

APPENDIX A ELECTRUM LABORATORY

INTRODUCTION

Electrum Laboratory and Albanova Nanofabrication Facility are the two laboratories operating within the KTH node of Myfab, the Swedish research infrastructure for micro/nanofabrication. Both these labs present exciting meeting places for students, researchers and entrepreneurs from disciplines as diverse as fundamental science and mature technology. This environment affords you the chance to realise your ideas.

CLEANROOM BASICS

Kista is home of the Electrum Laboratory with its 1,300 m² of cleanroom space and 1,500 m² of additional laboratories. This is an outstanding base for fabrication and characterisation on the nano/micro scale. The lab supports the whole chain from education, research and development, to prototyping and production.

At KTH Campus, the Albanova Nanofabrication Facility has a 285 m² cleanroom and 60 m² of additional laboratories. With focus on direct writing technology, the Albanova Nanolab is a flexible resource for basic research that needs nanofabrication and nanocharacterisation using a wide variety of materials and substrates.

Cleanroom layout

Electrum Laboratory is basically a secluded space within the main building served by a separate ventilation system. Evacuation of the cleanroom in this text means exiting the cleanroom by the nearest emergency exit and reassembling at a specified point.

Figure A1 shows the cleanroom. White areas are clean zones and grey areas are service fingers, in other words areas comprising the back end of installed equipment plus the supply of media to that equipment. These service fingers are not as clean as the clean zones, and the only work normally performed is service work.



Figure A1: Electrum Laboratory cleanroom. The figure shows the current state but due to changes (tool installation/removal) the actual details can look different.

As shown in the figure, the cleanroom is divided into zones. These divisions are not actually visible. However, alarms, ventilation and the distribution of certain gases can be controlled automatically or manually for each separate zone.

Resources

Our resources are available at open access:

- A fully equipped cleanroom with complete, highly qualitative process lines for device research and manufacturing.
- A flexible cleanroom environment for materials and device-orientated research and development.
- World-class characterisation laboratories, providing an integrated in-depth understanding of materials, structures and devices by combining relevant analysis techniques from our palette.
- Sophisticated software for advanced calculations, simulation and design.

You may also rent detached laboratory space for your own specialised tools whilst having access to our full range of services.

Quality Management System

A web-based Quality Management System (QMS) exists with documentation and routines for how the Electrum organization operates. It defines the management structure and it is intended to standardize administrative processes and give users an easy way to find information. It especially describes the quality work (policy, goals, planning etc.). There are also specifications and records of the running of the Electrum Laboratory.

It is also used to make sure that we fulfil the ISO 9001 quality standard and the ISO 140001 environmental standard.

The QMS is accessible from the Electrum LIMS system and from the Myfab portal, with the same user name and password.

ISO 9001 Quality standard

The Electrum laboratory is certified according to the international ISO 9001 quality standard. The standard makes it easier to maintain the quality and improve the consistency the Electrum Laboratory operation.

ISO 14001 Environmental standard

The Electrum laboratory is certified according to the international ISO 14001 environmental standard. Following the standard help us to improve the environment and help us to comply with legal requirements.

5S in Electrum Laboratory

‘5S’ is the name of a workplace organisation methodology that uses a list of five Japanese words. Transliterated and translated into English, these all start with the letter “s”.

The 5S Philosophy focuses on effective workplace organisation and standardised work procedures. 5S simplifies the work environment, reduces waste and non-valuable activity while improving quality, efficiency and safety.

The 5S methodology can be summarised in the following activities:

1. Sort: Sort and remove all material, equipment, papers and so on that are not needed,
2. Stabilise: This means ensuring every item has its dedicated place.
3. Shine: Continuous cleaning and troubleshooting of the work area.
4. Standardise: Standardising means giving people responsibilities for monitoring the 5S activities.
5. Sustain: Resolve identified root causes, make continuous improvements.

Facility Staff

Our highly skilled staff is available for your projects

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

Improvement Groups

Every room in the Electrum Laboratory has an “improvement group” including the person responsible for the room and the room’s most frequent users. Improvement groups are responsible for the 5S activities in their respective rooms. Improvement groups hold regular meetings in which ideas are discussed, decided upon, documented and implemented. Standardised binders and documents are available to aid every 5S improvement group. The 5S activities are an everyday part of the work performed in the Electrum Laboratory.

Regular revisions of the different improvement groups are conducted so that the progress of 5S in the laboratory can be monitored. These revisions follow a standardised protocol that objectively measures and gives feedback of the current status and progress made by the group.

WORKING ENVIRONMENT AND SAFETY

Working Hours

Normal working hours are Monday to Friday 07.00-18.00. Work should always be planned so that only exceptionally does it take place outside normal working hours. Working alone in cleanrooms is strictly prohibited. At least one colleague must be present.

