APPENDIX C MC2 NANOFABRICATION LABORATORY

Introduction

The Nanofabrication Laboratory (NFL) at the Department of Microtechnology and Nanoscience, Chalmers University of Technology, offers a broad platform for conducting advanced processing in micro and nano technologies. The laboratory is run as an open infrastructure for academic and commercial interests and offers access on equal terms to all users of the same category. The laboratory is run by a staff equivalent to 20 full-time employees from various backgrounds in academia and industry and with an average of 20 years' cleanroom experience.

Cleanroom Basics

The laboratory is divided into areas with different cleanroom classes (including lockers and gowning area) as follows: Process Laboratory 1 (PL1), see figure C1, Process Laboratory 2 (PL2), MBE Lab, Dicing/CMP room and Chemical Handling Room.

The PL1 is ISO 5 class and has all equipment relevant to handling processes for such things as microwave, terahertz and photonics device processing, nanostructuring, MEMS, microfluidics and bolometers. The total area is approximately 1,000 m^2. Temperature and relative humidity are well-defined, residing between 19±0.1°C and 43±3% RH, respectively. The air-handling system has a maximum capacity of approx. 500,000 m^3/h. The air entering PL1 passes through some 500 HEPA filters, covering approximately 25% of the total ceiling area. The vibration specifications are within the BBN-E class.

Figure C1: Distribution of equipment in the PL1 cleanroom.

PL2 is a cleanroom of ISO 6 class and includes specials areas for deposition of High Tc superconductors, functional oxides, ferroelectrics and Graphene/CNT using laser ablation (PLD), sputtering and CVD. The total area of PL 2 is approximately 240 m^2.

The MBE room is for production of III-V materials, the CMP room is for preparation, dicing, and polishing of semiconductor devices and materials and the Chemicals Handling Room is for preparation and limited storage of special chemicals for the cleanroom.

The laboratory hires specially trained personnel to clean the laboratories and other areas within the facility. Although the people within this group are not formally members of the lab group, they are nevertheless an integral part of the lab. As a user, you will meet them every now and then as they work, but if you need support please refer to the lab staff (dressed in green cleanroom garments).

Outside the cleanroom on floor 3, are two laboratories for XRD and PPMS. In the basement on floor 1, there is a tap station for LN2.

Rules and Work instructions

Cleanroom Access

New users are only allowed access during office hours. Extended access is only given to experienced users and is only granted upon request. For safety reasons, we urge all users to initially plan their activities during office hours. After their cleanroom course, each user must sign to confirm their awareness of cleanroom regulations and complete a questionnaire about cleanroom safety and practices.

Entrance is through the main entrance, D section, level 3 (D3) in the MC2 building outside PL1, or at section A, level 2 (A2) outside PL2. Entrance into PL1 is only allowed through the main entrance at D3, while other areas may be accessed through A2 (special approval required). To simplify the logistics of cleanroom garments, the general rule is that you should exit from where you entered. All other doors are locked and alarmed to ensure a properly protected internal shell.

Cleanroom garment

For PL1, the standard dressing procedure is as described in section 4.2.2. Regular users wear white apparel and Lab staff are dressed in blue. In the other lab areas, lab users and lab staff wear the same apparel.

Figure C2: Different cleanroom apparel depending on user and lab area. Left: PL1 garment for lab staff. Centre: PL1 garment for lab users. Right: Garment for staff and users in other areas.

Working Hours

The lab is open 24/7/365, except on certain holidays such as Christmas and New Year. All lab closures are announced in our newsletter and/or in Myfab LIMS about a month in advance, or with as much notice as is possible. Office hours are limited to weekdays between 07.30 - 18.00. People from the lab staff group are normally available during these hours. A lab buddy is required at all other times.

Materials Storage Options

Users may store processed materials and personal items inside or in close proximity to the cleanroom. There are three common storage locations inside the lab: wire-rack shelves for personal toolboxes, yellow N_2 purged storage boxes in lithography areas and a few cabinets dedicated for materials storage in which different user groups may have their own space.

These boxes are intended for temporary storage of processed materials and personal items such as tweezers, cleanroom pens and notebooks etc. The main reason for this is to limit the number of items and materials on work surfaces in the laboratory. It is the responsibility of each user to ensure that these surfaces are not used as long-term storage. Unlabelled items lying around for any length of time will be removed by lab staff and will eventually be disposed of. Only inert materials may be stored in personal tool boxes.

Facility Staff Responsibilities

The lab staff at MC2 has functions and responsibilities such as:

- To give advice and suggestions regarding process issues.
- To support users with process development and fabrication.
- To ensure that safety and equipment standards are maintained.
- To carry out servicing and maintenance.

It is NOT the responsibility of lab staff to clean equipment and wet bench areas after users.

Costs and Charges

All users are charged according to their use of the facility. Costs for standard consumables (chemicals, wafers, wipers and the like) acquired by the process lab are included in our charges and need not be accounted for by users. However, special items such as special wafers or expensive materials will be charged based on consumption.

Please note that lab staff cannot guarantee the outcome of a project. Charging is implemented regardless of whether the project was successful or not, or whether the expected yield could be achieved or not. Lab staff accept no responsibility for delays or unexpected cost increases related to the project.

