# Chapter 16
# Beyond NNCI: International Facilities


For those outside the United States, there are some excellent open-use, national laboratories around the world. Compiled in this chapter are several laboratory options with details on how to contact them for further information. This list is far from comprehensive, but is a good start for those seeking to use international MEMS fabrication facilities.

## Australia

### *Australian National Fabrication Facility (ANFF)*

**Website:** http://www.anff.org.au/

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| **Investigator(s):** | Dr Jane Fitzpatrick, Acting CEO and Chief Operations Officer<br>Tom Eddershaw, Marketing and Communications<br>Matthew Wright, Office Manager |
| **Sponsor:** | ANFF Headquarters<br>Registered office:<br>151 Wellington road,<br>Clayton VIC 3168 |

**Abstract**

The ANFF was established under the National Collaborative Research Infrastructure Strategy (NCRIS) and consists of eight nodes and includes researchers and partners from 21 institutions. ANFF provides services for both academic researchers and industry. Researchers are able to either gain direct access to facilities under expert



D. Munro, *DIY MEMS*, https://doi.org/10.1007/978-3-030-33073-6_16

guidance, contract for specialized products to be made, or undertake contract research projects.

Each node provides their facilities on an open-access basis for researchers to engage in interdisciplinary research across the following fields:

- Micro- and nanoelectronics.
- Microfluidics and MEMS.
- Bio-nano applications.
- Advanced materials.
- Sensors and medical devices.
- Photonics.

Equipment and resource capabilities are listed at http://www.anff.org.au/capabilities.html.

The nodes are hosted at the following institutions:

1. *Victorian Node*—Monash University, Melbourne Centre for Nanofabrication. Partner institutions: University of Melbourne, Deakin University, LaTrobe University, Swinburne University, RMIT (Royal Melbourne Institute of Technology) University, and CSIRO (Commonwealth Scientific and Industrial Research Organisation) Agency.
2. *Australian Capital Territory (ACT) Node*—Australian National University.
3. *Western Australia Node*—University of Western Australia Crawley. Incorporates: Microelectronics Research Group (MRG).
4. *Queensland Node*—University of Queensland and Griffith University. Laboratories: Soft Materials Processing Facility at the Australian Institute for Bioengineering and Nanotechnology (AIBN), the BioNano Device Fabrication Facility at the Centre for Organic Photonics and Electronics (COPE), and Queensland Microtechnology Facility as well as the Raman Spectroscopy Facility at the Queensland Micro- and Nanotechnology Centre (QMNC).
5. *New South Wales Node*—University of New South Wales.
6. *South Australia Node*—University of South Australia. Partner institutions: Flinders University.
7. *OptoFab Node*—Macquarie University. Partner institutions: University of Adelaide, University of Sydney and Bandwidth Foundry International.
8. *Materials Node*—University of Newcastle. Partner institutions and laboratories: University of Wollongong's Australian Institute for Innovative Materials laboratory, Intelligent Polymer Research Institute (IPRI), and Institute for Superconducting and Electronic Materials (ISEM), as well as the University of Newcastle's Centre for Organic Electronics.

### Collaborating

It is a stated goal of the ANFF to foster international collaboration. According to CEO Dr. Jane Fitzpatrick, they aim to "provide access to both tools and expertise on an open-access model to anyone who needs it." Researchers should contact the relevant node and submit a short proposal. If the interested party does not know which node would be most suitable, they are invited to contact the ANFF headquarters for guidance. Nodes aim to provide new users access within 1 month of application. Dr. Fitzpatrick further stated that they "have a number of modes of access but the preferred one in many places is that they train the users to the level they need to get the results they want with expert support and guidance along the way."

There is an initial contact form available on the website where the user identifies as a PhD student, publicly funded, or industry researcher. They then describe their project and submit it to the appropriate node.

