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Abstract Book

EUROnanoLAB

Poster Presentations

Oral Presentations

SESSION 1:
Tool and Process Development 1/2

ENRIS25-0006

The Role of Universities in Supporting Infrastructure for 300 mm Semiconductor Manufacturing Tools

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A recent cost-analysis of installing and operating a 300 mm semiconductor manufacturing facility for 'industry-relevant' microelectronics research in universities [1] suggests that the economics are not sustainable through a simple user fee cost-recovery model. To do so would require an increase in the number of facility users by at least an order of magnitude compared to a 150 mm or 200 mm toolset, an insurmountable challenge for most universities. The authors conclude [1] that a well-equipped 200 mm facility represents the 'sweet-spot' for a small number of universities across the country to support U.S. leadership in microelectronics.

While 150 mm and 200 mm tools offer a balance between cost of use and manufacturing flexibility for a wide range of technologies (GaAs, power electronics, MEMS, etc.) there will still be a need for university researchers to access state-of-the-art 300 mm tools to demonstrate proof-of-principle. For this to be realized, universities will need to partner with industry to develop the necessary infrastructure in facilities that are easily accessible by a wide range of users for advanced R&D and workforce development training purposes. To this end ASU and Applied Materials (AMAT) have announced [2] the creation of a 'Materials-to-Fab' research center located at the ASU science park. The new center will be housed in ASU's MacroTechnology Works, a 250,000 ft^2 manufacturing facility with 43,000 ft^2 of clean room space. An AMAT Centura plasma etch cluster system has been installed as the first in a number of 300 mm tools to be donated by AMAT and managed by ASU for core facility users. This presentation will review on-going progress with the Materials-to-Fab center and discuss the challenges of managing a 300 mm tool set in a university environment.

[1] https://usmicroelectronics.mit.edu/wp-content/uploads/2021/09/microelectronics_white_paper_v13.4.pdf
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ENRIS25-0012

Integrated Generative AI, Machine Learning, and Genetic Algorithms Frameworks to Model and Optimise Micro-Nanofabrication Processes: Application to Femtosecond Laser Micromachining

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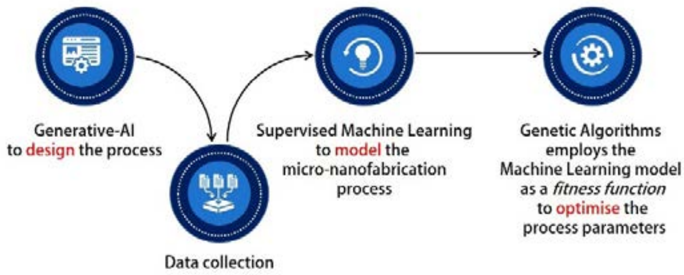
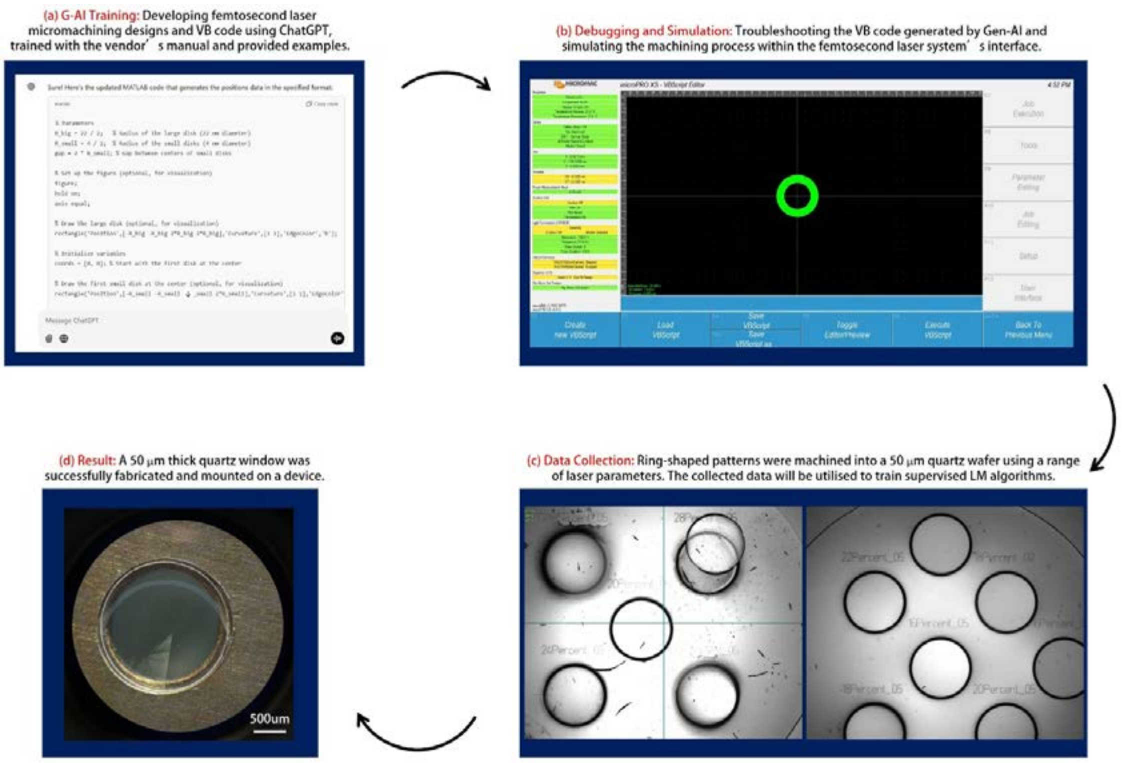
Artificial Intelligence (AI) plays a pivotal role in advancing micro- and nanofabrication processes. Different methods of AI offer unique capabilities that address the diverse challenges in this field. In this work, a comprehensive framework integrating Generative AI (G-AI), Machine Learning (ML), and Genetic Algorithm (GA) for designing, modelling, and optimising micro- and nanofabrication processes is presented. As depicted in Figure 1, the framework begins with G-AI, which develops machining designs and fabrication codes. These designs produce experimental data that are then used during the modelling process by supervised ML algorithms, i.e. ML training. Finally, GA leverages the ML model as a *fitness function* to optimise the process parameters.



As shown in Figure 2, after training a G-AI model with the vendor's manual and programming examples, (a) the G-AI generates various laser movement strategies in the form of VB codes to machine a precise ring-shaped feature into a delicate 50 μm quartz wafer. The objective is to achieve excellent side-wall quality for seamless mounting onto a beamline window. The G-AI-generated code is (b) debugged within a 3DMM femtosecond laser machining system, followed by (c) a series of experiments to refine the machining process under different laser parameters. Through systematic testing and iterative optimisation, (d) a well-machined circular window with solid side-wall quality has been successfully developed. Furthermore, this work lays the foundation for a more advanced framework, where ML models and GA could be integrated to systematically identify the most optimal laser parameters for enhanced precision and consistency in future implementations.



ENRIS25-0025

Automated Metrology for Improved Nanofabrication

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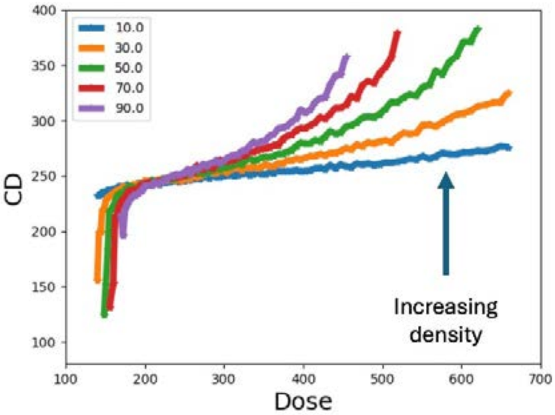
Precise and high-throughput metrology is crucial for advanced nanofabrication. Over the past few years, our approach has evolved from manual, low-throughput measurements to fully automated workflows analyzing tens of thousands of devices. Powered by automated optical- and electron microscopy, we explore large parameter spaces for process development, enabling more robust process points, and deeper insights into process stability.

In addition to accelerating process development, automated metrology significantly streamlines process documentation, allowing checks of device status at any fabrication step. These workflows also enable defect detection, giving immediate feedback on device yield.

Beyond process development, automated measurements are valuable for tool monitoring and optimization. In particular, we have deployed these capabilities to improve the performance of our Raith EBPG5200 electron beam lithography system. Examples include calibrating the height meter and optimizing the beam blanker. By establishing a reliable data feedback loop, we can accelerate iteration cycles, ultimately yielding higher-quality devices while reducing time and labor. This presentation will showcase the impact of automated metrology in advanced nanofabrication.



ENRIS25-0026

Advancing Silicon Carbide Nanofabrication at ANFF-Qld: Innovations in 3C-SiC Deposition and Doping

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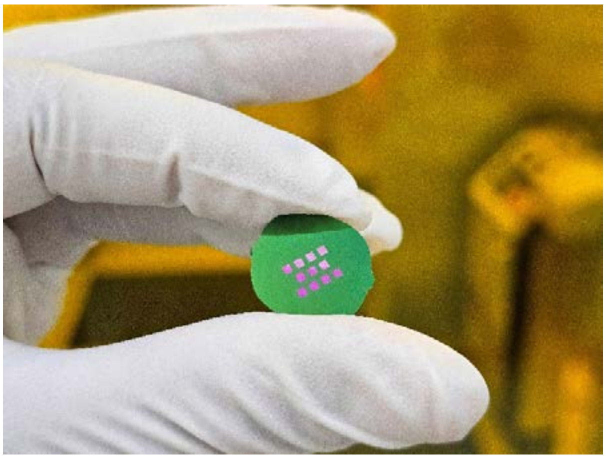
With the advancement of semiconductor technology, Silicon Carbide (SiC) has become a crucial material due to its superior electrical, thermal, and mechanical properties compared to silicon (Si). Its wide bandgap enables high-power and high-temperature operation, making it ideal for power electronics and electric vehicles.

The Australian National Fabrication Facility – Queensland Node (ANFF-Qld) is at the forefront of deposition and controlled doping of high-quality 3C-SiC films. Our facility specializes in growing single-crystalline 3C-SiC on silicon substrates using a high-temperature chemical vapor deposition (CVD) process. This method significantly reduces thermal mismatch stress and enables seamless integration into silicon-based fabrication workflows. In a groundbreaking achievement, we are the first in the world to successfully deposit 3C-SiC epitaxially on 300 mm Si wafers, setting a new benchmark in SiC nanofabrication. By mid-2025, our capabilities will expand with the installation of an epi-reactor for 4H-SiC deposition, further solidifying our leadership in SiC-technology.

This presentation reviews our recent fabrication advances in ultra-thin membranes, wearable devices, and bio sensors. Recently, our researchers developed a novel transfer printing method using a sacrificial aluminium layer to integrate SiC microstructures onto flexible substrates, enabling implantable and stretchable bioelectronics. Another recent study of our 3C-SiC demonstrates that its heterostructures exhibit exceptional lateral photovoltaic effects under thermo-magnetic conditions, enabling self-powered sensors for harsh environments. These advancements along with SiC's biocompatibility, chemical stability, and mechanical strength highlight its role in next-generation energy, biomedical, and flexible electronics, opening pathways for self-sustaining electronic devices.



An array of 100nm-SiC windows with nearly circular frame, fabricated at our facility.

ENRIS25-0029

A Unique Correlative Microscopy Platform for NanoScale Microscopy by combination of AFM, SEM, and EDS

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The direct correlation of atomic force microscopy (AFM), scanning electron microscopy (SEM), and Energy Dispersive Spectroscopy (EDS) is a powerful technique for the acquisition of complementary data of different micro- and nanostructures.

In this presentation, we introduce a highly integrated new correlative microscopy platform – the FusionScope – that offers the analysis of micro- and nanoscale objects with great efficiency by seamlessly combining AFM, SEM, and EDS within a unified coordinate system. FusionScope eliminates the need to transfer samples from one host system to another, therefore, allowing for maximum throughput using minimum resources.

To highlight the advantages of this new tool, we will present a variety of novel case studies focusing on:

- Correlative AFM, SEM, and EDS analysis of magnetic gold nano-shell particles
- Characterization of hard-to-reach sample areas
- Analysis of individual nanowires and fibers on TEM grid substrates
- Correlative Nanoprobing and EFM analysis of electrode structures

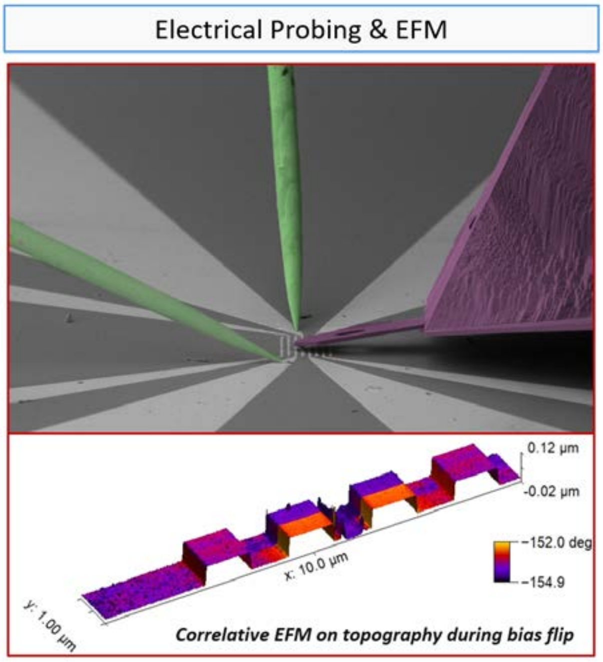

Figure 1: (Top) SEM image of two Microprobers in combination with AFM cantilever inside the FusionScope. (Bottom) Correlative EFM image of biased electrode structure.

ENRIS25-0073

Two Photon Polymerization Process Optimization and Potential Applications

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Two-photon polymerization (TPP) is an advanced fabrication technique that enables the high-resolution 3D printing of micro- and nanoscale structures with feature sizes reaching down to 500 nm. This process is based on the exploitation of a tightly focused femtosecond laser beam to trigger localized polymerization of a photosensitive resin. The high frequency laser pulse is the basis for the non-linear two photon absorption phenomenon, which consent to use resins sensitive at 390nm with a 780nm light source (Figure 1).

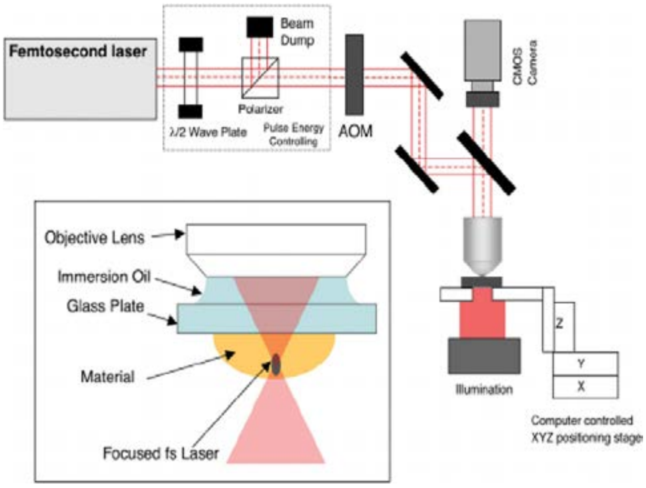

Figure 1: Schematic of the two-photon polymerization setup.

Due to the quadratic dependence of the polymerization rate on light intensity, polymerization occurs only within the focal volume, allowing for precise control over voxel size and structure geometry without the need for additional lithographic steps. The TPP ability to create complex and functional microstructures is explored in the implementation of various optical applications. Examples include the manufacturing of 3D woodpile structures and 2.5D sensitive elements which can be integrated in optical waveguide for biosensing applications. A systematic protocol for different resin formulation is under development in order to optimize the fabrication process. This includes the printing of specific test patterns while varying several parameters such as laser power and writing speed. The analysis of this tests allow for a quantitative evaluation of the resolution limit and enable a better understanding of the material response and fabrication window. By refining process parameters and expanding the library of printable resins, this study aims to enhance the reproducibility and scalability of TPP for cross-disciplinary bio-nano applications.

SESSION 2:
Tool and Process Development 2/2

ENRIS25-0037

Flexible Techniques of Medium to Small Pitch 3D and 2.5D Integration for Prototypes and Small-Scale Production

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In a research facility, we often face the task of testing a single idea or concept which is especially challenging in the field of semiconductor microfabrication as the majority of the activities typically require full-wafer processing. The process steps that require the best accuracy can only be performed on an entire wafer, making prototype development complex and resource-intensive. To bridge the gap between initial concepts and full-wafer production, we have established a roadmap to introduce technologies that enable efficient prototype fabrication and small-scale production. In the field of 3D and 2.5D integration technologies, we are focusing on electroless deposition of nickel, palladium, and gold to form under-bump metallization (UBM) layers suitable for solder material deposition. As the next step, we will incorporate two key technologies for solder deposition: (1) Solder ball laser placement system – that deposits preformed solder balls of arbitrary composition, ranging in size from 30 µm to 250 µm; and (2) Solder ink printing system – that dispenses solder ink of arbitrary composition, with a maximum solid particle size of approximately 5 µm. Both systems use single-spot, one-by-one deposition, inherently limiting production to low volumes. However, this limitation is also advantageous when only a small number of prototypes are needed, as neither technology requires lithography or full-wafer access. Moreover, these technologies support a wide range of bump sizes and interconnection pitches, from 50 µm to approximately 1 mm. The final steps of the planned 3D integration are flip chip bonding (thermo-compression or thermo-sonic compression) and finally wire bonding. As a result, our back-end line shall be able to bond chips with highly variable integration sizes - an essential capability for research activities that demand diverse product integration requirements.

ENRIS25-0038

Localized fabrication and integration of color centers in diamond by FIB

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Color centers (CCs) of group IV elements coupled to vacancies in diamond are emerging as robust solid-state single-photon sources with exceptional optical and spin properties, making them highly attractive for quantum technology applications[1,2,3]. At Fondazione Bruno Kessler, we have developed a comprehensive fabrication platform that enables the precise creation and integration of Group-IV defect centers, particularly silicon-vacancy (SiV) and germanium-vacancy (GeV) centers, with formation yields matching those reported in the literature[4].
In our approach focused ion beam (FIB) tool equipped with a liquid metal alloy ion source (LMAIS) was used to implant Ge and Si ions at extremely low fluences. This mask-less, highly localized process allows us to form shallow CCs with nanometer precision while minimizing collateral lattice damage. Furthermore, we have proved the possibility to finely align and fabricate nanopillar arrays in correspondence the implanted CCs, further improving the out-coupling efficiency, Figure 1. In addition, we integrate these emitters into prefabricated nanostructures like solid immersion lenses (SILs), achieving a high alignment accuracy, essential for enhanced photon extraction, Figure 2. Finally, by inducing lattice damage by ion implantation, we form localized graphitic regions that serve as ohmic contacts on the diamond substrate[5]. These conductive features are key elements for the development of integrated electronic and photonic diamond-based devices.
In this work we will present a summary of these activities to produce and integrate high-quality, localized diamond CC for scalable quantum photonic applications.

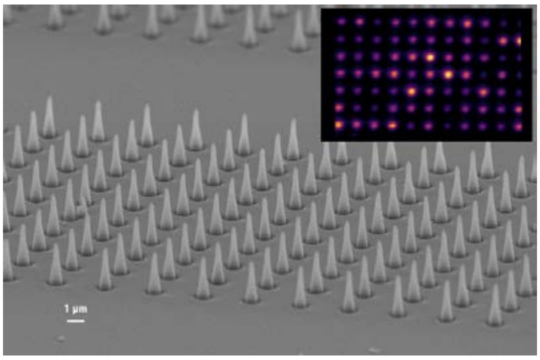

Figure 1. SEM and confocal image of nanopillars.

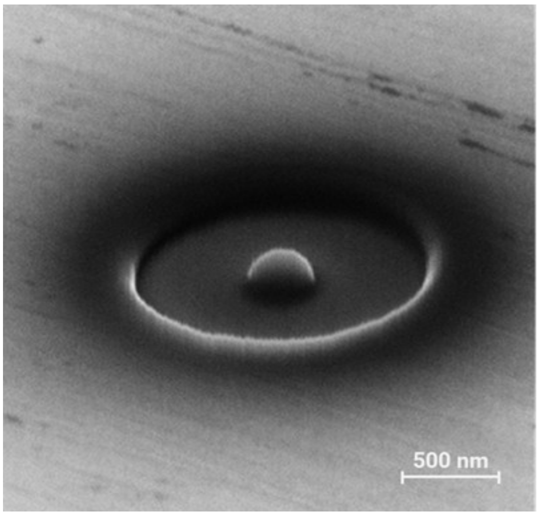

Figure 2. SEM image of a SIL.

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[2] 10.1038/srep12882
[3] 10.1103/PhysRevB.51.16681
[4] 10.1088/1367-2630/aaf2ac
[5] 10.1063/5.0139469

ENRIS25-0039

Quantitave Contamination Evaluation Framework Demonstrated for International Open Platform Process Cascading

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Summary

Since 2000s, open nanofabrication platforms have been established worldwide. Now they are the core facilities for micro-and-nano technologies as well as semiconductor research. Because core competences differ from one platform to another, the cleanroom engineers' natural dream is to combine the best competences by "cascading" sample wafers to provide the world's best nanofab process. We the UTokyo Takeda Sentanchi Supercleanroom, Japan, and LAAS-CNRS, France cleanroom teams run several inter-cleanroom technological development collaborations. The most critical issue to cascade wafers between platforms is surface contamination. Contamination is an issue not only for semiconductor manufacturing [1] but also for exploratory research in open facilities, through degradation of reliability in critical layers [2]. Such contamination is introduced not only through different contamination control level but might also be though transportation. Being aware of such future issue, the UTokyo d.lab nanotech ARIM team have recently acquired a contamination-quantification equipment: non-destructive assessment by Total reflection of X-ray fluorescence analysis (TXRF 3760, Rigaku). Although the method is internationally standardized [3] and widely used in semiconductor manufacturing cleanroom; the equipment is rarely installed in open academic platform (at least UTokyo is the only one in ARIM 25 network). We validated our new scheme (contamination assessment for inter-platform process) by quantitatively evaluating the difference in material existence before and after certain ("cleanest" and "non-controlled") processes, as well as 20,000 km round trip transportation. We will report this new opportunity for worldwide platforms with promising results.

Experiment

Materials on six "just purchased" 4in-wafers have been quantified in UTokyo site. Then, one (Wafer #71) is left in an individual wafer holder in UTokyo SCR and five individually packed wafers made a round trip between Tokyo and Toulouse. In LAAS, three wafer holders were open and exposed to different processes: W66: kept 24 h in an uncontrolled metallic environment: electroplating bench, W68: "cleanest" process: Piranha etch cleaning, and W70: Plasma O_2 in "multi-user (no control)" chamber. The rest (W67/W69) just made a round trip in a "packed in vacuum". Three results were confirmed:

1) no significant change by just ageing nor a round trip (W71/W67/W69),
2) contamination in an uncontrolled draft chamber as well as plasma chambers (W66/W70), and
3) decrease in contamination by Piranha cleaning (W68). All results coherently supported our cleanroom management policy.

