

**High Resolution
Scanning Ion Microscope
SMI2200**

Instruction Manual

Rev.1.1

SII ●

Seiko Instruments Inc.

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Foreword

This manual provides the basic operating procedures for the SMI2200 high resolution scanning ion microscope manufactured by Seiko Instruments Inc. (SII).

This manual includes chapters on operation and maintenance. The Operation Chapter provides information for the operators of the SMI2200. However, please note that only trained and qualified personnel (hereafter referred to as 'staff') should perform some of the operations described in this chapter. Operator should not perform such operations.

The maintenance chapter provides information for staff. However, if error message appears or a trouble occurs during operation, the operators should take appropriate corrective actions according to the section of " Error Messages and Troubleshooting."

In order to use the SMI2200 correctly and safely it is important to read this manual thoroughly. Be sure to keep this manual where it can be easily accessed.

If the operating instructions in this manual are disregarded or not followed correctly, there is the hazard of electric shock, fire, etc. Observe the precautions that this manual specifies as well as the warning labels in order to prevent such hazards from causing injury or damage.

Definition of signal words in alerts

The signal words "Danger", "Warning" and "Caution" found in this manual and on warning labels affixed to the SMI22000 correspond to the degree of injury that may result.

DANGER: Indicates an imminently hazardous situation in which, if not avoided, will result in death or serious injury.

WARNING: Indicates a potentially hazardous situation, if not avoided, could result in death or serious injury

CAUTION: Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It is also used to alert against property damage.

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Operation Chapter

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1. Intended Use

The SMI2200 performs the following operations while scanning and irradiating the Focused Ion Beam (FIB) on the surface of the specimen.

1. Magnified observation of the specimen surface configuration by working as a scanning ion microscope.
2. Etching processing by irradiating the ion beam on the specimen surface to carry out sputtering.
3. Deposition processing to form a thin film on the specimen surface by spraying gas material for thin film while irradiating the ion beam.

1. Intended Use

2. Principle of Operation

SMI2200 generates ion from the ion source when the vacuum degrees of ion source chamber and the main chamber reaches the prescribed values. Then acceleration voltage is applied to ions to make ions pass through the ion column and move toward to the main chamber. While passing through the ion column, ions are focused to the fine ion beam by the aperture and lens in the ion column.

When a specimen is transferred into the sub-chamber, evacuation of the sub-chamber starts. When the vacuum degree of sub-chamber reaches to the prescribed value, the gate valve between the sub-chamber and main chamber opens, and the specimen is transferred into the main chamber and held at the specimen stage. Then the specimen is moved to the irradiation position by the movement of the specimen stage.

The scanning ion beam, which is controlled by the deflection electrode located in the ion column, is irradiated to the specimen. When ion beam is irradiated, the secondary electron and the secondary ion are generated from the specimen surface. The secondary electron or the secondary ion is converted into the electric signals, and the two-dimensional distribution of these signals is displayed as a microscope image.

When ion beam is irradiated to the specimen, the atoms of surface materials are expelled. The spatter-etching process utilizes this phenomenon to remove material from the specimen.

When irradiating ion beams while spraying a specific compound gas on the specimen surface, the solid elements of gas are adhered to the specimen surface and accumulated. The deposition process utilizes this phenomenon to adhere the material to the specimen surface.

2. Principle of Operation

3. Appearance



Figure 3-1 Appearance

3. Appearance

4. Types of Processing

4.1. Cross Section Processing and Observation

Section processing means to bore a hole in the specimen. Cross section observation means to observe the cross section structure by irradiating the ion beam to the section of hole and displaying it as a microscope image.

There are two kinds in the section processing: rough processing and finish processing. The rough processing bore a hole quickly in high sputtering speed with high probe current. The finish processing smoothes the holes' walls in low sputtering speed with low probe current.

In the rough processing, the slope boring can be selected to reduce the processing time. The slope boring is a process to bore a deep, vertical hole just in one side to be observed.

4.2. TEM Specimen Preparation

The TEM specimen preparation process involves boring two square holes adjacent each other in a specimen by sputter etching, and using the remaining part between the holes as the specimen for the Transmission Electronic Microscope (TEM).

To make these two holes, the cross section processing is carried out twice. After establishing the processing frame, rough and finish processing take place within the processing frame.

4.3. Integrated Circuit Wiring Cutting

In this process, the fine wiring of integrated circuit is removed using sputter etching.

To cut the integrated circuit wiring, the processing frame is set at the location of cutting the wiring, and sputter etching takes place within the processing frame. Because the metal wiring is generally covered with an insulation coating, sputter etching need to be performed on this insulation coating and the metal wiring underneath.

4.4. Integrated Circuit Wiring Forming

In this process, two points on the circuit are connected with new wiring formed by sputter etching and deposition.

A processing frame is set at two locations on the existing circuit, sputter etching is performed on the inside of each processing frame to remove the insulation coating and bore holes into the metal wiring underneath. These two holes are then covered by one processing frame and deposition is carried out inside the frame to accumulate tungsten conductive coating that forms a new wiring connecting these two points.

Note: The carbon film cannot be used to form the wiring because of its low conductivity.

4. Types of Processing

5. Safety Precautions



CAUTION

— Pinch Hazard—
Keep hands clear of moving parts in the sub chamber.
The moving parts can injure your hand.



CAUTION

— Pinch Hazard—
Open and close the cover of sub-chamber carefully.
If the cover falls, your hand can be injured.



CAUTION

— Risk of Electric Shock—
Operators are not allowed to open the maintenance door of main body or the control cabinet door. Accessing inside may cause electric shock.
When using the SMI2200, make sure that the enclosure panels of main body, control panel, transformer box, operation table, and roughing pump are all attached to the prescribed positions.



CAUTION

— Chemical Hazard—
The SMI2200 uses metallic gallium for its ion source. The IATA has designated metallic gallium as a dangerous (corrosive) material.
Ion source should be replaced after using for a certain period of time.



CAUTION

— Chemical Hazard—
The SMI2200 uses phenanthrene or hexacarbonyltungsten as gas deposition materials. Both of these substances are hazardous. The deposition gas requires replenishment when it gets empty, and only the qualified personnel (staff) are allowed to perform its replenishment. Operator should not carry out its replenishment.



CAUTION

— Chemical Hazard—
The exhaust duct is used to vent harmful deposition gases outside the chamber. Be sure to install and use the exhaust duct during operation of roughing pump.

5. Safety Precautions

6. Specifications

6.1. Performance

| | | |
|-------------------------------------|--|---|
| Secondary electron image resolution | 5 nm | @ acceleration voltage 30kV |
| Maximum probe current density | 20A/cm ² | @ acceleration voltage 30kV *calculated value |
| Maximum probe current | 20nA | @ acceleration voltage 30kV |
| Observation view | 0,5 × 0,5μm ² to 2,4 × 2,4mm ² | @ acceleration voltage 30kV |
| Beam irradiation position stability | 0.1μm/10min. | |

(While the automatic correction of the beam irradiation position is activated with SII's standard specimen.)

6.2. Ion source

| | |
|-------------------|---|
| Ion source | Liquid metallic Gallium, needle-type ion source |
| Expected lifetime | 1000 h |

* when the regular maintenance for condensing lens block is conducted

6.3. High resolution focused ion beam optical system

| | |
|-----------------------------------|--|
| Acceleration voltage | 30 kV |
| Ion source controls | Filament current, suppressor, extractor |
| Lens | Two-stage electrostatic type |
| Condensing lens | High-potential type |
| Object lens | EintzweI type |
| Blanking | Two-segment cylindrical electrode/electrostatic type |
| Optical axis correction electrode | Eight-segment cylindrical electrode/electrostatic type |
| Aperture | Two-axis motor drive |
| Stigmator | Eight-segment cylindrical electrode/electrostatic type |
| Deflecting electrode | Four-segment cylindrical electrode/electrostatic type |
| Scan rotation | 0 to 359,9°/0,1° step setting |

6.4. High vacuum main chamber

6.4.1. Detector

Scintillator-type secondary electron detector
MCP-type secondary electron and the secondary ion detector [optional]

6.4.2. Gas Injector

In standard configuration, a carbon gas injector or a tungsten gas injector can be selected. In the optional configuration both of carbon and tungsten gas injectors can be installed.

6. Specifications

Specifications common to both gas injectors

| | |
|----------------------------|----------------------------|
| Nozzle | Up/Down method |
| Gas generation method | Heating evaporation method |
| Raw material supply method | Vial method |

Gas raw materials

| | | |
|-----------------------|-----------------------|----------------|
| Carbon gas injector | Phenanthrene | $C_{14}H_{10}$ |
| Tungsten gas injector | Hexacarbonyl tungsten | $W(CO)_6$ |

Note 1): The raw material for gas cannot be changed to another material.

Note 2): The empty vial can be treated as an industrial waste

6.5. Sub chamber

| | |
|-----------------------------|-----------------------|
| Cassette transfer equipment | Motor transfer system |
|-----------------------------|-----------------------|

6.6. Specimen stage

| | |
|-----------------|---|
| Structure | Five electric driven axes-eucentric tilt stage |
| Operating range | X-axis: 0 to 200mm Y-axis: 0 to 200mm Z-axis: 0 to 21,5mm T-axis: -3 to 60° inclination R-axis: 0-360° endless rotation |
| Specimen holder | For 200mm or 150mm SEMI standard wafer Note 1) Select either the 200mm wafer holder or 150mm wafer holder when ordering. Note 2) The holder can be used for both orientation flat type and notch type wafers by changing the standard accessories. Note 3) In case of using wafers other than SEMI standard type, a dedicated sample holder must be ordered. |

6.7. Evacuation system

| | |
|-------------------------|--|
| Control method | Automatic control |
| Vacuum pump | High vacuum main chamber: Turbo molecular pump 450 l/s Sub chamber: Turbo molecular pump 50 l/s Ion source chamber: Noble ion pump 60 l/s For roughing operation: Rotary pump |
| Vacuum degree detection | High vacuum main chamber: Combination gauge (Penning and Pirani gauge) Sub chamber: Pirani gauge Ion source chamber: Noble ion pump discharge current |

| | |
|-----------------|---|
| Ultimate vacuum | High vacuum sample chamber: 8×10^{-5} Pa or lower Ion source chamber: 1×10^{-5} Pa or lower Note: Ultimate vacuum is measured with vacuum degree detector equipped with the instrument. |
|-----------------|---|

6.8. Computer system

6.8.1. Computer for operation

| | |
|----------------|---|
| CPU | DOS/V Pentium II, 333MHz or higher |
| Memory | 64 MB or more |
| Hard disk | 2GB or more |
| OS | Windows NT (Japanese) |
| Storage media | CD, FDD and MOD |
| Display | 19" high-resolution color display 1280 x 1024 dot |
| Operation part | USB Japanese Type 109 keyboard PS2 MS IntelliMouse |

6.8.2. Computer for controlling hardware

| | |
|----------------|---|
| CPU | MC68030 25 MHz |
| Memory | 4 MB or more |
| Hard disk | 1GB or more |
| OS | OS 9 |
| Operation part | Dedicated operation panel MAG for changing field of view FOCUS STIG X, Y for stigma correction BRIGHTNESS CONTRAST |

6.8.3. Operation

| | |
|-----------------------------|---|
| Entry | Operator mode / Staff mode Operator registration Login record |
| Ion source | Beam Ctrl. Start Heating Flushing function |
| Cassette transfer | Load/Unload |
| Ion beam current adjustment | |
| Ion beam scan | Scanning speed change Dot accumulation Frame accumulation |

6. Specifications

| | |
|------------------------|---|
| | View size change |
| | Scan rotation |
| Specimen position | Eucentric position calculation |
| Adjustment | Centering |
| | Specimen stage transfer |
| | Storing observation/process position |
| Observation | Image storage |
| | Image print |
| Basic processing | Spatter etching |
| | Deposition |
| | Slope cut |
| Application processing | Processing for section observation |
| | Specimen preparation for TEM observation |
| Processing support | Automatic correction of ion beam irradiation position |

6.9. Utility

6.9.1. Electricity

| | |
|-----------------------|--|
| Voltage | 200/208/220/230/240 V AC $\pm 10\%$, single phase |
| Current | 12A |
| Consumption power | 1,6 kVA in normal mode |
| | 1,2 kVA in sleep mode |
| Frequency | 50/60Hz |
| Grounding | Category III, 100 ohm or lower |
| Installation category | Installation category III |

6.9.2. Gas

| | |
|--------------|---|
| Intended use | For driving valves and for ventilating vacuum chamber |
| Kind | Dry N ₂ |
| Supply | 24 hours continuously |
| Pressure | 0,5 to 0,7 MPa (5,1 to 7,1 kg/cm ²) |
| Flow rate | 30L/min. at exchanging specimens |
| Connection | 6 mm or 1/4 inch swagelok joint |

6.9.3. Exhaust duct

| | |
|---------------|--------------------------|
| Intended use | Exhausting roughing pump |
| Connection | NW25 quick coupling |
| Pumping speed | 200L/min. or more |

6.9.4. Network

| | |
|----------|---------|
| Standard | 10BaseT |
|----------|---------|

Note: Creation of network and its related work are customer's responsibility.

