Singapore Synchrotron Light Source (SSLS)

Users' Safety Brief Ver. 2.0 (SUSB 2.0)

(Revised on 14.10.2010)

1. Safety at SSLS is the concern and responsibility of each individual.

2. Users have to register through the users' portal on SSLS' website.

3. While doing so, they have to declare any hazardous material or processes they would propose to use. If so, a risk assessment sheet (NUS form: http://www.chemistry.nus.edu.sg/PSSO/Safety/Risk/risk.htm#Forms) must be submitted to SSLS first. If SSLS accepts the experimental request, then the risk assessment sheet must be submitted to OSHE (http://www.nus.edu.sg/osh/).

4. Acceptance of an experiment is only given for one or several specific beamlines. Users will be granted access to those beamlines only.

5. Upon acceptance, users will be given an experiment ID.

6. For any other beamline, the status of a user is that of a visitor, i.e., he/she must be chaperoned by a staff member of SSLS.

7. Users have to study and sign this short SSLS Safety Brief concerning the specific beamline(s) they are accepted for.

8. Moreover, users are encouraged to study the full SSLS Safety Management Manual.

9. For any safety-related questions, users should not hesitate to ask the respective beamline scientist.

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1. Accelerator system

Accelerator system is crucial to SSLS. Therefore, necessary roles have to be implemented to make sure it smooth and safe operation. **FAULTY ACTIONS MAY CAUSE DIPOLES' QUENCH OR DAMAGE OF THE SUBSYSTEM. ONLY TRAINED PERSONS ARE ALLOWED TO OPERATE THE MACHINE.**
The accelerator has two superconductor dipoles. The dipoles are the main bending magnets and have a field of 4.5 T. To keep the dipoles superconductive, they are cooled down to 4.2 K by liquid helium and liquid nitrogen system. Electrons from the Gun in Microtron are injected into the ring. The electrons circulate inside the ring and are ramped to full energy 700 MeV. When the electrons are bent by dipoles, they give off radiation and lose energy. Their energy loss is compensated by RF system. Therefore, the potential hazards regarding the accelerator system are mainly:

- X-ray radiation during injection from Microtron (10 mA, at 2 Hz and 100 MeV),
- X-ray radiation during ramping and stored beam (115 W each of 21 ports),
- Magnet field, very large attractive forces, up to 22 N,
- Extremely low temperature of the cryogens (-269 °C),
- High voltage hazards from the accelerator electrical power supply (120 KV),
- Heating and burns risk in RF system (50 kW).

The detail descriptions of these hazards are presented in Safety Management Manual Appendix A. For machine and human safety, the following general roles must be followed by staff, users and visitors. Please consult the duty shift leader if there is any doubt about the roles.

- Do not enter the Vault, Plant Room, Cryogenics room, and Control Room without permission, please inform the shift leader if you wish to do so,
- Do not apply any force/load on the cooling water pipes and compressed air pipes, and liquid nitrogen/helium lines,
- Do not stand close the safety valves and burst discs,
- Do not touch ice balls by hand in cryogenic plant or Vault,
- Do not standing or apply pressure on the any part of the accelerator, such as vacuum pipes, kickers, septum, RF cavity, RF wave guides helium transfer lines, etc.,
- Keep away from the Vault wall when beam is stored,
- Do not enter the vault immediately after beam dump, please consult the duty shift leaders for vault entry, the radiation monitor came with the machine should be carried when entering into the vault; please consult the duty shift leaders for vault entry,
- Keep away from the RF and Microtron HV power supply,
- Do not use the compressed air whenever dipoles are full of liquid helium.

2. XDD (X-ray Development and Demonstration) beamline operates with X-rays with energies from 2.4 keV to 10 keV

Beamline Scientist

Dr YANG Ping (Tel.: 651 64749, e-mail: slsyangp@nus.edu.sg)

XDD beam line covers single crystal and powder diffractometry, reflectometry, fluorescence detection and absorption spectroscopy. As it is a hard X-ray beamline, ionizing radiation safety is a crucial issue to this beamline.