References

[1] T. Hattori (Ed.), Springer-Verlag, p. 39, p. 43(1998)
[2] P.S.D. Lin et al., J. Electrochem. Soc. Vol. **130**, 1878 (1983).
[3] ISO 14706:2014

ENRIS25-0041

An Industrial Approach to Research Lab Optimization: Using SPC for Tool Capability Evaluation and Cost Efficiency

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Efficient process flow and tool capability assessment are essential for maintaining high-quality production while minimizing costs. This study integrates industrial best practices with research lab methodologies to explore the application of Statistical Process Control (SPC) tools in achieving laboratory objectives.

Our approach evaluates tool capability in maintaining consistent process quality while reducing tool usage, raw material consumption, and overall costs. By implementing a structured process flow that incorporates SPC tools—such as control charts and Pareto charts—data is systematically collected and analyzed within research lab settings to identify key areas for improvement.

The application of SPC tools demonstrates a significant reduction in raw material usage and operational costs while offering a comprehensive assessment of lab capability. This hybrid industrial-research methodology provides valuable insights into optimizing process flow and enhancing tool performance.

Integrating industrial methodologies into research lab environments strengthens process efficiency and cost-effectiveness, establishing a robust framework for research, services, and manufacturing projects.

ENRIS25-0042

Cleanrooms for Quantum Photonic Circuits: Requirements and Realization at Paderborn University

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In the past two decades, quantum optics has made significant advancements, leading to applications in sensing and information processing. These advancements are largely supported by sophisticated fabrication facilities and laboratory environments. At the Institute for Photonic Quantum Systems (PhoQS) in Paderborn, we combine expertise in quantum optics and cleanroom technology to create a state-of-the-art lab complex. PhoQSLab includes a 1,000 m² cleanroom, classified as ISO 6 (600 m²) and ISO 5 (400 m²), currently under construction.

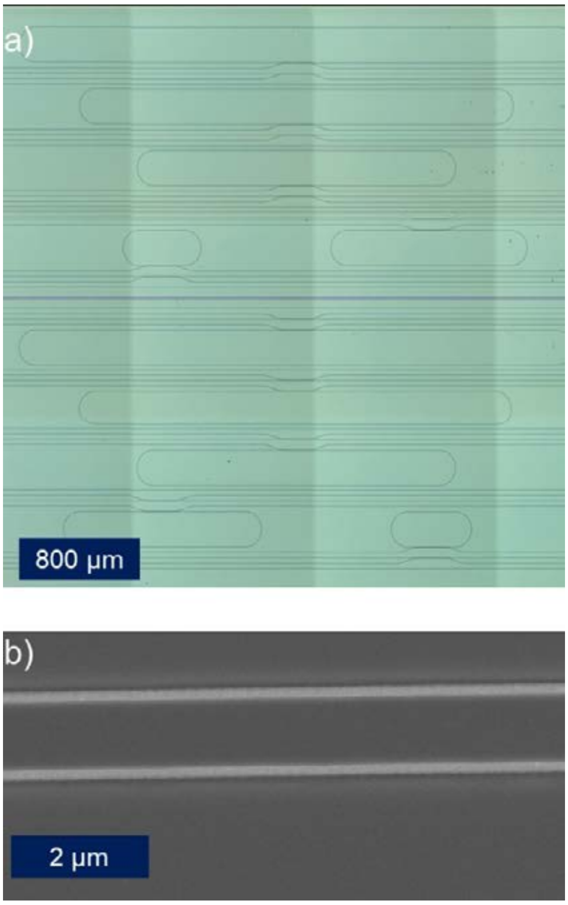

Figure 1. a) Large view of a TFLN chip b) SEM image of a waveguide.

One focus is fabricating quantum optical circuits in thin-film lithium niobate (TFLN) using electro-optical modulators, resonators, and directional couplers from waveguide arrangements, as shown in Figure 1a. Achieving waveguides (Figure 1b) with high repeatability and low loss is crucial for integrating multiple elements into functional large-scale quantum photonic devices, but these circuits are highly sensitive to manufacturing imperfections. For example, the fabrication includes reactive ion etching, which requires dedicated plasma etching tools. Further, analysis tools like scanning electron (SEM) and atomic force microscopy (AFM) are necessary to control fabrication with high repeatability, but optical performance often depends on features (e.g., waveguide roughness) as small as 5 nm. To achieve the necessary precision, the building has a high vibration rating, and many tools are shielded from noise, mechanical vibration, and electromagnetic interference. This presentation discusses the challenges of fabricating quantum optical circuits and the corresponding requirements for cleanroom facilities. By addressing these challenges, the PhoQSLab aims to advance quantum optics and technology.

ENRIS25-0063

Floating-Gate Organic Electrochemical Transistors for In-Memory Sensing

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Traditional sensing architectures rely on data transfer between sensors, memory, and processing units, hindering data transfer efficiency. Differently, biological neurons integrate these functions within a single unit, achieving remarkable energy, time, and area efficiency. In-memory sensing technologies mimic this approach, allowing devices to operate locally and autonomously. This minimizes reliance on external data transmission, enhances data security, and facilitates the development of on-chip processing for more effective performance.

This study presents a floating-gate organic electrochemical transistor (OECT) that functions both as sensor and memory. Organic mixed ionic-electronic conductors are well-suited for in-memory sensing, having been used in biosensing and neuromorphic computing. Organic electronic devices offer low operating voltage, high conductivity, and excellent tunability, making them highly adaptable. The floating-gate architecture separates memory from sensing, preventing contamination of the channel material by the analyte and allowing material optimization for each function. The memory gate (FG1 in Fig. 1), made of PEDOT:PSS, ensures state retention via electrochemical doping/dedoping of gate and channel. Meanwhile, the sensing gate (FG2 in Fig. 1), made of gold, facilitates electrode functionalization with artificial bioreceptors for capacitive sensing. Transconductance and state retention serve as key performance indicators for sensing and memory, respectively. The chips were fabricated using the standard double parylene process commonly used for OECTs. The circuit shown in Fig. 2 was designed for LTspice simulations to better understand the device's working principle, analyzing the sensing gate's impact on device operation.

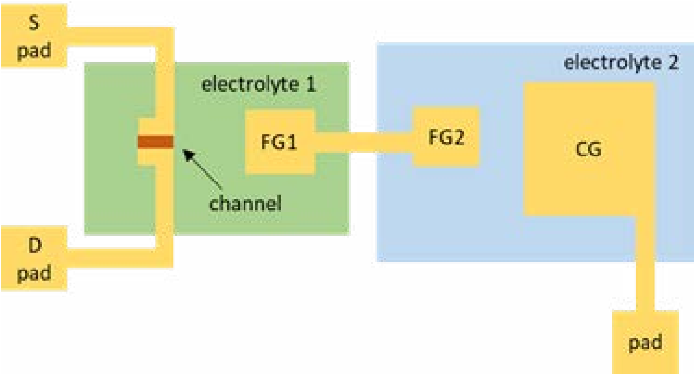

Figure 1: Schematic of the FG-OECT geometry.

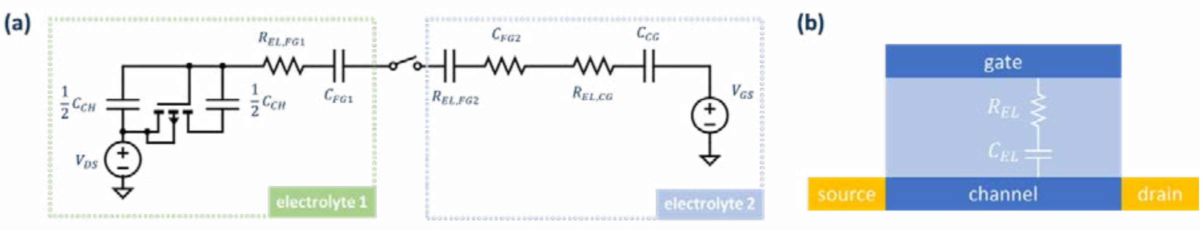

Figure 2: (a) Circuit used for LTspice simulations. (b) LTspice electrode model.

SESSION 3: Collaboration and Networking

ENRIS25-0023

NNCI as a Model for Shared Governance and Innovation

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In 2015, the US National Science Foundation restructured its decades-old network of national nanoscale fabrication labs, creating the National Nanotechnology Coordinated Infrastructure (NNCI). The objective of opening university facilities for access by external academic, industry, and government researchers to maximize the benefit of their state-of-the-art tools and expert personnel remained the same, but the organizational structure was decentralized. As a consortium of independent sites distributed across the US, the structure of the NNCI allows each site to pursue its own programs with dexterity, flexibility, and novelty, while sharing the network goal of supporting a broad and diverse set of users and leveraging resources to support education, policy, entrepreneurship, and computation activities. To support this agenda, a Coordinating Office was established, not to authoritatively mandate site actions, but to help manage progress toward mutually agreed upon objectives. This talk will describe how this cooperative governance model encouraged distributed innovation and experimentation in the creation of new programs and activities, which were then shared across the network. This tactic led to the development of programs for assistance of research users, staff professional development, improved operational efficiency, and even responses to a universal crisis such as the COVID-19 pandemic. Not everything worked as planned, but the consortium model, unhindered by sponsor directives, was able to pivot quickly as needed. As the NNCI nears its tenth anniversary, the decentralized model continues to inspire collaboration and innovation with multiple new initiatives.

ENRIS25-0024

Fostering Direct Write Lithography: Building an Australian Community for Knowledge Sharing and Collaboration

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The establishment of a robust Direct Write Lithography (dwl.org.au) community in Australia is an essential step towards fostering collaboration, knowledge transfer, and technological advancement within the field of micro- and nanofabrication. This presentation outlines our recent efforts and successes in creating a DWL community, highlighting the importance of international collaboration, sustainability, and the integration of cutting-edge technologies.

In the past year, we organised a highly successful DWL workshop and webinar series, which attracted 140 national and international attendees. The series, which included lithography resist webinars, provided valuable insights and garnered positive feedback. This was made possible through collaborations with MAEBL, EIPBN, and TPW. They helped to advertise and attract participants, demonstrating the importance of partnerships in promoting such events.

Our motivation for establishing an Australian DWL community stems from personal experiences during my PhD, where the lack of a supportive network made the research journey challenging. By creating this community, we aim to connect researchers, share the latest technology advancements, and introduce new nano-microfabrication approaches. Australia, being an isolated continent, lacks a dedicated DWL community like EIPBN in the US or MNE in Europe. Our goal is to bring expertise and experience to Australia, providing a platform for young researchers and PhD students to learn and connect with peers.

The significance of this initiative lies in Australia's large community of DWL researchers and engineers who can benefit from shared knowledge and expertise. By hosting international top-level speakers, we enable participants to stay abreast of technology trends and advancements, fostering interactions with leading researchers and technicians.

However, establishing a new community is not without challenges. The workload for the organising committee, composed entirely of volunteers, is substantial, and there has been much discussion about the benefits and needs of such a community.

We are open to international collaborations to generate awareness about the Australian DWL community, improve outreach, and bring global expertise to our shores. Motivating experts in the field is easier when they share our passion, and highlighting the benefits of learning about new aspects within the DWL field helps maintain engagement.

The idea for this community evolved from the ANFF electron beam expert working group, inspired by successful events like the Australian BEAMeeting and MAEBLx Asia Pacific meeting. Sustainability conversations have led to practical implementations, such as reducing chemical usage, switching to less hazardous developers, and encouraging more sustainable practices.

ENRIS25-0055

Opportunities and Challenges towards Portable Nanotechnology Processes over Open Facilities

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3 Centre National de la Recherche Scientifique CNRS- Universite de Toulouse, Laboratoire d'Analyses et d'Architecture des Systemes LAAS, Toulouse, France

Introduction

One of the advantages of Open Platform Networking such as EuroNanoLab is that users can obtain best process results by combining the most powerful techniques and equipment. Through such networking, not only can users combine the best process, but also can facility engineers learn the best processes from each other about the best process. On the other hand, the challenges to the process are increasing year by year, and it is becoming more and more difficult. Now we believe it is high time to "standardize" commonly-required processes and make them accessible from anywhere in the world, so that we engineers secure time to tackle cutting-edge process problems. By porting process technologies to each other, it also may be improved both quantitatively and qualitatively. At the conference we will introduce these examples and will explore whether we can make our common-sense interoperable.

Experimental Process Porting

As a test case, UTokyo Takeda Sentanchi Supercleanroom engineers team (TakedaSCR) and CNRS LAAS cleanroom TEAM are exploring deep sub-micron high aspect ratio Nano Structures [1] (Details will be presented in [2]). Wafers with molds written by an ultra-rapid Electron Beam Lithography equipment in UTokyo were brought to LAAS in July and December 2024. Electroplating and seed layer removal were successfully made in LAAS. Then the same process was duplicated in UTokyo TakedaSCR.

The challenge encountered was "non-equivalence" of environment. Naturally, the equipment is different (at LAAS the ICP etching machine Multiplex Alcatel AMS4200 is used, and at UTokyo the NLD etching machine ULVAC NLD-5700 Si), so the process conditions will never be identical. Through our experiments, it was verified that "by knowing quantitative values such as plasma self-bias voltage (-200V), it was straightforward and easy to port the plasma condition. Within four trials in one hour, seed layer removal process was successfully ported. In contrast, a mystery remained in a "chemical bath" of the electroplating; The obtained surface morphology was not identical. Besides the experiments of our original purpose, we also learned a lot of "common techniques'' within each platform. These "common techniques'' include everything from using chemicals to the equipment. Knowing these things has made our daily process work much easier.

[1] N.Kawai, et al., "Nano-EB LIGA Process through LAAS-RENATECH and UTokyo Engineers Exchange", JNTE 2024, 27-29 Nov., St-Etienne, France.
[2] A.Beghersa et al., "How an international engineers exchange brings to a successful process/project", ENRIS 2025 (submitted)

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Acknowledgments

Renatech, the French academic nanofabrication network and Japanese ARIM (JPMXP1224UT1120), X-nics JPJ011438, and Kakenhi 24H00307 jointly supported.

ENRIS25-0045

How an international engineers exchange brings to a successful process/project

Amel Beghersa[1], Noriko Kawai[2], Ayako Mizushima[3], David Bourrier[1], Etsuko Ota[2], Mita Yoshio[2,3], Hugues Granier[1]

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2 University of Tokyo, Systems Design Lab d.lab- School of Engineering- the University of Tokyo, Tokyo, Japan
3 University of Tokyo, Department of Electrical Engineering and Information Systems- the University of Tokyo, Tokyo, Japan

In the world of research, international collaborations between researchers are common, well-structured, and benefit from a lot of funding. Exchanges between technical staffs in general are rarer, it is difficult to find dedicated funding. Through the opportunity offered by MEXT X-nics UTokyo Agile-X project two engineers of LAAS-CNRS have been hosted in Takeda Super Clean room in 2023; and two engineers and the Professor Mita has been welcomed in LAAS clean room during 3 weeks in two times in 2024.Each institute have their own knowledges and specialties; that have been share, train and learn. The two first exchanges permit to learn each other habits and work procedures. Between these, the distance exchanging also introduce some misunderstandings that create some fails. But learning about our errors the third exchange was crowned with success in only 2 days of technology. We did a large gap due to these win/win technological exchanges.

We will show that these exchanges are an opportunity for real scientific and technological collaborations; and that as such they deserve to be developed.

We will present very good results about HARNS technology [1]; as well as all the benefits brought by these exchanges on the technological, scientific and human points of view (Fig.1). They will benefit the two laboratories and will accelerate new scientific results.

These international exchanges allow us to confront and enrich different and complementary visions of how to implement technologies. Which is all the more enriching and motivating for the evolution of ways of working and exchanging. We hope that our presentation will create new opportunities, and show the real interest for our supervisory bodies to organize this type of opportunities beneficial to the whole scientific and technological community.

[1] Y. Mita, *et al.*, Advantage and Challenge of Electrical Critical Dimension Test Structures for Electroplated High Aspect Ratio Nano Structures (HARNS) on insulating materials, IEEE ICTMS 2025, San Antonio, 24–27 Mar.

Acknowledgments

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SESSION 4: Access and User Training + People and Staff Development

ENRIS25-0013

The Australian National Fabrication Facility Expert Working Group Program

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The Australian National Fabrication Facility (ANFF) is a federally funded facility which provides open access to state-of-the-art micro and nanofabrication facilities for both academic and industry researchers. The ANFF network has over 500 instruments spread across 21 sites in Australia. Since its inception in 2007, ANFF has grown to approximately 3200 users and 216,00 user hours in 2023/2024. Due to ANFF's area of expertise, many tools are imperative to facilitate its unique offering. Tools for ellipsometry, profilometry, wafer dicing, reactive ion etching, direct write lithography and plasma enhanced chemical vapour deposition are therefore in high demand and duplication is required both due to geographical distance and their need for co-location for complementary fabrication and/or analysis. Each tool is looked after by one of ANFF's over 100 process specialists, who each undertake a unique mixture of tool maintenance, process development, advanced training, expert assistance and creation of training/safety documentation. As these ANFF staff are spread across the 21 sites, there was not significant opportunities for staff working on common tools or applications to collaborate and share knowledge and/or resources. Resulting from staff feedback, the ANFF expert working group (EWG) program was officially launched in 2020. The goals of the EWG program are to increase communication, share knowledge, standardise processes, reduce duplication and thereby increasing quality across the Australia wide ANFF network. The program was initially comprised of technique groups spread across ANFF's tool categories of deposition, lithography, testing, etching and packaging. The EWG groups have evolved over time, with groups forming and amalgamating. There are no specific KPIs for each group. These groups are '*by the people, for the people*'. The groups are given guidelines on what topics/goals/initiatives they could work on but are given free reign to run the groups independently. Some groups are simply regularly communicating on topics such as tool charging rates while others are running annual workshops reaching beyond ANFF users. Currently, there are 20 EWGs. In addition to the technique-based groups, such as photolithography, sputtering, 3D printing and bonding, applications-based groups have been added to the program, on sustainability, business development, medical devices and operations. The ANFF EWGs will continue to evolve over time, based on the aspirations of each group's members. It is hoped that the program will continue to be perceived as providing benefit to ANFF staff and the overall ANFF network.

ENRIS25-0032

An Intensive Training Package For New Fabricators

Joe Bronstein[1], Linda Pollock[1], Archie McIver[1]

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At the James Watt Nanofabrication Centre (University of Glasgow, UK), we train roughly 70–80 new members each year. We recently started to assess the needs of each new user to accelerate their translation to a new facility or, as is more often the case, their initial training in fabrication methods. Those found to have intensive needs but little prior experience are fast-tracked through a boot-camp-style course which introduces them to a broad range of theories and techniques. Signing off these users on a diverse array of tools as soon as possible after induction, our "Post-Induction Course" has reduced the burden both on providing and on administering distinct training sessions, as well as imparting a holistic-process mindset on users setting out on challenging projects. This provides an opportunity also to develop our own staff and now plays a key role in the staff-induction process.

ENRIS25-0050

A Symbiotic Nanofabrication Internship Program: Training New Talent, Enhancing Staff Professional Growth, and Strengthening Facility Operations

Sara Ostrowski[1], Daniella Duran[1], Alexander Denton[2], Chloe Goings[2], Grant Shao[3], Karrie Weaver[4], Rachelle Salmani[2], Maurice Stevens[2], Ulrike Thumser[2], Swaroop Kommera[2], Lavendra Mandyam[2], Neel Mehta[2], Stanley Lin[3], Grace Hsieh[1], Mary Tang[2], Tobias Beetz[3], Kate Maher[5], Yuri Suzuki[6], Debbie Senesky[7]

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2 Stanford University, Stanford Nanofabrication Facility, Stanford, USA
3 Stanford University, Stanford Nano Shared Facilities, Stanford, USA
4 Stanford University, Stanford Isotope & Geochemical Measurement and Analysis Facility, Stanford, USA
5 Stanford University, Department of Earth System Science, Stanford, USA
6 Stanford University, Department of Applied Physics and Geballe Laboratory for Advanced Materials, Stanford, USA
7 Stanford University, Department of Aeronautics and Astronautics, Stanford, USA

The U.S. CHIPS and Science Act and the European Chips Act have emphasized the importance of cultivating a global workforce that is well-educated in fields related to semiconductor manufacturing. The Semiconductor Industry Association projected there will be 67,000 unfilled jobs in the U.S. chips industry by 2030, demonstrating a strong need for workforce development.[1] Community colleges in the U.S. offer affordable postsecondary education for students to earn certificates and associate degrees, while on an optional path to transfer to a four-year institution. These community colleges are an overlooked resource for talent that could support the semiconductor industry; however, advanced semiconductor processing equipment is typically not available at these schools. Stanford University developed a year-round internship program to provide community college students with paid, hands-on experiences in nanofabrication while they contribute to facility operations. By learning from staff mentors, they gain technical skills in process control, equipment maintenance, deposition, etching, lithography, and metrology in Stanford's class 100 cleanroom. The interns play a vital role supporting facility operations, which alleviates staff and enables smooth cleanroom operation. They stock supplies, run process controls, monitor equipment, watch for safety concerns, train new users, and collaborate on lab support projects. In one project, they fabricated pocket wafers which are now inventory items available for users doing chip-scale processing. Another benefit of the program is that staff have reported increased job satisfaction from mentoring interns.

This presentation will share best practices for establishing and growing a nanofabrication internship program. We developed successful recruitment strategies, such as inviting local colleges for facility visits and raising awareness through an intern-run Instagram page. These strategies resulted in over 300 students applying for 5 positions last winter. Another best practice has been onboarding cohorts of interns together and requiring a minimum commitment of 20 weeks. This program length ensures the interns have in-depth exposure to fabrication and cleanroom operations, and allows ample time for community-building which helps with retention. Interns who stay beyond the 20 weeks assist staff with training new interns while developing their leadership and durable skills. Finally, we hired a previous intern as a program coordinator, which was imperative for program growth (e.g., 3 interns in 2020 to 25 interns in 2024).

[1] "Chipping Away: Assessing and Addressing the Labor Market Gap Facing the U.S. Semiconductor Industry." Semiconductor Industry Association Report with Oxford Economics. 2023.

ENRIS25-0052

Knowledge Exchange across Multiple Platforms

Anders Jorgensen[1], Berit Herstrøm[1], Flemming Jensen[1], Thomas Pedersen[1], Jesper Hanberg[1], Jan Eriksen[1], Jörg Hübner[1]

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Nanofabrication relies on clean practices and predictable processes. Retaining fabrication knowledge is key for efficient use of resources. It doesn't really matter if efficiency is gauged by financial, environmental or time perspectives. To tackle this, DTU Nanolab has implemented multiple repositories on multiple platforms. Some of the platforms are open for everyone and thus have a global reach (LabAdviser and YouTube channel), whereas others are only available locally, here specifically DTU Learn.

LabAdviser is a wiki-based knowledge retention system (https://labadviser.nanolab.dtu.dk/). In 2024 it was opened to the public and has had more than 1.7 million page views since. It contains processes, equipment information and various troubleshooting guides. The content is written by both DTU Nanolab Staff and users of our facility.

DTU Nanolab's YouTube channel (https://www.youtube.com/@dtunanolab1398) contains all manner of different videos. Currently there are more than 100 videos with more than 200.000 views. Video quality ranges from rather rough to highly polished content. The point is that form should not hinder release of content.