Information about access and pricing is provided on the website as a PDF document. Some of the pricing information is excerpted below (Table 16.1):

Australia is also host to the biennial International Conference on Nanoscience and Nanotechnology (ICONN). This conference is held every other year in February in even number years (https://www.iconn2020.com/). ICONN features a diverse array of multidisciplinary talks designed to connect world-leading scientists, students, engineers, industry participants, and entrepreneurs working in the field of nanoscale science and technology to discuss new and exciting advances in the field.

## Brazil

### *Brazilian Nanotechnology National Laboratory (LNNano)*

**Website:** https://lnnano.cnpem.br

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| **Investigator(s):** | Adalberto Fazzio, Director<br>Edson Leite, Scientific Director |
| **Sponsor:** | Brazilian Center for Research in Energy and Materials (CNPEM)Giuseppe Max Scolfaro Street<br>10,000 - High Tech Polo II of Campinas<br>Sao Paolo, Brazil<br>ZIP Code 13083–970 |

**Table 16.1** Sample prices for ANFF Victoria Node

| Equipment at Victoria Node | Academic or publicly funded | Industry |
|---|---|---|
| Flagship equipment (i.e., electron beam lithography) | $90 AUD/hour ($750 cap per 24 hrs) | $225 AUD/hour ($1875 cap per 24 hrs) |
| Tier 1 equipment (i.e., atomic force microscope) | $70 AUD/hour | $170 AUD/hour |
| Tier 2 equipment (i.e., optical profilometer) | $45 AUD/hour | $115 AUD/hour |


## Abstract

The LNNano is one of four national laboratories under the Brazilian Center for Research in Energy and Materials (CNPEM). The other three are the National Synchrotron Light Laboratory, National Biosciences Laboratory, and National Biorenewable Laboratory. It is also the headquarters for the Binational Brazil-China Center of Nanotechnology with its partner, the Chinese Sciences Academy.

The LNNano was created in 2011 and incorporates several distinct laboratories with different capabilities. They provide multiple services to users, including R&D, consultancy, and customized training for individuals, groups, or companies:

- Electron microscopy (LME).
- Laboratory for surface science (LCS).
- Thin films and microfabrication (LMF).
- Metal characterization and processing laboratory (CPM).
- Nanostructured soft materials (LMN).
- Single-particle CryoEM.
- Functional devices and systems group.
- Nanobiotechnology and nanotoxicology group (NBT).
- Special functional and advanced dispositives (DCS).
- Support to business and industrial partners.

The last is actually a support group to facilitate use by industry partners and fits well with their mission statement regarding partnership on projects (translated):

*LNNano is fully willing to associate to start-ups, nascent companies or consolidated companies of any size and business nature to act as a partner in short and long-term R&D projects.*

*Any LNNano partner in projects has the prospect to have its financial participation partially funded by development agencies to which LNNano is associated, which have specific programs or open calls for the funding of R&D projects in nanotechnology. Examples of these agencies are Embrapii, Sibratec, BNDES, FINEP, FAPESP among others.*

*Partners can also take advantage of funds from thematic networks specifically focused on nanotechnology, such as the Brazilian Nanotechnology System – SisNano, or from funds originated from cooperation programs between LNNano, and Brazilian and abroad R & D institutions.*

### Collaborating

To request services, such as to have LNNano develop your MEMS device, you must fill out a Request for Services form available on their website. https://lnnano.cnpem.br/innovation-initiatives/innovation-qa/.

LNNano wants to increase user engagement and offers tours on Wednesday to high school, college, and academics to foster interest in nanotechnology. Tours last 1.5 hours and are meant to accommodate groups of 15–20 people. They also offer scholarships, summer internships, workshops, and seminars as part of their comprehensive educational suite. https://lnnano.cnpem.br/education/educational-resources/.

Industry users must request LNNano to conduct research and fabricate MEMS devices on their behalf per the Request for Services form listed above.

All new academic users must register and submit a proposal through the User Portal at https://portal2.cnpem.br/cadastro/login.jsf. Before submitting a research proposal, users are advised to visit the relevant LNNano facility webpage to review the available services and technologies, as well as recommendations about sample preparations, protocols, and other detailed specifications about the research proposal submission process.

