



APPENDIX D ÅNGSTRÖM MICROSTRUCTURE LABORATORY

INTRODUCTION

The new cleanroom, with shared equipment for materials research, was the single most important reason for Uppsala University to establish the Ångström Laboratory during the 1990s. It has been operated as an open user facility from the start; a model which has been further developed and fortified by the involvement with Myfab. The Ångström Microstructure Laboratory (MSL) is a versatile toolbox for materials science with special emphasis on micro/ nanotechnology.

CLEANROOM BASICS

The Ångström Laboratory cleanroom is divided into two main sections with differing cleanliness and gowning procedures. The largest part is the classified section, with lab areas ranging from ISO 7 (class 10,000) to ISO 5 (class 100). Everyone entering this area must wear overalls, cleanroom shoes and gloves. The non-classified section (about 1/3 of the total area), where lab coat and cleanroom shoes are sufficient, maintains a particle level corresponding to ISO 8 (class 100,000). This is about one order of magnitude lower than in a normal office. Most of the processing tools are in the classified section, whilst all analysis tools are found in the non-classified section.



Figure D1: Cleanroom layout with separate classified and non-classified sections, vibration-free area and location of some important instruments (not exhaustive).

The temperature is set at 20 °C in the classified section and 21 °C in the non-classified section (where long stationary sessions on various analysis tools are common). In both cases, the temperature is controlled to within ± 1 °C. Humidity should not exceed 65 % RH anywhere and is kept to 43 ± 5 % RH in the most well-controlled areas (such as lithography and ISO 5).

Independent foundations support a "vibration-free" area in the cleanroom (fulfilling requirements for class BBN-E). This extends into both sections, providing the right conditions for such activities as lithography and electron microscopy.

Specially trained personnel are assigned to clean the cleanroom. They have a very important mission and try to do an excellent job, but can only do so if everybody else contributes by keeping surfaces clear and removing all objects that are not being used.





ADMINISTRATIVE **G**UIDELINES

Laboratory Access

Preliminary (interim) lab access can be obtained once the following three steps have been carried out:

- Approval from an acknowledged supervisor/project leader (brief e-mail to lab management).
- Submission of an electronic access application (http://lims.msl.angstrom.uu.se).
- Participation in on-site introduction (pre-scheduled with MSL staff once the first two steps are complete).

This will give access to all areas except lithography and wet chemistry. With regular lab access, a user may then apply for tool training to gain operator licence(s) and booking privileges to tools of interest.

An introductory seminar (held approximately once a month) must be attended for permanent lab access to be granted. The interim access will be revoked if the user has not taken this seminar within two months of activation (without presenting an acceptable explanation to the MSL management).

A separate chemical safety seminar (normally held the same day as the introduction for new users) is required for access to lithography and wet chemistry. Users with this level of access are charged a higher access fee (to cover the cost of chemicals and other consumables) and approval from a supervisor/project leader is therefore mandatory.

Most consumables are covered by the access fee, but some expensive material such as wafers, lithography masks and noble metals are charged based upon consumption.

Before starting an individual project, a new user is recommended to have a start-up meeting with his/her supervisor and an appropriate MSL staff member to ensure their project plan is compatible with lab resources. This is particularly important for users planning to run process sequences and for users unconnected with any established user group.

Individual user access remains in force until actively terminated by the user or the supervisor/project leader. Access fees are charged for full calendar months and the month of notice will be charged in full. Swift processing is conditional upon the user removing all personal items and returning all lab property.

RULES AND WORK INSTRUCTIONS

Cleanroom Entry

Basically, two types of garment are used in the cleanroom. In the non-classified section (essentially materials analysis) a lab coat and lab shoes are mandatory, but a hairnet is highly recommended and cleanroom gloves should be worn in specific situations, such as handling samples or tools. Entrance to the classified area requires overalls, lab shoes and cleanroom gloves. Please note that additional protective wear is required when working with chemicals (see the section on chemicals).

Material in the Cleanroom

Users who need to store personal items (sample boxes, tweezers, notebooks and so on) in the cleanroom may request to have a blue storage box on a designated shelf in a cabinet. Lithography masks that are in use may be stored in mask boxes (one labelled box per user) on wire-rack shelves outside the lithography area. These storage provisions should eliminate the need to leave material on work surfaces in the laboratory. Items left behind will be removed and disposed of by lab staff. Only harmless material may be stored in the personal storage boxes.

Mobile phones and notepads (not laptops) are allowed in the cleanroom, but must be properly cleaned before entry to the classified section, where they should be carried openly (not inside overalls).

Staff Responsibilities

The MSL lab staff has the following functions and responsibilities:

- To provide technical support and maintain lab equipment.
- To maintain basic processes on important (frequently booked) equipment.
- To provide operator training and issue operator licences for lab equipment.







Figure D2: User dressed for non classified and classified sections respectively.

- To provide user support related to tool operation and work procedures.
- To supervise lab order and safety in the cleanroom.
- (If time allows: to provide commissioning services).