DTU Learn is an implementation of the Brightspace e-learning platform from D2L. DTU Nanolab uses the platform for structured learning using the content on YouTube as well as LabAdviser. Training modules within the e-learning platform are tied into access to the facility or to specific classes of tools. This allows students to study at their own pace and also gives them reference points they can revisit as needed in the future.

DTU Nanolab enables new users to gain the necessary knowledge to access and use the facility through the DTU Learn e-learning platform. This approach was developed because more and more staff time was needed to train a growing number of new users.

It is not always easy to make the content openly available, there have been issues related to time, cost, copyright, non-disclosure agreements, fear of publishing mistakes, worry about being in front of a camera, production quality and recently more and more issues related to export control. Overcoming these issues requires continual management focus and support as well as documenting the benefits for the organization.

Nanofabrication content on the internet is plentiful and that is a good thing. It is easier than ever to research processes and find inspiration. By sharing our knowledge and resources, we contribute to a global community of innovation and progress. Together, we can push the boundaries of technology and create a brighter future for all.

ENRIS25-0056

Accommodating Accessibility Needs in Cleanrooms

Vijayalakshmi Krishnan[1]

[1] University College London, London Centre for Nanotechnology, London, United Kingdom

Introduction

Cleanrooms are labs that require controlled particle counts to guarantee the cleanliness of air within the lab. These spaces are accessed through strict gowning procedures which include hair covers, bunny suits/overalls, overshoes, gloves and face covers.

Presently, these labs are not always accessible to users with mobility needs or disabilities. Under the UK 2010 Equality Act, the workplace has a duty to provide reasonable adjustments to reduce or remove the disadvantage to disabled users. These adjustments may consist of making changes to the work environment, finding a different way of doing certain activities and providing tools, services and support.

Methods

The first step to improving accessibility comes with the assessment of the needs of the user. The most efficient approach is to discuss their needs and work plans ahead of time. The aspects to consider include disabilities such as sensory (including partial sight, colour blindness, hearing impairments), physical (mobility requirements) or other conditions that require adjustments at the work place.

Risk assessments should be performed for each lab user based on their work requirement and the cleanroom in which they will be working. Each hazard present in the cleanroom must be considered against the conditions of the lab user to identify areas where additional safety measures are required.

Recommendations

A list of actions and implementations are applicable to each user's requirements may be put in place as needed. The actions could range from recommending a buddy system, providing tools, service or assistance to making structural changes such as rearranging the gowning area for wheelchair access and investing in height-adjustable wet benches when replacing old ones. Some new ideas that could be ventured towards this include wheelchair-friendly lab coats as pioneered by the UCL Innovation Lab (https://www.ucl.ac.uk/ucl-east/news/2024/dec/wheelchair-users-needed-test-new-lab-coats).

Significance

While it is easier to include accessibility considerations at the point of design and construction, existing labs can gradually increase accessibility features when replacing existing tools.

Reasonable changes would improve the accessibility of these labs to allow lab users to work carry out their research in the cleanroom without compromising safety and the individual's dignity.

Increasing inclusivity in cleanrooms will benefit not only to students and researchers who will need occasional access to the lab, but also technical staff for whom the cleanroom is the primary workplace throughout their scientific career.

ENRIS25-0074

Spreading Awareness of Our Cleanroom Facility and Training Future Experts for EU Chip Production

Peter Fecko[1], Jan Prášek[1], Jaganandha Panda[1], Radim Hrdý[1], Jiří Zita[1]

[1] Central European Institute of Technology BUT, Core Facility, Brno, Czech Republic

Recent years have shown the EU's dependence on non-European microchip fabrication facilities. This lack of microchip fabrication facilities persuaded the EU's leadership to maintain the EU's self-sufficiency in this crucial field as soon as possible. One of the key means to achieve this goal is to increase the attractivity of this field amongst prospective students of technical universities to educate enough future experts in this field.

With the support of the Brno University of Technology and EU projects, the CEITEC Nano started organizing microfabrication courses for secondary grammar and technical schools to spread microfabrication knowledge. The nature of these classes is to spark interest in nano-fabrication work by presenting them with standard process flow and methodology in semiconductor microfabrication. The learning curve must be optimized to deliver the general idea to a younger mind and reinforced by practical experience in the cleanroom. After 90 minutes of theoretical introduction, they go for additional 180 minutes to the nanofabrication laboratory, where they can practice these processes hands-on. The outputs are two 4″ silicon wafers with the structure made in one lithography step with engraved names of all participants and their institution's logo, which they could take with and present to their fellows.

So far, we have finished five courses showing the basics of nanofabrication to twenty-five high school students and five teachers. We received excellent feedback from both students and teachers, and the Brno University of Technology is willing to organize additional courses in the following semesters.

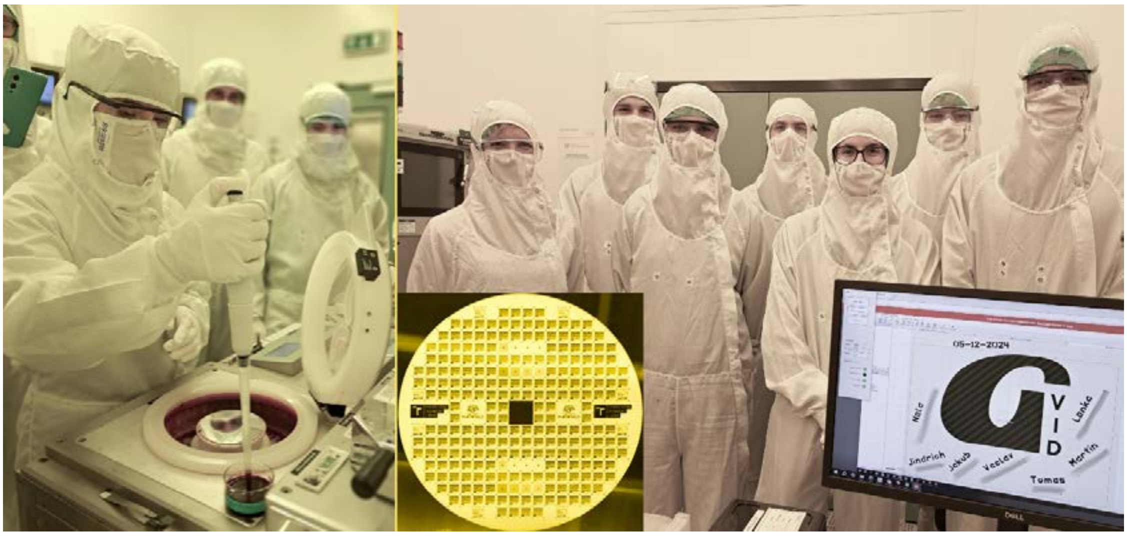

Figure: Local secondary school students practicing microfabrication techniques.

SESSION 5:
Data Gathering and Management

ENRIS25-0009

NEMO – An Open Source Lab Management System

Gerald Lopez[1], T. Jamie Ford[1], David Barth[1], Mathieu Rampant[2]

1 University of Pennsylvania, Singh Center for Nanotechnology, Philadelphia- Pennsylvania, USA
2 Atlantis Labs- LLC, Atlantis Labs- LLC, Charleston- South Carolina, USA

The National Institute of Standards and Technology (NIST) has developed NEMO, an open-source laboratory management system designed to streamline operations in cutting-edge research facilities. NEMO's intuitive platform helps in equipment reservation/billing management, user training, and access control in multi-user scientific environments. NEMO's functionality is extended through available plugins for advanced reporting, billing, invoicing, publications, stockroom management, etc. More recently, the NEMO-CE (Community Edition) fork has emerged as an independently maintained version of the platform, developed to serve the academic and industrial research community with tailored features and broader community-driven contributions.

Highlights

- NEMO is an open source platform that supports the reservation and billing of lab, tool, and instrumentation through the use of interlocks and sensors
- NEMO has a flexible plugin architecture to extend functionality
- The NEMO-CE (Community Edition) is sponsored by the University of Pennsylvania and maintained by Atlantis Labs
- NEMO-CE includes additional features like tool training management, publication tracking & leaderboard, support for tool accessories, user charge validation, stockroom inventory/sales, complex financial scenarios, and more
- Of the known facilities using NEMO, 50% run the main NEMO version, while 34% run NEMO-CE, and 16% run their custom version of NEMO.

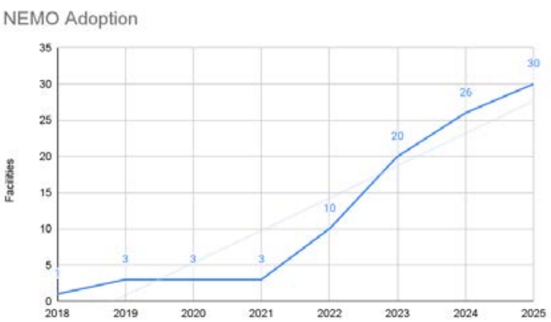

Figure 1. The Number of Facilities Using NEMO Over Time.

This presentation will highlight NEMO's core features and its deployment in real-world scenarios. As an open-source initiative, contributions are encouraged from the scientific and technical communities to improve and adapt NEMO to meet evolving needs. By empowering modern research facilities with a freely available, well-documented lab management tool, NEMO aims to support innovation and open collaboration worldwide.

ENRIS25-0020

FabLIMS: a Flexible LIMS for Managing Cleanrooms and Experiments

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1 Fondazione Bruno Kessler, Sensors and Devices, Trento, Italy
2 MicroFabSolutions, MicroFabSolutions, Trento, Italy

Fondazione Bruno Kessler (FBK), is a public research institution in Italy, well recognized in two main scientific areas: AI and silicon sensors. The FBK Facility includes more than 1500 sqm of laboratories with cleanrooms for sensor fabrication, dicing and packaging setups, characterization tools. Unique in the Italian panorama, this Facility gives the possibility to develop complete sensors, especially radiation sensors and MEMS. Tents of users accessing the facility every day and hundreds of wafers running around among the cleanrooms require dedicated organization and tools to guarantee traceability, quality, and safety. Since 1995, FBK Facility has invested in having a LIMS (Laboratory Information Management System) to manage all of that, and in 2021 the new LIMS, FabLIMS, was deployed. FabLIMS manages laboratories, users, projects and completely track wafers processing and sensor fabrication, accountability. The FBK Facility is certified 9001:2015, and most of the information yearly examined by the ISO auditors are managed in FabLIMS. Recently, FBK started to collaborate within iEntrance PNRR RI to test FabLIMS as centralized platform to manage iEntrance equipment and as eHub to transfer equipment, process and experiment data and metadata to the NOMAD (https://nomad-lab.eu/) platform, to share research output on a well-known FAIR repository, already widely used by material scientists.

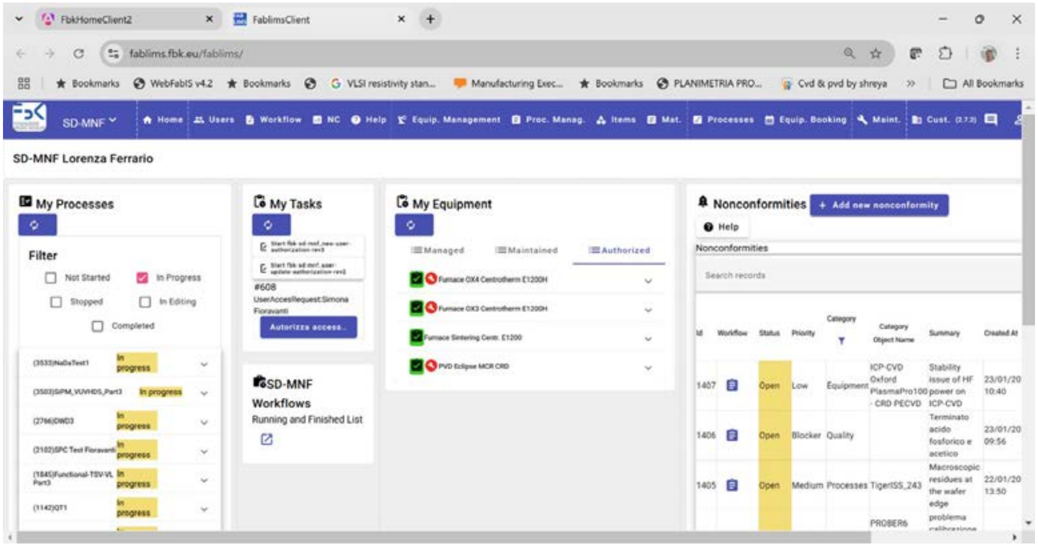


Fig. 1: FabLIMS entry dashboard.

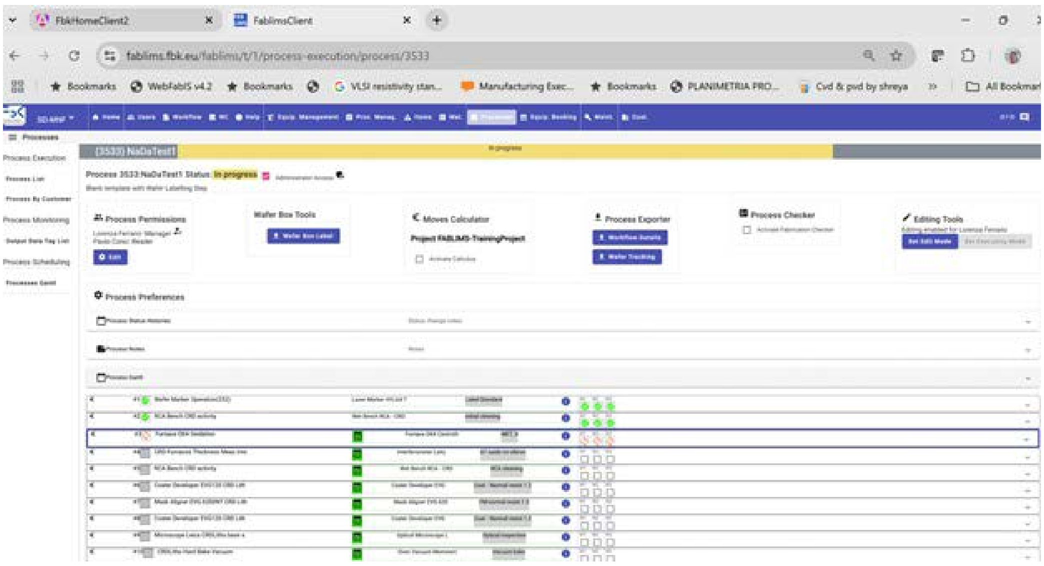


Fig. 2: FabLIMS process flow management function.

ENRIS25-0027

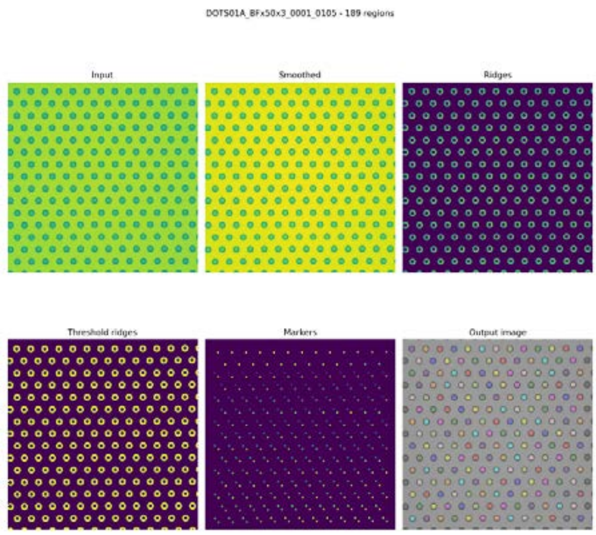
Leveraging Python for Automation and Image Analysis in Nanofabrication

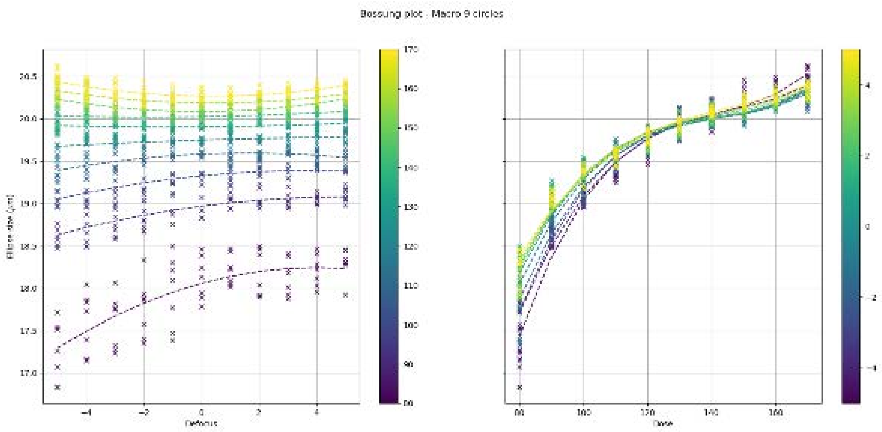
Roger Ackroyd[1]

[1] University of Sydney, Research and Prototype Foundry, Sydney, Australia

The Research & Prototype Foundry (RPF) at the University of Sydney utilizes Python as an indispensable tool in advancing nanofabrication capabilities. By enabling automation, image analysis, and statistical analysis, Python enhances process efficiency and characterization across various stages of the fabrication workflow.

By leveraging python to generate coordinate lists in manufacturer specific formats, to direct control of tools with scripting support, we can collect much more data than would normally be available to a relatively small multi-user research facility. With this data, image segmentation scripts are utilized, for example, to extract critical dimensions (CDs) from dose-defocus matrices, or step heights from dose to clear tests. Extracted data can then be used to generate bossing plots that offer insights into isofocal dose, defocus, and CD bias. This allows us to make data driven decisions and speeds up failure analysis. This also allows for more accurate assessments of wafer-to-wafer and within-wafer repeatability, ultimately driving process optimization.





ENRIS25-0028

PIMS: Platform Information Management System

Benjamin Lecha[1]

[1] CNRS, CNRS Ingenierie, Paris, France

The RENATECH network decides to finance an IT team in charge of developping a PIMS (Platform Information Management System).

The PIMS has to be able to answer every problems associated to cleanreoom management, from Access to Operation's cost history.

PIMS's philosophy is to create unique bricks that can handle the management of a specific type of problems. The different bricks are developped with full open access API to communicate with each other and with external projects.

PIMS bricks already made:

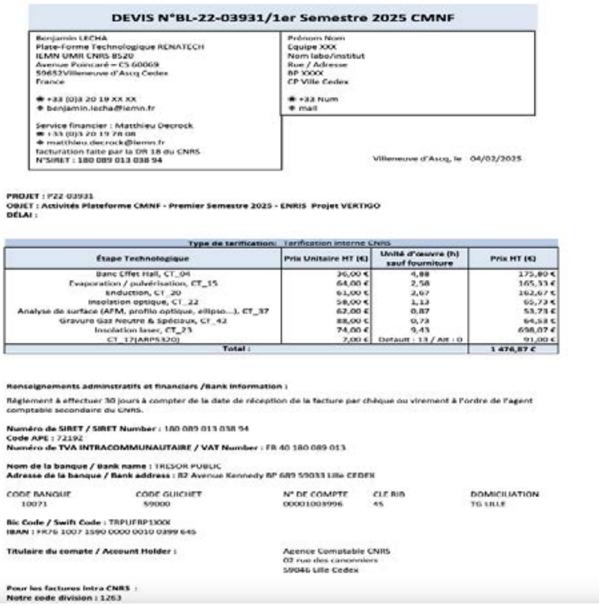
- REPOTECH : Science Project Manager for Platform Network, prized by a 'Cristal Collectif' from CNRS in 2023. 3 000 projects are saved inside the RENATECH's instance and statistics generation on demande are available.
- CROSS : CleanROom Support Service, an ambitious project split into electronic Boxes based inside cleanrooms and a centralized web server. For exemple, in IEMN's cleanroom more than 20 000 operations were saved and can be exported at any time in EXCEL and PDF with fully generated costs history. Dino EL HANI, Lead Dev of this project, submited an abstract on CROSS specificly.

Link wih external projects:

- DigiCleaR : Electronic lab Notebook and Process Management.

Some other bricks for storage, authentification, training, acknowledgment and link with new external projects like eLabFTW (Electronic lab Notebook) are under consideration.

Costs history generated by CROSS



DEVIS N°BL-22-03931/1er Semestre 2025 CMNF

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Villeneuve d'Ascq, le 04/02/2025

PROJET : P22-03931
OBJET : Activités Plateforme CMNF - Premier Semestre 2025 - ENRIS Projet VERTIGO
DÉLAI :

Type de tarification: Tarification interne CNRS

Étape Technologique	Prix Unitaire HT (€)	Unité d'oeuvre (h) sauf fourniture	Prix HT (€)
Banc Effet Hall, CT_04	36,00 €	4,88	175,80 €
Evaporation / pulvérisation, CT_15	64,00 €	2,58	165,33 €
Enduction, CT_20	61,00 €	2,67	162,67 €
Insolation optique, CT_22	58,00 €	1,13	65,73 €
Analyse de surface (AFM, profilo optique, ellipso...), CT_37	62,00 €	0,87	53,73 €
Gravure Gaz Neutre & Spéciaux, CT_42	88,00 €	0,73	64,53 €
Insolation laser, CT_23	74,00 €	9,43	698,07 €
CT_17(ARPS320)	7,00 €	Defaut : 13 / Alt : 0	91,00 €
Total :			**1 476,87 €**

Renseignements administratifs et financiers /Bank information :

Règlement à effectuer 30 jours à compter de la date de réception de la facture par chèque ou virement à l'ordre de l'agent comptable secondaire du CNRS.

Numéro de SIRET / SIRET Number : 180 089 013 038 94
Code APE : 7219Z
Numéro de TVA INTRACOMMUNAUTAIRE / VAT Number : FR 40 180 089 013

Nom de la banque / Bank name : TRESOR PUBLIC
Adresse de la banque / Bank address : 82 Avenue Kennedy BP 689 59033 Lille CEDEX

CODE BANQUE	CODE GUICHET	N° DE COMPTE	CLE RIB	DOMICILIATION
10071	59000	00001003996	45	TG LILLE

Bic Code / Swift Code : TRPUFRP1XXX
IBAN : FR76 1007 1590 0000 0010 0399 645

Titulaire du compte / Account Holder : Agence Comptable CNRS
02 rue des canonniers
59046 Lille Cedex

Pour les factures intra CNRS :
Notre code division : 1263

Statistics generated by REPOTECH:

ENRIS25-0046

Electronic Laboratory Notebooks: the new standard in the cleanroom labs

Richard Kolář[1], Michal Urbánek[1]

[1] Brno University of Technology, CEITEC Nano, Brno, Czech Republic

In recent times, data management, laboratory notebooks, and raw data have gained prominence in the daily lives of researchers. Grant calls now stipulate terms and conditions requiring scientists to describe their data management practices and adhere to the FAIR policy during project submissions. While individual researchers can achieve this by using free, open-source software tools, e.g. Kadi4Mat or eLabFTW, and scientific data repositories like Zenodo or OSF, our team has taken a step further by integrating these practices into our Research Infrastructure Booking system.