Once the research proposal is approved, the user will receive an email with instructions for the following three steps to be carried out prior to working at LNNano facilities:

1. Confirm the team and delegate responsibility (Confirme a equipe de campo).
2. Accept Commitment Term (Aceite o termo de Compromisso).
3. Safety Training (Responda o questionário de treinamento de segurança).

## China

### *Ministry of Education (MOE) Key Laboratory of Thin Film and Microfabrication Technology*

**Website:** http://en.sjtu.edu.cn/research/centers-labs/moe-key-laboratory-of-thin-film-and-microfabrication-technology/

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|---|---|
| **Investigator(s):** | Professor Zhang Yafei, Director<br>Professor Zhuang Songlin, Director of Academic Committee |
| **Sponsor:** | Shanghai Jiao Tong University<br>International Science and Technology Project Office<br>800 Dongchuan Rd. Minhang District<br>Shanghai, China |

### Abstract

The MOE Key Laboratory's mission is to work on basic and applied research for cutting-edge micro- and nanoscience and technology, by engaging in thin-film electronic materials and thin-film sensors, microfabrication technology, microelectromechanical systems (MEMS), nanoelectronics, and nanomaterials and technology. Its key areas of research are as follows:

- Non-silicon microfabrication and MEMS.
- Nanofabrication and device design.
- Nano-bio and medical technology.

### Collaborating

As part of the Chinese Sciences Academy, Shanghai Jiao Tong University has a long history of collaboration with prestigious international and US universities, including MIT and UC Berkeley. They have launched dozens of companies and have undertaken over 900 projects over the years, resulting in several dozen patents.

It is unclear from the website how one goes about establishing a research collaboration to work with the MOE Key Laboratory, so it is suggested that interested parties contact the Lab Director, Dr. Yafei, for more information.

## Denmark

### *National Centre for Nano Fabrication and Characterization (DTU Nanolab)*

**Website:** https://www.nanolab.dtu.dk/english/aboutus

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|---|---|
| **Investigator(s):** | Jorg Hubner, Director<br>Anders Jorgensen, Deputy Director and Head of Customer Support<br>Leif Johansen, Head of Operations<br>Flemming Jensen, Head Of Process Engineering<br>Jakob Birkedal Wagner, Scientific Director |
| **Sponsor:** | Technical University of Denmark (DTU)<br>National Centre for Nano Fabrication and Characterization<br>Oersteds Plads – Building 347<br>DK-2800 Kongens Lyngby<br>Denmark |

## Abstract

DTU Nanolab is an open use facility with over 500 users from academia and industry, including international users. Their laboratory expertise is research-based, including viewing chemical reactions with atomic resolution. More than 30 companies use their open-access facilities and expertise to develop devices and conduct small-scale production run testing.

Their cleanroom facility features the following activities and prides itself on flexibility and cooperation:

- Direct access to DTU Nanolab's wide range of equipment and expertise.
- Installation of customer-owned equipment.
- Rent of restricted access areas inside the cleanroom.
- Insourcing of development and production to carry out complex development and production work.
- Quality assurance and controlled fabrication environment.
- Consultation services in connection with process design, product development, and production.
- Education of bachelor, master, and PhD students as well as education and training for industrial customers.

DTU Nanolab's Microscope Facility is impressive with a suite of seven electron miscroscopes—four scanning electron microscopes (SEM), two of which are dual beam, and three transmission electron microscopes (TEM).

Pricing for microscope and cleanroom equipment use is available in the pricebook, which is a PDF that can be accessed here, https://www.nanolab.dtu.dk/english/Microscopes/FAQ/Prices. A table from the pricebook is excerpted below for reference. All prices are in Danish kroner (10 kroner equals about 1 US dollar) (Table 16.2).

## Research

DTU Nanolab has several special interest research groups:

- Molecular windows.
- Biomaterials microsystems.
- Polymer micro- and nanoengineering.
- Silicon microtechnology.
- Microscopy.