Radiation safety at XDD

- To ensure safe operation and a safe work site for personnel, the beamline is controlled by its beamline control system, which consists of the Beamline Safety System (BSS) and the Personnel Safety System (PSS), the control panel as shown in Fig. 5 of Appendix D. Beamline components such as vacuum shutters, crystals and mirror are protected by interlocks and cooling water.
- Gamma-shutter, a 70 mm Ta equivalent, acts as a shutter to shield gamma ray and synchrotron radiation, to ensure that there is no dose inside the experimental hutch and hence to let users prepare the experiment safely inside the hutch.
- Extra shielding for the beamline after the mirror will be installed or respective area is controlled.
- No-one must be present inside the hutch while beam is ON and the interlock is in operation. To evacuate the hutch, search procedure is provided in the control system and should be abided every time before new experiment runs. The procedure is shown in separate Figures of Appendix D.
- The hutch is built for protecting the personnel to conduct the experiment outside.
- Do not operate the beamline during the electron beam injection.
- No visitors are allowed to operate the XDD beamline without supervision from the beamline scientist or staff member. Only trained users can operate the beamline and conduct the experiment. After training they must sign a form as attached in Appendix D, i.e. "Authorized users at XDD experimental station".

Chemical samples handling

For staff and users, who have approved by SSLS to handle chemicals, should note that

- All samples storage and preparations must be done in chemistry room.
- Clean and/or sample disposal practices must be done in the Chemistry room.
- Wear gloves and goggles prior handling samples.
- Use the Hood located in the chemistry room when manipulating liquid or gas samples.
- Toxic gases are purchased and stored in smallest quantities as possible.
- During use and storage, highly toxic gases are located in continuously ventilated gas cabinets.

- A continuous gas monitoring should be used for signaling releases of toxic gases.
- When not in use toxic gases should be removed and placed in safe area.
- When toxic gases are in use do not keep regulators and pipes pressurized after samples transfer.
- Never let valves of toxic gases open. Immediately close them after use.
- Purge the pipes with inert gases (He, Ar).
- Gas cylinder should be transported on a wheeled cylinder trolley.
- Never slid or roll a cylinder, even practiced handlers can easily lose control of them.

In case necessary, SSLS chemical safety officer or OSHE safety officer should be called in.

Radioactive samples

Radioactive sample has to be approved by the Director before bringing to SSLS.

Electrical connection

There are special electrical connectors to XDD beamline and its equipments.

- Do not disable or disconnect them. Consult with the beam managers.
- XDD provides users with wall socket.
- Do not overload the electrical circuit.
- Check with the electrical personnel WONG Hock Weng John (Tel.: 651 61072, e-mail: slswhwj@nus.edu.sg) for powering particular equipment.

Vacuum pump safety

There are some general safety considerations in using a rotary pump that should be followed for user safety and extending the usable life of the pump. These and other safety issues are covered in more detail in the documentation provided by the pump manufacturer. The vacuum pump manual supplied by the manufacturer should be completely read and understood before the user attempts to operate, repair, or perform maintenance procedures.

Vacuum pumps (rotary, turbo pumps and ionic pumps) belonging to XDD beamline are specifically designed for the beamline.

- Do not disconnect or use them. XDD vacuum pumps are used to evacuate clean air only.
- Do not obstruct the ventilation around the pumps to prevent the units from overheating.
- Check with beamline managers and with qualified personnel CHEW Eh Piew (Tel.: 651 64748, e-mail: slscep@nus.edu.sg)

3. ISMI (Infrared Spectro-/Microscopy) beamline ranging from 10000 cm^{-1} in the near infrared to 10 cm^{-1} in the far infrared (1.3 eV to 1.3 meV)

Beamline Scientist

Dr Agnieszka BANAS, (Tel.: 651 67005, e-mail: slsba@nus.edu.sg)

Radiation safety

a) Radiation safety (X-rays and VUV radiation safety at ISMI)