As a research infrastructure, we recognized the importance of securing the raw data generated by our equipment and granting users seamless access. Creating a unified solution has been challenging, with over 80 diverse pieces of equipment spanning nanofabrication to characterization.

We've integrated an electronic laboratory notebook into our Booking system to facilitate access to and organization of RAW data. Users provide essential parameters, experiment plans, and results for each reservation. Additionally, they can enrich their LabBook with supplementary information such as samples, image thumbnails, and documents – all seamlessly connected to the corresponding raw data.

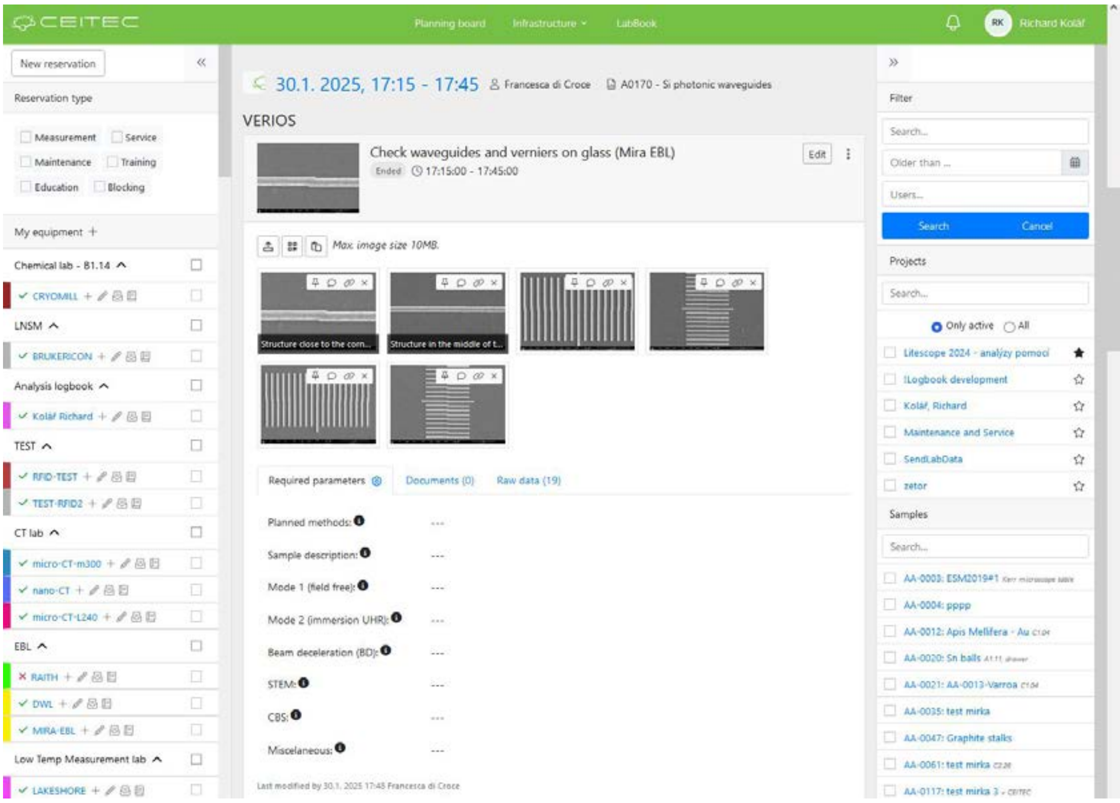


Figure: An example of the electronic LabBook with RAWdata and images in the reservation.

This approach benefits our specialists and technicians in monitoring equipment usage and empowers researchers with efficient data management and retrieval capabilities. By bridging the gap between raw data generation and user access, our integrated system enhances the overall research experience.

During my presentation, I will share my experiences with the electronic laboratory notebook and data management implementation within our Booking system.

ENRIS25-0061

Creating a Whole Lab Monitoring Solution for Predictive Maintenance and User Support

Aleksander Buseth Mosberg[1], Travis Edward Gustafson[1], Dorothea Mücke-Herzberg[2], Quentin Ramasse[2], Peter Andreas Köllensperger[1]

[1] Norwegian University of Science and Technology NTNU, NTNU NanoLab, Trondheim, Norway
[2] SuperSTEM, STFC Daresbury Laboratory, Daresbury, United Kingdom

To achieve reliable nanofabrication outcomes, several pieces of advanced instrumentation and environmental conditions must be carefully controlled. With so many potential factors influencing fabrication outcome, simply maintaining an overview of the state of each individual piece of equipment in the lab can be a challenge. Nevertheless, this overview is vital to keep on top of maintenance and identify potentially recurring issues with instruments and processes. Much of this information is already logged and available at an instrument level, but often hard to access, and can easily become a wasted resource.

This presentation will demonstrate the advantages of maintaining a single 'digital twin' system at a facility level, using freely available software and a minimum of hardware. By collecting the variety of relevant metrics and logs already presented by equipment in the lab into a single unified portal for the whole facility, the barrier for both engineers and users to gain an overview of the cleanroom is lowered. Both the current and historical state of equipment in the cleanroom (Figure 1), as well as environmental factors (Figure 2) influencing fabrication processes can be explored. Crucially, by making the system locally managed and using lab engineer expertise to identify and highlight the most relevant metrics, it can be an effective tool for predictive maintenance, saving valuable engineer time and ensuring high uptime and reliable nanofabrication outcomes.

Figure 1: Long-term performance statistics on ion source performance, an important health metric for advanced focused ion beam instruments.

Figure 2: Environmental monitoring for temperature-sensitive electron microscopes.

ENRIS25-0078

Simplified Lab Facility Management and Operation using NIS A Perspective on a Homogenous Virtual Lab System across Multiple Physical Locations

Raoul Oostenbrink[1]

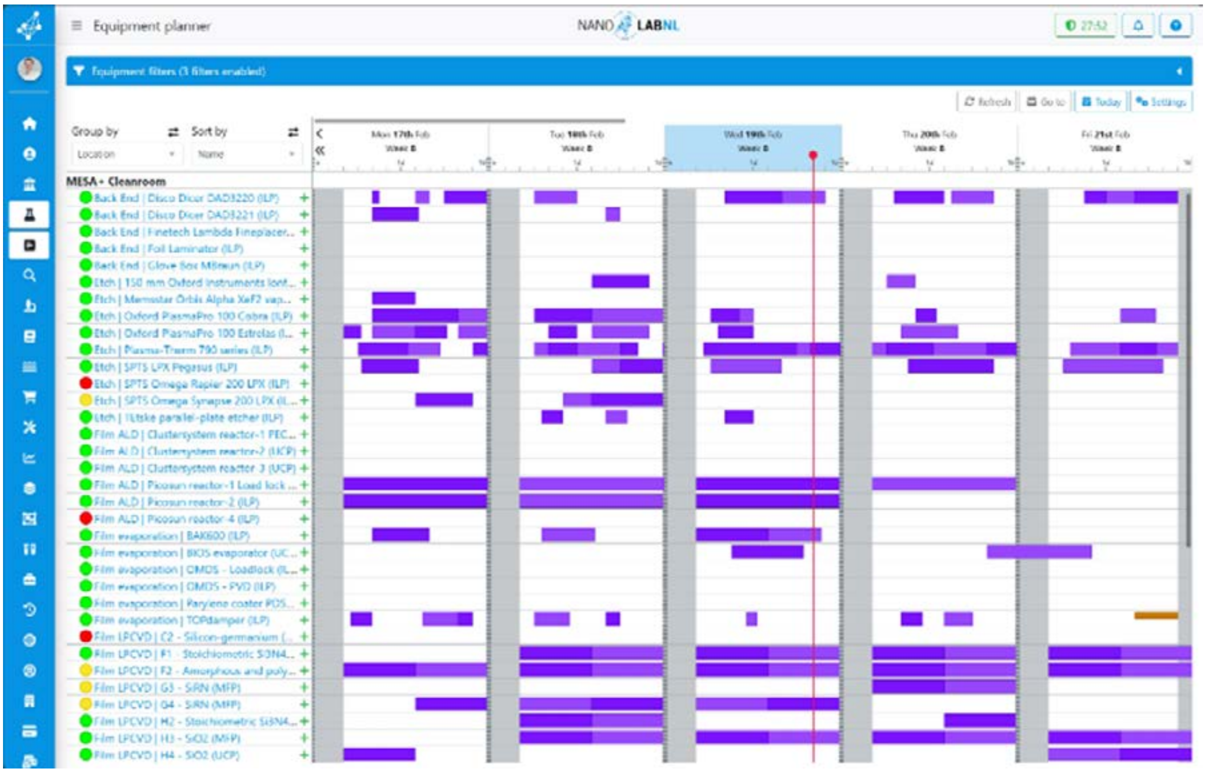
[1] NanoLabNL, Steering Committee, Enschede, Netherlands

Author: B. van de Vijver
Co-author: R.A. Oostenbrink

The NanoLabNL Information System (NIS) is a custom-built software solution created and actively maintained by the Dutch NanoLabNL national facility interconnecting five locations, to simplify (nano)lab facility management and operation. NIS enables inter-lab cooperation, helps to optimize redundancies , and provides perspective for standardising lab protocols and harmonizing and validating workflows across multiple locations. Since its release in 2021, NIS has grown to successfully serve over two thousand users.

NIS supports a wide range of features to streamline daily lab management and operation, while remaining powerful and flexible for almost all scenarios within common labs. Examples of such features are: equipment state and maintenance management, equipment reservations (Figure 1) with advanced access control possibilities based on memberships and course validity, usage specifications for invoicing purposes based on dedicated project numbers, registration of extensive and fully customisable equipment logbooks, and communication with (selections of) your users and organisation management. The application is being extended with a full process flow builder with advanced batch and sample tracking, and hardware integrations to control and register access to the physical equipment within the lab.

NIS has proven to highly capable and flexible system that could benefit many organisations in this field. With this tool, labs can improve their lab facility management and operations over multiple locations.



SESSION 6: Commercial Use

ENRIS25-0002

The National Platform for Semiconductor Technologies – A New Romanian Initiative to Promote Industrial Access to Cleanroom Facilities

Andrei Avram[1]

[1] National Institute for R&D in Microtechnologies - IMT Bucharest, Bucharest, Romania

The main objective of the PNTS project is to support Romania's involvement in the European strategic field of microelectronics by revitalizing the national ecosystem in the field of semiconductor technologies through the development and technological transfer of products and services for key integrating technologies. As a result of the implementation of the PNTS project, the distributed research and technological infrastructures will be able to efficiently ensure the coverage of the semiconductor value chain, the implementation of industrial-academic projects, the provision of knowledge and technological services, the carrying out of micro-production activities, as well as the carrying out of educational and training programs. The project is implemented in partnership with five nationally representative research organizations: the National University of Science and Technology Politehnica București, NIRD for Material Physics, NIRD for Lasers, Plasma and Radiation Physics, NIRD for Technical Physics, NIRD for Molecular and Isotopic Technologies, and 21 innovative SMEs selected through a competitive and transparent process. The main estimated results are: 3 pilot lines: (1) Microfabrication of semiconductor devices; (2) Additive mask-less microfabrication; (3) Non-standard processes for deposition of functional thin films; 40 education and training sessions per year for students and industry specialists; 20 prototypes or demonstrators fabricated according to the companies' specifications; 70 new technological services offered to the industrial environment; 30 innovative semiconductor systems with applications in automotive, energy conversion and distribution, space and security.

The project is co-financed by the European Regional Development Fund through the Smart Growth, Digitalization and Financial Instruments Program 2021–2027.

ENRIS25-0003

Networked Support for Innovation and Entrepreneurship: a Case Study on the US National Nanotechnology Coordinated Infrastructure (NNCI)

Matthew Hull[1]

[1] Virginia Tech, Institute for Critical Technology and Applied Science, Blacksburg, USA

Networked nanotechnology infrastructures play a critical but often overlooked role supporting entrepreneurship and broader regional-to-national economic development priorities. Early-stage entrepreneurs and small companies are among the most prevalent users of these networks, as they often lack resources to acquire and operate advanced tools for nanoscale characterization and fabrication. This presentation will describe efforts undertaken by the US National Nanotechnology Coordinated Infrastructure (NNCI) to develop, implement, and scale programming aimed at stimulating and supporting innovation and entrepreneurship (I&E). Programs discussed will include a network-wide Nanotechnology Entrepreneurship Challenge (NTEC) focused on supporting start-up teams led by students and post-doctoral scholars; an entrepreneurship experience linked to the US National Science Foundation's (NSF) research experience for undergraduates (REU); and a network industry seminar series for featuring local-to-national innovation/entrepreneurship successes, challenges, and resources. Strategies for fostering site-specific buy-in and network-wide leveraging of expertise and resources will also be discussed.

ENRIS25-0004

Bridging the Gap: Enhancing Client Engagement at the Australian National Fabrication Facility

Oded Vanham[1]

[1] Australian National Fabrication Facility, Headquarters, Clayton, Australia

The Australian National Fabrication Facility (ANFF) is a not-for-profit, open-access facility that provides advanced micro- and nanofabrication services. To increase awareness of ANFF's capabilities and expertise among target industries, enhance client interactions, and encourage industry collaborations, ANFF launched the Client Engagement Facilitator (CEF) initiative.

The CEF team engages prospective and existing industry users to inform them of ANFF's resources and work with them to find solutions to their manufacturing, engineering and technology challenges. The CEF team work directly with clients, guiding them through the engagement process. This approach addresses challenges such as:

Increasing non-academic access: ANFF's clients have mostly been academics. Industry engagement has increased awareness, which has led to increased industry use of ANFF's resources.

Navigating complex technical landscapes: Many clients are unsure what capabilities they require and sometimes what technologies exist to address their challenges. CEFs offer guidance on available technologies and assist in selecting the most suitable solutions; these may result in a referral to an ANFF hub, or an external provider.

Streamlining communication: ANFF includes over 500 capabilities, operated by 100+ technicians, at 21 hubs across Australia, which can be difficult to navigate. CEFs act as a single point of contact, facilitating communication between clients and ANFF's technical teams, connecting clients with the most appropriate expert(s).

Accelerating project timelines: CEFs remain available after project initiation to troubleshoot if necessary to ensure timely delivery of results.

The CEF team consists of professionals with an understanding of both client needs and ANFF's capabilities, as well as the industries across which we operate. Continuous training programs keep CEFs updated on industry practices and technological advancements.

The CEF initiative has led to better awareness, increased client satisfaction, improved project success rates, and valuable insights into client needs and preferences as well as ANFF's service levels across all hubs, informing service improvements and future development.

This presentation will discuss key learnings from the CEF experience, including the role of clear communication, the importance of continuous professional development, and the advantages of a client-centric approach. The ANFF's CEF program serves as a model for enhancing client engagement and fostering collaborations within the advanced manufacturing sector, contributing to Australian innovation.

ENRIS25-0005

Advancing Australia's Manufacturing Capabilities

John Morrison[1]

[1] Australian National Fabrication Facility, ANFF-C, Melbourne, Australia

The Australian National Fabrication Facility (ANFF) provides research infrastructure supporting nano- and micro-fabrication at 20 sites across Australia. ANFF administers a pre-seed fund (ANFF-C) designed to reduce the commercial risks associated with early-stage entities. Together, ANFF and ANFF-C serve as important enablers in efforts to establish an advanced manufacturing sector in Australia.

Over the past four decades, Australia has witnessed a significant decline in its manufacturing sector, creating a gap in its ability to translate research into impactful industrial applications. This presentation explores key strategies and mechanisms required to rebuild this capability, focusing on critical success factors.

The ANFF-C pre-seed fund provides critical gap funding of up to AUD120K per project. This non-diluting funding assists early-stage entities in overcoming significant capital requirements at a time when valuations are challenging. Additionally, we offer comprehensive support through access to technical networks, industry advisors, and prospective funders. Support is available to entities that have utilized ANFF facilities as part of their product development, achieved TRL3 (or better), and demonstrated a potential path to market (e.g., the technology is scalable).

Having been operational for 2.5 years, it is premature to evaluate the program's overall success. To date, we have invested approximately AUD1.5M in over 30 early-stage entities. All of these entities remain operational, with some advancing to seed funding, Series A funding rounds, and securing significant commercial grants. Collectively, these efforts have resulted in over AUD17M in additional funding raised (10 x multiplier).

Despite considerable progress, the commercialization of deep-tech in Australia remains constrained by a critical bottleneck: the limited availability of late-stage funding required to develop global production and distribution capabilities. Achieving global competitiveness for these startups often necessitates upwards of AUD100M, a difficult threshold to meet within the current funding landscape. This highlights the need for robust partnerships with international investors and policy frameworks incentivising large-scale funding commitments. To address this challenge, the Australian Federal Government has recently launched a new AUD15B fund which leverage existing funding sources and support the development of an advanced manufacturing sector while reducing dependence on global supply chains.

This presentation aims to engage international entities in a dialogue about the transformative potential of Australia's nanotech capabilities. We also see the value of establishing a collaborative global ecosystem that enables the commercialisation of technologies through open dialogue and effective partnerships.

ENRIS25-0048

The Stanford Nano Shared Facilities in Transition: Growing External Use While Maintaining Core Mission

Tobi Beetz[1]

[1] Stanford University, Stanford Nano Shared Facilities, Stanford, USA

The Stanford Nano Shared Facilities (SNSF) comprises a group of core research centers covering Nanofabrication, Electron & Ion Microscopy, X-ray & Surface Analysis, and Soft & Hybrid Materials. SNSF provides shared scientific instrumentation, laboratory facilities, and expert staff support to enable multidisciplinary research and educate tomorrow's scientists and engineers. About 1,200 researchers from Stanford University and external organizations access SNSF annually to advance their research programs.

Since establishing an external user program in 2011, SNSF has seen a significant growth of the external user base which now includes about 300 researchers from over 100 external organizations, including industry, academia and government labs.

In this presentation I will share opportunities and challenges encountered in growing the external user base at SNSF. Topics include agreements, financial account management, pricing and cost recovery, and impact on internal users. I will explore potential solutions for overcoming challenges and fostering a sustainable model for external user engagement.

ENRIS25-0053

From-Lab-to-Fab Transition: Key Challenges

Giulia Aprile[1], Lorenza Ferrario[2], Matteo Cocuzza[3], Davide Calonico[1]

[1] Istituto Nazionale di Ricerca Metrologica, Quantum Metrology and Nanotechnology, Torino, Italy
[2] Fondazione Bruno Kessler, Micro Nano Facility, Trento, Italy
[3] Politecnico di Torino, Dipartimento di Scienza Applicata e Tecnologia, Torino, Italy

Translating scientific research from the laboratory bench to large-scale fabrication—often referred to as "From-Lab-to-Fab"—represents a significant challenge in modern technology development. The main reason is that research laboratories and industrial fabrication facilities operate under fundamentally different constraints and objectives: laboratories typically focus on exploratory science, where flexibility and the pursuit of new discoveries are paramount. In contrast, fabrication plants—"fabs"—are optimized for scalability, reproducibility, yield, high-volume combined with high utilization rates and cost-effectiveness.[1] Despite these differences, bridging the gap between the two environments is essential for a new and effective approach to technology transfer and crucial in the micro-nanoelectronics context.[2]

We delve into the challenges and the fundamental obstacles that can limit progress when scaling up from academic research to industrial-level production, particularly in the public-sector context. By examining real-world constraints and the possible solutions, we hope to provide a roadmap for future OpenLabs, a new public research laboratory model, seeking to strike a balance between innovative research and industrial application. This perspective should foster collaborative environments in which technology transfer can flourish. Indeed, our goal is to offer positive, constructive insights that can benefit new entities venturing into this arena, bridging the gap between companies and research centers.

We provide a structured analysis of the primary challenges associated with a "From-Lab-to-Fab" transition, in which the main transformative element is a public Lab which evolves into an OpenLab ready to strengthen technology transfer activities in favor of SME and large companies. Through real-world examples and practical insights referred to semiconductor cleanrooms we explore the organizational, technical, and economic factors that underpin the "From-Lab-to-Fab" journey. Our goal is putting this concept into practice by reinterpreting organizational models typical of research laboratories [3] to allow the fruitful coexistence of basic research and technology transfer in the semiconductor sector. We aim both to supply a roadmap for institutions worldwide seeking to bridge the laboratory–fab divide and demonstrate how academic and industrial missions can be reconciled. This reconciliation is the crucial element for accelerating innovation, reducing time-to-market, and facilitating more robust technology transfer.[2]

[1] STMicroelectronics 2024 Sustainability report–Performance 2023 (https://sustainabilityreports.st.com/sr24/_assets/downloads/ST-Sustainability-report-2024.pdf)
[2] European Parliament and Council, Regulation (EU) 2023/1781, 13.09.2023, Chips Act – (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1781)
[3] Liddle J. A. et al., Journal of Research of the National Institute of Standards and Technology – So, You Want to Have a Nanofab? SharedUse Nanofabrication and Characterization Facilities: Cost-of-Ownership, Toolset, Utilization, and Lessons Learned, Volume 125, Article No. 125009 (2020) https://doi.org/10.6028/jres.125.009

SESSION 7: Operations 1/2

ENRIS25-0007

The Melbourne Centre for Nanofabrication: Operating an Open-Access Nanofabrication Facility as a Joint Venture

Nicolas Voelcker[1]

[1] Monash University, Melbourne Centre for Nanofabrication, Melbourne, Australia

The Melbourne Centre for Nanofabrication (MCN) is an open-access nanofabrication facility located in the south-east of Melbourne, Victoria, next to the Australian Synchrotron. It is a key part of the Australian National Fabrication Facility (ANFF): the MCN is the central facility of the Victoria Node of ANFF (ANFF-Vic), which is organised as a university joint venture with seven university partners and the Commonwealth Scientific & Industrial Research Organisation (CSIRO) as an eight partner. With more than 1400 registered users, the MCN is the largest university and government collaboration in Australia with respect to provision of research infrastructure and plays a vital role in supporting cutting-edge research and development from very fundamental research to translation and commercialisation of research. Indeed, the MCN is a unique and highly successful demonstration of the impact achieved by the sharing, collaborative management, curation, and talent attraction of cutting-edge open-access research infrastructure.

MCN is the southern hemisphere's largest open access micro- and nanofabrication cleanroom with class 10,000 and class 100 spaces. It also features a number of non-cleanroom facilities including wet chemistry labs, cell and tissue culture lab, microscopy facilities, and segregated rooms to work with PDMS. The proximity to the Australian Synchrotron provides further exciting opportunities for fabrication of structures, materials and devices, and their characterisation.

MCN employs Lean operating principles, akin to those of a high-throughput industry environment, to ensure a targeted, consistent and efficient client experience for all users of the facility. MCN's quality management system is certified under ISO 9001. It operates under an IP neutrality framework, which leaves IP in the hands of the user or client. This makes for an attractive value proposition to both start-ups and more mature industry. Not surprisingly, MCN is hosting and supporting around 30 companies every year, many choosing to take up full-time residency at the MCN. MCN is therefore also serving as a small high-tech incubator and accelerator.