Users with interest in these research focuses should click on the relevant link under the Research tab. Access to the "Silicon Microtechnology" group is via http://nanolab.dtu.dk/english/Research/Silicon-Microtechnology, where you can find information about collaborations, publications, current research, and more.

**Table 16.2** Sample prices for DTU Nanolab

| Service from Nanolab | Unit | Commercial activity | External project work, Danish academia | DTU Partner with budget in external projects | Internal DTU projects |
|---|---|---|---|---|---|
| Cleanroom access (below cap) | Kr/hour | 800 | 255 + 44% OH | 255 | 0 |
| Category A tools | Kr/hour | 410 | 125 + 44% OH | 125 | 0 |
| Category B tools | Kr/hour | 650 | 330 + 44% OH | 330 | 0 |
| Category C tools | Kr/hour | 3600 | 840 + 44% OH | 840 | 0 |
| Category D tools | Kr/hour | 1200 | 240 + 44% OH | 240 | 0 |
| Category E tools | Kr/hour | 1700 | 415 + 44% OH | 415 | 0 |
| Category P tools | Kr/hour | 410 | 0 | 0 | 0 |
| Nanolab assistance | Kr/hour | 1350 | 330 + 44% OH | 330 | 0 |
| Area rent | Kr/$m^2$/imonth | 2000 | NA | NA | NA |
| Materials | | At cost+20% | At cost + 44% OH | At cost | At cost |

### Collaborating

DTU Nanolab welcomes all types of users from academia and industry. The lab will engage with users in any number of ways, including research and development, prototyping, consulting, small-scale production, and education. They invite guest researchers to the lab, and DTU offers international unpaid guest researchers and PhD students assistance with administrative, practical, and cultural issues before and after arrival. They will even provide assistance with the process for a work or residence permit and/or EU residence documents.

## France

### *Micro Nano Bio Technologies (MNBT)*

**Website:** https://www.laas.fr/public/en/micro-nano-bio-technologies

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|---|---|
| **Investigator(s):** | Bernard Legrand, Head<br>Anais Moulis, Secretary |
| **Sponsor:** | Laboratory for Analysis and Architecture of Systems (LAAS)<br>7, avenue du Colonel Roche BP 54200 31,031<br>Toulouse cedex 4, France |

## Abstract

The MNBT laboratory is part of the national Laboratory for Analysis and Architecture of Systems (LAAS) in Toulouse, France. It is leading research activities at the intersection of materials engineering, applied physics, and life sciences with an objective to deliver enabling micro- and nanotechnologies in biological and environmental applications. Some of their current research foci are as follows:

- Materials science investigation of electronic materials.
- Device design and fabrication.
- Multiplexed biofunctionalization techniques of surfaces at the nanoscale.
- Probing living matter in real time with micro- and nanoscale resolution (e.g., sensing based on electrochemistry, electromagnetism, and optics).

Their research is divided into several groups, many of which have links to their own webpages:

- ELiA (engineering in life sciences applications).
- MEMS (microelectromechanical systems).
- MH2F (fluidic high-frequency micro and nano).
- MICA (microsystems analysis).
- MPN (materials and processes for nanoelectronics).
- NBS (nanobiosystems).

One such page, MEMS, at https://www.laas.fr/public/en/MEMS gives further information about research topics, team members, recent publications, PhD dissertations, current and completed research contracts, and opportunities to join the MEMS group as a PhD student or intern.

## Collaborating

LAAS features many interesting ways to collaborate, including the Affiliates Club, which is a service providing technical and scientific information to the members of the club. There is also a webpage devoted to start-ups launched by LAAS-CNRS that provides links to several recent start-up success stories, https://www.laas.fr/public/en/start-ups. A stated goal is to support "its researchers, engineers, technicians and PhD students in creating their own business and assists them during the first years of their existence by providing technological and local support, and hosting them during the incubation phase."

A list of all equipment in the MNBT lab is available via an online portal, which is accessible to registered users https://lims.laas.fr/WebForms/Equipment/EquipmentList.aspx.