6.10. Room where the instrument is installed

6.10.1. Installation environment

| | |
|-------------------------|---|
| Room temperature | 18 to 25 °C |
| Allowable fluctuation | ± 1 °C or less |
| | Note: Temperature change can cause beam irradiation position fluctuation. For stable operation, the following condition is recommended. |
| | Temperature fluctuation: 0,5°C/h or lower |
| Humidity | 35 to 60 % without condensation |
| External magnetic field | 5μT or lower (50mG) or lower |
| Fluctuation | Constant external magnetic field should be the ground magnetic level of approx. 30 μT (0,3G) or lower. |

Floor vibration Both in horizontal and vertical direction

| Frequency | Allowable limit |
|--------------|--|
| to 10 Hz | Amplitude 0,2μmp-p or lower |
| 10 to 50 Hz | Amplitude 0,5μmp-p or lower |
| 50 to 300 Hz | Acceleration 5 x 10 ⁻² m/s ² (5gal) or less |

Sound pressure

| | |
|-----------------|---|
| Allowable limit | 65 dB (A mode) or lower 80 dB (C or F mode) or lower |
|-----------------|---|

Floor allowable load 4000 N/m² or more (408 kg/m² or more)

Note 1) If a heavy installation is in or is passed through the same room, its weight against the allowable load of the floor should be taken into account.

6. Specifications

6.10.2. Installation example

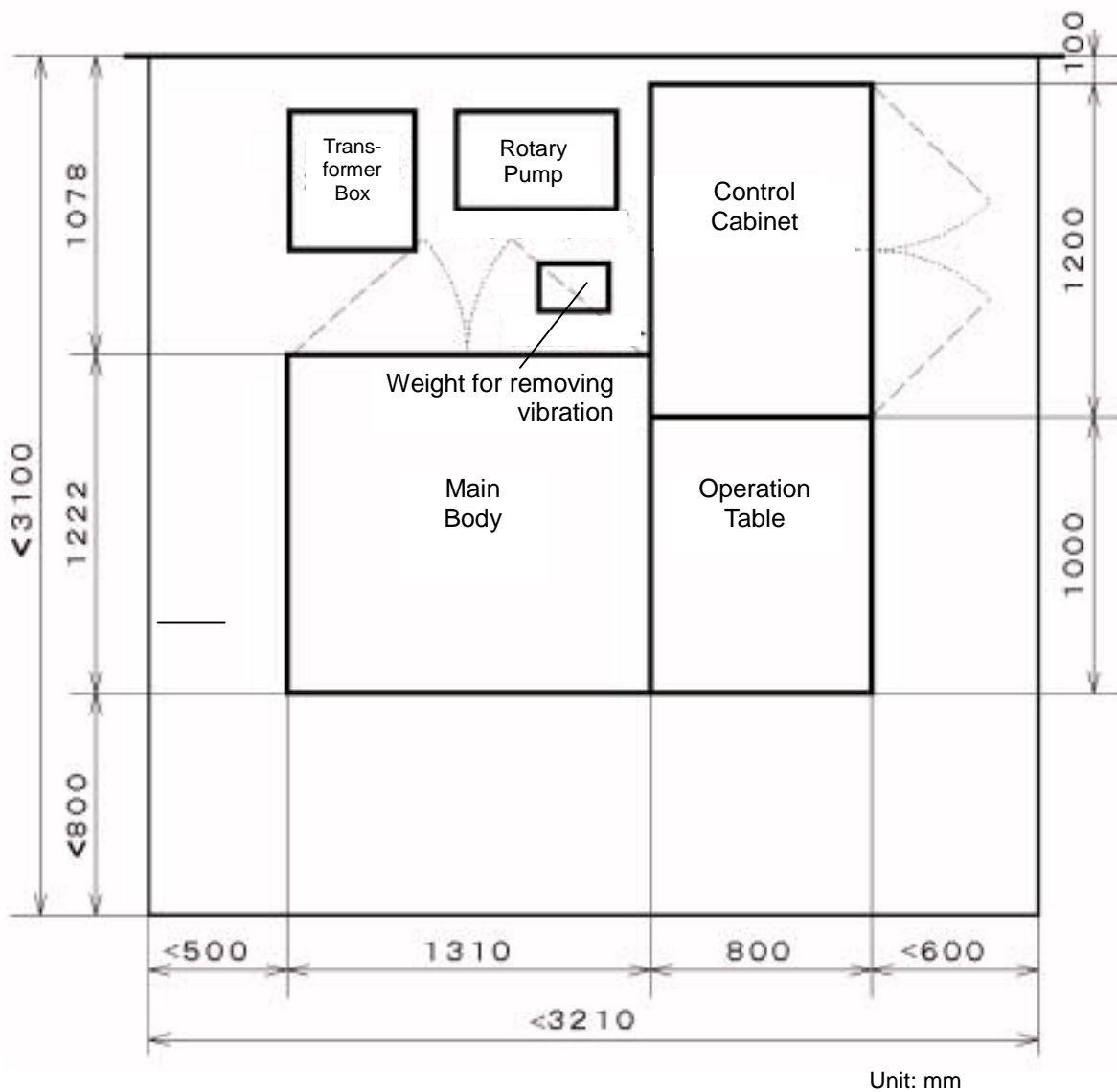


Fig. 6-1 Typical Installation

6.11. Standard accessories

| | | |
|------------------------------|-------|---|
| Ion source | 1 | It is equipped with the instrument on delivery. |
| Gas raw material | 1 | Raw material corresponding to the gas injector is equipped with the instrument on delivery. |
| Precision screw driver | 1 set | |
| Ball point hexagon wrench | 1set | |
| O ring | 1 set | |
| Specimen height checking jig | 1 | |
| Step | 1 | It is used as a step while replacing ion source. |
| Instruction manual | 1 set | The ones accompanied with purchased components |
| Container | 1 | It is used for storing tools provided as standard accessories. |

6.12. Guarantee

6.12.1. Guarantee period

Repair of any faults found within a year after the acceptance date will be carried out in free of charge. Note that updating of software is excluded.

6.12.2. Exclusion

In following cases, repairing cost will be charged.

- (1) Fault caused by wrong operation
- (2) Fault caused by unauthorized remodeling
If software other than the operational software provided by SII is installed, it is considered as remodeling.
- (3) Fault caused by natural disaster
- (4) Fault caused by changing installation environment
If the product is moved without having SII's permission it is considered as the change of installation environment.

Expense of consumable supplies and their replacement, and any cost required for the regular maintenance are paid by customers regardless of the guarantee period.

6.13. Consumable supplies

| Item | Product name | Frequency of replacement | Remarks |
|---|--|--------------------------|---|
| Ion source | Ion source for SMI 2000 series | 1000h | On condition that the regular maintenance is carried out for condensing lens, the period of 1000 operating hour is guaranteed. Also, refer to the note below. |
| Aperture assembly. | Aperture assembly F4 for SMI 2000 series | 1000h | |
| Raw material for vial carbon gas injector | Vial carbon gas injector raw material | 300h deposition time | Phenanthrene $C_{14}H_{10}$ Replenishment amount: 0.3g |
| Raw material for vial tungsten gas injector | Vial tungsten gas injector raw material | 80h deposition time | Hexacarbonyl tungsten $W(CO)_6$ Replenishment amount: 2.5g |
| Scintillater | Scintillater($\varnothing 9$) | 1000h | Replacement should be carried out by SII's service personnel |

Note 1) The replacement frequency of aperture assembly and scintillater is based on the ion source operating time. For the gas injector raw material, it is based on the deposition time.

Note 2) For handling details of gas injector raw materials, refer to the instruction manual accompanied with each material.

Note 3) Operation guarantee of ion source

Repair of any faults found within a guarantee period is carried out in free of charge except for following cases.

- (1) If a fault is caused by the ion source replacement done by the person who has not received the training.
- (2) The accumulated operating time of ion source, including the operating time of ion

6. Specifications

source already been replaced free, exceeds 1000 hours. If the operating hour of ion source, which has broken even if it has been used properly, is less than 50 hours, it is not added to the accumulated operating time.

- (3) If an ion source was used after the one-year or longer storage period from the delivery date.

6.14. Regular maintenance

In order to maintain the instrument performance, following maintenance has to be carried out by the SII's service personnel.

| Inspection item | Frequency |
|-------------------------------------|-------------|
| Condensing lens block | 2000h |
| Blanking electrode | 2000h |
| Secondary electron detector | 2000h |
| Rotary pump | Once a year |
| Turbo molecular pump of sub chamber | Once a year |
| Gas injector maintenance | Once a year |

Note: The maintenance frequency of condensing lens block, blanking electrode and secondary electron detector is based on the ion source operating time.

7. Specimen and Application Materials

7.1. Specimen

The specimen used for scanning ion microscopic image observation, sputter etching, and deposition should be suitable for the specimen holder attached to the instrument.

The specimen holder generally accompanied with the SMI2200 is for the 200mm or 150mm diameter silicon wafers that meet SEMI standards. The specimen holder for SEMI standard wafers can be used both for orientation flat-type wafers and notch-type wafers by changing accessories.

When using a specimen other than a SEMI standard silicon wafer with 200mm or 150mm diameter, a special specimen holder is required.

Note 1) Do not use a silicon wafer having a polished backside.

Note 2) If a specimen unsuited for the specimen holder is used, it may fall into the main chamber since it is not placed securely on the holder. If the specimen falls into the main chamber and the specimen stage is moved, both the specimen and the specimen stage may be damaged. Use only the specified materials suited for the attached specimen holder.

7.2. Application Materials

7.2.1. Metallic Gallium

The SMI2200 uses metallic gallium for its ion source. Since the ion source is housed in the ion source cartridge, the metallic gallium is not exposed to the outside of the instrument during operation.

7.2.2. Phenanthrene or Hexacarbonyl tungsten

The SMI2200 uses phenanthrene or hexacarbonyl tungsten as a raw material for deposition gas. Phenanthrene is used for carbon deposition, and hexacarbonyl tungsten is used for tungsten deposition.

Both of these materials are hazardous combustible powders.

7. Specimen and Application Materials

8. Major Components

8.1. Main Body

In the main body, the ion beam is generated and irradiated to the specimen.

8.1.1. Ion Source Chamber

The ion source chamber houses the ion source that generates the ion beam.

8.1.2. Ion Source

The ion source emits ion particles. The SMI2200 uses a needle-type, liquid metallic gallium as an ion source.

The metallic gallium is stored in the coil in a liquid state and is supplied to a needle under the coil, and the surface tension of the liquid gallium causes it to adhere to the point of the needle. Gallium ion particles are emitted from the needle tip by the electric field created by the extracting voltage that is applied between the needle and the extractor. The suppressor maintains ion flow at a certain rate. By applying the accelerated voltage to the ground potential on the ion source, kinetic energy is imparted to the ion particles generated from the ion source to irradiate them the specimen in the main chamber.

8.1.3. Ion Column

The ion column focuses the ion generated from the ion source to the fine ion beam while the ion is passing through the column. The lens, aperture and electrode are built in the ion column. These are generally referred to as the ion optical system.

The condensing lens controls the diameter of the ion beam.

The object lens focuses the ion beam, and aligns it with the focal point on the surface of the specimen.

The aperture has the holes of different diameter and moves to position a suitable hole to the ion beam path. The probe current is controlled by regulating the ion beam amount with the size of the holes.

The blanking electrode creates a large difference in the electric potential between the electrodes to generate an electric field, and bends the path of the ion beam so that the ion beam cannot pass through the movable aperture while the ion beam is not necessary to irradiate the ion beam on the specimen.

The alignment electrode adjusts the path of the ion beam slightly with an electric field so that the ion beam passes through the center of the object lens.

The stigmator generates the electric field by applying the necessary voltage, and adjusts the cross section form of the ion beam closer to a perfect circle.

The deflecting electrode bends the path of the ion beam in the electric field generated by

8. Major Components

the voltage applied between electrodes, and determines the irradiation location on the specimen surface. The deflecting electrode scans the ion beam above the specimen by continuously changing the applied voltage.

8.1.4. Main Chamber

The main chamber is a vacuum chamber used for the microscope image observation, sputter etching processing and deposition processing. In the main chamber, there are the specimen stage, the detector and the gas injector(s).

8.1.5. Specimen Stage

The specimen stage holds a specimen securely and moves it to the irradiation position. The specimen stage is driven by the motor of five (5) axes, X, Y, Z, T and R. The X, Y, and Z-axes move the specimen stage horizontally, longitudinally, and vertically. The T-axis tilts the stage by rising the front side of the specimen stage. The R-axis rotates the specimen stage within the horizontal plane.

8.1.6. Faraday Cup

The Faraday cup is a measuring device that measures the probe current of the ion beam. It directs the ion beam through the injection opening (1mm diameter) on the top face of the Faraday cup into the inside, causing the ions to collide with the electrode located in the bottom of the Faraday cup. The electrode is connected to the probe amp, and this makes it possible to measure the current of the ion beam that collides with the electrode. The Faraday cup is located near the origin of the specimen stage coordinates.