MCN's approximately 20 process engineers provide a broad range of expertise for training of users and fee-for-service work across most aspects of micro- and nanofabrication. User access to this vast physical and intellectual research infrastructure environment catalyses both the development of new high-tech products, and improvements to current production methods across many fields of research and industry sectors, particularly in the areas of medical technologies, renewable energy research and quantum technologies.

ENRIS25-0017

Facilitating Research and Low-Volume Manufacturing in an Open-Access Cleanroom

James Grant[1]

[1] UNIVERSITY OF GLASGOW, College of Science and Engineering, GLASGOW, United Kingdom

Nanofabrication facilities play a crucial role in advancing both academic research and industrial innovation by providing access to cutting-edge processing technologies. Open-access nanofabrication environments enable researchers, startups, and industry partners to develop novel materials, devices, and prototypes while benefiting from shared expertise and infrastructure. Bridging the gap between academic research and production requires balancing flexibility for experimental work with the reliability and repeatability needed for manufacturing.

As one of the largest open-access semiconductor facilities in the UK, the James Watt Nanofabrication Centre provides a unique platform for research, innovation, and production. With a highly skilled team of 29 staff members, many with extensive industry experience, we support a diverse user base of 225 full-time researchers, including 146 PhD students, and 145 MSc. students each year. Our strong commitment to training is reflected in the 68 new inductees we welcome and the 614 training events (processing and tools) we conduct annually. Additionally, our intensive two-week nanofabrication training course graduates 30 participants per year, equipping them with critical skills for advanced research and industry applications.

This paper explores strategies for integrating academic research with production in an open-access nanofabrication facility. Key aspects include process standardization, quality assurance, and training programs that equip researchers with the skills to transition from fundamental research to scalable fabrication. A key strength of our facility is its capability to work across multiple material sets, an essential factor in advancing heterogeneous integration for next-generation semiconductor and quantum technologies. By supporting a broad range of materials, we enable users to develop cutting-edge devices in fields such as quantum technologies, photonics, and biomedical engineering.

Collaboration between academia and industry fosters technology transfer and accelerates innovation. By implementing structured workflows, robust process documentation, and well-defined access policies, nanofabrication centers can accommodate diverse user needs while maintaining high operational efficiency. Approximately 30% of our income is generated through Kelvin Nanotechnology (KNT), providing services via commercial contracts, while our open-access framework ensures direct industry engagement. This model accelerates innovation, supports technology transfer, and enables researchers and businesses to address complex fabrication challenges in a shared, world-class environment.

Ultimately, a well-managed nanofabrication environment can serve as a catalyst for advancing scientific discovery and supporting small-scale manufacturing, enabling breakthroughs in fields such as photonics, quantum technologies, and advanced semiconductor devices. This paper provides insights into best practices for managing open-access cleanrooms and ensuring their long-term sustainability as hubs for both research and production.

ENRIS25-0035

Debugging a New ISO 7 Cleanroom for Life Science Polymer Fabrication

Leif Steen Johansen[1], Anders Gregersen[1], Yochai Arial[2]

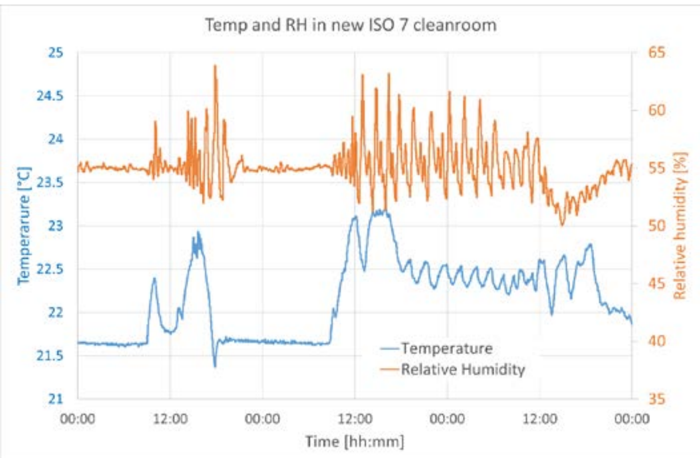
1 Technical University of Denmark, DTU Nanolab, Kongens Lyngby, Denmark
2 Technical University of Denmark, DTU Campus Service, Kongens Lyngby, Denmark

In May 2024 DTU Nanolab was handed over its new 4 million Euros, 126 m2 ISO 7 cleanroom dedicated to polymer fabrication such as additive manufacturing, polymers, hydrogels and soft lithography using polydimethylsiloxane (PDMS). However, during construction and after handover, several issues were encountered.

During construction, a steel reinforcement in the concrete deck was accidentally cut, necessitating a new to be installed. The carefully planned and expensive 3D model of the building was flawed, leading to delays and on-the-fly rerouting of supplies. A large cooling coil in the makeup air handler unit (MAHU) burst due to frost damage, and construction work was delayed until a new coil could be delivered. In the meantime, the MAHU was off whilst the exhaust was still on, thereby sucking large amounts of particles into the cleanroom under construction.

After handover, the cleanroom pressure was oscillating due to slow acting damper motors in the makeup air and exhaust ducts. These motors had to be changed. Several design errors in the building management system (BMS) were encountered and had to be corrected. Poor plumbing caused a water leak inside the cleanroom. Brass parts were found in the deionized water line and had to be exchanged. The cleanroom is now in operation, but BMS control of temperature and humidity still needs optimization.

The main take-away message is that construction of a cleanroom is a complex matter, and it is important to allow the facility operations organisation time for debugging errors after receiving a new cleanroom.



Temperature and RH fluctuations.

ENRIS25-0058

Research Cleanroom Environmental Assessment and Sustainability Strategy

David Quirion[1], Zito Guillermo[2], Petit-Boix Anna[2], Talens Peiró Laura[2,3]

1 IMB-CNM CSIC, Cleanroom facility, Cerdanyola del Vallès, Spain
2 Institute of Environmental Science and Technology ICTA-UAB, Sostenipra Research Group, Bellaterra, Spain
3 Universitat Autònoma de Barcelona, Department of Chemical- Biological and Environmental Engineering, Bellaterra, Spain

Cleanrooms are energy-intensive infrastructures, contributing significantly to environmental impact due to their high resource consumption. Much of the focus of sustainability studies has been on industrial semiconductor cleanrooms, given their considerable energy usage and environmental footprint. However, sustainability is a global challenge, and attention must also be given to any infrastructure with notable environmental impact. Academic cleanrooms, particularly those dedicated to research in micro- and nano-fabrication, share similar technologies and tools with industrial semiconductor cleanrooms but differ greatly in their objectives and operational management.
The cleanroom of the Institute of Microelectronics of Barcelona (IMB-CNM, CSIC, Spain) is dedicated to the development and application of innovative technologies in the field of microelectronics together with other emerging micro- and nanotechnologies. In this context, we will highlight the ongoing efforts made by IMB-CNM to reduce the environmental impact of its facilities. A significant milestone in the institute's sustainability journey was the environmental assessment conducted in 2024. This comprehensive analysis utilized a life cycle assessment (LCA) methodology, specifically focusing on the cleanroom's operations. In this presentation, we will share the key findings from the assessment, which provide insight into the environmental challenges faced by academic cleanrooms. Furthermore, we will outline the sustainability strategy that emerged from the life cycle assessment, addressing its implications for cleanroom operations, tool choices, infrastructure investments, and management decisions. By detailing these initiatives, we aim to offer a framework that can be adapted by other academic cleanrooms, thereby contributing to the broader global efforts in mitigating climate change.

ENRIS25-0071

Measuring the Lab-Wide Impact of Fab Equipment

Joerg Scholvin[1]

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The tools in a typical nanofab see a wide range of utilization: some are only occasionally used, while others are in constant demand. Usage fees collected by tools with low utilization will likely not recover their operating costs. It is therefore tempting to assume that the most under-utilized tools can (or should) be retired and removed from the lab.

In this presentation, we are proposing a simple metric to classify nanofab equipment and provide a path for better understanding the economic impact of under-utilized tools, by asking: If a specific tool disappeared, and its core user-base would equally vanish – what are the consequences? We identify the core user-base per tool, and their total lab-fee contributions. The result is a measure of potential economic impact on the lab overall.

We roughly classify tools into three categories: under-performing, supportive, and self-sustaining – to assess their lab-wide impact or importance. Supportive tools are of particular interest: they may not provide significant user-fees, but help enable more complex projects (and thus contribute positively).

The analysis can help lab-managers explain the importance of tools that don't generate high user fees. Focusing further on a specific process category, we suggest how tools that cover the "dirty" or "clean" ends of the process spectrum still benefit other lab users.

Our analyses provides lab managers with new ideas to analyze and compare equipment in their labs, with approaches to explain financial and technical decisions to both users and administrators.

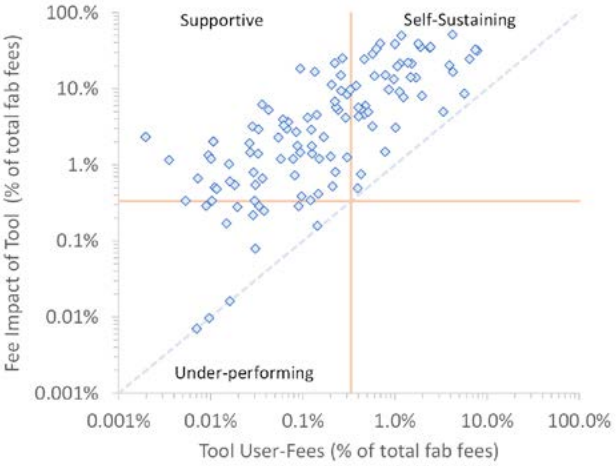

Figure: Measure of fee impact for tools in the fab.

ENRIS25-0079

Enhancing Cleanroom Operations through Automated Monitoring Systems

Michel De Cooman[1], Masoumeh Keshavarz[1], Arvin Sain Tanwar[1], Frederik Ceyssens[1], Michael Kraft[1]

[1] KU Leuven, Electrical engineering, Leuven, Belgium

At KU Leuven, our cleanroom facility is dedicated to advancing research in nanotechnology and semiconductor fabrication, utilizing sophisticated instruments integral to our innovation efforts. The ongoing lines of research are micro-electro-mechanical systems (MEMS), Micro- and nanosystems, bioMEMS, Sensors, & Actuators. To optimize performance and ensure efficient usage, we are exploring the implementation of automated monitoring systems to replace our current badge system for user access and instrument usage tracking.

The existing badge system allows for basic monitoring of cleanroom access but lacks comprehensive insights into instrument performance, error tracking, and detailed usage analytics. To address these limitations, we are considering advanced solutions like ToolSquare, which can provide real-time data logging, tracking instrument usage, logging errors, and delivering performance analytics that will facilitate streamlined operations. This integration promises to enhance operational efficiency by optimizing scheduling and usage patterns, reducing downtime, and ensuring timely access to critical equipment. Additionally, automated systems will log errors and alert users to potential issues, allowing for proactive maintenance and minimizing unexpected equipment failures.

Comprehensive usage reports generated by such systems will enable informed decision-making regarding resource allocation and cleanroom management, as well as help identify trends and areas for improvement. By streamlining monitoring processes, users can concentrate more on their research without administrative burdens, fostering greater utilization of facility resources. Furthermore, these automated systems will integrate essential safety features, ensuring adherence to protocols and providing documentation for compliance with industry standards.

In conclusion, the transition to automated monitoring systems will significantly benefit the KU Leuven cleanroom community by creating a more efficient, user-friendly environment. This enhancement aims to empower our researchers and technicians, allowing them to focus on their innovative projects while ensuring optimal operation and safety within the cleanroom. This initiative not only supports the growth of our research capabilities but also fosters a collaborative atmosphere conducive to academic success and meaningful contributions to the scientific community.

SESSION 8: Operations 2/2

ENRIS25-0036

(Almost!) 50 Years of the Democratization of Fabrication at the Nanoscale in an Open-Access Facility

Christopher Alpha[1]

[1] Cornell University, Cornell Nanoscale Facility CNF, Ithaca, USA

In 1976 the US National Science Foundation (NSF) held a series of workshops to assess the need and requirements for a University-based National Research and Resource Facility for Submicron Structures (NRRFSS). Cornell won the competition and since 1977 the Cornell Nanoscale Facility has existed in several NSF funded incarnations, under various acronyms, for almost half a century. Our 50^{th} anniversary rapidly approaches us in 2027. Throughout this time the bones and underpinnings of the facility have remained solid, they have grown and expanded with increasing reach across numerous disciplines, similar core research facilities have sprouted up all over the planet and the still rising arc of the Science of Nanotechnology and its reach has geometrically expanded into almost all aspects of our lives.

The CNF exists as an open-access user facility, we stand ready to provide access to not only well characterized fabrication tooling but also importantly to the collective expertise of a large professional technical staff to literally any researcher or organization on the planet. Academics from all across the globe, National (Government) laboratories, and Industrial concerns are all welcome to join our community of research into devices and structures at the nanoscale. We operate 15,000 sq ft of cleanroom space open to our trained researchers 24 hrs a day, 7 days a week to utilize on their own timescales. The toolset consists of several hundred instruments enabling full process flows with a wide variety of materials and lithography to below 10nm. In any given year we typically take in ~150 new projects and ~300–500 newly trained researchers.

In this talk I will discuss the formation and framework of the CNF as a user facility, independently operating outside any particular department at Cornell, some of the lessons we have learned, daily operations, new user onboarding and training, safety, facility and tooling care. Our mission is also expanding into K-12 youth outreach activities and workforce development for CHIPS act efforts to onshore chip fabrication. Out of CHIPS act monies is the advent of the $2B Microelectronic Commons program and the formation of regional hubs for accelerating lab-to-fab transitions to manufacturing, Cornell is now part of a the Northeastern hub – Nordtech – and received over $8M in funding for new tooling focused on Quantum Technologies, AI Hardware, Secure Edge Computing, and Commercial Leap Ahead which we are installing this year.

ENRIS25-0062

Towards data driven operation of an open access nano fabrication/characterization facility

Jörg Hübner[1], Leif Johannsen[1], Thøger Eskildsen[1], Anders Jorgensen[1]

[1] Technical University of Denmark, DTU Nanolab, Kgs., Denmark

An open access cleanroom facility is generating a lot of data. Most facilities run advanced software systems for user and usage management where data is collected from users including training, competences on tools, usage, booking. Equipment data is monitored in form of uptime and in our case from quality control procedures. Cleanroom data is collected by many sensors distributed across the facility monitoring temperature, particle level and humidity. In addition we are monitoring usage of consumables (gases, chemicals, etc). Thus the challenge is not to accumulate data but to process the vast amount of data generated in order to be helpful in making operational and strategic decisions.

We have chosen the Balanced Scorecard (BSC) methodology proposed by Kaplan and Norton in 1992 in order to distill the data so it becomes useful and operational for strategy implementation. Our BSC approach consisted of 5 objective areas which are business, financial, people, quality and sustainability. The integration of our quality control (ISO 9001) into the BSC system proved to be an efficient fusion of quality management and strategy implementation.

In practice we monitor around 20 key performance indicators that are compiled out the data that is delivered from our systems. Whenever possible automatized routines are deployed in order to compile the data and feed it into the BSC system. In the talk we will present the reasons on our choice of KPIs and how we use these data to merge daily operations with strategy implementation.

Equipment up and accessible for users.

7. Quality objective

Internal process perspective: Ensure cleanroom equipment is up and running

Responsible: fi, jve

Responsible for reporting data: jetro

2024

Action: Ensure that equipment is up and running

Measure: Average of equipment uptime

Target: Equipment up and accessible to users 85% of normal office hours Monday - Friday 8:00-16:00

	Target	Actual
Jan	85%	87%
Feb	85%	89%
Mar	85%	89%
Apr	85%	92%
May	85%	92%
Jun	85%	89%
Jul	85%	88%
Aug	85%	87%
Sep	85%	89%
Oct	85%	86%
Nov	85%	83%
Dec	85%	86%
Total	*85%*	*88%*

How to reach the objective:

All processes involving equipment and training of users

Status colour key:

chart requires individual uptime of all machines, will also be monitored

up = ready for use = available for users = control process is up to specs

>= 75% yellow

>= 85% green

Power consumption.

17. Sustainability objective

Internal process perspective: BSC Sustainability - Electrical power from UPS systems

Responsible: Jan

Responsible for reporting data: jetro

2023

Measure: Electrical power from UPS systems

Target: 5%

>= 2%: Green, 0-2%: Yellow, <0%: Red

	2022 power, kWh	2023 power, kWh	2024 power, kWh	% Reduction 2022/2023	% Reduction 2023/2024
Jan	381.730	331.179	317.222	5%	[illegible]
Feb	328.438	305.022	295.264	13%	7%
Mar	375.194	337.445	316.984	4%	[illegible]
Apr	368.839	307.094	311.005	12%	2%
May	352.037	314.907	318.891	10%	[illegible]
Jun	317.340	314.560	309.814	10%	2%
Jul	338.655	317.479	328.973	9%	[illegible]
Aug	363.209	315.206	327.693	10%	[illegible]
Sep	342.299	305.983	311.916	11%	2%
Oct	339.152	322.450	312.344	8%	1%
Nov	319.355	313.542	309.773	10%	2%
Dec	333.281	314.273	312.832	10%	1%
YTD	4.199.429	3.803.118	3.772.910	9%	4%
Yearly Average	349952	316927			

ENRIS25-0070

Ten Years of Polifab, the Cleanroom of Politecnico di Milano

Claudio Somaschini[1]

[1] Politecnico di Milano, Polifab, Milano, Italy

In our presentation, we will discuss Polifab, the micro- and nano-fabrication facility of the Politecnico di Milano. Polifab was created to provide the highest technological standards for a wide range of applications, including photonics, micro and nanoelectronics, MEMS, biotechnologies, advanced materials, and nanotechnologies. It is an open infrastructure, meaning that both academic and industrial partners can access the cleanroom and directly develop their projects. In this way, Polifab also serves as an aggregation center for academic researchers, start-ups, and companies operating within the same ecosystem.

Ten years after the cleanroom's opening, we will analyze our past, present, and future, starting from our specific case to draw broader conclusions about the operations of academic research infrastructures. We will describe how the facility was established and how it has evolved over the years, transitioning from a relatively small university cleanroom to a larger and more structured research infrastructure capable of attracting investments from both funding agencies and industrial partners.

We will demonstrate how Polifab accommodates different levels of access and collaboration. Every year, more than 150 researchers, many of whom are experiencing such an environment for the first time, utilize Polifab's facilities. Alongside them, research and development projects with companies take place, characterized by a medium to high Technology Readiness Level (TRL). This dual nature of our infrastructure presents challenges but also great opportunities, as it allows fundamental research activities to merge with market-oriented applications.

During the presentation, we will analyze the strengths and weaknesses of our infrastructure, assessing our current situation. Among Polifab's strengths are its accessibility to a large number of users, integration with the academic and industrial ecosystem, and its ability to attract funding. However, there are also challenges to be addressed, such as the continuous need to update equipment, managing the high demand for access and trainings and ensuring the long-term sustainability of the infrastructure. In this respect, we believe that in our case it will be crucial the presence of both industrial capital and the placement of our research infrastructure in national and transnational projects able to support the cleanroom operation.

ENRIS25-0075

Community Driven Change for Sustainable Nanofabrication Labs

Sarah Mckibbin[1], Luke Hankin[1], Anders Kvennefors[1], Håkan Lapovski[1]

[1] Lund University, Lund Nano Lab- Department of Physics, Lund, Sweden

Nanofabrication cleanrooms are some of the most energy intensive workplaces on the planet due to ventilation requirements, climate control, HVAC power for equipment, chemical use, and waste generation from daily processing. There are very specific challenges to address for our industry in order to achieve sustainability outcomes while ensuring high-level research outputs and lab safety.

There is a growing international community working to improve sustainability within research and manufacturing environments. Initiatives such as *My Green Labs* and the *Laboratory Efficiency Assessment Framework*, provide resources to evaluate areas of operation that can be addressed such as energy consumption, user behaviour, and waste streams. In these activities there are not just improvements for climate outcomes to be made but also clear economic gains from an operational lab perspective by increasing efficiency and minimizing wasteful practices.

Individually there is generally issue of lack of time and personal accountability for users and staff to tackle these issues. Participation in organized movements can be the catalyst needed in our lab spaces to start conversations and enact the long-term changes required for a carbon neutral industry. However the majority of the aforementioned sustainability movements are driven by work in the medical and life sciences industries and there is an urgent need to grow a community within the nanofabrication sphere. Only then can we develop and share the knowledge required to change established lab practices and reach a collective critical mass customer base to encourage suppliers to reduce carbon footprint of consumables, develop special waste and recycling collection schemes of lab materials.

Lund Nano Lab has recently started our sustainability journey with My Green Labs (https://www.mygreenlab.org/), and we would like to share some first impressions of the certification process. There are many areas in our lab operation meeting sustainability standards that are highly regulated thanks to EU and Swedish law; such as detailed government mandated chemical inventory and chemical waste collection. In other currently unregulated areas which are not addressed by this initiative, we have a responsibility to do more to improve environmental outcomes; for instance preventing the environmental release of significant greenhouse gas equivalent gases used for plasma processing.

Research culture needs time to slowly change and we would like to invite the ENRIS community with this presentation to prioritize these topics of conversation within your own labs and for operational change to improve lab sustainability.

SESSION 9: European and International Policies

ENRIS25-0064

On the CO2 footprint of nanofabrication facilities – there is more than meets the eye

Jörg Hübner[1], Kristian Speranza Mølhave[1], Leif Johansen[1], Anders Jorgensen[1], Henri Jansen[1]

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Cleanroom operation requires substantial air handling and especially conditioning the air is very energy consuming. In addition cooling water is required for most tools and an abundance of ultrapure water has to be guaranteed. Therefore the focus on a more sustainable cleanroom operation is often directed towards energy consumption.

However a closer look reveals that in terms of CO2 equivalents, the power consumption is vastly outcompeted by the usage of high global warming potential (GWP) gases. The largest contributor might in most cases be SF6 with a GWP of 22000. This means that the emission of 1 kg of SF6 equals the emission of around 23 tons of CO2 (100 year GWP), but other fluorinated (hydro)carbons also show GWPs of more than 10000.

In Norway also R&D facilities are therefore taxed with a tax rate of around 33000 NOK (around 2800 Euro) per kg of SF6. Tax exemption on R&D facilities in other EU countries are not unlikely to be phased out within the decade.

At this point it is difficult to entirely stop usage of. e.g. SF6 in micro and nano processing but there are strategies to minimize usage and thereby reduce the CO2 footprint of nanofabrication facilities considerable without heavy investments.

One strategy is to replace fluorocarbons used for passivation (e.g C4F8 in the Bosch process) with oxygen (CORE process) when etching silicon. A welcoming side-effect of this substitution is the avoidance of carbon fluoride deposition in the chamber which simultaneously leads to more stable processes. The often lower etch rate might be compensated by the absence of a lengthy gas and energy consuming chamber conditioning procedure.

In case of SF6 the strategy must be to utilize all SF6 molecules in the actual etching process. In research facilities etching processes are often developed incrementally and adapted from previous users, in many cases containing a trial and error component. It is therefore likely, that narrow zones of optimal gas usage are overlooked and the SF6 gas flow in the pursuit of high etch rate is too high compared to other parameters, leading to non-utilized gas "streamed" through the chamber. The relation between parameters such as gas flow, ICP power, pressure and etch load should be optimized for etch efficiency. Especially when etching nano dimensions (etch depth of around 500 nm) and using careful etch efficiency optimization, calculations suggest that many thousands of 6 inch wafers can be etched with a single bottle of SF6.