Infrared SpectroMIcroscopy (ISMI) beamline is a very low energy delivering beamline. The light is emitted in the infrared range and extends to the visible. The spectral range is within ~0.001 eV to 1.8 eV. The vertical extraction beamline design of the emitted light from Helios2 machine excludes automatically all higher energy photons (x-rays and soft x-rays) from reaching the end station. Vacuum ultra violet (VUV) light and ultra violet light (UV) are filtered out with a diamond window. Moreover the Gold coated mirrors used to transport the light to the end station greatly attenuate both VUV and UV light.
There is no specific protection needed from X-rays and VUV light at ISMI end station. The beamline end station is constructed in open area and there is no hutch at the working place. However the user should fully comply with the radiation safety procedures at SSLS institute. X-ray radiation safety personnel is Dr YANG Ping (Tel.: 651 64749, e-mail: slsyangp@nus.edu.sg)

Do not operate the beamline during the electron beam injection. However you still can work, independently, with the FTIR equipments at the end station.

b) Radiation safety (Infrared and visible light radiation safety)

To operate ISMI beamline please check first with the beamline scientist. (Dr Agnieszka BANAS (Tel.: 651 67005, e-mail: slsba@nus.edu.sg)).
Also "ISMI Beamline Operating Instruction" manual is available for trained users who are familiar with the beamline equipments.
The equipments of ISMI end station are two Fourier transform spectrometers and one infrared microscope. They operate under seal and in the vacuum. No infrared scattered light is emitted from these equipments. Sample chambers of the spectrometers are manufactured and designed in isolation from the rest of the optics. However, for alignment purposes or particular experiments, venting optics and opening of covers might be required. In this particular case, consult with the beamline managers at first. IR light or He-Ne laser (class II bellow 5 mW) light might reflect or scatter out from the instruments.

- Although weak in energy and intensity, never expose yourself or your eyes directly to these light sources.
- Warning: Do not operate the microscope if the covers are removed or appear damaged. Never look or use optical instruments to look into the laser beam or its

reflection of any surface. Directly looking into the laser light can cause permanent eye damage.

- Do not use highly reflecting surfaces to watch and align the spot light.
- Do not wear a watch in your hands. Uncontrolled reflected light might harm other nearby person.
- Incorporated He-Ne Laser component inside the spectrometer is of class II, delivering intensity bellow 5 mW. However do not remove any filters or beam dump within the laser path. Consult with the beamline managers and with the company engineers.
- Wear a safety goggles.
- Infrared optics are hygroscopic, easily damaged and in general poisonous. Wear gloves.
- Each instrument has "instruction manual" read it carefully.

Cryogenic liquid handling

a) Liquid Nitrogen

ISMI beamline uses small quantities of liquid nitrogen to cool down a (250 ml Dewar) MCT infrared detector. To these purpose ISMI provides a 2 l Dewar for Nitrogen handling as well as a reservoir tank (vessel) of 60 l.
Operation with liquid nitrogen can cause serious frostbites.

- Protect your face with a vizor or goggles.
- Protect your hands with cryogenic gloves.
- Do not touch any frozen or unprotected part of the cryogenic pipes when transferring the liquid.
- Do not obstruct the relief valve of the vessel.
- Use the 2 l Dewar to collect the liquid nitrogen from the vessel.
- If no liquid nitrogen in the 60 l vessel do not shake it or tilt it.
- Vent (using venting valve) the vessel prior you open it.

The beamline scientist or trained personnel are the only responsible to fill up the liquid nitrogen in the mobile 60 l vessel when empty. They should comply with the regulation and safety transfer of liquid nitrogen from the main reservoir tank located outside the storage ring.

- Check for registration and inform the personnel (room 004) LI Zhiwang (Tel.: 651 67931, e-mail: slslizw@nus.edu.sg) and CHEW Eh Piew (Tel.: 651 64748, e-mail: slscep@nus.edu.sg)
- Follow the procedure provided by LI Zhiwang (Tel.: 651 67931, e-mail: slslizw@nus.edu.sg) instructions pages.

Warning: Stand clear of boiling and splashing liquid and its issuing gas. Boiling and splashing always occur when charging a warm container. Always fill in liquid nitrogen slowly to minimize boiling and splashing.

b) Liquid Helium

At ISMI beamline the use of liquid Helium is required only when performing experiments with the Bolometer detector. Several operations need to be coordinated at a time for successful experiments performing.