8.1.7. Sub-chamber

The sub-chamber is a load-lock chamber that prevents the vacuum degree from decreasing while a specimen at atmospheric pressure is loaded into the main chamber, or a specimen in the main chamber is unloaded to atmospheric pressure



Figure 8-1 Sub-chamber

An operator sets the specimen on the specimen holder and places it in the sub-chamber. After the sub-chamber is closed, the sub-chamber is evacuated using the vacuum pump. When the vacuum degree in the sub-chamber reaches the prescribed value, the gate valve between the sub-chamber and the main chamber opens. The transfer arm operates to move the specimen with the specimen holder to the specimen stage in the main chamber. When the specimen transfer is completed, the transfer arm returns to the sub-chamber and the gate valve closes.

8.1.8. Detector

It detects secondary electrons and secondary ions generated from the specimen when it is irradiated by the ion beam, and converts them into electric signals.

The SMI2200 is equipped with either a secondary electron detector that detects secondary electrons, or a secondary electron and secondary ion detector that selects and detects secondary electrons or secondary ions. Dual installation of the secondary electron detector and the secondary electron and secondary ion detector is not possible.

8.1.9. Gas Injector

The gas injector sprays compound gas, which becomes the raw material for deposition, onto the specimen. The gas injector heats and evaporates the compound and also stores the compound, and sprays the raw material gas from the nozzle tip to the specimen surface. The gas injector is located in the back of the main chamber.

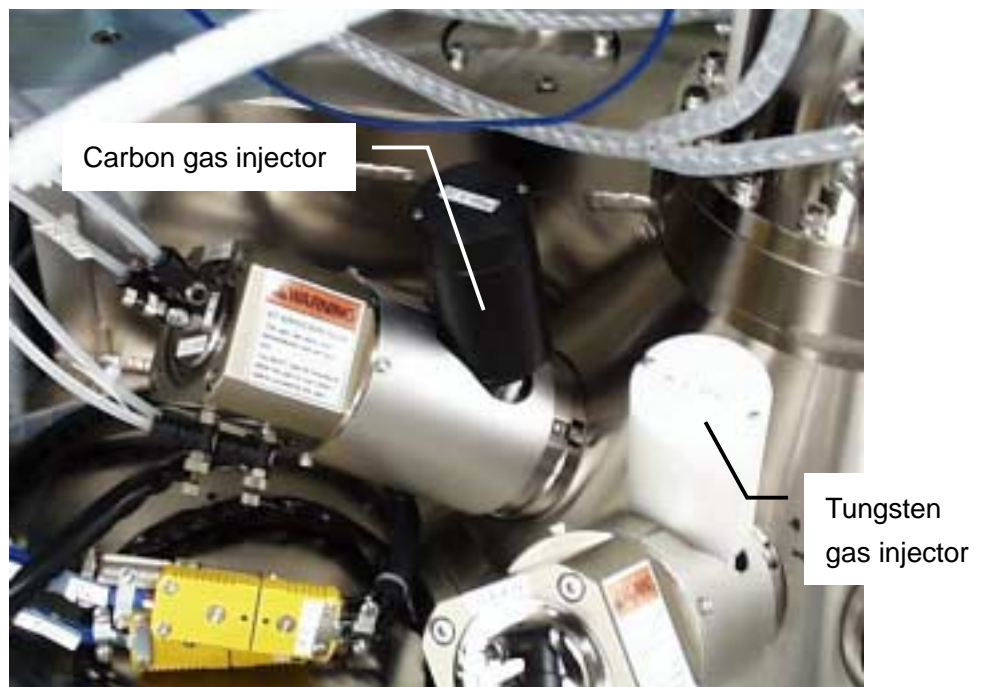


Figure 8-2 Gas Injector Mounting Position

Note: Example when using both Carbon gas injector and Tungsten gas injector

8. Major Components

The SMI2200 is equipped with either a carbon gas injector or a tungsten gas injector, or both.

A heater is provided to maintain both the reservoir, which stores the gas raw material supply, and the nozzle, which sprays the specimen, at a specific temperature while they are in the main chamber.

8.1.10. Vacuum Pump

The vacuum pumps evacuate the ion source chamber, the main chamber and the sub-chamber in order to keep the vacuum degree in these chambers at the prescribed values. There are three kinds in the vacuum pumps: roughing pump, noble pump and turbo molecular pump. The roughing pump evacuates each chamber roughly. Then the noble pump evacuates the ion source chamber, and the turbo molecular pumps evacuate the main chamber and sub-chamber respectively to achieve the high vacuum degree.

The turbo molecular pumps cannot exhaust the evacuated gas to the air directly. In order to function the turbo molecular pumps properly, the roughing pump is used to evacuate the exhaustion side of turbo molecular pump.

The roughing pump is placed on the floor as a single unit. The Noble pump is installed outside of the ion source chamber of the body. The turbo molecular pumps are installed under the main chamber and the sub-chamber respectively.

8.1.11. Maintenance Panel

The maintenance panel is equipped with the ON/OFF switches for the main power, and the high-voltage power supply, and the release switches for vacuum interlocks. The maintenance panel is mounted inside of the door with a lock in front of the main body. Operation of the maintenance panel is limited to staff only.

8.1.12. Valve Reset Switch

The valve reset switch is used when the supply pressure of nitrogen gas supply drops and the protection function is activated. When the pressure restores, the solenoid valve is reset before starting the operation.

The valve reset switch is located in the lower back of the main chamber
Operation of the valve reset switch is limited to staff only.

8.1.13. Air gun

The air gun is used to clean the dust by blowing the nitrogen gas. The gas is blown against the specimen before putting it into the sub-chamber to blow the dust off.

Note: The dust is not vanished but just blown away. Use the air gun with taking the surrounding conditions into account.

8.2. Control Cabinet

The main electric units such as the distribution panel, the gas temperature controller, and the vacuum pump power supply are built into the control cabinet.

Operation of equipment inside the control cabinet is limited to staff only.

8.3. Operation Table

The operation mode panel, the operation panel, and the PC for operation are installed on the operation table.

8.3.1. Operation Mode Panel

The operation mode panel is used to start up the PC and provide the power supply to the ion source high-voltage power and ion optical control power supply. The operation mode panel is installed under the top board of the operation table.

8.3.2. Operation Panel

The operation panel is a tabletop operation panel for adjusting the brightness, contrast, focal point, and stigma correction, and for changing the view size of the image. The operation panel is located on the operation table.

8.3.3. Operation PC

The operation PC is a computer that performs operations necessary for using and maintaining the SMI2200.

8.4. Transformer Box

The transformer box is used to supply 200VAC and 100VAC, necessary for operating and controlling the SMI2200, from the 200VAC power supply of the facilities.

The transformer box is placed on the floor as a single unit.

The line breaker, 200VAC breaker, 100VAC breaker, isolation transformer, and the thermal relay for protecting roughing pump, etc., are built into the transformer box.

8. Major Components

9. Safety Devices and Protective Functions

9.1. Safety Devices

9.1.1. Emergency Stop Switch

The emergency stop switch stops the equipment if smoke appears or unusual noises occur while the SMI2200 is operating. When the emergency stop switch is pressed, all power supply circuits, except the emergency stop switch, are cut immediately, and the equipment stops operating.

The emergency stop switch is located next to the maintenance panel in front of the main body.



Figure 9-1 Emergency Stop Switch

The emergency stop switch is a push-and-lock type. To release the emergency stop switch, rotate the switch button in the direction of the arrow. Releasing the emergency stop switch does not start the equipment. To restart the equipment, start from turning on the power.

9.2. Protective Functions

9.2.1. Overtemperature Sensor for Main Transformer

When the main transformer in the transformer box exceeds the prescribed temperature, the overtemperature sensor for the main transformer shut off all power circuits except the emergency stop switch circuit.

9.2.2. Power Failure Detection Function

When the mains voltage of the SMI2200 drops more than 50% for over 50msec continuously, the power failure detection function operates to shut off all power circuits except the emergency stop switch circuit.

9. Safety Devices and Protective Functions

9.2.3. Roughing Pump Motor Protection

The roughing pump motor protection stops the motor when it overheats due to the blockage or the like. When the roughing pump stops the turbo molecular pump for evacuating the main chamber also stops. At this time, the main chamber is sealed in a vacuum state.

9.2.4. Vacuum Interlock

When the vacuum degree in the ion source chamber or the main chamber falls below the prescribed value, the vacuum interlock automatically cuts off the control power for the ion source and ion optical system.

When the vacuum degree in the ion source chamber falls, the ion source high voltage power supply and the ion optical system control power are cut off.

When the vacuum degree in the main chamber falls, the ion optical system control power is cut off.

9.2.5. Gas Injector Overtemperature Protection

The gas injector overtemperature protection cuts off the power to the gas injector heater when the heater exceeds the prescribed temperature.

10. Controls

10.1. Transformer Box



Figure 10-1 Front Side of Transformer Box

10.1.1. LINE Breaker and Indicator Lamp

The LINE breaker is a leakage breaker that works as the main power switch of the SMI2200. When LINE breaker is turned ON, the power is supplied to the SMI2200 and the LINE lamp lights.

10.1.2. POWER1 Breaker

The POWER1 breaker is a power supply switch for 200VAC on the secondary side of the isolation transformer to the equipment. It is a leakage breaker that shuts off the power when leakage occurs in the 200VAC circuits.

10.1.3. POWER2 Breaker

POWER2 breaker is a power supply switch for 100VAC on the secondary side of the isolation transformer to the equipment. It is a leakage breaker that shuts off the power supply when leakage occurs in 100VAC circuits.

10.1.4. POWER Lamp

The POWER lamp lights when power is being supplied to all of the equipment. When the POWER ON switch of the main body maintenance panel is pressed with the

10. Controls

transformer box LINE, Power1, and Power2 breakers are ON, the POWER lamp lights up. It turns off when the emergency stop button is pressed, or when the POWER ON switch is pressed again to cut off the power to all of the equipment.

10.1.5. Thermal Relay Reset Switch for Roughing Pump Protection

The thermal relay reset switch is used to reset the thermal relay that operates when the roughing pump motor overheats.

10.2. Main Body

10.2.1. Gas Flow Meter

The gas flow meter measures and displays the nitrogen supply pressure used to drive pneumatic valve and ventilate the vacuum chamber. When the nitrogen supply pressure is insufficient, the pneumatic valve does not operate properly, and results in the vacuum chamber leakage, which in turn damages the specimen.

10.3. Maintenance Panel

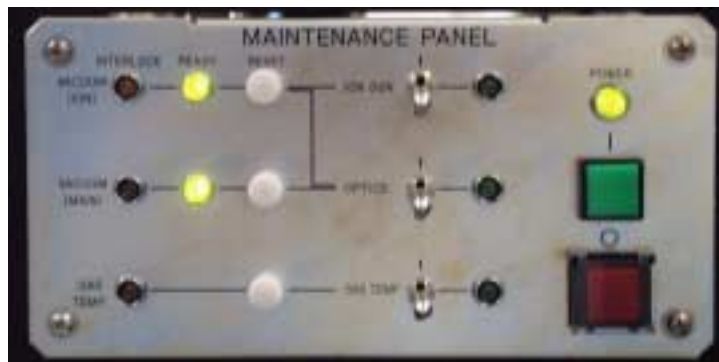


Figure 10-2 Maintenance Panel

10.3.1. POWER ON Switch and Display LED

The POWER ON switch is used to supply power to each piece of equipment. When each power supply breaker of the transformer box is turned on and the POWER ON switch is pressed, the evacuation process begins. In addition, the gas injector power switch becomes enable. The POWER LED lights while the POWER ON switch is on.

10.3.2. Ion Source High-Voltage Power (ION GUN) ON/OFF Switch and Display LED

The ION GUN ON/OFF switch supplies and cuts off power to the ion source high-voltage power supply controlling the ion source. Ion beam starts generating when the Beam Ctrl-Start button in the Start-up window before Login is clicked on the PC screen while

the ION GUN ON/OFF switch is ON. If the vacuum degree in the ion source chamber deteriorates, and the ion source chamber interlock is activated, the power supply to the ion source high-voltage power supply is cut off automatically.

The ION GUN display LED lights up while the electric power is supplied to the ion source high-voltage power supply. If the ion source chamber vacuum interlock is activated, the display LED turns off even if the ION GUN ON/OFF switch is in the ON position.

10.3.3. Ion Optical System (OPTICS) ON/OFF Switch and Display LED

The OPTICS ON/OFF switch supplies and cuts off the power to the ion optical system, which controls the lens and electrodes in the ion column. This switch is normally set in the ON position. If the vacuum degree in the ion source chamber deteriorates and the interlock for the ion source chamber activates, or if the vacuum degree in the main chamber deteriorates and the interlock for the main chamber activates, the power supply to the ion optical system is cut off automatically.

The OPTICS display LED lights up while the power is supplied to the ion optical system power supply. The display LED is turned off even if the OPTICS ON/OFF switch is in the ON position when the vacuum interlock for the ion source chamber or the vacuum interlock for the main chamber is activated.

10.3.4. Ion Source Chamber Vacuum Interlock (VACUUM (ION)) Display LED and Release Switch

When the vacuum degree in the ion source chamber falls below the prescribed value, the ion source chamber vacuum interlock cuts off the power to the ion source high-voltage power supply and the ion optical system control power supply. The VACUUM (ION) INTERLOCK LED lights up when the ion source chamber vacuum interlock activates.