ENRIS25-0049

Progress on the Sustainability of the Semiconductor Value Chain

Dmitri Petrovykh[1]

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For semiconductors, the cleanroom-based production is responsible for a significant fraction of their environmental impact over the lifetime of the chips. The Safe and Sustainable by Design (SSbD) approach for guiding the innovation for chemicals and materials was announced in December of 2022 in a Recommendation of the European Commission (EC). Since then the applicability and implications of the SSbD principles have been examined for different industries following the Methodological Guidance published by the EC Joint Research Centre (JRC). The application of the SSbD principles in the semiconductor value chain has been examined within the context of the IRISS project and the recently established IRISS SSbD community.

While the explicit adoption of the full SSbD methodology is not yet common in the semiconductor value chain, strategies for improving sustainability have advanced significantly in recent years. An important district feature of the production of chips is that its impact is largely related to the resources required for the transformation of the materials, rather than associated with the materials contained in the resulting chips. Therefore, improving the sustainability of cleanroom-based processes can dramatically improve the overall suitability of electronics. This is an area where the research cleanrooms can initiate and develop innovative practices for subsequent adoption by the industry. The long timelines required for process development and substitution of chemical or materials in the semiconductor industry accentuate the importance of promoting and supporting the initial efforts

The IRISS project receives funding from the EU HORIZON EUROPE research and innovation programme under grant agreement n° 101058245. UK participants are supported by UKRI grant 10038816. CH participants receive funding from the Swiss State Secretariat for Education, Research, and Innovation (SERI).

Poster Presentations

Operations

P01

ENRIS25-0083

Southeastern Nanotechnology Infrastructure Corridor (SENIC): One Facility at Two Locations

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The Southeastern Nanotechnology Infrastructure Corridor (SENIC) is one of 16 sites of the US National Nanotechnology Coordinated Infrastructure (NNCI), which provides open access to state-of-the-art nanofabrication and characterization facilities and associated staff expertise across the US. SENIC is a partnership of two modern nanotechnology centers along the I-85 corridor in the southeastern US: the Institute for Matter and Systems (IMS), an interdisciplinary research institute and former National Nanotechnology Infrastructure Network (NNIN) site at the Georgia Institute of Technology (Georgia Tech), and the Joint School of Nanoscience and Nanoengineering (JSNN), an academic collaboration between North Carolina A&T State University (NCA&T) and the University of North Carolina, Greensboro (UNCG). Since its inception in 2016, SENIC has continued to facilitate the "one facility, two locations" mindset and partnership between IMS and JSNN. This presentation will discuss the strategic goals, programs, implementation, and operational management of this model. One of the strategic goals of SENIC is operate as a single user facility with two locations to outside users while developing strong partnership initiatives that strengthen staff expertise, fabrication and characterization capabilities, as well as the education & outreach and societal & ethical implications (SEI) programs offered at the two locations, which are over 300 miles apart. Particularly, facility operations thrives to maintain the "one facility, two locations" approach to the SENIC partnership, with active collaborations and joint activities at the leadership, technical, user outreach, and education levels. In general, the goal of SENIC is to strengthen and accelerate discovery in nanoscience and nanoengineering across the southeastern US, to allow nanotechnology-based innovations to reach the market quicker, and to provide education, outreach and SEI programs in nanotechnology with a focus on the southeastern US. SENIC pursues this vision by providing open access to a combined total of 350 nanotechnology fabrication and characterization tools, which are housed in more than 35,000 sq. ft. of cleanroom and other lab space. Those physical resources are supported by almost 40 technical staff members, who maintain the equipment, train the users, and run a wide variety of processes and characterization techniques. In the last year, SENIC facilities was used by over 1400 unique users from academia, industry and government labs. The impact of the SENIC facilities can be assessed by the high scholarly output (over 600 publications, presentations, and patents during last year), and support for 200+ faculty with 600+ awards worth at least $600 million.

P02

ENRIS25-0015

Proactive Strategies for Managing Equipment Obsolescence in Nanofabrication Cleanrooms

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In nanofabrication cleanrooms, maintaining cutting-edge equipment is essential for ensuring process integrity, product quality, and compliance with stringent industry standards. However, rapid technological advancements and the discontinuation of support for older equipment models present significant challenges related to obsolescence.

This poster examines the specific impacts of equipment obsolescence within nanofabrication facilities, highlighting risks such as increased operational downtime, escalated maintenance expenses, and potential non-compliance with evolving regulatory frameworks.

We propose a comprehensive approach to mitigate these challenges, emphasizing proactive lifecycle management (LCA), strategic sourcing of alternative components, and forward-thinking upgrade planning. We illustrate how these strategies can effectively extend equipment lifespan and minimize operational disruptions.

This work aims to provide valuable insights for cleanroom managers, engineers, and stakeholders dedicated to sustaining high-performance nanofabrication environments amidst the evolving technological landscape.

P03

ENRIS25-0051

Characterization of Fan Filter Unit Operation in a New ISO 7 Cleanroom

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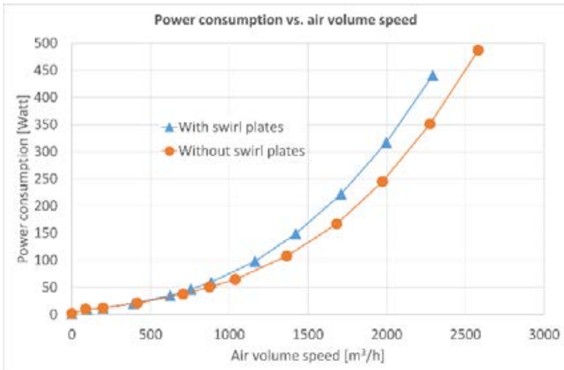
When DTU Nanolab was handed over its new 4 million Euros, 126 m2 ISO 7 cleanroom dedicated to polymer fabrication, several technical issues delayed tool installation. This provided a rare opportunity to use the cleanroom as a test facility for characterization of the installed fan filter units (FFUs).

Due to space constraints, the cleanroom ceiling height is 2.4 metres, while the plenum height is 0.6 metres, leaving only 20 cm of "breathing space" above the FFUs. FFU coverage is approximately 25% of the cleanroom area. The FFUs are equipped with H14 low pressure drop HEPA filters for lower power consumption. The fan is large, facilitating lower rotation speeds and power consumption.

FFU performance was characterized at various FFU fan speeds with respect to air volume speed, power consumption and sound pressure level. Furthermore, particle concentrations at 19 test points were measured according to ISO 14644 for various fan speeds. All of the above measurements were performed for turbulent airflow, using swirl diffuser plates, as well for unidirectional air flow, without swirl plates. Additional long term experiments with continuous online particle measurements yielded a trend of the particle concentration versus the number of persons in the cleanroom for various fan speeds.

The characterisation work gave basis for the selection of an optimum operation setting of the FFUs. A scheme for lowering the power consumption in off-peak hours was also suggested.



Left: FFU with swirl plate. Right: Power vs. air volume speed for a FFU with and without swirl plate.

P04

ENRIS25-0057

How to manage sputtering targets worn-out in open platform?

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Ayako Mizushima[1], Atsushi Toyokura[1], Sun Yasunaga[1], Yurie Inoue[2], Makoto Fujiwara[2], Tomoki Sawamura[2], Mitsuhiro Yoda[2], Yukinori Ochiai[2], and Yoshio Mita[1,2]

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The University of Tokyo participate the MEXT project "ARIM" and a wide-range of equipment is provided for research community. Our clean room (Takeda SCR) is an open place where users can operate equipment which they need for their own processes. Equipment in cleanroom should always be maintained in best condition, however, it is often difficult due to the wide variety of ways users use equipment. In this study, we focus on sputtering machines, especially sputtering targets.

We are having difficulty managing the remaining amount of target. However, managing target ware-out is an important issue because when sputtering is done with insufficient amount target, a layer of unknown composition (composed with backing plate materials...) will be deposited on the user's valuable sample. In the case of sputtering machine with a load lock chamber, the main chamber is held in a vacuum and there is not much opportunity to open it. Users therefore rarely check the target before sputtering, and cannot avoid the risk by themselves.

On the other hand, it is difficult to ascertain the exact amount of target remaining and to judge whether there is enough amount for the next use by simply visually checking, and measuring accurate height of target is also difficult due to the non-flat surface with erosion.

In principle, the target ware-out can be monitored by "Watt * Hour history", but there are other problems. Newer equipment has a system which automatically calculate this, but older equipment does not have such a system, so the calculation has to be done by human. Though this calculation is supposed to be done by each user, sometimes mistakes and failures are seen. Even if the "Watt * Hour history" is correct, the life of target is depends on the material, so we must verify the life for all targets. Currently we are running over 40 varieties of targets, of which only 5 or 6 have known lives that are used very frequently.

Through this presentation, we would like to discuss how the management of sputtering targets is managed, with our internal attempts.

P05
ENRIS25-0082
Upscaling Clean Room Facility @ CNR Bologna: up to 6″ Wafer Processing

Rita Rizzoli[1], Emanuele Centurioni[1], Fabrizio Tamarri[1], Filippo Bonafè[1], Michele Sanmartin[1], Michele Bellettato[1], Giulio Pizzochero[1]

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CNR in Bologna provides access to a 500 m2 cleanroom with a complete micro/nanofabrication line for 4″ wafers, based on Si microelectronics technology, for the design and manufacture of custom-made devices, including high-temperature treatments up to 2000 °C, photo-, e-beam and nanoimprint-lithography, wet and plasma chemical etching techniques, thin film depositions by CVD (LP- and PE-CVD) and by PVD techniques (such as sputtering and e-beam evaporation), wafer bonding processes. The Clean room facility of ISMN Bologna can manufacture microelectronic devices and microsystems (MEMS and MOEMS) both for industrial and for research purposes, with the aim of meeting the needs of innovators, both scholars and entrepreneurs, that want to investigate new device properties or boost new applications into the market. This facility is part of IT-fab, the Italian network of facilities of nanofabrication, which provides an optimal interface towards the national industrial partners and is established as the Italian node of EuroNanoLab (ENL), a distributed European research infrastructure in the field of micro- and nanotechnologies. In the framework of iENTRANCE@ENL and NFFA-DI, two projects funded by the PNRR (National Recovery and Resilience Plan) and led by the CNR for the creation and strengthening of research infrastructures, the CNR ISMN Bologna has started upgrading its micro-/nanofabrication line to process wafers up to 6″. The aim of the above-mentioned projects was to overcome the obsolescence of the equipment to be able to face the challenges proposed in the projects, such as the development of new concepts to integrate advanced materials (as an example graphene and others) with the existing Si technology platform at wafer scale, or as the development of innovative approaches to micro/nanofabrication processes. The new micro/nanofabrication facility available in the clean room of ISMN Bologna will be described along with its potentiality.

P06

ENRIS25-0018

How to Run a Facility with over 50 Tools with only 3 Technical Staff

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The Münster Nanofabrication Facility (MNF) is a core facility funded by the German Research Foundation (DFG). It houses state-of-the-art equipment for nanofabrication and nanoanalytics in laboratories and clean rooms classified ISO 5 to 7. Nanostructuring and nanofabrication capabilities down to molecular length scales below 10 nm are provided to an interdisciplinary research community by the Center for Nanotechnology (CeNTech) and the Center for Soft Nanoscience (SoN) of the University of Münster (compare Figure 1). At present, the facility is utilized by more than 80 regular users, including scientists and engineers from the fields of physics, chemistry, earth sciences and biology. The facility is used by internal academic users, external partners and start-up companies.

MNF is managed by a core staff consisting of a coordinator, nanoanalytical engineer, nanofabrication engineer, technician, and e-learning and communications project manager. While this core team of only 3 technical staff ensures the operation of the cleanrooms and laboratories, most of the instrumentation is maintained by instrument managers from the participating research groups. These Instrument Managers are typically PhD Students using the instruments regularly for their own Projects. As the MNF operates primarily in user mode, meaning that users operate the instruments themselves, a thorough training of users is required. A general introduction to cleanroom work and safety regulations is provided by the MNF core staff. A digital training course based on Moodle complements this general training. The Instrument Managers take care of the training, coordinate service and maintenance work on their respective instruments. For some high performance tools (e.g. EBL, TEM, HIM) the instrument managers and core staff offer service operation for users. All this makes the instrument managers experts on their respective tools, benefitting their own research as well as their future careers. The respective group leaders benefit from this in the form of lower prizes for using the facility.

The presentation will provide an overview of the Münster Nanofabrication Facility, the way the instruments are managed by PhD students, as well as some of the unique challenges that arise when research groups are responsible for managing their favorite tools.

Access and User Training

P07

ENRIS25-0033

CROSS : Clean Room Support System

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The CMNF platform's cleanroom spans 1,600 m² and is utilized by 172 active users.

The platform required a system to manage access to its cleanroom tools, gather statistics, and monitor occupancy in real-time for security purposes. These tasks can be time-consuming for both researchers and platform managers.

CROSS is a tool designed to address these challenges and minimize the time researchers spend on such tasks. It comprises two components: a website and IoT devices within the cleanroom. CROSS is included in RENATECH's PIMS, and communicates with the other bricks thanks to its API.

The IoT devices are boxes equipped with touchscreens and RFID sensors. Cleanroom users must scan their badges to enter; at the entrance, a screen displays current occupancy and equipment usage to enhance user experience. When a user wishes to operate equipment, they scan the box, select their project, and begin working immediately, minimizing user input.

The website allows users to view logs, extract data, generate statistics automatically, manage user authorizations, tools, and teams, as well as generate acknowledgments and estimates.

Since July 2023, CROSS has recorded 23,000 operations across more than 200 projects in our lab. It is slated for deployment to other platforms within our lab and to other labs in France; 80 CROSS boxes have been ordered nationwide.

P08

ENRIS25-0068

REPOTECH, Project management web application for platform networks

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The Renatech Network needed a better management about projects. REPOTECH was created to ease the management of more than 3000 projects requested during the last 10 years within the network and give a complete solution to work, save and collaborate on this history. That is why we came up in 2018 with the idea of our application.

REPOTECH is a web application designed to ease and centralize the concept of project management, in the context of a platform network distributed all around France. It is divided in two main parts :

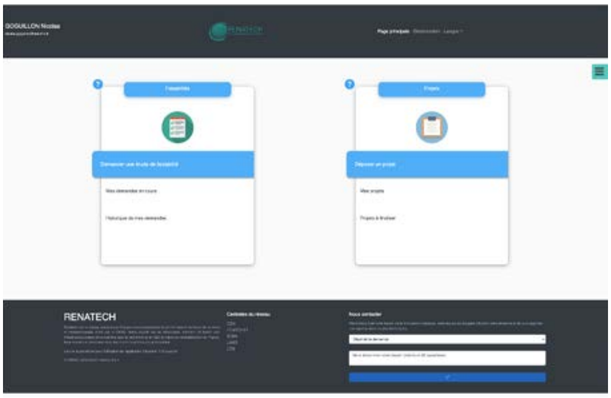
- The user interface, created to give researchers a simple tool to create, access and manage their feasibility or project requests;
- The administration interface, used to receive, accept, reject, edit, transfer, delete or comment these projects requests collaboratively with other administrators from other network's laboratories.

REPOTECH also allows networks to generate, access and share advanced statistics about the network and its works along the years.

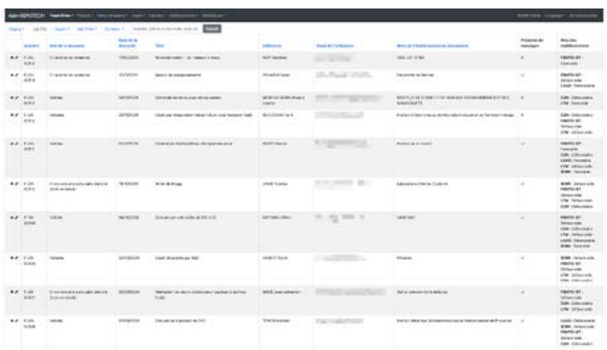
Since 2022, REPOTECH has hosted more than 3000 projects and counts more than 4000 users.

The app is in production for the Renatech network since 2022; moreover, it has recently opened to new networks with similar needs like RF-NET, a platform network in characterization or Ramses, a platform network on aero-hydro-combustion. The project continue to extend and grow with active developpement and is a part of the Platform Management Information System (PIMS) made up by RENATECH's Networks in recent years.

REPOTECH, user interface, main page:



Administration interface, feasibility requests panel:



P09

ENRIS25-0054

FabuBlox: A Unified Process Design and Collaboration Platform Connecting the Nanofabrication World

Jan Tiepelt[1]

[1] Fabublox- Inc., CEO and Co-Founder, Somerville, USA

The nanofabrication world faces a critical communication and knowledge management challenge. Across the decentralized R&D ecosystem of academic, government, and industrial fabrication facilities, there are no standardized frameworks for tool and process data management, visualization, and knowledge transfer. This fragmentation leads to repeated problem-solving, limited process interoperability, and inefficient use of engineering time and resources, thereby heavily stifling innovation in a sector associated with immense R&D cost. Moreover, it creates significant hurdles for modern day R&D challenges requiring multi-facility, highly flexible, and custom nanofabrication solutions.

The **FabuBlox** cloud platform, originally developed by MIT engineers for internal process database building, addresses these challenges by providing an accessible, cross-facility data standard that seamlessly integrates process design and simulation, knowledge management, and communication. Since its first release in 2023, the FabuBlox platform, freely accessible at **fabublox.com**, has gained 1,500 users, across nearly 100 mostly academic fabrication facilities in 12 different countries.

Shared cleanroom facilities and R&D groups can leverage FabuBlox to create **private GitHub-like process repositories** to streamline user onboarding, reduce friction in process design, and automate approval workflows. A key feature of the Fabublox design interface is its ability to algorithmically generate cross-sectional images of fabricated structures on-the-fly, significantly lowering the barrier for process planning, design, and communication. Advanced features include automated cutline extraction from GDS design files and instant generation of slide decks and run sheets for complete process flows. As a communication platform, FabuBlox recently launched FabuForum, a standalone discussion portal that seamlessly integrate with the FabuBlox process design interface and offers private discussion channels linked to FabuBlox groups - bringing StackOverflow-style problem-solving to nanofabrication.

Beyond standardization of process data management, FabuBlox Facility Portals standardize documentation and management of tool infrastructure. Facility Portals enable association of templated tool blox with real-world tool capabilities and restrictions, thereby helping facilities **prevent tool downtimes due to contamination** and optimize tool usage and process execution.

With its AI-driven **simulation and fab tracking features** in development, FabuBlox accelerates lab-to-fab transitions, revolutionizes process-design co-optimization, and automates fab service coordination. More broadly, the platform enables nanofabrication networks to unify process capabilities into a shared, intelligent database. This fosters cross-facility collaboration, enhances fab coordination, and creates an end-to-end marketplace for nanofabrication services - providing researchers faster access to expertise and unlocking new opportunities for innovation across Europe's nanofabrication ecosystem. In short, FabuBlox connects the nanofabrication world.

Collaboration and Networking

P10

ENRIS25-0077

RIANA – Research Infrastructure Access in NAnoscience & Nanotechnology

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RIANA is a Horizon Europe-funded project designed to promote both curiosity-driven nanoscience research with long-term, open-ended questions and challenge-driven nanotechnology research with specific, targeted goals for short- and mid-term results. The project is centered around the ARIE network (Analytical Research Infrastructures in Europe), a collaboration of European networks focused on large-scale research infrastructures.

RIANA unites seven top European research networks to provide access to advanced techniques in nanofabrication, material synthesis, characterization, analysis, and simulation. The project coordinates streamlined access to 69 research infrastructures through a single-entry point, supported by a range of scientific and innovation services provided by senior researchers, facility experts, and trained junior scientists. RIANA thus serves both long-term curiosity-driven inquiries in nanoscience and short- and mid-term challenge-driven research in nanotechnology.

RIANA is designed to engage both established researchers and new users from academia and industry, enabling them to develop innovative ideas and push them toward higher levels of technology readiness (TRL). By staying adaptable to emerging scientific topics and collaborating with stakeholders in the Nano-community, RIANA also offers access to infrastructures within and outside Europe and customizes its services through specialized junior scientists. Drawing on four years of experience, the consortium will develop a roadmap for the future of nanoscience and nanotechnology across European research infrastructures.

The scope of RIANA spans the entire research cycle in nanoscience and nanotechnology: from simulations to synthesis and manufacturing, and finally, to characterization and analysis, all with the support of expert guidance. The Innovation Service unlocks the potential for innovation through RI access, supporting industry-focused research infrastructure access and creating the framework and methodology to cater to small and medium-sized enterprises (SMEs).

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101130652.

P11

ENRIS25-0081

Future Challenges – and Opportunities – for University Nanofacilities

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University nanofacilities are a powerful force for technology innovation and workforce development. Our nanofacilities graduate students, train post-docs, and incubate companies that go on to shape the world. Inspired by the innovation engine, universities and government invest in nanofacilities: to date, there are about 160 such facilities in the US, according to the Nanotech NY website.

Due in large part to these alternating, biennial ENRIS and UGIM meetings, university nanofacilities have created a large, vibrant community. Facility staff look forward to these opportunities to learn and share and support each other. But looking ahead, research infrastructure faces many challenges, from funding to data management and the role of AI.

Stanford University will be hosting UGIM 2026. We would like to invite the community of nanofacilities stakeholders here at ENRIS to contribute and even participate in discussions about the role of nanofacilities in the research ecosystem of the future and how we might adapt to or even shape it.

We invite you to vote on and comment on possible topics of interest – and to suggest your own. Please follow the survey link below:

Tool and Process Development

P12

ENRIS25-0076

A Sustainable Nanostructured δ-MnO_2 Derived from Amazon Rainforest Mn-Ore Tailings for Applications in Lithium-Ion Batteries

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Achieving net-zero emissions by 2050 necessitates a rapid expansion of clean energy technologies, with renewable sources like solar and wind projected to account for nearly 90% of electricity generation by 2050. However, the intermittency of renewables sources underscores the need for efficient energy storage systems, such as lithium-ion batteries (LiBs). Among potential materials for LiB anodes, manganese oxides (MnO_x) stand out due to their stability and high theoretical capacity. Despite these advantages, MnO_x-based anodes face challenges, including low conductivity, poor ion diffusion, and structural degradation during cycles. Additionally, current manganese sourcing is environmentally and socially problematic, with significant reliance on high-grade ores and wasteful mining practices. Addressing this, our study explores a novel approach to recover manganese from mining tailings in Brazil's Kalunga Dam (Pará) and synthesize a nanostructured δ-MnO_2 (Figure 1). Using alkali fusion, leaching (90.1% efficiency), and green reductants, we produced a high-purity MnO_2 (free of Al, Fe, Si, Ti) with a nanometric structure (nanocristallites of approximately 7 nm).