- Check your beam time availability.
- Make sure your experimental set up is operational.
- Make sure you have a pumping unit at your disposal. Bolometer detector need to be pumped every time before cooling.
- Coordinate your beam time and the liquid helium delivery.
- For Liquid Helium vessel handling check the procedure provided by LI Zhiwang (Tel.: 651 67931, e-mail: slslizw@nus.edu.sg) instructions pages.
- Read carefully and follow the instruction manual for cooling the Bolometer detector. It is a must.
- Never operate or transfer Helium when you are alone.
- Use safety goggles and gloves when handling cryogenic equipments.
- Operate in an open area.

Warning: Stand clear of boiling and splashing liquid and its issuing gas. Boiling and splashing always occur when charging a warm container.

Chemical samples handling

All samples storage and preparations must be done in chemistry lab. However samples storage and usage must be within the risk level permitted in the chemistry lab.

- For staff and users who have been approved by SSLS to handle chemicals.
- Cleaning and/or sample disposal practices must be done in the Chemistry lab.
- Wear gloves and goggles prior handling samples.
- Use the Hood located in the chemistry lab when manipulating liquid or gas samples.
- Toxic gases are purchased and stored in smallest quantities as possible.
- During use and storage, highly toxic gases are located in continuously ventilated gas cabinets.
- A continuous gas monitoring should be used for signalling releases of toxic gases.
- When not in use toxic gases should be removed and placed in safe area.
- When toxic gases are in use do not keep regulators and pipes pressurized after samples transfer.
- Never let valves of toxic gases open. Immediately close them after use.
- Purge the pipes with inert gases (He, Ar).
- Nitrogen and Helium cylinder should be transported on a wheeled cylinder cart.
- Never slid or roll a cylinder, even practiced handlers can easily lose control of them.

Electrical connections

There are special electrical connectors to ISMI beamline and its equipments.

- Do not disable or disconnect them. Consult with the beam managers.
- ISMI provides users with wall socket.
- Do not overload the electrical circuit.
- Check with the electrical personnel WONG Hock Weng John (Tel.: 651 61072, e-mail: slswhwj@nus.edu.sg) for powering particular equipment.

4. SINS (Surface-, Interface- and Nanoscience) beamline operates with X-rays with energies from 50 eV to 1.2 keV

Beamline Scientist

Dr. YU Xiaojiang (Tel.: 651 67951, e-mail: slsyxj@nus.edu.sg)

SINS comprises a soft X-ray beamline and an end-station, is a research facility equipped with soft X-ray photoemission spectroscopy (PES) and X-ray absorption spectroscopy (XAS). The SINS beamline inside the vault has a 6° horizontal deflection angle, so high energy radiation is shielded by the thick wall of the vault, the low energy radiation soft X-ray transportation in the beamline is isolated by the wall of beamline pipes, there should be no hazard radiation existing in the SINS working place. It also has a twin anode X-ray gun in end-station, the produced Soft X-ray (with energy 1486.6 eV or wavelength 0.834 nm) is encapsulated inside the stainless steel analysis chamber only, no dose can be leakage.

Before the personnel begin their research at SINS beamline, they must read completely **SINS User Manual** which can be requested at the beamline scientist and experimental coordinator. And they must comply following description:

- Do not operate the beamline without supervision under SINS beamline scientist, except for those who has been trained by beamline scientist.
- At least two persons are required on the site when doing experiment.
- After hour visitors should be reported.

Other Safety concern

- General laboratory safety please refer to chapter 9 Safety Management Manual
- Ionizing and Non-Ionizing radiation concern refer to chapter 6 Safety Management Manual
- Chemical hazard safety refer to chapter 7 Safety Management Manual

5. PCIT (Phase Contrast Imaging and Tomography) beamline operates with X-rays with energies from 2 keV to 12 keV

Beamline Scientist

Dr Krzysztof BANAS, (Tel : 651 67837, e-mail: slskb@nus.edu.sg)

PCIT Beamline Safety

The PCIT beamline at SSLS is connected to a radiation protection hutch. The PCIT beamline provides X-rays for imaging. The PCIT beamline comprises of 4 groups:

Group 1: Power Shutter:
The Power Shutter is directly connected to Dipole 2 of Helios 2.