Safety Arrangements

Electrum Laboratory is responsible for the general safety of its laboratory and coordinates safety work and measures between its users. This is done by the safety group, comprising members from the user groups and Electrum Laboratory itself.

Specifically, this means managing such issues as:

- Safety infrastructure: Eye showers, hydrogen and toxic gas monitoring plus other parts of the alarm system, exhaust air and so on.
- Safety arrangements: Organising an alarm group, on duty outside of normal working hours.
- Authorisation contacts: Managing necessary permits for the possession and use of certain chemicals and gases. Keeping track of legislative updates relating to laboratory activity and implementing them as necessary.
- Review of the laboratory environment from a safety perspective, at least once every 12 months.

Faults and discrepancies regarding laboratory operations should always be reported to Electrum Laboratory.

Alarm Group

Electrum Laboratory organises an alarm group, consisting of Electrum Laboratory staff and experienced lab users; some 8-10 people with a fair knowledge and understanding of the cleanroom. The alarm group’s tasks are:

- assembly at the alarm centre in case of an alarm,
- investigating the reason for the alarm,
- preparing equipment and protective gear for this purpose,
- searching for any injured personnel inside the cleanroom (using protective gear if necessary), once the reason for the alarm has been established,
- finding, evacuating and attending to any injured personnel,
- notifying the emergency services if necessary,
- attending to the cause of the alarm,
- supporting the emergency services once they arrive.

Electrum Laboratory does not expect all 8-10 members of the alarm group to be present in, or just outside, the cleanroom at any given time. The idea is that with that many members, at least four or five should be present during normal working hours and able to implement alarm group tasks as needed.

On Duty

During normal working hours, there are always enough people from the lab’s alarm group available to deal with an incident. Outside normal working hours, Electrum Laboratory has a person on call at home. This person will

always answer the telephone at the on duty number (above) and will, if necessary, arrive at the Laboratory within 45 minutes (usually within 20-30 minutes) of an alarm or telephone call. Outside normal working hours, the consequences of an accident may be much more serious than during them. Primarily, this is because only a few people are present, however it also takes time for the on duty person to get from their home to the laboratory.

Those who work in the laboratory outside normal working hours should:

- work with a colleague who will be ready to help in case of an accident,
- notify the Electrum group and the alarm group. This must be made by email to elab-techsupport@ict.kth.se (combined elab-center@ict.kth.se and QLA@acree.se) – before 13.00 the same day,
- for weekend work the Electrum group and the alarm group, elab-techsupport@ict.kth.se, must be informed no later than Friday, 13.00.

NB this registration must always be submitted for work conducted outside of normal working hours.

Outside of normal working hours you may only carry out operations and processes which are well known and described in manuals and recipes. For potentially dangerous work there must always be two people present in the same room and both well-versed in the process. These include:

- handling acids, bases and warm solvents,
- processes using corrosive, toxic and/or flammable gases.

It is forbidden, for any reason whatsoever, to perform potentially dangerous servicing work:

- on equipment for handling corrosive, toxic and/or flammable chemicals or gases,
- changing of gas bottles or corrosive, toxic and/or sources of ignition.

Red lights outside the entrance locks indicate that the cleanroom is closed.

The card readers will still allow you to open the doors, but you should always bear in mind the risk of contaminating a cleanroom by opening a door.

Chemicals may remain in the acid/solvent baths during night, but all bath lids and fume hood doors should be closed, as they should always be if the bench or fume hood is not in use.

Cleanroom Rules

Please obey the recommended proper cleanroom practices as described in the Myfab general manual.

When entering a cleanroom, users should wear cleanroom coveralls, hood with face mask, cleanroom shoes and disposable gloves, see figure A2. For more info, please see document: [acr 024688-Instruction for entering and leaving the cleanroom](#).

Violation of safety rules or irresponsible conduct may result in disciplinary actions. The Laboratory Director has the right to adjudicate these cases. The penalty for lesser violations will be a warning, but more serious offences will result in suspension. See also the routine for Disciplinary Action for Misconduct, laboratories, ICT-school.

Costs and Charges

At Electrum, the costs are distributed between the various laboratory groups. This covers all general costs for maintenance of the infrastructure at Electrum Laboratory and includes personnel, rent, electricity, cooling and heating, media including house gases, wet chemicals for general use, some depreciation and so on. All costs associated with the tools in the laboratory are defrayed by the responsible user group, including spares, service and maintenance, consumables, such as tool-specific gases and chemicals and, in some cases, depreciation related to those tools.

This also means that the charges must be distributed between the various groups. Hence, Electrum Laboratory charges its users in three ways:

- A monthly fee for all registered users (applicable for the full period for which the cleanroom access card is activated).
- Hourly fees for time spent in the cleanroom (based on card reader registration).
- An area fee for all tools in the cleanroom (the responsible group is charged).