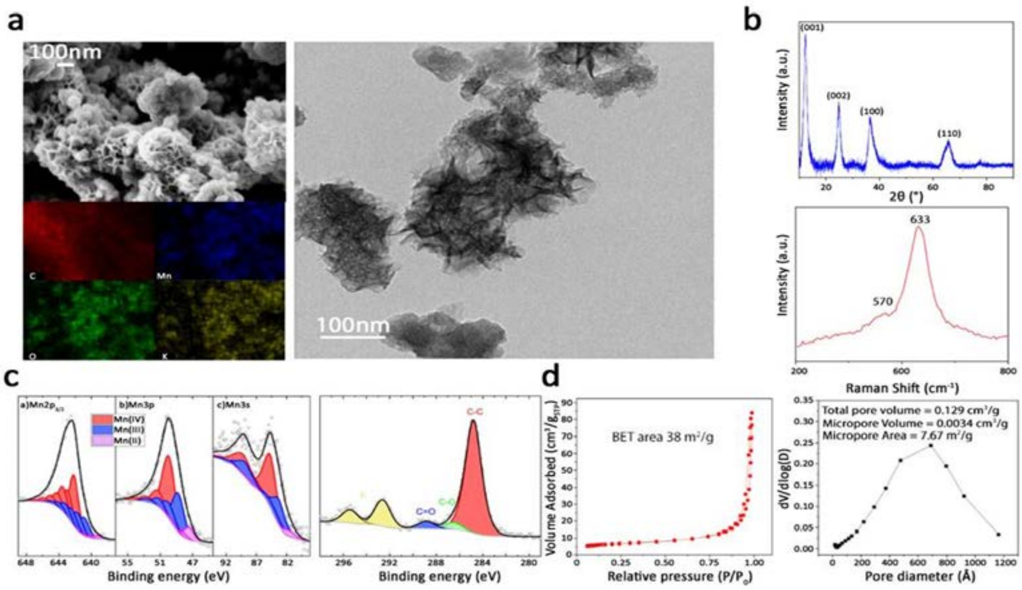

Figure 1. Characterizations of the synthesized material.

The recovered material was tested as an electrode in rechargeable Li-ion batteries, demonstrating good cycling performance. The peculiar manganese oxide nanostructure was instrumental in achieving high specific capacities by favoring lithium diffusion through the closed-spaced birnessite layers. The charge storage mechanism is typical of conversion anodes, characterized by a multielectron process which allows to reach a specific capacity of about 450 $mAhg^{-1}$ after 200 cycles of charge/discharge (Figure 2).

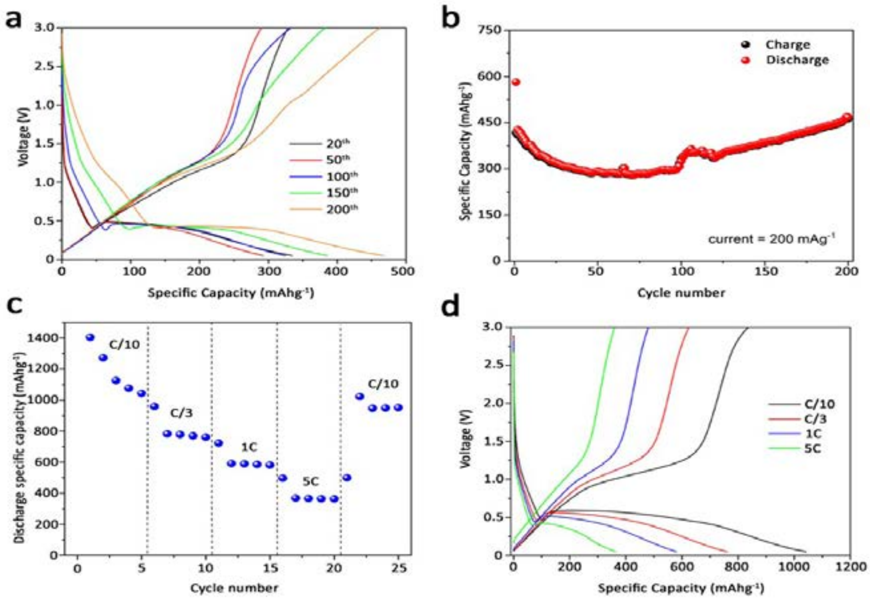

Figure 2. Electrochemical performance of the synthesized material.

P13

ENRIS25-0043

Electroplating deposition from sub-millimetric to sub-micronic scale using the same tool and bath while maintaining good plating distribution

David Bourrier[1], Amel Beghersa[1], Noriko Kawai[2], Ayako Mizushima[3], Shun Yasunaga[3], Etsuko Ota[3], Naonobu Shimamoto[3], Yoshio Mita[2,3], Hugues Granier[1]

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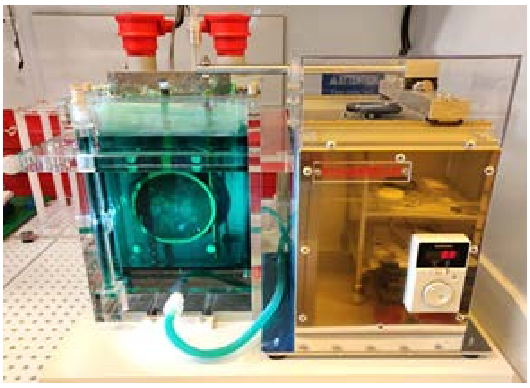
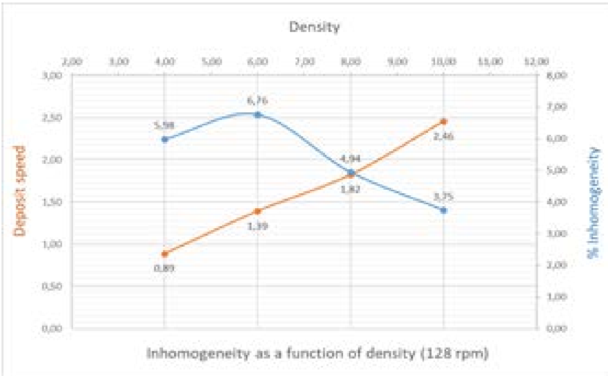
Regarding electroplating, as in every technology the ideal equipment should be capable to meet all research projects' needs. It should allow the deposition of layers with thicknesses varying over several orders of magnitude while ensuring very low inhomogeneity, regardless of the substrate size. It should also meet the requirements of various application fields, such as power and radio frequency components, which require thick layers (10 to 500 µm) over large surfaces with high throughput, while maintaining good uniformity to prevent shifts in component responses. Additionally, it should be adaptable to the needs of MEMS or biomedical components, where thicknesses range from a few microns to a few hundred nanometers.In these cases, even the slightest inhomogeneity or roughness can compromise the good formation of the deposit itself. To achieve this, it is essential to identify, control, and optimize key parameters throughout the deposition process to define specific deposition windows for each application all using a single system and bath.We will present how, through an international collaboration, we successfully tackled this challenge. First, we optimized a conventional deposition system from Yamamoto-MS, then improved the deposition process regardless of substrate size. By precisely controlling the bath chemistry we were able to achieve homogeneous thicknesses ranging from sub-micronic to sub-millimetric on substrates ranging from a few millimeters to 100 mm in diameter. This approach and expertise have been demonstrated on two different materials and successfully applied and transferred to the Takeda Super Clean Room at the Tokyo University.



Plating tool from Yamamoto-Ms



Plating distribution

P14

ENRIS25-0040

The PhoQSLab Cleanroom – A Shared Resource for Photonic Quantum Systems

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The Institute for Photonic Quantum Systems (PhoQS) at Paderborn University is an interdisciplinary research institute dedicated to developing innovative quantum photonic technologies.

Paderborn serves as a prominent hub for cutting-edge quantum research, fostering interdisciplinary collaboration among physicists, computer scientists, engineers, and mathematicians. This synergistic environment drives both fundamental research and the translation of fundamental research into real-world applications, significantly advancing the quantum research landscape in Germany and internationally.

A central component of the PhoQS research infrastructure is the state-of-the-art cleanroom, which provides researchers with a controlled environment for the fabrication and characterization of sensitive photonic components. The PhoQS cleanroom serves as a common platform for various research projects that focus on the exploration and development of photonic quantum computers, quantum communication, and quantum simulations. This presentation will detail the cleanroom's capabilities and highlight its crucial role in facilitating cutting-edge research within the PhoQS institute.

Key features of the PhoQSLab-cleanroom:

- **Environment:** The development of highly complex quantum circuits, crucial for advancing quantum device technology, is made possible by scaling up quantum components in an ISO-5 cleanroom environment.
- **Versatile equipment:** The cleanroom has a comprehensive range of precision tools and equipment (lithography, deposition and etching) specialised for the fabrication and characterization of quantum photonic components.
- **Interdisciplinary use:** The cleanroom is used by scientists from various disciplines, including physics and electrical engineering, the institute serves as a collaboration basis also for computer science, and mathematics.
- **Close collaboration:** The shared use of the cleanroom promotes the exchange of knowledge and ideas and enables close collaboration between the various research groups.

P15

ENRIS25-0022

Grayscale exposure challenges using direct-write laser exposure on thick positive resist

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Grayscale lithography is a manufacturing method to create 2.5 dimensional structures. Here, a photosensitive positive resist is exposed with spatially modulated intensity levels. These different intensity levels, also called gray values, can be exposed with a Direct Write Lithography System – DWL, manufactured by Heidelberg Instruments Mikrotechnik GmbH. The height of the created structure is limited by the nitrogen (N_2) bubble formation that deforms the structures in ultra-thick layers of commercially available DNQ-based photoresists. The new photoresist prototype mr-P 22G_XP manufactured by micro resist technology GmbH is designed for grayscale applications in very thick films. The test exposures made with a DWL 66+ show good results by realizing structures over 100 µm in height without nitrogen bubbles. Controlled multiple exposure with low doses is necessary to create high-quality grayscale patterns in the resist. This can be done using the "N-Over" (N times overlapping) DWL exposure mode. The resist-inherent bleaching during exposure allows the exposure light to reach very deep into this positive resist. The other big challenge in grayscale lithography process is the shape optimization. Higher sensitivity of the thick positive photosensitive resist requires even more stability control of the environment and the lithography process.

P16

ENRIS25-0019

Fully digital 3D imager for hard X-rays: fabrication challenges

Matias Antonelli[1], Fulvia Arfelli[1,2], Giorgio Biasiol[3], Gabriele Bonanno[4], Andrea Costa[4], Giuseppe Cautero[5], Marco Cautero[2,5], Matija Colja[5], Davide Curcio[3], Simone Dal Zilio[3], Francesco Driussi[6], Daniele Ercolani[3], Gabriele Fiumicelli[4], Fabio Garzetti[4], Angelo Geraci[4], Nicola Lusardi[4], Ralf H. Menk[1,5,7], Pierpaolo Palestri[8], Enrico Ronconi[4], Luca Sbuelz[3]

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5 Sincrotrone Trieste SCpA, Elettra, Trieste, Italy
6 Università di Udine, Dpia, Udine, Italy
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Time-resolved ultrafast phenomena with radiation from hard-X to gamma-rays are one of the groundbreaking research fields at the base of scientific and medical applications like pump-and-probe spectroscopy and Time-of-Flight Positron Emission Tomography.

GaAs, thanks to higher atomic number and mobility, has the potential to be much more efficient and faster than silicon in absorbing hard X-rays. Coupled with cross-delay lines and a high precision time-to-digital converters, we aim at a ~1cm^2 detector with 2D spatial resolution of 100 µm and 10 ps of temporal resolution.

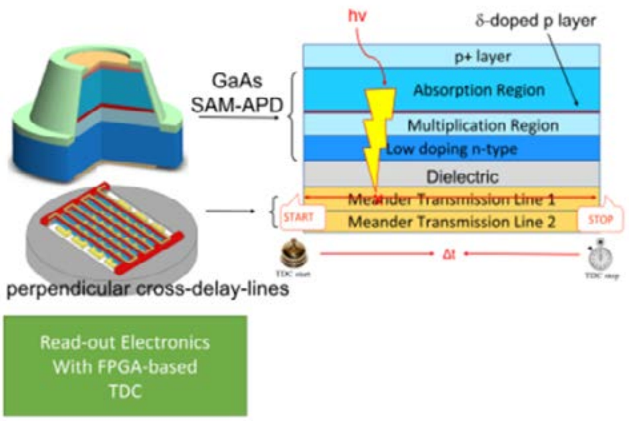

Fig. 1. A sketch of the complete device along with a schematic cross section of the active region.

MBE growth of the p-, absorption, multiplication, and n- regions will be reported along with the subsequent fabrication steps. The fine tuning of the doping levels of the p- and n-layers and tailoring of the multiplication region based on simulations will be described. Special attention will be devoted to the various fabrication steps leading to the final device, along with their optimization.

The authors acknowledge the financial support from Italian MIUR through PRIN 20227N9LW7.

P17
ENRIS25-0044
Nanofabrication for Photonic and Quantum Technologies: Tools, Processes, and Challenges at PhoQSLab

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At PhoQSLab, we are building a state-of-the-art nanofabrication facility designed to support cutting-edge research in photonic and quantum technologies. Although still in its early stages, our current cleanroom is already equipped with a wide array of advanced tools that enable the fabrication of high-performance, complex structures. Our lithography capabilities include electron beam lithography (EBL) for high-resolution patterning, laser lithography for large-scale structuring, and mask lithography for high-throughput fabrication. These are complemented by a range of deposition and etching techniques, including dry etching (ICP-RIE) and deposition methods such sputtering, e-beam evaporation and plasma enhanced chemical vapour deposition (PECVD). Together, these capabilities allow us to fabricate high-precision nanostructures that are essential for leading-edge research in photonic and quantum technologies. Our work spans a broad spectrum of device fabrication, including metasurfaces with Si and plasmonic antennas, photonic integrated circuits (PICs) based on thin-film lithium niobate (TFLN) and bulk lithium niobate (LN), and high-speed electro-optic modulators. These PICs are critical for the development of both quantum and nonlinear photonic systems. Additionally, we are advancing quantum photonics by fabricating quantum dots embedded in resonant cavity micropillars. Through these efforts, PhoQSLab is driving innovation in nanofabrication processes, facilitating progress in photonic integration, and contributing to the ongoing quantum revolution. We will introduce our toolset and processes, emphasizing how they address current nanofabrication trends and challenges.

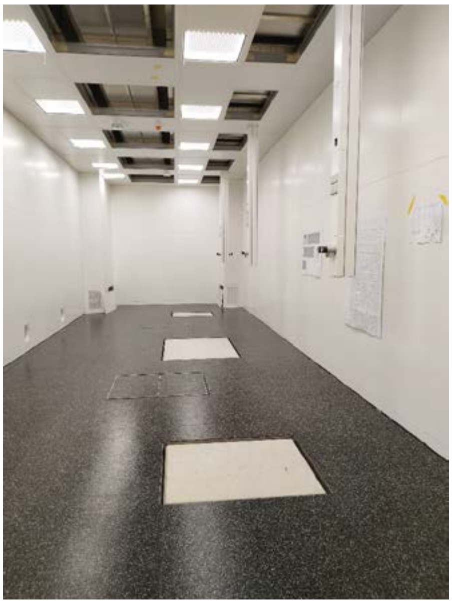

Figure 1: One of two magnetically shielded rooms at PhoQSLab, featuring vibration isolation.

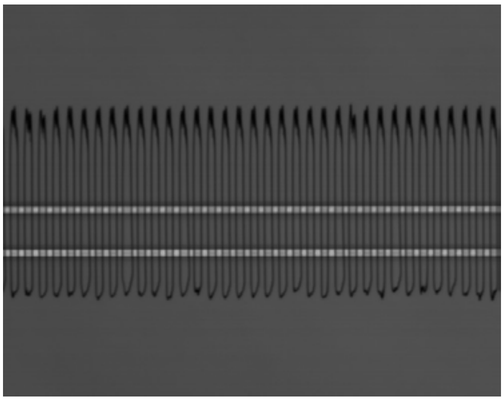

Figure 2: Second harmonic microscope image of periodically poled thin film lithium niobate waveguides.

P18

ENRIS25-0059

Direct access to graphene-metal interface by Raman spectroscopy for studying the origin of contact resistance by using a transparent substrate

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The contact resistance at graphene/metal interfaces is a critical parameter that significantly influences the performance of graphene-based devices. High contact resistance can hinder current flow in graphene field-effect transistors (GFETs)[1] and is the primary factor limiting the radio-frequency bandwidth of graphene phase modulators.[2] The integration and miniaturization of graphene electronic devices present a major challenge in developing a Complementary Metal-Oxide-Semiconductor (CMOS) compatible process that enables the reproducible fabrication of low-contact-resistance interfaces.[3] For these reasons, the choice of metal and its preparation is very important and advanced fabrication techniques together with careful consideration of metal properties, are essential for optimizing the device performances. However, the exact origin of contact resistance remains a topic of debate, as direct spectroscopic characterization cannot be performed on operational devices.

In this work, we propose a robust method for analyzing the graphene-metal interface in top metallic contacts of functional devices using Raman spectroscopy. We optimized a transparent substrate—suitable both for graphene visualization and processing—by fine-tuning the thickness of aluminum and amorphous silicon nitride layers on a glass substrate. After graphene photolithography and the deposition of Cr/Au contacts, the graphene-metal interface was examined using Raman spectroscopy with 457 nm laser excitation. Furthermore, electrical measurements were conducted on the same devices and techniques like the modified transmission line (TLM) and Van der Pauw measurements are used to estimate the contact resistance, sheet resistance, and contact resistivity. The approach presented here permits to establish a correlation between the observed increase in the D peak and decrease in the 2D peak at the graphene-metal interface, as measured by Raman spectroscopy, and the electrical properties of the graphene-metal contact.[4]

[1] F. Xia, “The origins and limits of metal–graphene junction resistance”, Nature Nanotechnology **6** (3), 179 (2011).
[2] V. Sorianello “Graphene–silicon phase modulators with gigahertz bandwidth”, Nature Photonics **12** (1), 40 (2018).
[3] F. Giubileo “The role of contact resistance in graphene field-effect devices”, Progress in Surface Science **92** (3), 143 (2017).
[4] A. Kovtun, L. Martini, P. Maccagnani, manuscript under review APL

This research was partially funded by the project PNRR–M4C2INV1.5, NextGenerationEU-Avviso 3277/2021 -ECS_00000033-ECOSISTER-spk001. The Raman spectrometer used in present work was funded by the project iENTRANCE@ENL: Infrastructure for Energy TRAnsition aNd Circular Economy @ EuroNanoLab, Project Code: IR0000027, funded under the National Recovery and Resilience Plan (NRRP), Mission 04 Component 2 Investment 3.1 – NextGenerationEU

P19

ENRIS25-0065

Projects and Opportunities of the Photonics Platform Dedicated to Thin-Film Optical Filters

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The Photonics Platform is a technological facility dedicated to the development advanced thin-film optical filters. It includes state-of-the-art deposition machines (evaporation and sputtering) all equipped with in-situ optical monitoring that allow manufacturing multilayer structures with up to several hundreds of layers, total thickness of several tens of microns and sub-nanometers resolution. In this presentation we will first introduce the philosophy of our platform (Open-access to high-end optical components). Then will describe these deposition machines and how we manage to work with and improve these technologies through preferred partnership with their manufacturer. We will also present training that are offered through this platform for both students and professionals, and examples of the various collaborations (academic and industry) and opportunities that are offered with these unique tools including space components, filters for large national and European projects such as ELI, LMJ, ITER...(see figure below) To finish, we will show how this technology can be combined with other technologies such as etching, in order to provide new structured filters for multispectral imaging.

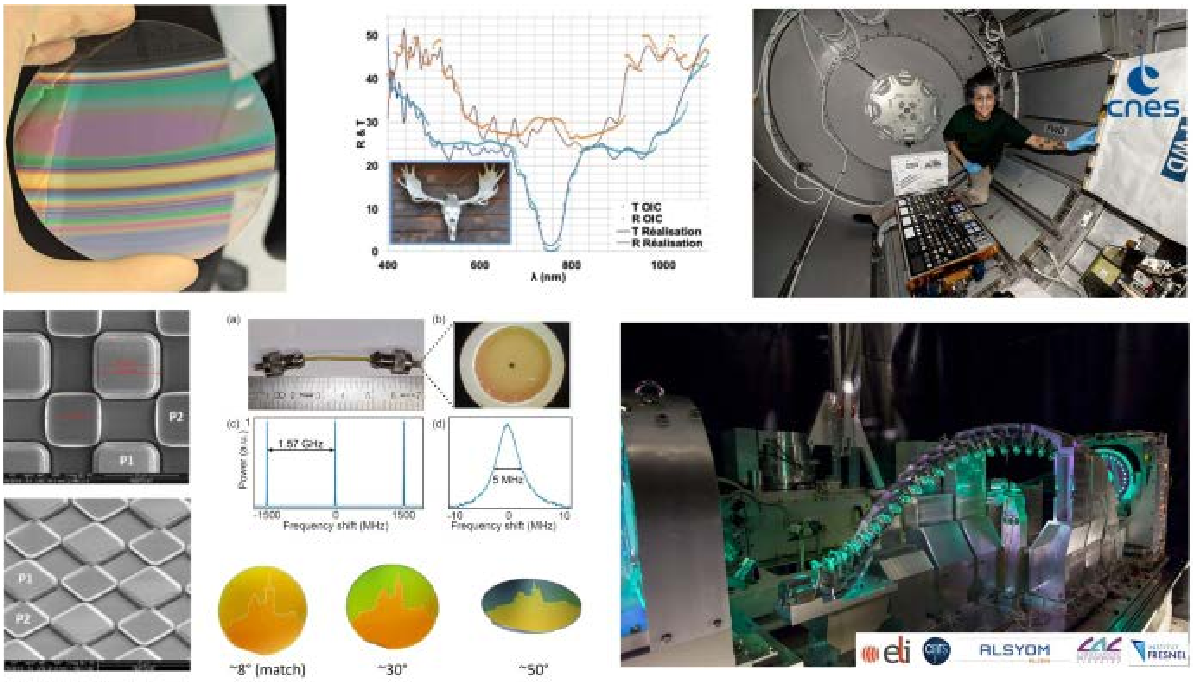

Figure: Examples of advanced thin-film optical filters for space, imaging, fibers or colorimetric applications.

P20

ENRIS25-0021

Optimizing Multi-Cycle Chamber Conditioning to Enhance Lot Processing Stability in Fluorocarbon-Based SiO_2 Etching

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Hydrofluorocarbon gas chemistries are widely used for SiO_2 etching due to their high etch rate and selectivity. However, the fluorocarbon polymer produced as a by-product contaminates the chamber walls. The adhesion of this polymer depends on the temperature of the chamber walls, which is an important parameter in controlling the polymer deposition rates and maintaining stable etch characteristics. Additionally, the rising gas temperature during processing also increases polymer precursor production. Therefore, proper conditioning or seasoning of the chamber, before initiating the actual lot process, is crucial in achieving an adequately high and stable temperature of the chamber walls. In this study, we optimize a multi-cycle chamber conditioning process using an Inductively Coupled Plasma Reactive Ion Etcher for two C_4F_8/H_2-based chemistries. Optical emission spectroscopy (OES) analysis reveals that etch characteristics are more sensitive to conditioning time for the highly polymerizing recipe. When conditioning time is insufficient (<15 min), unstable plasma species indicate that the chamber temperature has not yet stabilized, leading to a ~60% reduction in silicon recess depth during lot processing. Systematic etch tests show that increasing the conditioning time to ≥30 min stabilizes plasma species, reducing silicon recess depth variation to just 13%. Furthermore, we have developed a method to assess plasma species stability in real-time, enabling the identification of the optimal moment to initiate lot processing. By comparing the two etch recipes, our study establishes a clear correlation between conditioning time and the polymerizing degree of the etch recipe, providing insights for improving process stability and repeatability in hydrofluorocarbon-based SiO_2 etching.