To collaborate with the Micro and Nano Technology lab, information is provided in a guidebook downloadable as a PDF from https://www.laas.fr/public/en/micro-and-nanotechnologies-platform. It includes information about Renatech, which is a network of labs within France. Information from the guidebook is excerpted here:

- Hyperlinks are provided to apply to use the labs and register a project.
- Additional hyperlinks link to safety training and protocols.
- A training plan and calendar are provided to get scheduled after you obtain approval.
- Information on booking equipment, ordering supplies, and touring the cleanrooms is also provided.

## Netherlands

### *MESA+ Institute Nanolab*

**Website:** https://www.utwente.nl/en/mesaplus/

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| **Investigator(s):** | Albert van den Berg, Scientific Director<br>Guus Rijnders, Scientific Director<br>Janneke Hoedemaekers, Managing Director |
| **Sponsor:** | University of Twente<br>MESA+ Institute Nanolab Building<br>Hallenweg 15, 7522 NH Enschede<br>The Netherlands |

**Abstract**

The MESA+ Institute is a leading nanotechnology research institute with a focus on key enabling technologies (KETs) in the following areas:

- Photonics.
- Fluidics.
- Hard and soft materials.
- Devices.

Their main areas of research focus are in health, ICT, and sustainability. For health, their areas of research are in diagnostics and biomarkers of disease. In ICT, their research involves developing energy-efficient computational power needed for highly challenging applications. In sustainability, they focus on energy storage applications.

### Collaborating

The MESA+ Institute actively seeks cooperative alliances with business and industry, (semi)government, nongovernment organizations (NGOs), and knowledge institutes. Contact information to discuss your project https://www.utwente.nl/en/mesaplus/about/organization-governance/.

MESA+ specializes in the following:

- Matching experts for your project: They will put you in touch with the right contact person and/or researcher at the MESA+ Institute.
- Business development: They will help you to create impact with the results of your research by helping bring them to the market.
- Funding acquisition: They will provide strategic advice, possible funding opportunities, planning, and funding proposal development for your project.

They have a tech transfer office to help you convert your idea into a spinoff or licensed technology. For details on how to discuss these options and support services, contact them from https://www.utwente.nl/en/mesaplus/innovation/tech-transfer/.

## New Zealand

### *University of Canterbury Nanostructure Engineering, Science and Technology Research Group*

**Website:** https://www.canterbury.ac.nz/research/facilities-and-equipment/research-equipment-and-facilities/electrical-and-computer-engineering-labs/

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| **Investigator(s):** | Maan Alkaisi, Director<br>Martin Allen, Co-Director<br>Volker Nock, Co-Director |
| **Sponsor:** | University of Canterbury College of Engineering<br>Electrical and Computer Engineering<br>Level 5 and 3 Link Building, Private Bag 4800<br>Christchurch 8020<br>New Zealand |

### Abstract

The Electrical and Computer Engineering's (ECE) Nanofabrication Laboratory contains facilities for semiconductor material processing, nanofabrication, sensor, and microfluidic device development. This is the national micro- and nanofabrication facility for New Zealand and is the main fabrication facility for the interdepartmental Nanostructure Engineering, Science and Technology (NEST) research group (https://www.canterbury.ac.nz/engineering/schools/ece/research/nest/), as well as the MacDiarmid Institute for Advanced Materials and Nanotechnology (https://www.macdiarmid.ac.nz/).

Research interests are focused on the following:

- Functional nanostructures.
- Materials for energy capture and utilization.
- Tomorrow's electronic devices.

### Collaborating

The ECE Nanofabrication Lab is a small facility with a variety of micro- and nanofabrication capabilities. It is most suitable for early stage investigations and small production runs. Users are expected to conduct their own fabrication; however, there is training and support for purchase of supplies. Pricing for academics is on a per annum user fee. Industrial users not affiliated with the MacDiarmid Institute should contact the lab director for more information on how to gain access to the facility.