Some examples of services that should NOT be expected or required from the MSL staff:

- To clean or restore equipment to idle condition after user sessions.
- To provide user specific process development.
- To supervise research or development projects.

MSL does not guarantee the outcome of a project and does not take any responsibility for project delays or unexpected cost increases.

Working Hours

All approved users have access to the lab during extended working hours (regular lab hours), weekdays 07:00-18:00. Experienced users may be granted 24/7 access upon request. There should be clear reasons for this, such as a need to use heavily booked equipment, maintaining one's own tools or running prolonged processes.

Permission to work outside regular hours is always on the condition that the lab buddy system is respected. Wet benches with stationary baths may be used if the lab buddy is present in the same room, but filling or mixing of new chemicals is strictly forbidden outside regular working hours.

Interim access (prior to the introduction seminar) and access for undergraduate students is always restricted to regular lab hours (with the possible exception of highly restricted activities).

Normal staff hours are weekdays 08:00-17:00, and all users are recommended to carry out their lab activities when staff is available.

CHEMICALS

The Chemical Engineer (CE) is responsible for providing the chemicals, equipment and guidance needed for safe chemical processing. Always consult the CE (or stand-in) if there is any doubt as to the correct action. Contact data is available in LIMS and posted in the lab.





Protective Wear and Gowning Procedures

All chemical processing must be done in a ventilated work area (wet bench or fume hood). It is compulsory to use cover boots, a blue apron (pp type), latex gloves and a face shield when handling strong and/or warm chemicals or toxic chemicals in any concentration (such as hydrofluoric acid). For work involving any other chemical, latex gloves and a face shield must be used. Check your protective wear and dispose of any damaged item (rubbish box in acid fume hood). Put on the cover boots first, followed by apron, gloves and face shield (in that order).

After use, check carefully whether any of the protective wear is damaged or contaminated. Anything contaminated with HF or toxic chemicals should be disposed of according to instructions (see Waste Management). If damaged or contaminated with non-toxic chemicals, your cover boots or apron should be discarded (rubbish box in acid fume hood), as should damaged gloves. Everything else may be reused. Gloves should be washed and dried, face shields should be cleaned (with IPA, NOT acetone) and all items should be put in the right place for the next user.



Figure D3: Fume hood and wet bench – all options for working with chemicals. The picture at far right shows the full apparel for working with chemicals.

Non-Standard Processing

Any non-standard processing must be carefully planned and prepared with the CE. Search the literature for useful references and check with the CE whether all necessary chemicals, glassware, protective clothing and so on is available. (You may also obtain login information for KLARA, the chemical database, from the CE.) Any non-standard chemical that is not available in the cleanroom must be approved, ordered and introduced by the CE. Approval is also required for non-standard mixtures of standard chemicals.

Before initiating any new chemical process, you should read the material safety data sheets (SDS) for all chemicals that will be used and ensure that these are available in the KLARA database. Special attention should be given to the instructions regarding disposal of chemical waste. Present your proposed process (preferably a written step-by-step procedure from start to finish) to the CE for approval.

Select a suitable location, where all workstations are close together (contact the CE if you need assistance). Make sure all your chemicals are compatible with each other and with the equipment and materials you are to use. Check that all tools work properly and that you know the nearest location of all emergency aids (shutdown button, emergency alarm, emergency shower and so on) and emergency exits.

All non-standard chemicals MUST be marked with:

- the name of chemical (if mixed solution),
- the user's name,





- the user's telephone number,
- the user's affiliation (group/department/company),
- the date of preparation/introduction,
- a colour-coding dot.

Glassware containing chemicals are NOT allowed outside exhaust-ventilated areas. The container should be marked with the name of the chemical, its concentration and the appropriate hazard symbol.

After Processing

All tools and instruments should be returned to the proper location after use. Glassware should be rinsed and any marks should be removed with acetone before they are placed in the proper box for machine washing. Scales, magnetic stirrers and hotplates must be cleaned with cleaning solution (IPA 5 % / DIW 95 %) and returned to the cabinet in 3R47.

If required, baths should be emptied and washed (see specific instruction). Please note, baths with pumps should not be left empty; they should be filled with DIW which is then circulated until the pump is completely filled. Wet benches and fume hoods must be cleaned after use.

Bottles of chemical waste, contaminated wipers and other disposable labware should be disposed of according to instructions (see Waste Management).

Waste Management

Solid chemical waste and liquid chemical waste which is not allowed to be poured into the chemical drains should be removed to the waste storage room for delivery to the chemical waste station. All users are responsible for collecting, identifying and removing their chemical waste to the assigned shelf in a chemical cabinet.

Chemical waste containers MUST have a chemical waste label with the complete chemical names (abbreviations, trade names or chemical formulas are not permitted). If waste chemicals are mixed, the amount and concentration of each constituent must be listed on the container or in a log next to it. Be sure not to mix incompatible chemicals! Carcinogens (group A or B) should be identified. Use a suitable fume hood to carefully pour the chemical into the waste bottle and put the cap on tightly. Warm mixtures should be cooled to room temperature before they are moved to the chemical cabinet.