Figure A2: Image of user gowning for Electrum Laboratory.

The responsible groups then charge lab users for their tool usage, according to what is recorded in the logbooks in LIMS. Usage fees follow the Tool Rates laid down by Myfab, and are shown in Myfab LIMS. It is of the utmost importance that all lab usage is logged and presented properly so that costs are distributed fairly.

Rules for Tool Booking

1. Myfab LIMS is used for booking and logging laboratory tool usage.
2. All tools marked “Booking: compulsory” on the tool label or “Booking type: Compulsory” in LIMS must be booked before use.
3. You must create a log in LIMS every time you use any tool marked “Logging: Compulsory” on the tool label or “Log level: Compulsory” in LIMS and for every booking you make.
4. To make it easier for all users to get access, you may book no more than 8 hours per day, or two consecutive days on the same tool. This rule does not apply to tools with very long process times (such as furnaces).
5. Exceptions to rule no. 4 may only be made during those periods when the tool is not fully booked by other users. In this case, you may book more time on the same day you want to use the tool.
6. The responsible person may lay down special rules for booking/logging. For example, minimum or maximum times allowed/recommended for booking/logging.
7. If you cannot use the tool as planned due to a major miscalculation of the time needed for a process, or due to other problems, you must cancel the booking. Please note that only future bookings can be cancelled by users.
8. If it is too late to cancel the booking, you should reduce the time booked as much as possible and contact the relevant responsible person to explain the situation and get help with logging.
9. You may use up tool time that was booked by another user if that tool is still free within half hour of the beginning of your booking period. However, the “booking owner” should be contacted before you begin using the tool. In this case, you should log your use without booking, by using the Log status page.

10. Charging for tool usage is based on the time logged.
11. The usage time that you log should not be shorter than the time booked. Only when rule no. 8 applies may you report a shorter time than was booked.
12. If rule no. 11 is not observed, you may be charged for equipment usage according to your booking.
13. For runs shorter than full hour(s), the usage time will be rounded up.

CHEMICALS

All chemicals must be approved for use by the Lab Director and should be registered in the Myfab LIMS system and KLARA system. Such chemicals must be registered with an SDS. Standard chemicals, for use by multiple laboratory groups, will be supplied by the Electrum Laboratory. Other chemicals may be used after approval, but ordering and costs must be covered by the group needing them. For more information, see the Electrum quality manual.

Handling Chemical Waste

General rules:

- After use, all chemicals are to be treated as hazardous waste.
- If in doubt, seek advice from experienced personnel and contact Electrum Laboratory personnel before processing.
- “Standard” acids and bases may be emptied into the acid drain (HCl , H_2SO_4 , HNO_3 , HF , KOH , H_2O_2 , H_3PO_3 , NH_3 , acetic acid and the like).
- “Standard” organic solvents may be emptied into the solvent drain. Avoid discharging n-methyl-2-pyrrolidone (aka NMP or Remover 1165) into the solvent drain. Collect this waste in plastic bottles and dispose of as a common waste product (see below).
- No chemicals may be emptied into the communal/external drain or disposed of with the paper waste. Empty bottles are to be rinsed thoroughly (check with pH/litmus paper as necessary) and disposed of in the container for hard plastic, without the cork/cap screwed on.

Failure to follow this procedure can damage waste disposal equipment or cause personal injury.

All other waste products are to be sent for destruction.

- Use plastic bottles to collect waste. Avoid glass bottles if at all possible.
- Ensure that packaging is clear of spills and enclosed in a plastic bag. Clearly mark the packaging with its contents plus your own name and department.
- Common waste products known to users and Electrum Laboratory must be placed on the bottom shelf of the pass-through. Indicate on the whiteboard of the outer room that this waste is to be collected. Common waste products means those that accumulate and are disposed of on a regular basis (every few weeks) such as photoresist, gold etch, NMP, GaAs contaminated waste and polishing slurry.
- All other waste must be packaged and labelled as above and the Electrum Laboratory staff contacted for its immediate removal from the lab. Unusual or high-risk waste must be transported directly to the hazardous waste storage area and must not be allowed to accumulate in the lab.

Under no circumstances must this type of waste be left on the floor or in cupboards for collection in the general disposal process.

ALARMS AND EMERGENCIES

The Electrum Laboratory alarm system is a collection of monitoring subsystems in the building, including a system for forwarding alarms by SMS. These alarms are displayed on a chart at the alarm centre.