## Portugal/Spain

### *International Iberian Nanotechnology Laboratory (INL)*

**Website:** https://inl.int/

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| **Investigator(s):** | Lars Montelius, Director-General<br>Paulo Freitas, Deputy-Director General |
| **Sponsor:** | Governments of Portugal and Spain<br>INL – International Iberian Nanotechnology Laboratory<br>Avenida Mestre José Veiga s/n, 4715–330<br>Braga, Portugal |

**Abstract**

The INL is a joint laboratory between Portugal and Spain that serves as an international hub for the development of nanotechnology. It is divided into six departments:

- Nanoelectronic engineering.
- Life sciences.
- Quantum and energy materials.
- Micro- and nanofabrication.
- Nanophotonics.
- Advanced electron microscopy and spectroscopy.

Their applied research areas are comprehensive, with broad coverage of the following:

- Health—INL is focused on the development of novel technologies for the early diagnosis and treatment of diseases.
  - Diagnostics.
  - Therapeutics.
- Food and environment—INL covers complementary fields ranging from food technology to biology and chemistry, enabling a versatile approach to address challenges in the food quality and safety and in environmental monitoring.
  - Lab-on-chip.
  - Smart packaging.
  - Nanomaterials.
- Information and communication technologies—INL activity is focused on 5 technologies: spintronics, graphene, thin films, MEMS, and CMOS IC design.
- Renewable energy—INL performs research and development along a wide range of research lines, including solar energy harvesting, conversion, and storage.

INL has specific interest in developing commercial enterprises and states, "We facilitate the development and uptake of new ideas and transfer them into commercial value that will increase improve industry's productivity, competitiveness and foster economic growth." To foster this, they provide customized services for each project and the highest level of confidentiality. They also offer an international market square for nanotechnology and key enabling technologies (KETs). Through INL, partners can easily reach international governments and countries. They also have an incubator program and space for up to ten start-up companies to be located on site.

### Collaborating

To obtain access, users must first fill out an application form available at https://inl.int/user-facilities/user-access/. After approval, user will receive an email with login credentials to access the Laboratory Information Management System http://lims.inl.int. This platform supports the management of all equipment, including training request, booking, logging, and billing.

## South Africa

### *National Centre for Nano-Structured Materials (NCNSM)*

**Website:** https://www.csirnano.co.za/

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| **Investigator(s):** | Suprakas Sinha Ray, Director and Chief Researcher<br>Gugu Mhlongo, Facility Manager |
| **Sponsor:** | CSIR Building 19B Scientia Campus<br>Meiring Naude Road<br>Brummeria, Pretoria 0184<br>South Africa |

### Abstract

The NCNSM Characterization Facility run by the Council for Scientific and Industry Research (CSIR) provides a wide range of instrumentation for use by the nanotechnology community, and others, to characterize their research samples. They welcome other universities, researchers, and industry to use their facilities.

Active research within the facility includes the following:

- Advanced Materials for Device Applications—This group focuses on the development of nanomaterials that can ultimately be used in an array of sensors such as gas sensors.
- Nanomaterials Industrial Development Program—This program focuses on the development of new and advanced materials through the incorporation of nanotechnology.
- Nanomaterials for Water Remediation Project.
- Catalysis research—This project is developing biomass-derived green chemicals, fuel blending chemicals, and biofuel using nanocatalytic processes.

The NCNSM has numerous local collaborators, including the following:

- University of Cape Town.
- University of the Free State.
- University of Witwatersrand.
- University of Western Cape.
- iThemba Laboratories,
- University of Pretoria.

In addition, they have at least ten international collaborators from around the world and three featured industry collaborators.

The NCNSM links to several other micro- and nanotechnology initiatives within South Africa https://www.csirnano.co.za/about-us/links/, including the following:

- Main CSIR website.
- The Department of Science and Technology.
- The National Nanotechnology Strategy.
- South African Nanotechnology Initiative.
- Microscopy Society of Southern Africa.