Group 2: Collimator, Gamma Shutter and 1st Beryllium Window (500-µm thickness) :
The collimator selects small part of a beam and hence reduces the amount of radiation downstream. The gamma-shutter, in closed position, absorbs the gamma-radiation from Helios 2. The beryllium is located in the experimental hutch and separates the high vacuum from the atmospheric pressure outside the beam tube. The X-rays are travelling about 2 m in atmosphere before reaching sample and detector.

Group 3: Gamma-stop is constructed from the thick lead brick and allows stopping all gamma radiation inside the experimental hutch.

Group 4: The experimental hutch eliminates radiation hazard almost completely. The door to experimental hutch is interconnected with the operation of the gamma-shutter. If the door to experimental hutch will be opened by mistake the gamma-shutter will automatically be activated and shut down the beam.

General Safety
In normal operation, PCIT beamline users can operate the beamline without any radiation hazard. Users must, however, be aware of the potential hazard in and around equipment to avoid possible injury and equipment damage.

Radiation Safety
The PCIT beamline poses no potential radiation hazard to its users. However, users must understand and fully comply with the radiation safety procedures at SSLS. No alteration of the radiation safety equipment is allowed without prior knowledge of beamline scientist and Radiation Safety Officer. Please refer to the Radiation Safety Manual.

Electrical Safety
Users are protected from potential hazards associated with voltage, current and power levels. Any attempt to modify, rectify or dismantle the equipment must be done by trained or qualified personnel.

Mechanical Safety

There are a number of moving parts in the system which are powered by electrical motors. In normal use, Users are not required to undertake mechanical work. Any servicing or repair work must be done by trained or qualified personnel.

Vacuum Safety

Vacuum components can fail and cause explosion which can result in injury and equipment damage. Please report any malfunction of the vacuum system to Beamline Scientist.

Hazardous/Toxic Material

Beryllium is used in the beryllium windows in the PCIT beamline. Beryllium may oxidize to highly toxic beryllium oxide powder when expose to fire. Do not attempt to clear up the remains of any fire. Inform relevant personnel if an accident involves possible beryllium or beryllium oxide contamination. The windows must be protected from oxidation.

Vacuum Control System

Users should **NOT TURN OFF** the vacuum without prior knowledge of beamline scientist and SSLS' operating team.

6. LiMiNT (Lithography for Micro- and NanoTechnology) beamline operating with X-ray energies above 2 keV

Beamline Scientist

Dr JIAN Linke (Tel.: 651 61691, e-mail: slsjl@nus.edu.sg)

LiMiNT Beamline Safety

The LiMiNT Beamline in SSLS is connected to an X-ray scanner in the cleanroom. The LiMiNT Beamline provides a photon flux for (deep) X-ray Lithography. The LiMiNT beamline comprises of 4 groups:

Group 1: Power Shutter, Filter Unit and collimator:
The power shutter and filter unit is directly connected to Dipole 2 of Helios 2 and the collimator blocks radiation from reaching the scanner and reduces the heat load on all downstream components

Group 2: 1st Beryllium Window (200-µm thickness) and g-Shutter:
The beryllium separates the UHV in Group 1 from the HV in Group 2.The gamma-shutter, in closed position, absorbs the gamma-radiation from Helios 2. This allows users to work on the X-ray scanner without any radiation hazards.

Group 3: Beam Position Monitor.

Group 4: 2nd Beryllium Window (200-µm thickness) and X-ray Scanner
The 2nd beryllium window separates the HV in Group 3 from the scanner section. Between the 2nd beryllium window and the scanner, a gate valve which is interlocked by the control system such that the 2nd beryllium window cannot be set under atmospheric pressure even when the scanner is being vented.

General Safety

In normal operation, LiMiNT beamline users can operate the X-Ray scanner without any radiation hazard when the scanner lid is in open position. users must, however, be aware of the potential hazard in and around equipment to avoid possible injury and equipment damage.

Radiation Safety

The LiMiNT beamline poses no potential radiation hazard to its users. The power shutter (in Group 1) and the gamma-shutter (in Group 2) is actuated simultaneously, thus absorbing all synchrotron and gamma-radiation from Helios 2. These shutters are closed by an interlock whenever the scanner lid is in the open position. However, users must understand and fully comply with the radiation safety procedures at SSLS. Refer to the Radiation Safety Manual.