The VACUUM (ION) READY LED lights up when the vacuum degree in the ion source chamber is restored.

The ion source chamber vacuum interlock releases by pressing the VACUUM (ION) RESET switch after the VACUUM (ION) READY LED lights up. When the interlock releases, the VACUUM (ION) INTERLOCK LED turns off.

Once the ion source chamber vacuum interlock releases, the power supply to the ion source high-voltage power supply and the ion optical system control power supply are restored automatically, provided that the ION GUN ON/OFF switch and the OPTICS ON/OFF switch are in the ON position.

Note: When the vacuum interlock in the ion source chamber and in the main chamber are activated simultaneously, the power supply to the ion optical system control power supply are not restored until the vacuum degrees in both the ion source chamber and the main chamber are restored.

10.3.5. Main Chamber Vacuum Interlock (VACUUM (MAIN)) Display LED and Release Switch

When the vacuum degree in the main chamber falls below the prescribed level, the main chamber vacuum interlock cuts off power to the electrode on the side of the main chamber and to the detector.

The VACUUM (MAIN) INTERLOCK LED lights up when the main chamber vacuum interlock is activated.

The VACUUM (MAIN) READY LED lights up when the vacuum degree in the main chamber is restored. The main chamber vacuum interlock releases by pressing the VACUUM (MAIN) RESET switch after the VACUUM (MAIN) READY LED lights up. When the interlock releases, the VACUUM (MAIN) INTERLOCK LED turns off.

Once the ion source chamber vacuum interlock releases, the power supply to the ion source high-voltage power supply and the ion optical system control power supply are restored automatically, provided that the ION GUN ON/OFF switch and the OPTICS ON/OFF switch are in the ON position.

Note: When the vacuum interlock in the ion source chamber and in the main chamber are activated simultaneously, the power supply to the ion optical system control power supply are not restored until the vacuum degrees in both the ion source chamber and the main chamber are restored.

10.3.6. Gas Injector Power Supply (GAS TEMP) Switch and Display LED

The GAS TEMP ON/OFF switch is a switch that supplies and cuts off the power to the gas injector heater.

The heater is used to heat the reservoir and the nozzle to maintain a prescribed temperature for the nozzle that sprays gas on the specimen and the reservoir of gas raw material.

The display LED lights up while the power is supplied to the gas injector power supply.

10.3.7. Gas Injector Overtemperature Interlock (GAS TEMP) Display LED and Release Switch

When a gas injector overtemperature sensor mounted on the reservoir or the nozzle detects an abnormal temperature, the gas injector overtemperature interlock cuts off the gas injector power supply.

When the interlock is activated, the GAS TEMP INTERLOCK LED lights up and the display LED of Gas Injector Power Supply turns off, even if the GAS TEMP ON/OFF switch is in the ON position.

10.4. Operation Mode Panel



Figure 10-3 Operation Mode Panel

10.4.1. OPERATION Switch

The OPERATION switch used to turn on the SMI2200 PC, and enable the ion source high-voltage power supply and the ion optical system control power supply to be on.

The OPERATION switch functions only if the LINE switch of transformer box and the POWER ON switch of maintenance panel are turned on. When the OPERATION button is pressed, it lights up and the SLEEP switch lamp turns off.

10.4.2. SLEEP Switch

The SLEEP switch is used to cut off power to the PC, ion source high-voltage power supply and the ion optical system control power supply. The vacuum pumps and the gas injector heater continue operating while the SLEEP switch is ON.

The SLEEP switch keeps vacuum evacuation and gas injector temperature regulator functioning during holidays and during the night in order to reduce the rise time of the instrument in everyday operation. When the SLEEP switch button is pressed, the switch lights up, and the OPERATION switch lamp turns off.

10.5. Operation Panel



Figure 10-4 Operation Panel

10.5.1. FOCUS Dial

This dial focuses the observation image.

10.5.2. STIG-X and STIG-Y Dials

These dials are used for stigma correction of the observation image.

10.5.3. MAG Dial

This dial changes the view size (magnification) of the observation image.

10.5.4. BRIGHTNESS Dial

This dial adjusts the brightness of the observation image.

10.5.5. CONTRAST Dial

This dial adjusts the light and shade differences of the observation image.

10.6. Operation PC

The operation PC controls SMI2200 operations, and displays equipment conditions. The PC runs Windows NT® software from Microsoft Corporation.

11. Major Screens

11.1. Basic Screen Structure

The SMI2200 screen consists of the SMI window and an application window.

Note: The different functions are displayed for operator and staff. The functions displayed only for the staff mode is indicated with [Staff]. The functions displayed only when the optional equipment is employed are indicated with [Option].

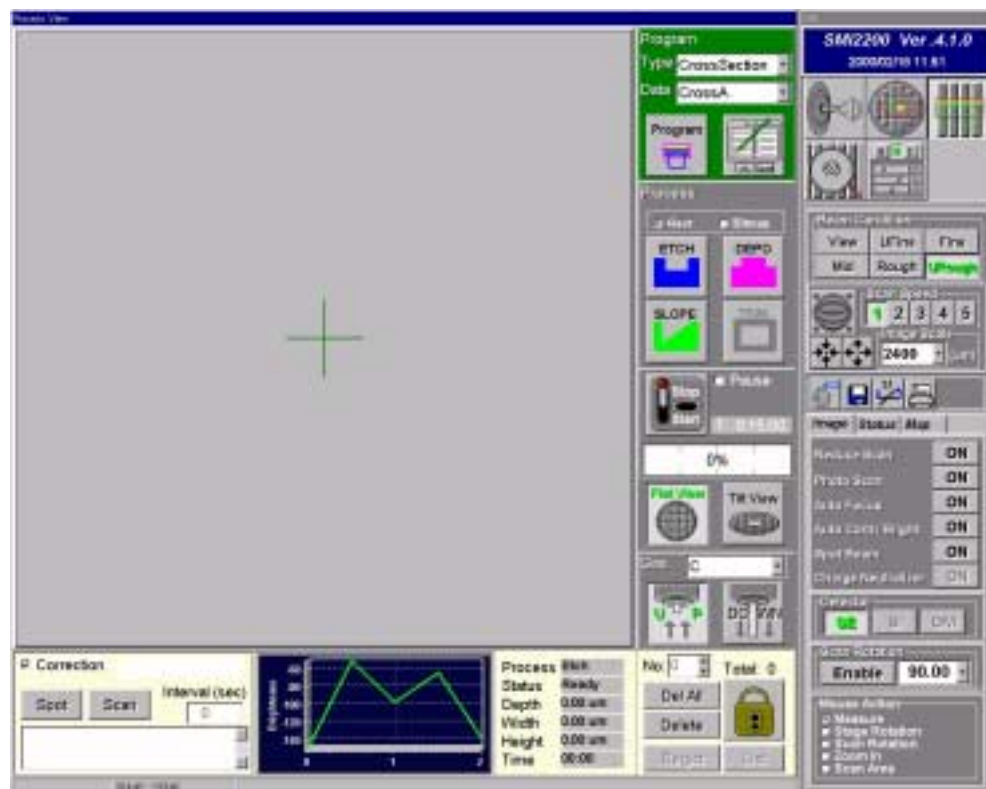


Figure 11-1 Main Screen

11.1.1. SMI Window

The SMI window is the basic operating window for the SMI2200. The SMI window makes it possible to select the appropriate application window that corresponds to application objective. The SMI window includes the operational functions that are common to each application window.

The SMI window is always on screen whether or not the application window changes.

11.1.2. Application Windows

The application window includes the following windows:

11. Major screens

- ① Startup window
- ② Linkage window
- ③ Process View window
- ④ Large View window
- ⑤ Maintenance window

Each application window is selected by operating the SMI window application button.

11.2. Description of Each Window

11.2.1. SMI Window

The SMI window has a title, an application button area, a FIB control button area, a toolbar, and a tab switch area.

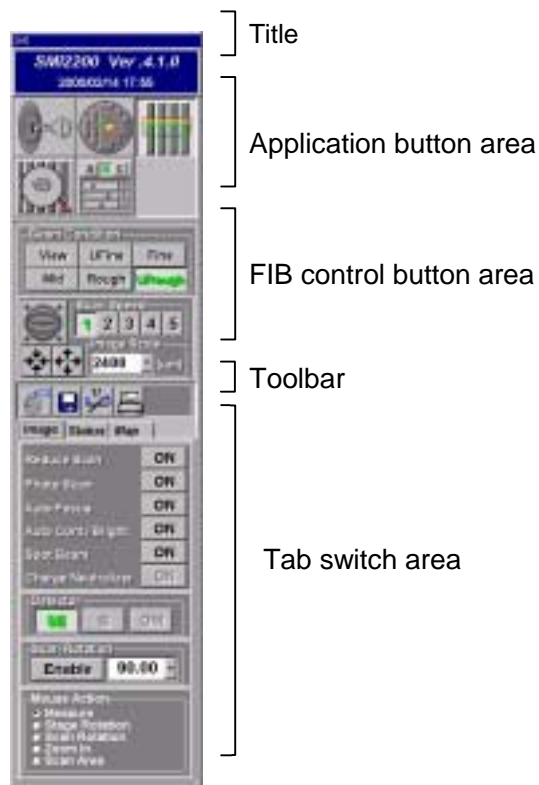


Figure 11-2 SMI Window

11.2.1.1. Title

The product name, software version, and current time are displayed in the title.

11.2.1.2. Application Button Area

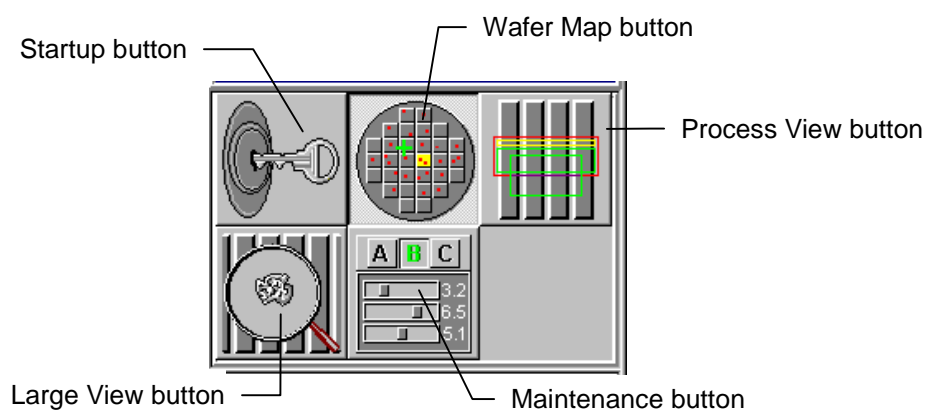


Figure 11-3 Application button area

- (A) Start-up button
This is the button for accessing the Startup window after Login.
- (B) Wafer Map button
This is the button for accessing the Linkage window.
- (C) Process View button
This is the button for accessing the Process View window.
- (D) Large View button
This is the button for accessing the Large View window.
- (E) Maintenance button
This is the button for accessing the Daily Adjust Window.

11.2.1.3.FIB Control Button Area

- (A) Beam Condition Buttons
The beam condition is divided into six stages: View, UFine, Fine, Mid, Rough, and URough. These buttons are used to select the ion beam condition. View has the lowest probe current and the slowest sputter etching, and URough has the highest probe current and the fastest sputtering-etching.

11. Major screens

(B) Scan Button

The scan button is used to start and stop the scanning of the ion beam. While the eye icon is in open status, ion beam is irradiated to the specimen. While it closes, ion beam is not irradiated. While it has an eye bandage, ion beam scan cannot be executed even if the button is clicked.

(C) Scan Speed Buttons

The scan speed buttons are used to select the scanning speed of the ion beam. The Scan Speed buttons are numbered from 1 to 5: 1 being the slowest, and 5 being the fastest.

(D) Image Scale Column

The image scale column displays the view size of each application window (the length of one side of the image display area).

Note: The view size is also changed by turning the MAG dial on the operation panel. The view size set by the MAG dial is displayed as a numerical value in the Image Scale column.

11.2.1.4. Toolbar

The toolbar includes a position Memory button, a Disk button, an Eucentric Calculation button, and a Print button.

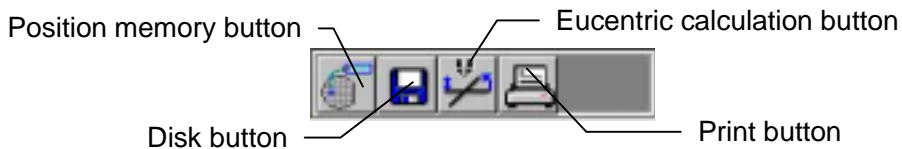


Figure 11-4 Toolbar

(A) The Position Memory Button

The position memory button is the button for accessing the Position Memory subwindow. The position information images displayed in the Position Memory subwindow are used to decide the position on the specimen to be irradiated by the ion beam.