Work environment and Safety

Protective Gear

All users at MC2 are expected to wear safety goggles at all times when working in any of the cleanroom areas. All users who work with hazardous chemicals must wear full protective gear, which includes aprons, goggles, chemical gloves, sleeves and face shields. For a complete chemical safety gear, see figure C3.

Handling Chemical Waste

There are two drainage systems installed in the labs; solvent drains and acid drains. It is extremely important that you use the correct drainage system for your used chemicals, since mixing of incompatible chemicals could cause an explosion in the waste-handling facility.

The acid drain should be used for standard acids and bases. This waste is passing through a neutralisation tank which ensures that water released into the public drainage system is always neutral, with a pH of 7.0.

Users who intend using large quantities of chemicals are requested to contact lab personnel, who will ensure that there are sufficient quantities on hand in the lab. If a chemical is used up, please contact the lab personnel. After training and instruction by lab personnel, any non-standard chemicals or mixtures should be prepared in the Chemical Preparation Room.

Ventilated Work Areas

A large number of process benches are installed in PL1, PL2, CMP/Dicing, and in the Chemical Preparation Room. These benches have built-in functions for etching, spin-coating/developing, wafer cleaning and so on. When you are about to start working at a process bench, you will see a status signal light mounted on the bench, showing continuous blue. This indicates that the bench is currently only using 10% of its nominal exhaust capacity. To increase the bench exhaust flow to its nominal value, push the exhaust button. If there is enough capacity in the total exhaust system at this moment, a valve will open to enable nominal exhaust flow for this bench. At the same time, the status light will change from continuous blue to continuous green. If the green light does not light up, too many benches are already in use and you will have to wait until a bench is turned off.

For safety reasons, you are only permitted to use a process bench when the continuous green light is on, i.e. when the exhaust flow is sufficient. To avoid accidents, never allow more than one person/chemical setup per bench.

Figure C3: First two pictures showing the hangers for protective gear; gloves, face shield, apron and arm cover. Fully equipped chemical protection seen to the right.

As soon as you have finished your work at the process bench, you should press the exhaust button again. This means the exhaust flow for the bench will return to 10% of its nominal value and that the electricity to the installed equipment such as hotplates, heating baths and so on will be turned off. Failure to turn the bench off may block the availability of benches to other users. Once your bench has been on for a certain time (normally four hours), you will hear/see a warning signal. At this point, you must press the button twice to quickly turn the bench off and on to continue working. If not turned off manually, the bench will eventually shut down automatically and the status light will change to flashing blue. The bench is now disabled and must be restarted.

Alarms and Emergency

Alarms and Evacuation

To reduce the risk of hazardous gases, MC2 employs an advanced system for detecting dangerous gas leaks. This system is supervised and maintained by the maintenance staff, according to a strict procedure. The gas detection alarm and general fire alarm are indicated by a flashing red light plus an audible signal.

In addition to the fire and gas-detection alarms, a 'process alarm' is installed. This detects conditions which are not dangerous to humans, but which post immediate danger to a product, equipment or the facility. This process alarm is indicated by a blue flashing light combined with three short, audible signals.

Alarm Type	Reason of the Alarm	What to do
Blue flashing light and three short acoustic signals at start of alarm	Process/service failure.	Find more information on the screen close to the exits. Quickly finish your process if it includes water or gases. Contact lab staff if necessary. Evacuation is normally not necessary.
Red flashing light and acoustic signal (gas alarm)	Leakage of hazardous gases within the lab	Evacuate the lab immediately. If there is no signal outside the lab it is acceptable to stay/enter in the office area in the building.
Red flashing light and acoustic signal (fire alarm)	Smoke, fire, manual alarm activation and/or high concentration of process gas	DANGER! Evacuate the building immediately! No time to change clothes! The acoustic signal may be silence, but don't re-enter the premises until the flashing light disappear.

Table C1: Possible reasons for an alarm and instructions on what to do.

In the event of a fire or gas alarm, the cleanroom should be evacuated immediately in a manner described in the relevant evacuation plan. Leave the lab through the nearest emergency exit. Do not take off cleanroom garments before exiting the building; these can be washed later.

The internal public address loudspeaker system can be accessed outside PL1 and PL2. This system is an important part of the overall safety function, as users can be quickly informed of risks and other important matters.

Chemical safety accidents

Folders with SDS for standard chemicals is available within the laboratory. This folder should be brought to the ambulance personnel if there is a chemical accident.

Fire extinguisher

Only qualified labb staff and rescue service are allowed to use the fire extinguisher in the MC2 cleanroom areas.

MC2 Contact Information

Telephones

The cleanroom has a few telephones available for outgoing calls. During the daytime, lab staff may be called any time if there is problem with the facility or process-related issue. At night, Chalmersfastigheter may be contacted regarding any issues relating to the facility, but problems related to processing must wait until office hours. A list of all the lab staff telephone numbers may be found near the telephones, inside the labs.

MC2 address:	Chalmers University of Technology Microtechnology and Nanoscience - MC2 Kemivägen 9 412 96 Göteborg
Important tel no:	Chalmersfastigheter AB – 031 7724937

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