Wipers, protective wear and other disposable lab material contaminated with HF or toxic chemicals (other than cyanide) should be put in a yellow plastic bag with a chemical waste label (the label must first be filled in and clearly state the name of the contaminant) and moved to the designated place (fume hood in 3R75). Items contaminated with cyanide should be disposed of in the waste box in the toxic fume hood.

Broken glassware or wafers (sharp waste) should be disposed of in the appropriate container in 3R15 or 3R47:

- Clean glassware plastic rubbish pail.
- Clean wafers stainless steel rubbish can (with foot pedal).

For contaminated waste or metal waste, contact the CE for the correct action.

Decontamination

Any chemical spillage can harm people, equipment or the environment and must be cleaned up. Large quantities or unidentified spillages should be reported to the CE for proper action, but each user is responsible for taking the right action to remove his/her spillage.

A decontamination kit is available in 3R47 (classified section) and in 3R87 (non-classified section). When ordering a new chemical, it is important to check whether the equipment in this kit is sufficient in the event of a spillage. Please note that yellow roll wipers, used to absorb large amounts of chemicals, are not cleanroom-compatible and must be removed directly after use. Contaminated yellow wipers should be placed in a yellow bag and taken to the fume hood in 3R75 (see Waste Management), or to any suitable fume hood in the non-classified section. The CE must immediately be informed when a spillage has occurred.

In the event of a major spillage, or if there is any doubt about the correct action, the CE must be contacted directly. Tell other users to evacuate the contaminated area. You should remain available until the CE arrives.





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Figure D4: Bags for HF and toxic contaminated wipes and items.

Specific MSL Chemicals

In addition to the chemicals listed in the main text (common to the Myfab labs), two hazardous chemicals are used in the MSL cleanroom.

"Cyanide" refers to a large group of chemical compounds containing the cyanide ion CN⁻, which is responsible for cyanide poisoning. Cyanide can enter the body by inhalation, absorption (through skin or eyes) and swallowing. The degree of toxicity depends on how easily the cyanide ion is released from the rest of the compound (such as toluene diisocyanate or sodium thiocyanate). One of the most serious effects of cyanide is that it interferes with the action of certain enzymes and prevents the body's cells from interacting with oxygen. The symptoms of limited cyanide poisoning are basically the same as for lack of oxygen (dizziness, nausea, anxiety, vomiting).

Cadmium (Cd) is used in the form of cadmium acetate and the waste generated is cadmium sulphate. Contaminated wipers are disposed of in a ventilated yellow rubbish bag in 3R47 (handled by authorised personnel only). Cadmium may harm kidneys and lungs. Prolonged exposure causes cancer whilst more limited exposure may include sore eyes, coughing, headache, weakness, chills, fever and breathlessness.

ALARMS AND **E**MERGENCIES

Three different alarm types may be triggered in the cleanroom (see table D1). A flashing red light with an audible signal is an evacuation alarm and calls for immediate evacuation through the nearest emergency exit. Be prepared to assist anyone in your vicinity who may need help. If you are at the site of a fire, that has just started and is not yet out of control, you should put it out if you are sure that you can do so. Be sure to alert others in your immediate vicinity, evacuate without changing or taking off any clothes or shoes and close the exit door. Move to the appropriate assembly point (see table below) and report all relevant information to MSL staff (for example, if you left an acid in a heated bath). Lab garments should be placed in boxes at the cleanroom entrance (house 1/floor 1). You will be notified by e-mail and a sign posted on the entrance door when you are allowed to enter the lab again.

The evacuation and fire alarms can also be triggered manually, which could be used in the event of a major chemical spillage. It is important to know that the fire







Alarm Type	Reason of the Alarm	What to do	
Flashing blue light	Technical failure.	No user action required.	
Flashing red light and siren	Evacuation alarm: Detection of hazardous gases within the lab or manual ac- tivation.	Evacuate the lab immediately! Reassemble outside the cleanroom entrance (house 1 floor $1 - if$ no signal outside the lab). Outside regular working hours, no reassembly or further action is required from the user.	
Flashing red light and bell	Fire alarm: Detection of smoke / fire or manual activation.	Evacuate the building immediately! Reassemble at assembly sign on the northern parking lot. Do not re-enter the building until the flashing light has been turned off (acoustic signal may stop earlier).	

Table D1: Possible reasons for an alarm and instructions on what to do.

alarm automatically summons the fire brigade, whilst the evacuation alarm does not have this function. If an ambulance is needed, this should be summoned by telephone (112). See fig. D5 for a lab layout with the location of the most important emergency aids.

Ångström Contact Information

The cleanroom has a few telephones available for lab-related calls (prefix outgoing calls with 00). Staff phone numbers are posted close to each telephone and should be used to get technical assistance during office hours (8:00-17:00). At other times, anything concerning the facility (ventilation, water, drain, light and so on) should be reported to Akademiska Hus.

Ångström address:	Uppsala University
	Angströmlaboratoriet
	Regementsvägen 1
	752 37 Uppsala

Important tel no: Akademiska Hus emergency number: (018) 683 204



Figure D5: Location of emergency aids within the cleanroom.

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