Figure 11-5 Position Memory Subwindow

11. Major screens

(B) Disk Button

The disk button is the button for accessing the Image Index subwindow. The observation image and the observation condition data are saved in the PC's hard disk and the magnetic-optical disk by clicking the Save button in the Image Index subwindow. When the Load button is clicked, the image and the observation condition saved in the hard disk and the magnetic-optical disk are displayed.

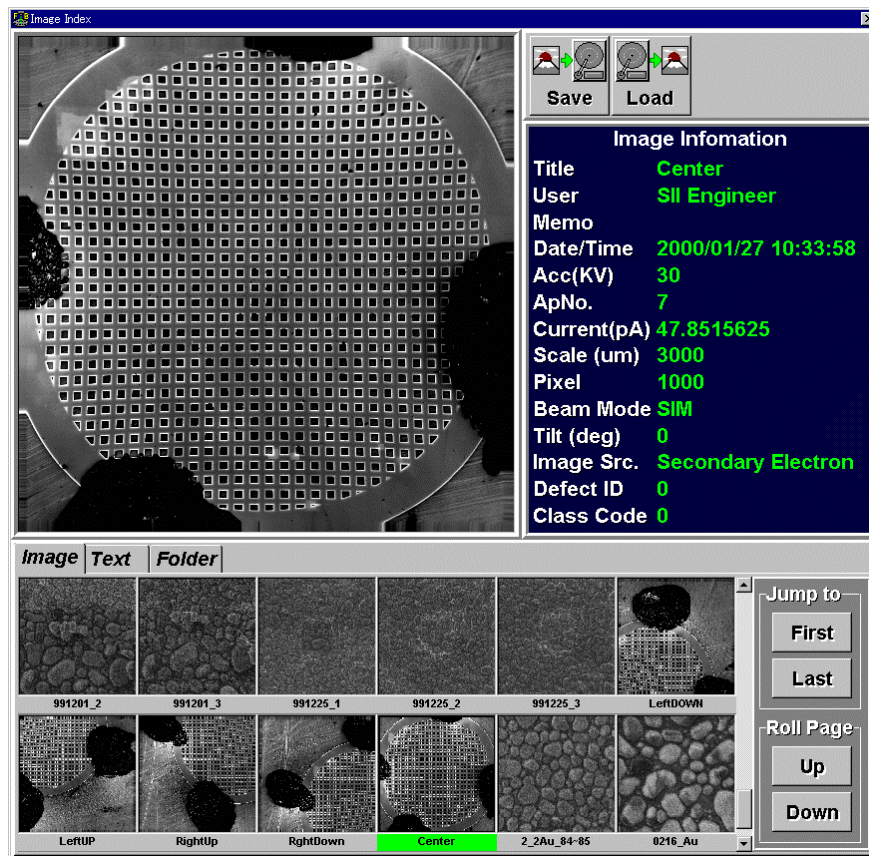


Figure 11-6 Image Index Subwindow

(C) Eucentric Calculation Button

The eucentric calculation button is the button for accessing the Eucentric Calculation subwindow. It moves the specimen stage to the eucentric position, and adjusts the height of the specimen stage.

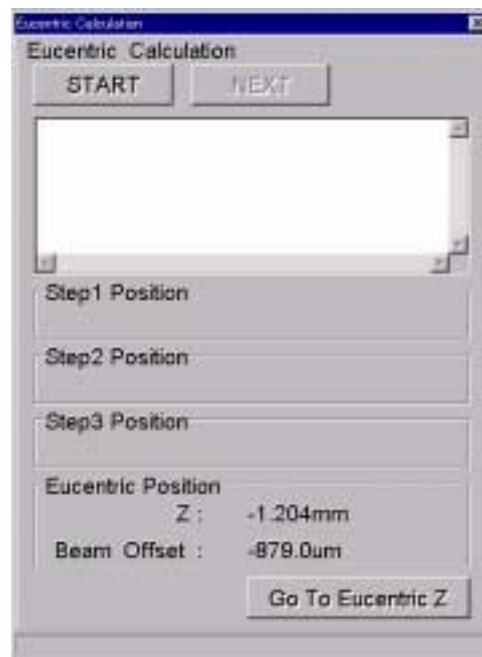


Figure 11-7 Eucentric Calculation Subwindow

(D) Print Button

The print button is the button that accesses the Print subwindow. The image displayed in the CRT is printed.

11. Major screens

11.2.1.5. Tab Switch Area

The Image tab and the Status tab are switched in the tab switch area.

(A) Image Tab

The Image tab controls image display setup and operation.



Figure 11-8 Image Tab

(1) Photo Scan-ON Button

The Photo Scan-ON button is used to display a clear observation image.

(2) Scan Rotation-Enable Button

The Scan Rotation-Enable button controls scanning rotation.

(3) Mouse Action Area

(a) Stage Rotation

Marking the Stage Rotation check box opens the Stage Rotation window.

Dragging the mouse between two points execute the stage rotation until the dragged line becomes level.

The angle of the stage rotation is displayed in the Stage Rotation window.

(b) Scan Rotation

Dragging the mouse between two points on the observation image after marking the Scan Rotation check box executes the scan rotation until the dragged line becomes level.

(B) Status Tab

The status tab displays the operation condition of the equipment, and used for the adjustment operations.



Figure 11-9 Status Tab

(1) Stage Position

The Stage Position displays the specimen stage coordinates.

(2) Stage Ctrl-Open Button

Clicking the Stage Ctrl-Open button opens the Stage Controller subwindow. This subwindow is used to determine the ion beam irradiation position using the wafer map or inputting the coordinates.

(3) Search-Open Button

Clicking the Search-Open button opens the Search subwindow. This subwindow is used to determine the ion beam irradiation position using the X•Y jog button or the search grid.

11. Major screens

11.2.2. Start-up Windows

11.2.2.1. Start-up Window before Login

The Start-up window before Login appears when the SMI2200 software opens,

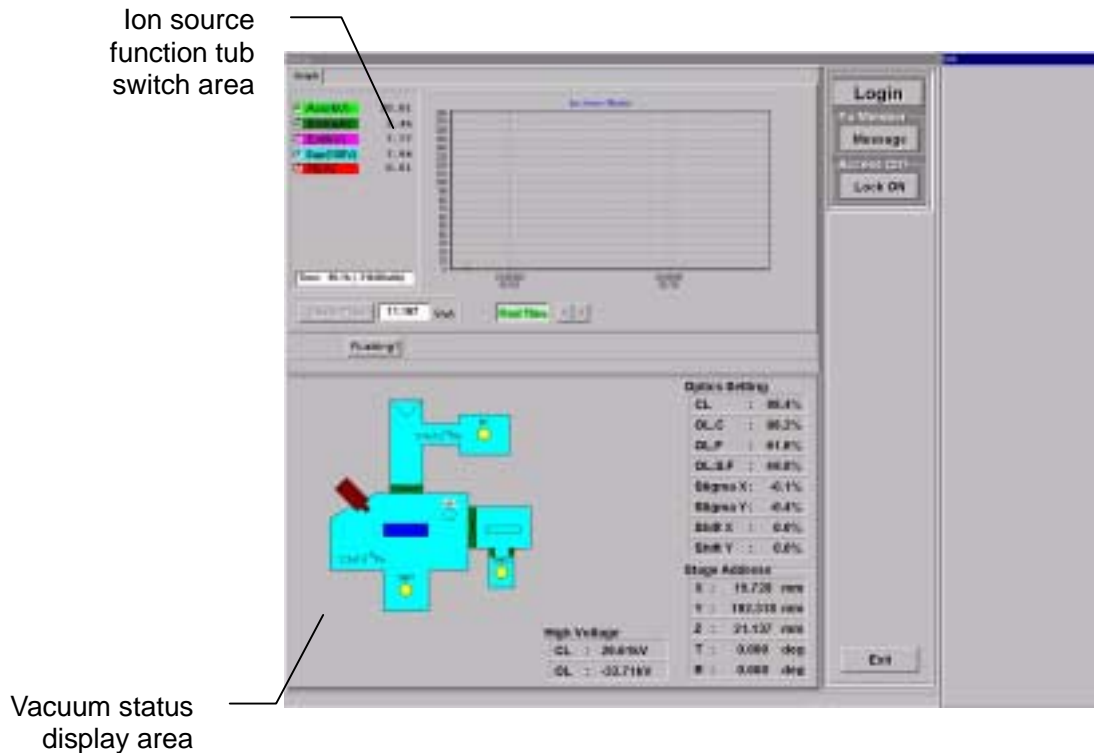


Figure 11-10 Startup Window Before Login

(A) Login Button

The Login button opens the Login Dialog subwindow in which the user's name and the password are entered to use the software. When these items are entered, the Start-up window after Login is displayed.

(B) Exit button

The Exit button closes the Start-up window before Login.

11.2.2.2 Start-up Window after Login

The Start-up window after Login is used to start operating the SMI.

The Start-up window after Login consists of:

- (A) start-up control area,
- (B) ion source function tab switch area, and
- (C) vacuum status display area.

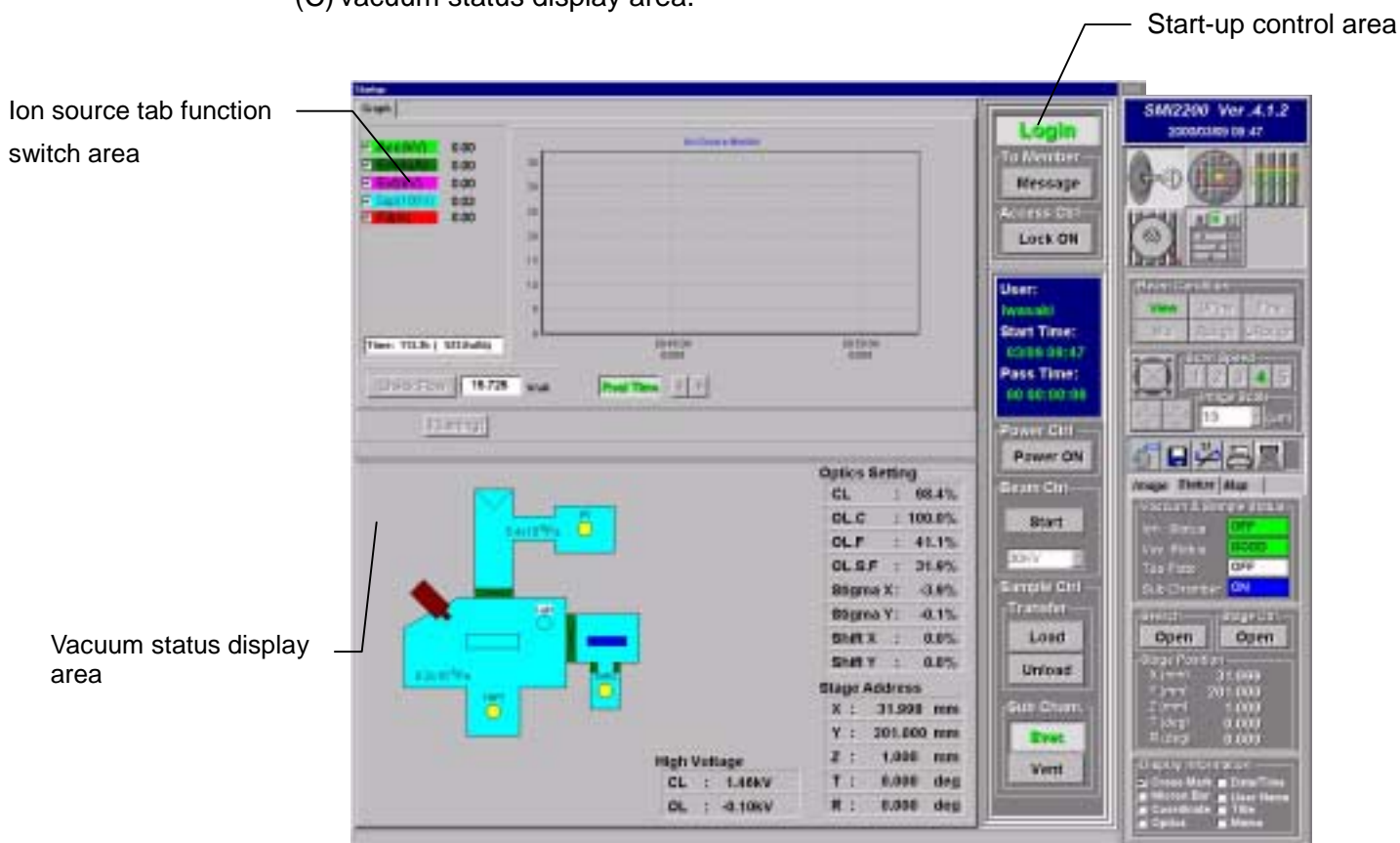


Figure 11-11 Start-up Window after Login

(A) Start-up Control Area

- (1) Power Ctrl—Power ON Button

It is used to startup the ion optical system high-voltage control power supply.

- (2) Beam Ctrl—Start Button

It is used to start and stop ion beam emission.

- (3) Sample Ctrl

- (a) Transfer—Load button /—Unload button

It is used to transfer the specimen between the main chamber and the sub-chamber.

- (b) Sub Cham.—Evac button /—Vent button

It is used to evacuate and ventilate the sub-chamber.