### Collaborating

To initiate contact with NCNSM, use the contact form, https://www.csirnano.co.za/about-us/contact-us/, and they will reply promptly. In addition to the contact form, this link also provides email addresses and phone numbers for key individuals.

## Sweden

### *The Electrum and Albanova Laboratories at KTH University*

**Website:** https://www.kth.se/en/eecs/forskning/electrumlaboratoriet-1.262770

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|---|---|
| **Investigator(s):** | Göran Stemme, Head of Devision<br>Wouter Metsola van der Wijngaart, Deputy Head of Division |
| **Sponsor:** | Division of Micro and Nanosystems<br>KTH School of Electrical Engineering and Computer Science<br>Malvinas väg 10<br>SE-100 44 Stockholm<br>Sweden |

**Abstract**

The Electrum Laboratory and Albanova Nanofabrication Facility, housed within Electrical Engineering and Computer Science at KTH University, offers complete processes for nano- and micro-manufacturing. The laboratories are operated by KTH and Acreo, and both support projects from start-up to mature technologies.

All resources are available as open access, including the following:

- A fully equipped cleanroom for device research and manufacturing.
- A flexible cleanroom environment for materials and device-oriented research and development.
- World-class characterization laboratories.
- Sophisticated software for calculations, simulation, and design.

Their staff is highly skilled and available for users' projects:

- Process and development services.
- Commissioned research and development.
- Prototyping and small-scale production.
- Courses in process technology, characterization, and cleanroom infrastructure.

The major research field of the division is micro- and nanoelectromechanical systems (MEMS/NEMS), where micro- and nanofabrication techniques and materials are adapted to the making of small, low-cost, high-performance electromechanical, optoelectromechanical, RF/microwave, and micro- and nanofluidic devices. Research areas of interest in micro- and nanotechnology include the following:

- Biomedical microtechnology.
- Micro and nanofluidics.
- RF microwave and terahertz microsystems.
- NEMS and nanosystems.
- Organ-on-a-chip and cell models.
- Photonics.
- Sensors.
- Soft materials.

**Collaborating**

KTH's Micro and Nano Laboratories actively encourages outsider researchers and companies to join their lab, and they state, "Collaborating with KTH gives you an excellent opportunity to develop the knowledge base of your company, gain new perspectives on research questions and access an advanced infrastructure for research and innovation in an international environment. We regularly collaborate with external corporations and organisations and base our questions on the needs of relevant industries."

Users have the option of collaborating with students, alumni, research personnel, and research groups or centers. https://www.kth.se/en/samverkan/samarbeta-med-oss/samverka-med-forskar.

The AlbaNova Lab is where users can train to use a variety of micro- and nano-fabrication equipment. Usage, training, and booking are all managed through the Lab Information Management System (LIMS), which can be downloaded as a PDF at http://www.nanophys.kth.se/nanophys/facilities/nfl/nfl-frames.html.

The academic user flat rate per year is 55,000 SEK, which converts to about $5500 USD per year. Ten Sweden krona equal about one US dollar. Occasional or infrequent users can pay per use per myFAB rate structure. Without registering for the lab, it is not possible to determine the fees for industry use.

## United Arab Emirates

### *Khalifa Semiconductor Research Center (KSRC)*

**Website:** https://www.ku.ac.ae/khalifa-semiconductor-research-center-ksrc/

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|---|---|
| **Investigator(s):** | Mohammed Ismail, Chair |
| **Sponsor:** | Khalifa University<br>P.O. Box: 127788<br>Abu Dhabi, UAE<br>https://www.ku.ac.ae/campus/location-map/ |

#### Abstract

Khalifa University's Semiconductor Research Center has three branches: nanotechnology, biomedical applications, and system-on-chip. Their focus on nanotechnology addresses growing interest in scaling down basic electronic devices to a nano range, as well as applications for power saving, small integrated devices, and high speed. This corresponds with needs identified by the International Technology Roadmap for Semiconductors (ITRS) and in the Abu Dhabi 2030 strategic plan.