Alarms and Evacuation

The cleanroom is fitted with a network of manually activated fire alarms in case of accident. Red coloured manual fire alarm buttons are located inside the laboratory, if a user discovers a fire but the alarm has not yet

Alarm Type	Reason of the Alarm	What to do
Blue flashing light	Technical fault.	Contact service personal. Other users can continue to work if they are not effected by the alarm.
Yellow flashing light, continuous siren. Only visible in the effected zone.	Low concentration of hydrogen has been detected, or that the alarm has been manually triggered by pushing one of the yellow buttons inside the cleanroom. At high concentrations of hydrogen the supply of hydrogen to that zone shuts down. If the alarm is not reset to normal conditions within 10 minutes, the hydrogen lines will automatically be flushed with nitrogen.	Only personnel working in the affected zone must evacuate that zone.
Yellow-Blue flashing light and continuous siren. Only visible in the effected zone.	Evacuation of the zone is triggered by low concentration of toxic gas in the monitored cleanroom zone or high concentration in the exhaust.	Only personnel working in the affected zone must evacuate that zone.
Red flashing light, oscillating siren	Triggered by the fire alarm, high concentration of hydrogen, high concentration of one of the other gases monitored by the toxic gas room sensors, or manually by pushing one of the red buttons in the central cleanroom corridor. The supply of hydrogen and oxygen to the cleanroom shuts down. If the alarm is not reset to normal conditions within 10 minutes, the hydrogen lines will automatically be flushed with nitrogen.	Total Evacuation, go to assembly point. The alarm system will stop the air supply and circulation, leaving the exhaust on, which creates an under pressure in the cleanroom, which makes the door difficult to open. This prevents any toxic gases to escape out into the main building, and also limit the supply of air to any fire.

Table A1: Possible reasons for an alarm and instructions on what to do.

activated. There are also yellow alarm buttons which manually trigger certain alarms, either when there is urgent need to evacuate a particular zone, or when assistance from the alarm group is needed urgently. The various alarm types are shown in the following table:

Fire Extinguishers

If a fire incident can be controlled and put out by a lab user early on and without any form of risk-taking, then this action is acceptable. However, any form of risk-taking, calculated or otherwise, is absolutely forbidden. Any incidents of this nature should be handles by the alarm group.

Evacuation

An evacuation alarm should be met with immediate action by lab users:

- Leave the cleanroom without hesitation and go to the nearest emergency exit. Emergency exits are marked with green and white signs as per international standards. All clean zones have emergency exits in the actual room where work is carried out. Almost all the service fingers have emergency exits. There is at least one alternative exit from all locations in the cleanroom.
- Go to your assembly point and await further instructions. Do not leave the assembly point unless the alarm group authorises this action.

The indoor assembly point is near the stairs to the cafeteria, see figure A3. If you need to exit the building, the outdoor assembly point is outside Isafjordsgatan 26, see figure A4. When evacuating, do not waste time removing your cleanroom clothing; leave it on. Do not delay evacuation by trying to complete work that otherwise might be spoiled.

During evacuation, be sure that your colleagues follow your example. Help them if necessary and possible. If possible, account for the whereabouts of colleagues who appear to be missing.

Some equipment and processes in Electrum Laboratory calls for certain actions by the operator in the event of an evacuation alarm. Those actions are machine and process-specific and will not be described here.

Electrum Contact Information

Electrum address: KTH, Royal Institute of Technology
Electrumlaboratoriet
Isafjordsgatan 22-24
164 40 Kista

Important tel.nr: Electrum laboratory emergency/on duty nr - 070-648 60 32
St Erik eye clinic 08-672 31 00

Quality Manual

<http://www.myfab.se/KTHAcreo/UserInformation/ElectrumQualityManual/>



Figure A3: Indoor assembly point, below cafeteria.



Figure A4: Outdoor assembly point, Isafjordsgatan 26.

Actions in case of a serious personal accident

- Call for help.
- Give first aid.
- Call for an ambulance.
- Give the address of your location (see below).
- If a chemical accident, also give the chemical name, concentration, volume, and exposure time, if known.
- Assist the injured person and send someone to meet the ambulance and paramedics.
- Guide the paramedics to the injured person.
- It is compulsory for at least one person to accompany the injured person to the hospital, if no lab staff is available, a user should do this.
- It is important that rinsing is continued during transportation to paramedics/hospital, using a handheld bottle.
- If no lab staff is available, contact a relative of the injured person. Each group has a register with this information.

Emergency number

112

Swedish Poison Information Centre

010-456 6700

Emergency contact information for the different Myfab sites:

Electrum: KTH, Royal Institute of Technology Electrumlaboratoriet Isafjordsgatan 22-24 164 40 Kista Emergency/on duty number: 070-648 60 32 St Erik eye clinic: 08-672 31 00	MC2: Chalmers University of Technology Microtechnology and Nanoscience - MC2 Kemivägen 9 412 96 Göteborg Chalmers Fastigheter emergency number: 031-772 49 37
MSL: Uppsala University Ångströmlaboratoriet Regementsvägen 1 752 37 Uppsala Akademiska Hus emergency number: (018) 683 204	LNL: Lund University Physics Department, Division of Solid State Physics Sölvegatan 14C 223 63 Lund