11. Major screens

(B) Ion Source Function Tab Switch Area

(1) Ion Source Monitor

It is used to display the condition of the ion source.

(2) Flushing 1/2 Buttons

It is used to execute flushing of the ion source.

Note: Flushing 2 [Staff]

(3) Heating Button [Staff]

It is used to execute the heating of the ion source.

(C) Vacuum Status Display Area

The vacuum status display area displays the status of the evacuation system, the setting value of the signal applied to each electrode of the ion column, the high voltage monitor value applied to the lens electrode, and the specimen stage coordinates.

11.2.3. Linkage Window

The Linkage Window consists of:

(A) wafer map area,

(B) tab switch area, and

(C) defect list area.

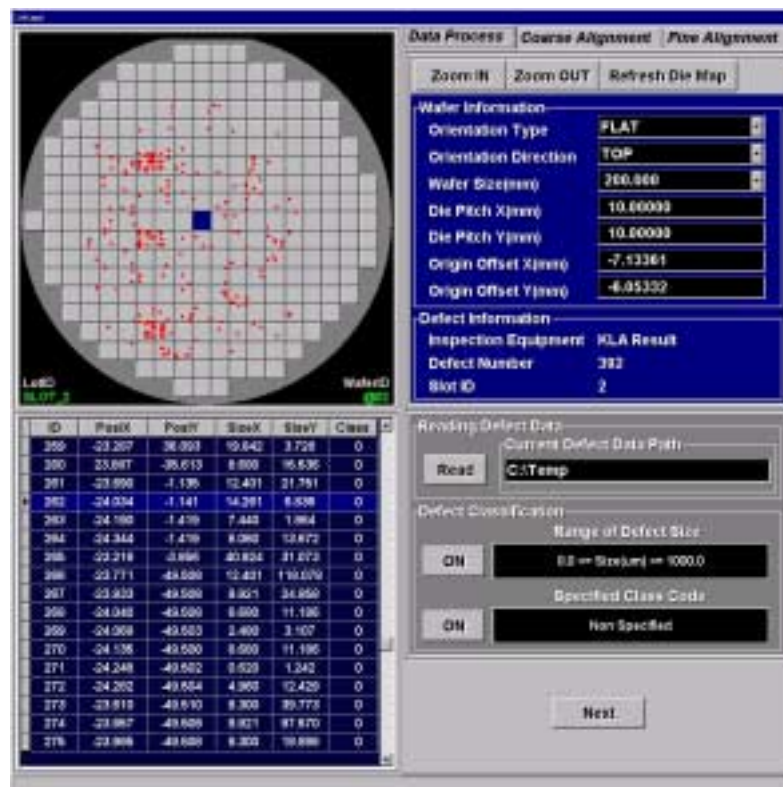


Figure 11-12 Linkage Window

11.2.3.1. Wafer Map Area

The wafer map area displays both the chip arrangement data read from the wafer inspection equipment, and the defect distribution of the defect data on the wafer map, and moves the specimen stage to the display position.

Note: The function of converting the data from the wafer inspection equipment to the data that can be read by this instrument is an optional function. In order to use this function, this option needs to be purchased.

11.2.3.2. Tab Switch Area

The tab switch area reads the data from the wafer inspection equipment, and aligns the inspection equipment data and the actual specimen coordinates.

(A) Data Process Tab

The data process tab reads data from the wafer inspection equipment, and displays the defect distribution on the wafer map.

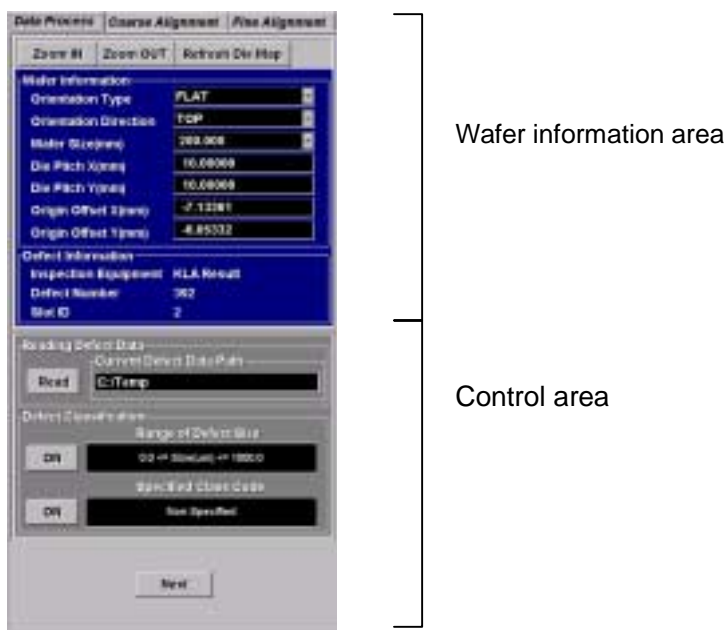


Figure 11-13 Data Process Tab

(1) Reading Defect Data—Read Button [Option]

The Reading Defect Data—Read button loads files from the floppy disk that has recorded the defective data provided by the wafer inspection equipment.

11. Major screens

(B) Coarse Alignment tab

The Coarse Alignment tab detects five (5) positions on the edge of the specimen, then aligns the coordinates of wafer inspection equipment and those of specimen stage of the SMI2200.



Figure 11-14 Coarse Alignment Tab

(1) Image display Area

It displays the observation image of the wafer to be aligned.

(2) Alignment Mode – Auto Button

It is used to select the mode to execute coarse alignment.

(3) Alignment Control – Start Button

It is used to start coarse alignment.

(C) Fine Alignment Tab

The Fine Alignment tab is used to perform alignment using the corner of chips in matrix on the wafer.

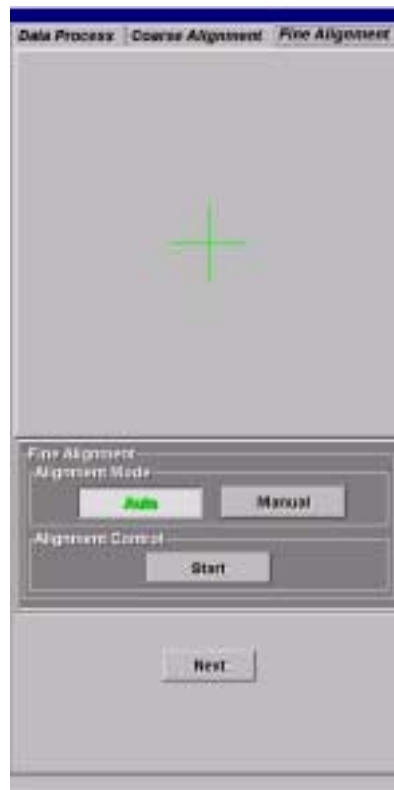


Figure 11-15 Fine Alignment Tab

(1) Alignment Mode – Auto Button

It is used to select the mode executing fine alignment.

(2) Alignment Control – Start Button

It is used to open the Pattern Template window. After registering a new pattern name, fine alignment is executed in the Pattern Template window.

11.2.3.3. Address Defect List Area

The address defect list area displays defective data obtained by the wafer inspection equipment. Clicking an item in the list moves the specimen stage to that defect position.

11. Major screens

11.2.4. Process View Window

The Process View window consists of:

- (A) process control area,
- (B) image display area, and
- (C) process status area.

—

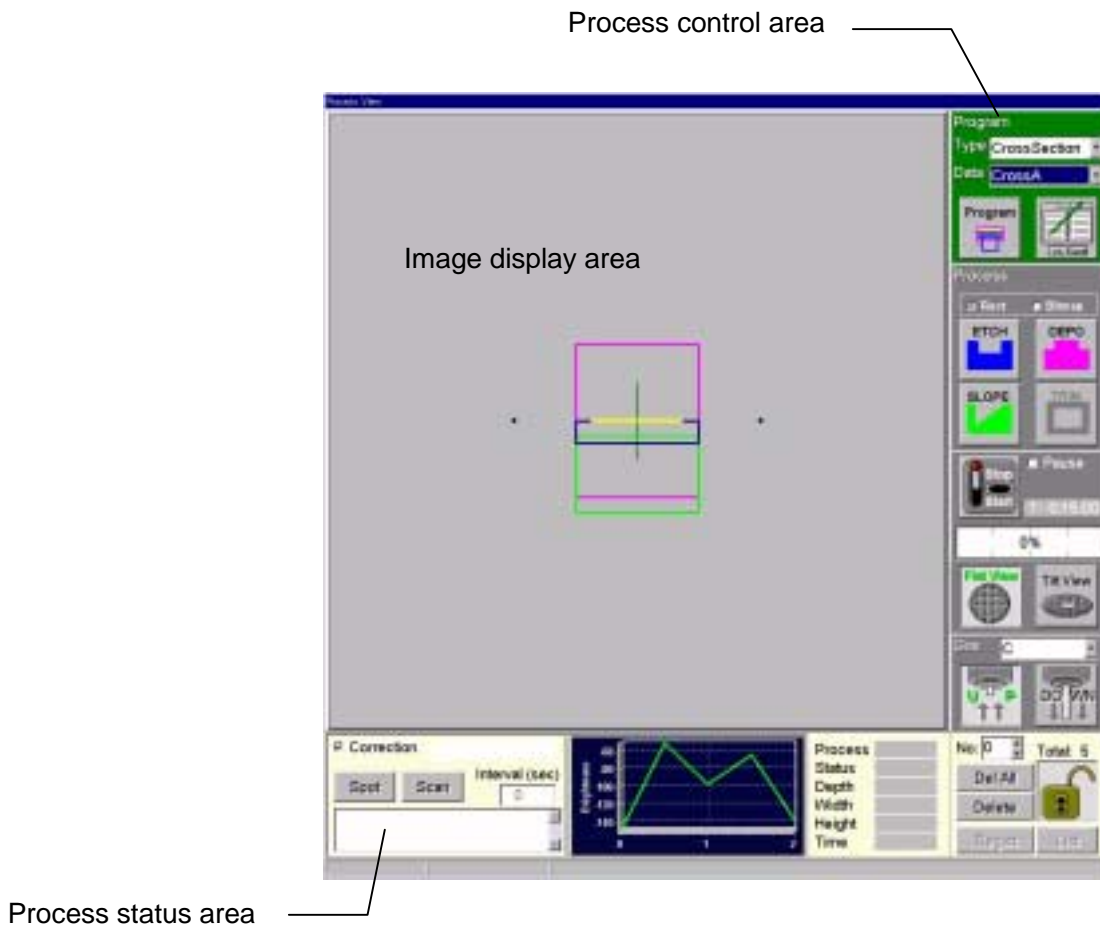


Figure 11-16 Process View Window

11.2.4.1. Process Control Area

The process control area consists of buttons for processing.

(A) Program

(1) Type column

It is used to select the type of program processing.

(2) Data column

It is used to select the program data having the processing conditions corresponding to the program processing type selected in the Type.

(3) Program button

It is used to access the selected program processing data.

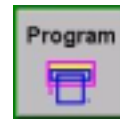


Figure 11-17 Program Button

(4) Program Data Properties Button

The Program Data Properties button is used to open the Program Properties subwindow, in which the processing conditions of the program processing are set and displays.



Figure 11-18 Program Data Properties Button

(B) Process

(1) ETCH button

The ETCH button is used to select the etching processing and displays the etching processing frame (shown in blue).



Figure 11-19 ETCH Button

(2) DEPO Button

The DEPO button is used to select the deposition processing, and displays the deposition-processing frame (shown in pink).



Figure 11-20 DEPO Button

(3) SLOPE Button

The SLOPE button is used to select the slope processing function desired, and displays the slope-processing frame (shown in green).



Figure 11-21 SLOPE Button

(4) Start/Stop Button

The Start/Stop button is used to start and stops processing. Clicking the button starts processing inside the processing frame, and clicking it again during processing stops processing.



Figure 11-22 Start/Stop Button

(5) Bar Graph

The bar graph displays the progress of processing. Once the bar graph reaches 100%, the processing stops automatically.

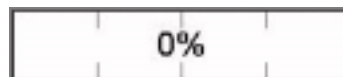


Figure 11-23 Bar Graph

(6) Flat View Button

The Flat View button levels the specimen stage from a tilt position after section observation has been completed.

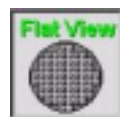


Figure 11-24 Flat View Button

(7) Tilt View Button

The Tilt View button is used to tilt the specimen stage for observing the cross section following cross section processing.



Figure 11-25 Tilt View Button

(8) Gas Injector Nozzle UP Button

The Gas Injector nozzle UP button is used to rise the gas injector nozzle after deposition processing has been completed, and draws the nozzle into the gas injector.



Figure 11-26 Gas Injector Nozzle UP Button

(9) Gas Injector Nozzle DOWN Button

The Gas Injector nozzle DOWN button is used to draw the nozzle from the gas injector prior to deposition processing and lower it near the specimen surface.



Figure 11-27 Gas Injector Nozzle DOWN Button

11.2.4.2. Image Display Area

The image display area displays the image at the location to be processed.

