transparent operations: Achieving trust in the selection of representatives in governance groups will be best achieved through transparent processes and operations in general (within the constraints of privacy laws).

Not abuse its trusted provider or GO FAIR status for undue lobbying for its own services, especially with the aim to monopolise critical components of the IFDS.