Electrical Safety

Users are protected from potential hazards associated with voltage, current and power levels. Any attempt to modify, rectify or dismantle the equipment must be done by trained or qualified personnel.

Mechanical Safety

There are a number of moving parts in the system which are powered by electrical motors or compressed air. In normal use, Users are not required o undertake mechanical work. Any servicing or repair work must be done by trained or qualified personnel

Vacuum Safety

Vacuum components can fail and cause explosion which can result in injury and equipment damage. Never exceed an overpressure of 0.1 bar gauge inside the vacuum system.

Hazardous/Toxic Material

Beryllium is used in the beryllium windows in the LiMiNT beamline. Beryllium may oxidize to highly toxic beryllium oxide powder when expose to fire. Do not attempt to clear up the remains of any fire. Inform relevant personnel if an accident involves possible beryllium or beryllium oxide contamination. The windows must be protected from oxidation during bakeout by having vacuum/ inert gas on both sides of the window.

Computer Control System

There are two ion pumps in the LiMiNT beamline to control the pressure in each of the groups mentioned above. They are controlled by a computer control system. As such, Users should **NOT TURN OFF** the computer system, especially when the Synchrotron is running.

Clean Room at the LiMiNT beamline

This training is undertaken to assure that individuals of differing backgrounds receive a uniform experience for working in the SSLS cleanroom. Most users of the SSLS cleanroom have had minimal exposure to a working chemical laboratory setting.

In addition to the special concerns of cleanrooms, this training targets the chemical hazards associated with processing of silicon wafers as well as thermal, electrical and other hazards of particular equipment.

In this session we will cover:

- Identify the various chemical hazards and how to deal with them

- What to do in an emergency situation
- How to conduct experiments
- Some basic guidelines for general chemical use, storage and hazards.

This training serves as an active portion of the SSLS right-to-know communication program. Right-to-know laws were implemented by OSHE and although, universities are strictly exempt from such laws, it has always been SSLS policy to adhere to these regulations. The right-to-know gives workers access to information on the hazards to which they can reasonably be expected to be exposed at SSLS. This information is contained in the MSDS.

Emergency Plan:

When an alarm is sounded, secure equipment / process and evacuate the clean room.

When an accident occurs, report it immediately.

When there is a spill

- Use pH paper to test
- Clean-up
- Always use Neoprene gloves, especially in fume hood
- Always rinse well with water

Clean room carries Special Hazards

Chemical use – processing and etching with strong oxidizers. **Always check the MSDS** sheet whenever using a new material.

Always have a mentor when using a piece of equipment for the first few times, until you are confident of using the equipment on your own.

If unsure about a procedure – **Stop and ask for help** from someone who knows.

Safety Consciousness

Reduce worry by going the extra mile

- Always leave equipment in at least as good condition as you found it
- Last person out – check all machinery is left in a safe (off) position and that all water is being turned off
- Mentor responsibility. Always show the best example even if in a hurry.
- Careless activities can result in lowered expectations both for you and others using the cleanroom
- For multi-use equipment such as the microscope, carelessness in the use of equipment may carry over to other processes and may endanger personnel and/or equipment.

Remember

1. Good housekeeping is integral to a safe environment.

2. Cleanroom rules are set up for your protection and the safety of equipment. Disregarding these rules can have long-term consequences.

3. Carelessness and/or blatant disregard of such rules may lead to the suspension of cleanroom access.

7. EPD (Electron and Photon Diagnostics) beamline

Beamline Scientist

Dr. DIAO Caozheng (Tel.: 651 67965, e-mail: slsdcz@nus.edu.sg)

The objective of EPD beamline is to perform experiments to diagnose the electron beam and photon beam. It is still in construction phase. The gamma shutter and the photon shutter in the beamline are all blocked at present. There is no hazard of X-ray or other radiation at the exit beryllium window.

EPD Beamline Safety

1. Do not hit any component of the beamline, especially the beryllium window which is very fragile.
2. Keep away from the high voltage cable of the ion pump power supply.

I hereby declare that I have read and understood Singapore Synchrotron Light Source Users' Safety Brief.

Name	Affiliation	Experiment ID	Signature
Name beamline scientist	Date		Signature beamline scientist