11.2.4.3. Process Status Area

The process status area displays the processing conditions associated with the processing to be executed.

(A) Brightness Display Graph

The Brightness display graph displays the brightness based on the material in the processing frame during sputter etching.

11. Major screens

11.2.5. Large View Window

The Large View Window displays the observation image on the entire application window.

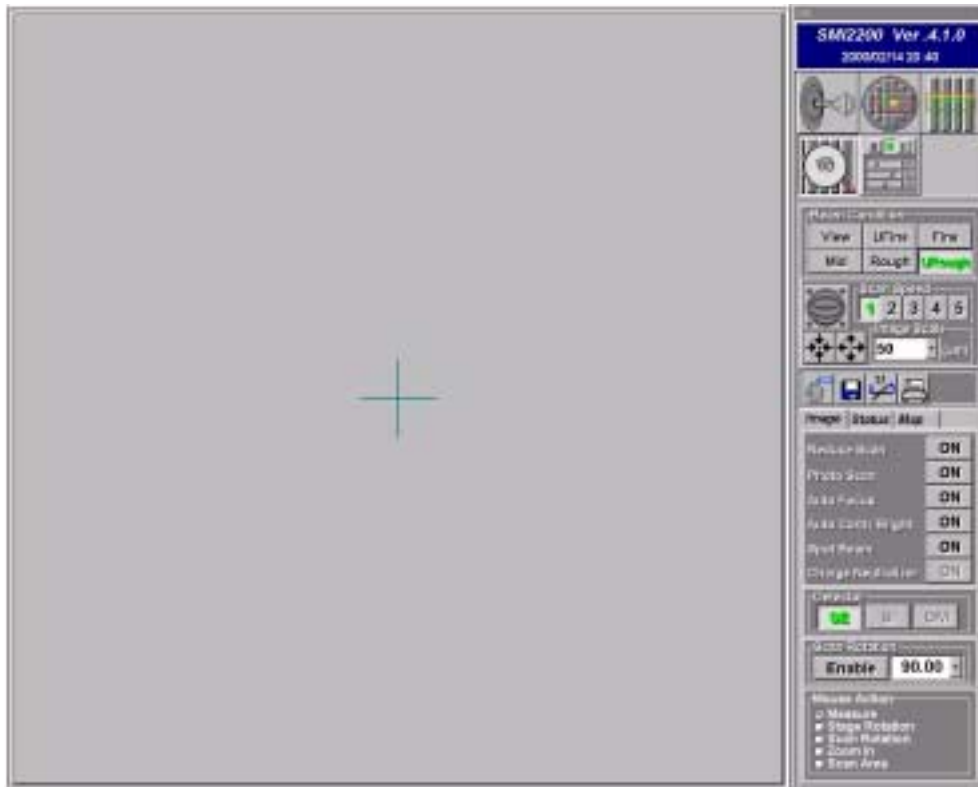


Figure 11-28 Large View Window

11.2.6. Daily Adjust window

The Daily Adjust window is used to adjust the ion beam in daily operation.

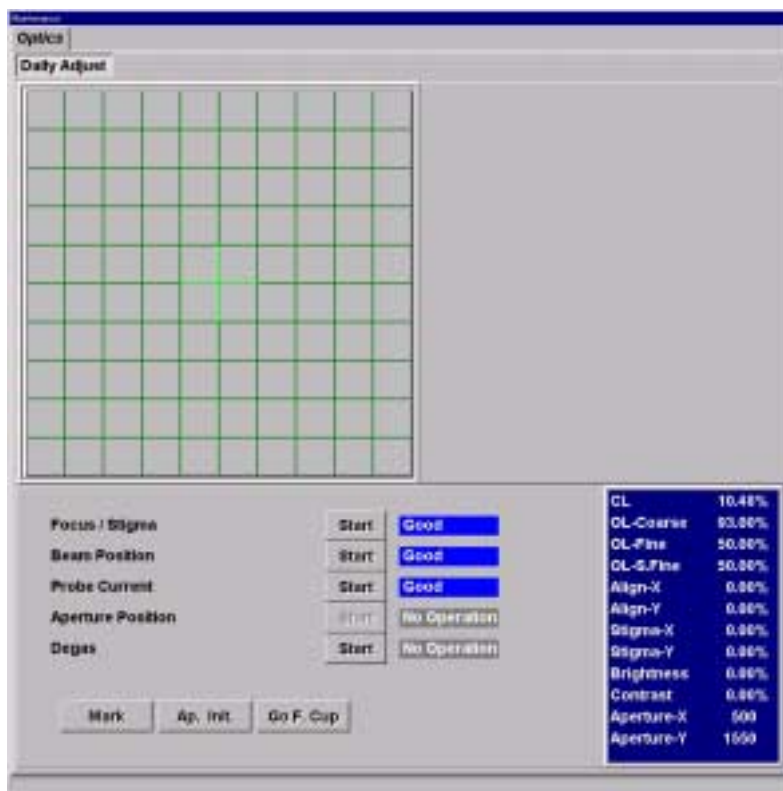


Figure 11-29 Daily Adjust Window

(A) Focus/Stigma— Start

It is used to open the Focus/Stigma tab. The Focus/Stigma tab adjusts the focus of the image to be displayed in the image display area, and performs stigma correction.

Note: Focus control and stigma correction are done by turning the FOCUS dial and STIG-X and STIG-Y dials on the operation panel respectively.

(B) Beam Position— Start

It is used to open the Beam Position tab. The Beam Position tab adjusts six (6) different types of beam conditions of the ion beam so that they irradiate the same location on the specimen. The Beam Position tab also opens automatically when the Focus/Stigma tab completes the processing.

(C) Probe Current— Start

It is used to open the Probe Current tab. The Probe Current tab measures the probe current for each beam condition.

11. Major screens

12. Start-up

Start-up from the complete shutdown must be carried out by Staff.

12.1. Checking Gas Pressure

Check the nitrogen gas regulator pressure gauge in the factory reads within a range of **0,5-0,7MPa**. If the reading is out of the range, turn the regulator knob until the displayed value is within the range described above.

Note: Be sure to perform this inspection everyday before starting up the SMI2200.

12.2. Start-up

12.2.1. Turning On Transformer Box

Turn the **LINE** switch to **ON**. The LINE lamp lights up.



Figure 12-1 Transformer Box

12. Start-up

12.2.2. System Start-up

12.2.2.1. Evacuation Start-up

Press the **POWER ON** switch on the maintenance panel. The POWER LED (green) lights up, and evacuation begins. The transformer box POWER lamp also lights up.

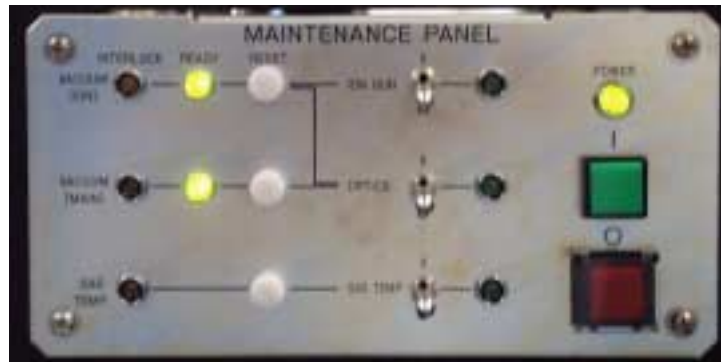


Figure 12-2 Maintenance Panel

12.2.2.2. PC Start-up

- 1) Press the **OPERATION** switch on the operation mode panel under the operation tabletop counter. The PC comes on, and the Windows NT screen and the Start Log-on window appear.



Figure 12-3 Operation Mode Pane

- 2) Press the **Ctrl** key, **Alt** key, and **Delete** key on the keyboard at the same time. The log-on information window appears.
- 3) Press the **Enter** key. The initial screen for Microsoft Windows appears.
- 4) Then SMI2200 software starts and the Startup Window before Login appears.

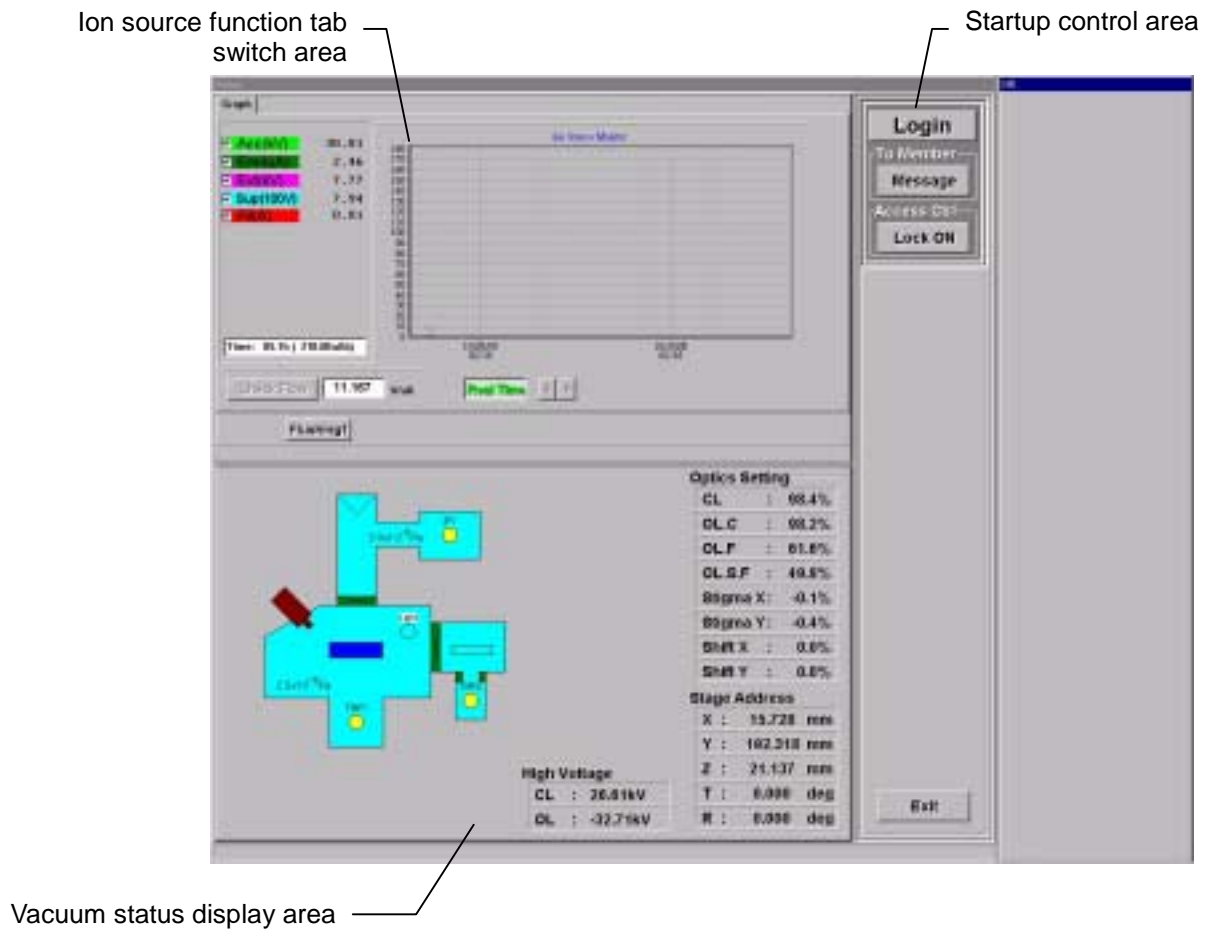


Figure 12-4 Startup Window before Login

12.2.2.3. Releasing Vacuum Interlock

Note: Vacuum interlock can be released after the evacuation of main body is completed. It takes approximately three (3) hours to complete the evacuation after performing the "Start-up evacuation" described in section 12.2.2.1.

- 1) Press the **VACUUM (ION) RESET** switch when the VACUUM (ION) READY LED (green) on the maintenance panel lights up. The VACUUM (ION) INTERLOCK LED turns off, and the vacuum interlock for the ion source chamber releases.
- 2) Press the **VACUUM (MAIN) RESET** switch when VACUUM (MAIN) READY LED (green) on the maintenance panel lights up. The VACUUM (MAIN) INTERLOCK LED turns off, and the vacuum interlock for the main chamber releases.

12. Start-up

12.2.2.4. Turning On Gas Injector Heater, Ion Source High-Voltage Power Supply, and Ion Optical Control Power supply

- 1) Turn on the **GAS TEMP** switch on the maintenance panel. The power supply to the gas injector heater turns on, and the LED (green) located to the right of the switch lights up.
- 2) Turn on the **ION GUN** switch on the maintenance panel. The ion source high-voltage power supply turns on, and the LED (green) located to the right of the switch lights up.
- 3) Turn on the **OPTICS** switch on the maintenance panel. The ion optical system control power supply turns on, and the LED (green) located to the right of the switch lights up.

12.3. Daily Start-up

Note: In everyday use of the SMI2200, the SLEEP switch should be ON without cutting off the main power supply after completing the day's operation because the continuous evacuation is required in order to keep the high vacuum conditions of vacuum chamber. (Refer to section 23.4 for how to turn on the SLEEP switch.)