P21
ENRIS25-0031
Overview of Silicon Drift Detectors Devices activities (2008–2025) at the Micro-Nano Facility of Fondazione Bruno Kessler

Antonino Picciotto[1], Alina Samusenko[1]

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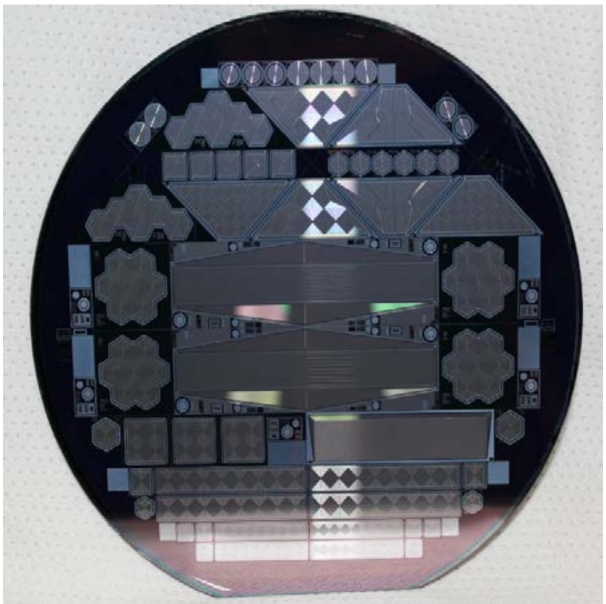
Silicon Drift Detectors (SDDs) have emerged as powerful technology for high-resolution, fast-response radiation detection in a wide range of applications, including X-ray and gamma-ray spectroscopy, medical imaging, and high-energy physics. These detectors (see figure below) offer several advantages over traditional silicon detectors, such as improved energy resolution, compactness, and the ability to operate at high count rates. The key principle behind SDDs is the drift of charge carriers in a high electric field, which allows for efficient signal collection and a reduction in readout time. Fabricating Silicon Drift Detectors (SDDs) presents several challenges due to the complexity of their design and the precise requirements for their performance.



A large area Silicon Drift Detectors realize at the Micro-Nano Facility of FBK.

This work explores the fundamental working principles of SDDs, their fabrication considerations and recent advancements in their development. Additionally, state of the art on large area detectors and the issue of yield are discussed together with the challenging scientific and technological applications ranging from astrophysics to nuclear and particle physics passing to the industrial applications.

Finally, we present an overview of SDDs manufactured by Fondazione Bruno Kessler (FBK) in the last 15 years.

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P22

ENRIS25-0084

A Cutting-Edge Facility for Fabrication and Integration of Organic and Hybrid Optoelectronic Devices and Systems

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The Facility presented here is an advanced technological infrastructure for the design, fabrication and characterization of nano-systems and integrated optoelectronic devices, including Organic-Field-Effect-Transistors (OFETs), Organic-Light-Emitting-Diodes (OLEDs), Organic-Light-Emitting-Transistors (OLETs), Organic-Photo-Diodes (OPDs), sensors, and smart surfaces. The major objectives of the experimental activity supported by the facility are the implementation of multifunctional organic and hybrid materials within single electronic, optoelectronic and photonic device components and their smart integration towards the realization of prototypal systems for real-setting applications.

The Facility is structured into two distinct environments: an ISO6 cleanroom dedicated to cleaning, functionalization and patterning of multiple substrates (i.e. glass, Silicon, polymeric), and an ISO7 cleanroom featuring state-of-the-art instrumentation for large-area thin-film deposition of metal, organic, oxide and hybrid materials by solution-processed and high-vacuum sublimation methodologies. The latter includes a modular glovebox with remotely controlled thermal evaporators, a fully automated setup for device encapsulation, a wire bonder for integration of devices and device arrays into printed-circuit boards and low-noise multifunctional probe-station for optoelectronic characterization of the fabricated systems

This facility has recently enabled the realization of highly-integrated and miniaturized organic optoelectronic systems for the implementation of portable fast and quantitative optical biosensors for biodiagnostics, food safety and quality and environmental monitoring [M. Prosa et al. Nanomaterials 2020, 10, 480]. In particular, we mention the realization of an array of organic light-sources and -detectors (OLEDs, OLETs and OPDs) into ultra-compact systems for plasmonic- and fluorescence-based detection without the implementation of bulky optical components [M. Bolognesi et al. Adv. Mater. 2023 2208719; M. Prosa et al. J. Mater. Chem. C, 2024,12, 4243-4252]. Suitable nanostructured bidimensional plasmonic photonic components (such as nanoplasmonic grating and Distributed Bragg Reflector, respectively) are implemented for enabling and improving the sensing capabilities. The equipment located in the Facility meets both scientific needs for advanced fabrication of advanced integrated systems and technological transfer requirements. In particular, the presence of two semi-industrial systems for thin-film deposition enables up-scaling of the engineered processes towards industrial development, facilitating technological transition from TRL 3 to TRL 7. Collaboration with laboratories for the industrial development and innovation such as Mister Smart Innovation Laboratory (https://www.laboratoriomister.it/) that is part of the Emilia-Romagna Technopole, further strengthens the bidirectional interactions with the local, national, and international industrial ecosystems.

Thanks to its unique capabilities, the Facility represents a strategic hub for research and innovation, providing companies and research centers with cutting-edge tools for developing new technologies and high-value-added products.

P23

ENRIS25-0034

Controlled Resin Filling Between Mesas Structures to Insulate Electric Contacts

Luca Sbuelz[1], Matias Antonelli[2], Fulvia Arfelli[2,3], Giorgio Biasiol[4], Gabriele Bonanno[5], Andrea Costa[5], Giuseppe Cautero[6], Marco Cautero[6], Matija Colja[6], Davide Curcio[4], Simone Dal Zilio[4], Francesco Driussi[7], Daniele Ercolani[4], Gabriele Fiumicelli[5], Fabio Garzetti[5], Angelo Geraci[5], Nicola Lusardi[5], Ralf H. Menk[2,3,6,8], Pierpaolo Palestri[9], Enrico Ronconi[5]

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Time-resolved ultrafast phenomena with radiation from hard-X to gamma-rays are one of the groundbreaking research fields at the base of scientific and medical applications, studied by techniques such as pump-and-probe spectroscopy or Time-of-Flight Positron Emission Tomography. Within the PRIN project (which is a programme of the Italian Ministry of Education, Universities and Research that supports research projects freely proposed by universities) *"Fully-digital 3D imager for gamma and hard-X rays,"* our group fabricated P-I-N (P doped - Intrinsic - N doped) GaAs-based devices, with the intrinsic layer composed of an absorption and a multiplication region. The devices required 30 μm tall mesas to be wet etched in an H_3PO_4:H_2O_2:H_2O solution, reaching and partially etching the n-doped GaAs substrate wafer. Ohmic contacts were evaporated onto the top of the mesas and on the back of the substrate wafer.

These devices require the application of several hundred volts of DC bias between the p and n contacts; a dielectric layer is needed to isolate the two contacts and the mesa edges. SiO_x and Al_2O_x were tested, but both underperformed, with relatively low breakdown voltages.

To obtain a working insulating layer we filled the spaces between the mesas with a thick layer of UV-cured resin. After depositing the p contacts on top of the mesas, the sample was positioned upside down, with the mesa tops resting on a PDMS foil (ELASTOSIL® Film 2030 250/200, 200 μm) spread over a glass plate. A small weight (130 g) was placed on the sample to allow the mesas to slightly sink into the PDMS. The assembly was then placed on a hot plate at 80 °C, and drops of UV resin (OrmoClear®) were applied on the sample's edges. The heat helped decrease the viscosity of the resin, allowing it to flow by capillarity between the sample and the PDMS, filling the gaps between the mesas. After through-the-glass UV curing the PDMS foil was peeled off. The resulting resin layer was 27–29 μm thick, nearly reaching the top of the mesas while leaving the tips, slightly embedded in the PDMS, exposed. Subsequent lithography and evaporation steps were carried out to deposit Cr/Au bonding pads on the resin, with conductive paths extending to the p contacts atop the mesas. The 27–29 μm-thick resin layer obtained exhibited superior insulation performance compared to SiO_x and Al_2O_x, with no breakdown observed in the voltage range available in our setup.

P24

ENRIS25-0047

High Stretchable Electrodes for bio-sensing

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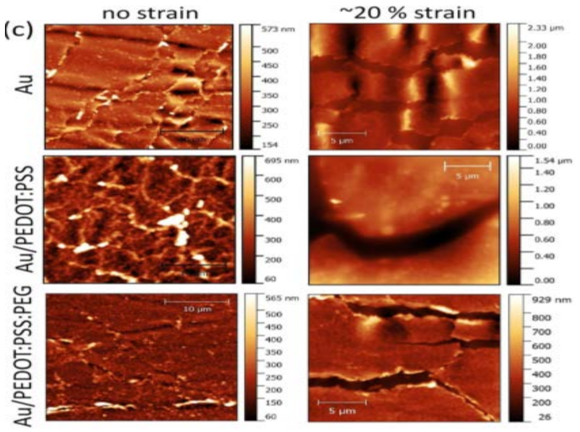
We present a highly stretchable, low-impedance electrode design that integrates microcracked gold films as metallic conductors with a stretchable conducting polymer composite.

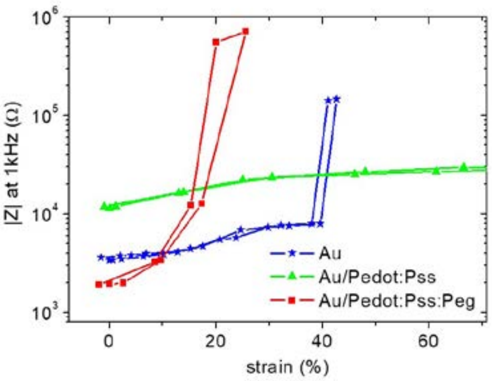
The conducting polymer, poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS), is electrodeposited onto the gold feedlines, forming a compliant interface with tunable mechanical and electrical properties. By incorporating polyethylene glycol (PEG) as a plasticizer in the electropolymerization process, we control the thickness, flexibility, and adhesion of the PEDOT:PSS layer while maintaining its low-impedance characteristics.

Atomic Force Microscopy (AFM) (figure 1) conducted in liquid and under mechanical strain confirms that the addition of PEG imparts softness and mechanical compliance to the PEDOT:PSS coating without disrupting the microfracture mechanics of the underlying gold layer.

The resulting electrode maintains stable low-impedance recording properties even under 40% strain (figure 2) demonstrating its robustness for dynamic biological environments. This work provides a promising approach for developing highly stretchable bioelectronic interfaces with superior mechanical adaptability and stable electrical performance, paving the way for advanced neural interfaces, bioelectronic medicine, and flexible sensing applications.

Decataldo, F., Cramer, T., Martelli, D. *et al.* Stretchable Low Impedance Electrodes for Bioelectronic Recording from Small Peripheral Nerves. *Sci Rep* 9, 10598 (2019). https://doi.org/10.1038/s41598-019-46967-2





P25
ENRIS25-0010
Expanding the lithography toolbox: t-SPL two years later

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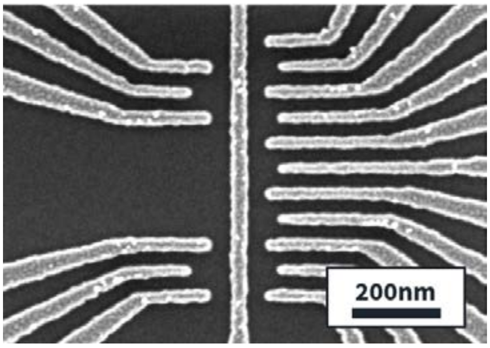
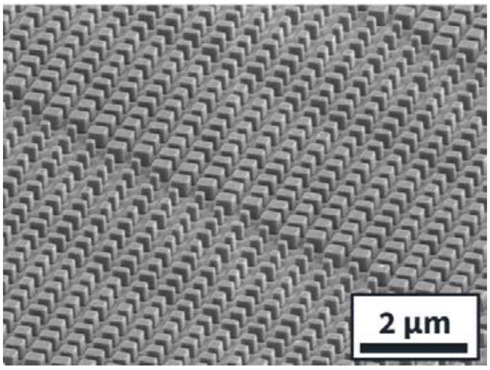
Two aspects of thermal scanning probe lithography (t-SPL) and the NanoFrazor will be explored. First, which applications are enabled by it, and second, what does it bring to nanofabrication from an operations and user's perspective.

The NanoFrazor is a t-SPL tool offering complimentary features to established lithography techniques such as photolithography, ebeam, and focused ion beam. It uses a heated cantilever to write features with sizes below 15nm. At the same time, grayscale patterning is possible with a resolution of 2nm. A reader is integrated at the tip allowing for parallel imaging to the patterning enabling markerless overlay. This simplifies the placement of features on 2D materials which are easily imaged under the resist. A laser can be used with the same resist stacks to create larger features >500nm such as contact pads. The latest results in 2D devices, plasmonics and biological applications will be presented from the scientific community and the team at Heidelberg Instruments Nano.

Finally, in the spirit of ENRIS, there will be a brief look into the installation and maintenance of such a tool as well as the material and strategy to train users on the NanoFrazor.





Lateral quantum dot electrode device, 30 nm line widths 30 nm gaps.
Metalens close up, 380 nm Si pillars.

P26

ENRIS25-0066

The PhoQS cleanroom: A platform for the technology development of advanced optoelectronic and photonic devices in cryogenic environments

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The Institute for Photonic Quantum Systems (PhoQS) at Paderborn University combines expertise in quantum photonics and state-of-the-art cleanrooms to develop innovative solutions for quantum photonic technologies.

One of PhoQS' specializations is the design, fabrication, and characterisation of advanced optoelectronic and photonic devices in cryogenic environments. The technology and fabrication methods range from Molecular Beam Epitaxy (MBE), Sputtering, Evaporation and Metallization to Optical, Laser, and E-Beam Lithography, as well as Dry and Wet Chemical Etching techniques.

The fabrication of quantum dot (QD) micropillar cavities in an AlGaAs material system is one of the focuses. Micropillar cavities are micrometer-size resonators that can trap light on a scale comparable with its wavelength. This strongly couples the electromagnetic wave to the matter, creating novel effects. The fabrication of QD micropillars includes the sample growth by MBE, QD localization, and processing of structures. The standard processing involves several e-beam overlay lithography steps and reactive ion etching procedures. A few major steps are depicted in Figure 1. To control the etching depth, the quality of the pillar sidewalls; tools as a profilometer, scanning electron and atomic force microscopes must be available in the cleanroom.

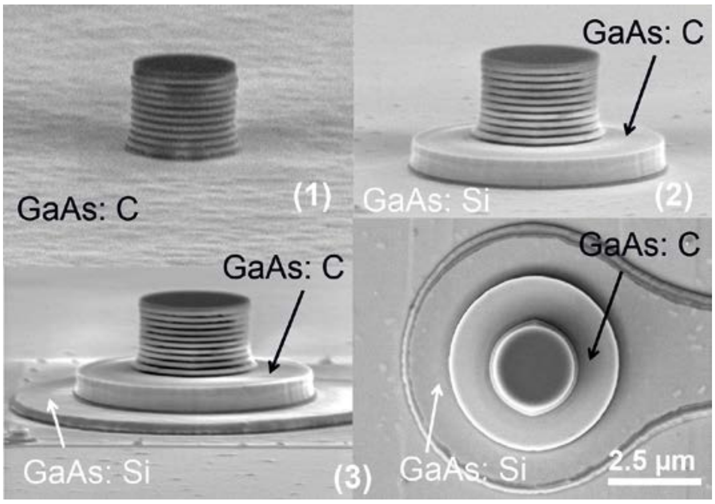

Figure 1. Fabrication of a micropillar cavity around the localized QD includes pillar etching (1), etching through the cavity region (2), and etching down to the undoped GaAs layer (3).

This poster will discuss the challenges of micropillar fabrication and the corresponding requirements for cleanroom facilities. PhoQS harnesses the combined power of quantum photonics and cleanroom fabrication to create innovative (cryogenic) quantum devices.

Commercial Use

P27

ENRIS25-0072

Technology Transfer and Small-Scale Production: Case Studies at CNR Bologna

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In collaborative research with small and medium-sized companies on MEMS devices, the need for a roadmap from research to market is a critical issue which needs to be addressed. Usually, after laboratory demonstrations of an innovative technology, the production of pre-series prototypes for in-field demonstration requires small-scale MEMS productions, which are not yet suitable to be transferred to MEMS foundries. The introduction of practices for non-academic activities in R&D clean-rooms can be a viable way to fill these gaps.

We will report on three different case studies of collaborations between a regional SME and CNR in Bologna, where novel MEMS devices were conceived, demonstrated and fabricated at pre-series level:

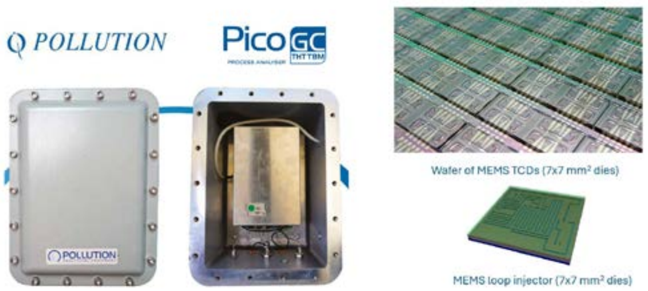
A) A MEMS-based device, completely conceived and demonstrated at CNR and then transferred to the SME;
B) A set of MEMS devices developed in collaboration with the SME in the framework of the Horizon "SME Instrument" project picoGC;
C) A MEMS device conceived and designed by the SME, and prototyped in the CNR clean-room.

In all three cases, the MEMS devices were produced in pre-series inside the CNR clean-room and are currently deployed in commercial products. Such success stories are made possible by a combination of visionary innovating companies and flexible access rules in academic clean-rooms.

Case A: designed at CNR and transferred to Pollution s.r.l.
Miniaturized MEMS-based GC/PID system for environmental BTEX detection

Pyxis-GC worldwide installation sites (as of 2023)

Case B: designed in collaboration between CNR and Pollution s.r.l. (Horizon SME Instrument)
MEMS-based GC/TCD system for the quantification of odorants in natural gas



P28
ENRIS25-0069
PICO – The New PSI Cleanroom at Switzerland Innovation Park Innovaare

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We would like to introduce PICO – the new, state-of-the-art cleanroom at the Paul Scherrer Institute (PSI), now in its first year of operation. PICO stands for Park Innovaare Cleanroom for Optics and Innovation and welcomed its first users at the beginning of 2024. It is located within Switzerland Innovation Park Innovaare, adjacent to PSI, which provides office and laboratory space for various companies and startups.The construction of the PICO cleanroom, as well as its process equipment, was fully financed by PSI. Its primary mission is to offer PSI scientists a cutting-edge nano- and microfabrication facility for manufacturing test samples, developing X-ray optics, and designing instrumentation for PSI's large-scale research facilities, such as the synchrotron, free-electron laser, and neutron source. To support scientific projects effectively, PICO is designed to provide maximum flexibility in adapting fabrication processes to researchers' specific needs.
At the same time, PICO is open to startups and established companies interested in using our equipment for developing and manufacturing their products.In this presentation, we would like to share our experience in managing a cleanroom that serves both fundamental science-driven research and industrial applications. We will also discuss the profiles of the companies that have chosen to establish themselves at Park Innovaare to gain easy access to PICO, as well as our vision for future developments.

P29

ENRIS25-0080

Production Scale-up of MEMS Sensors Through Commercial Use of A Research Infrastructure: The Case of HighSenseTech and CNR

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In this paper, the birth of HighSenseTech, a spin-off of CNR, the National Research Council of Italy, will be described as an example of commercial use of a research infrastructure. The research infrastructure related to HighSenseTech is a micro-nanofabrication line that is located in the Bologna section of the ISMN institute, belonging to CNR. In this laboratory, the MEMS technology that is being commercialized by HighSenseTech was developed in the course of previous research projects. It consists of a wafer-level vacuum packaged MEMS resonator build exploiting Silicon On Insulator substrates and thin-film vacuum encapsulation performed by low-pressure chemical vapour deposition of polycrystalline silicon. These silicon resonators are useful as high-resolution strain sensors, providing a strain resolution that is about two orders of magnitude higher than the one of the best commercial strain sensors available nowadays. Starting from the results of the technology development obtained during these previous research projects, HighSenseTech has started the industrialization of this technology the exploiting the micro-nanofabrication facility at CNR, first by introducing proper modifications to the fabrication process in order to achieve a higher yield and a larger process window, making the fabrication easier and improving the reliability and reproducibility of the technology. Moreover, since these sensors also need a peculiar package to work well in specific applications related to strain sensing, the spin-off company has set-up a packaging line in a room of the same building in which the nanofabrication line is located, completing the fabrication of working prototypes of the MEMS sensors. All these activities, which will be descried in the paper, will be preparatory for the scale-up of the technology, which will be realized through technology transfer towards external silicon foundries, relying to the experience gained by HighSenseTech working in the CNR research infrastructure.

P30

ENRIS25-0060

Supporting Industrial Users in an Academic Cleanroom

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Myfab-Uppsala's Microstructure Laboratory, established in 1997, was initiated by two departments at Uppsala University (UU) to consolidate resources for materials science processing and analysis. The initial funding was provided by the Knut and Alice Wallenberg Foundation (KAW). Special funding from KAW and UU covers the operational costs of the premises, while other ongoing expenses, such as staff salaries, machine maintenance, and consumables, are funded by the Swedish Research Council (Vetenskapsrådet), Sweden's largest governmental research financier, and user fees.

Despite a funding bias towards basic research, we have consistently rented out tools and space to companies at higher rates than those for academic users. This not only contributes to our income but also brings added value, as industrial users typically have more established processes and yield considerations, leading to a higher degree of quality control. Consequently, continuous feedback from industry provides valuable input for monitoring our tool and process performance.

Our cleanroom is a multi-user lab with high flexibility in processes and materials, making quality certification of the entire lab impractical. However, this does not prevent certain companies from certifying the processes that are part of their production.

Recently, we received funding from The Swedish Agency for Economic and Regional Growth (Tillväxtverket) to enhance our support for industrial users. This funding will be used for investments in equipment, improved user support through increased staffing, and external communication. In addition to senior staff, we plan to engage student coworkers to perform routine tasks such as tool maintenance and process monitoring.

In this new situation, we anticipate an increase in the number of industrial users and a potential shift towards improved quality assurance. The challenge will be to manage this without reducing the flexibility available to academic users.