KSRC researchers have published a book titled "Energy Harvesting for Self-Powered Wearable Devices." The book is a reference for design engineers, practitioners, scientists, and marketing managers in the semiconductor industry developing integrated, self-powered, platform system-on-chip solutions for wearable devices. https://www.springer.com/gp/book/9783319625775

KSRC nanotechnology-related research projects include the following:

- Energy loss minimization for magnetic tunnel junctions.
- Minimization of contact energy losses with end and side contacts for nanowires.
- All-optical quantum random generator driven by spin noise in semiconductor nanostructures.
- Low-power devices based on nano Schottky junctions.
- Energy efficient nano-contacts and for spintronics.
- Functional devices based on graphene composites.
- Development of a nanoparticle-based transistor.
- Wide band-gap semiconductors for high-power, high-temperature, and high-speed applications.

### Collaborating

Collaboration occurs at the university level. Khalifa University is actively involved in establishing long-term strategic partnerships with a variety of organizations. The university currently enjoys strong relationships with over 20 national and international partners including industry leaders, multinational entities, government agencies, universities, and other institutions. They use these partnerships to facilitate solving applied problems.

In response to Abu Dhabi's 2030 strategic goals, Kahlifa University has undertaken several broad university research initiatives and partnerships focused on the following areas: aerospace, biomedical, healthcare, national security, telecommunications, information technology, and nuclear energy.

They have set up a business development unit dedicated to working with outside collaborators, https://www.ku.ac.ae/business/.

They offer both consultancy services, https://www.ku.ac.ae/consultancy-services/, and laboratory rental https://www.ku.ac.ae/laboratory-rental/. To obtain more information about how an external user could gain access to the micro- and nanofabrication facilities, contact them via email at BusinessDevelopment@ku.ac.ae.

## United Kingdom (Scotland)

### *James Watt Nanofabrication Centre*

**Website:** http://www.jwnc.gla.ac.uk/index.html

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|---|---|
| **Investigator(s):** | Iain Thayne, Director<br>Arthur Smith, Operations Manager<br>Brendan Casey, Commercial Enquiries (Kelvin Nanotechnology Ltd) |

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| **Sponsor:** | University of Glasgow<br>School of Engineering<br>Rankine Building<br>Oakfield Avenue<br>Glasgow, G12 8LT<br>U.K. |

## Abstract

The Watt Nanofabrication Centre is a long-standing and well-known facility with over 35 years of experience delivering micro- and nanofabrication solutions. One of their specialties is in electron beam lithography to develop solutions in processing, nanotechnology, nanoelectronics, optoelectronics, bioengineering, biotechnology, lab-on-a-chip, clean tech, energy, and photovoltaics.

The James Watt Centre undertakes fundamental, applied, and commercial research and can develop devices for small production runs.

The James Watt Centre collaborates with over 90 different international universities and research institutes along with working with over 288 companies from 28 countries around the world.

Details on their equipment can be found at http://www.jwnc.gla.ac.uk/equipment.html and is categorized by the following:

- Electron beam lithography.
- Nanoimprint lithography.
- Nanoinjection molding.
- Optical lithography.
- Metal deposition.
- Dry etch.
- PECVD insulators.
- Metrology.
- Electron microscopes.
- Thermal processing.
- Miscellaneous.
- Electrical.
- Optical.
- Biological.

**Collaborating**

A large number of academic institutions already partner with the James Watt Nanofabrication Centre, and the center also conducts collaborative research with many government organizations, such as EPSRC, BBSRC, TSB, EC, DARPA, SRC, and Wellcome Trust.

Industry users access the center through Kelvin Nanotechnology (KNT) https://www.kntnano.com/. Services range from access to fabrication to consultancy. It is also possible to consult with an academic at Glasgow University, http://www.jwnc.gla.ac.uk/consultancy.html.

To gain access to the lab, users should contact either the James Watt Nanofabrication Centre director or the director for Kelvin Nanotechnology at http://www.jwnc.gla.ac.uk/contact.html.