- 1) Start up the PC following the procedures described in section 12.2.2.2.

Note: If the instrument has been in the SLEEP mode, the vacuum chamber keeps high vacuum degree, and vacuum interlock is not activated. Because of this, the procedures in sections 12.2.2.3 and 12.2.2.4 are not required.

- 2) Check the vacuum degree of ion source chamber displayed in the vacuum status display area of Startup window. In case that the vacuum degree is worse than $1 \times 10^{-5} \text{Pa}$, contact Staff and follow his/her instruction.

13. Login

13.1. Login

- 1) Click the **Login** button in the start-up control area. The Login Dialog subwindow appears, and the names of operators and staff are displayed.
- 2) Select your name from the **Entry User**, and enter the **password** and click the **OK** button. The Start-up window after Login appears.

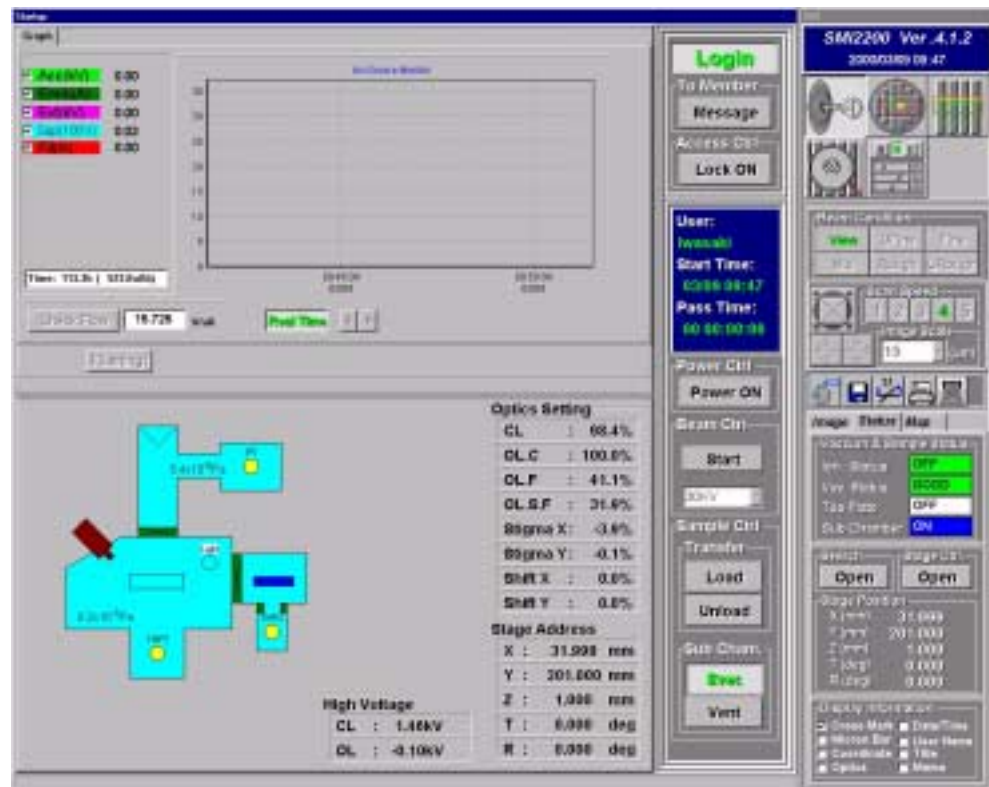


Figure 13-1 Start-up Window After Login

13.2. Ion Beam Emission

- 1) Click the **Beam Ctrl—Start** button. Ions are discharged from the ion source, the ion optical system control high-voltage power supply turns on, and flushing of the ion source takes place automatically. The Start button blinks during this operation. The Start button changes to green when the operation is complete.

Note: Contact the Staff if the Start button continue blinking and does not change to green.

14. Loading Specimen



CAUTION

Do not place your hand in the sub-chamber while parts in the sub-chamber are operating. The moving parts can injure your hand.

Open and close the sub-chamber covers carefully. If the cover drops, it can injure your hand.

Be sure to wear gloves before loading the specimen. The vacuum in the main chamber could be adversely affected from skin oils if the specimen or the specimen holder come into direct contact with the hand.

14.1. Unloading Specimen Holder from Sub-chamber

- 1) Click the **Sub Cham. – Vent** button. The Vent button starts blinking in green. When the correct atmospheric pressure in the sub-chamber is reached, the Vent button stops blinking, and the button lights up in green.
- 2) Open the sub-chamber cover by hand, and unload the specimen holder.



Figure 14-1 Sub-chamber with Cover Opened

14.2. Setting Specimen on Specimen Holder

- 1) Press the knob on the back of the specimen holder with your finger continuously, move the lock nail on the specimen holder outward, and set the semiconductor wafer on the specimen holder.



Figure 14-2 Back of Specimen Holder

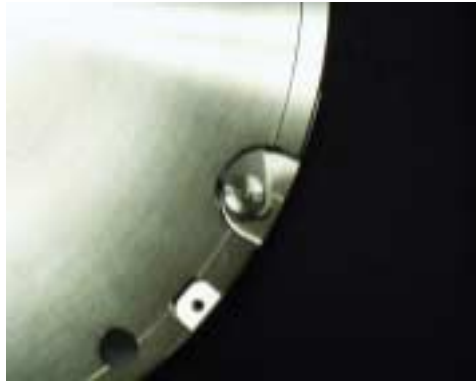


Figure 14-3 Specimen Holder Lock Nail

- 2) Release your finger from the back of the knob. The lock nail moves inward to secure the wafer on the specimen holder.

Note 1): If you use a specimen other than wafers (e.g. a chip of wafer or a specimen for TEM), be sure to buy and use a dedicated holder suitable for the specimen. Never use such specimen being fixed with conductive tape to unsuitable holder. It may fall from the holder during processing and brake the instrument.

A universal holder for a wafer chip and a TEM holder for a TEM specimen are available as a dedicated holder. Contact SII sales personnel for these holders.

Note 2): If you use a dedicated specimen holder, be sure to read its instruction manual provided separately. After attaching specimen to the holder, check that the specimen height is in the allowable range using the accompanying height-confirmation jig. Check the height as follows.

a) Put the specimen holder and height-confirmation jig on a level table.

b) Pass through the height-confirmation jig above the specimen holder. If the specimen does not contact the jig, the height of specimen is in the allowable range. If it hits the jig, the thickness of specimen exceeds the allowable range. Such specimen cannot pass through the gate valve between the main chamber and sub-chamber. Never use a specimen exceeding the allowable range.

Note 3): Even if the height of all specimens attached to the specimen holder is in the allowable range, make sure that the difference between the height is within $\pm 0.5\text{mm}$. If it is larger than $\pm 0.5\text{mm}$, remove a specimen (or some specimens) from the specimen holder so as to make the difference is in $\pm 0.5\text{mm}$. (In such cases, do not set all specimens at a time but carry out the operation separately.)

14.3. Loading Specimen Holder to Sub-chamber

- 1) Set the specimen holder in the sub-chamber while hanging the hook located on the back of the specimen holder on the pin of the transfer arm tip in the sub-chamber.



Figure 14-4 Transfer Arm Pin

- 2) Close the sub-chamber cover with your hand.

14.4. Transferring Specimen to Main Chamber

- 1) Click the **Transfer-Load** button. The Load button and Evac button start blinking in green. While blinking, evacuation of the sub-chamber takes place. When the vacuum degree in the sub-chamber reaches the prescribed value, the specimen is transferred to the main chamber. The Evac button stops blinking once the vacuum degree in the sub-chamber reaches the prescribed value, and the button lights up in green. The Load button stops blinking when the transfer of the specimen to the main chamber is completed, and the button changes to black. The transfer of the specimen from the sub-chamber to the main chamber can be checked by animation found in the vacuum status display area.

14. Loading Specimen

15. Beam Adjustment

15.1. Displaying Image

- 1) Click the **Maintenance** button in the application button area.
- 2) Click the **Optics Tab - Daily Adjust** button. Daily Adjust window appears.

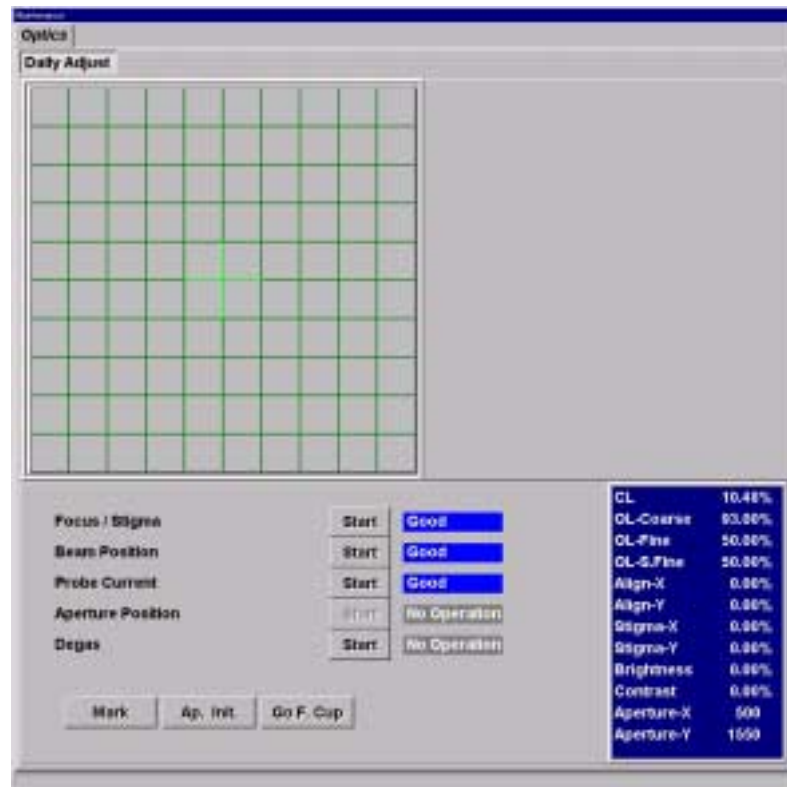


Figure 15-1 Daily Adjust Window

- 3) Click the **Go F. Cup** button. The specimen stage moves to the position from which the Faraday cup can be observed.
- 4) Click the **Scan** button in the FIB control button area. The Scan button icon changes in open eye status, the ion beam starts scanning, and the image appears in the image display area.
Note: If you want to change the scanning speed of the ion beam, click one of the numeric values, 1-5, in the FIB control button area, and choose the optimal speed that you want to switch to.

15. Beam Adjustment

5) Turn the **MAG** dial on the operation panel to display the entire image of the Faraday cup.



Figure 15-2 Operation Panel

6) Adjust the **BRIGHTNESS** dial and the **CONTRAST** dial on the operation panel to achieve the proper brightness if the image is too dark or too bright.

15.2. Specimen Stage Height Positioning

- 1) Click the **Focus/Stigma—Start** button in the Daily Adjust window. The Focus/Stigma tab and Eucentric Calculation Subwindow appear.



Figure 15-3 Focus/Stigma Tab

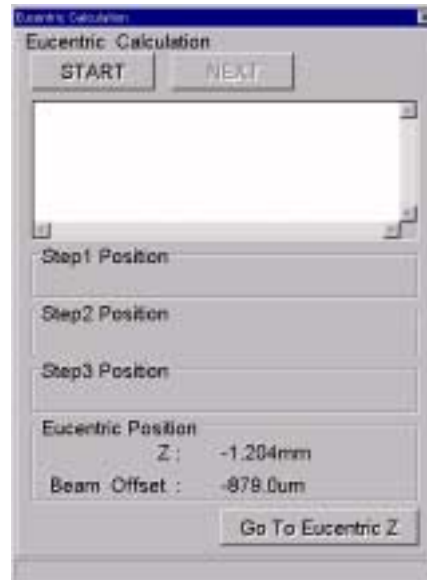


Figure 15-4 Eucentric Calculation Subwindow

- 2) Move the cursor to a location other than the hole of the Faraday cup, and double-click. This area will then move to the center of the screen.
 - Note 1): At this time select a location that will serve as a mark. It will make the following operation easier. If you cannot find any location that will serve as a mark, click the Focus/Stigma-Start button to stop the operation, and then click the Mark button. The hole is marked at the center of current screen. When the marking complete, the word "Mark" changes from green to black. To restart the operation, click Focus/Stigma-Start button again.
 - Note 2): Carry out the specimen stage height positioning again when it moves to the actual sample. If not, bad focusing may cause not only bad processing but also unexpected trouble such as hitting the tip of gas injector nozzle to the sample.

15. Beam Adjustment

- 3) Click the **START** button in the Eucentric Calculation subwindow. The START button changes to green, and the Eucentric Calculation subwindow displays the message, "Make sure that the stage tilt is 0, and click the mouse on the target position."
- 4) Click the same location clicked in step (2), and then click the **NEXT** button. The specimen stage tilts to 30°.
- 5) When the image stops moving, click the same place clicked in step (2) and click the **NEXT** button. The specimen stage tilts to 60°.
- 6) When the image stops moving, click the same place clicked in step (2), and click the **NEXT** button. The specimen stage returns to 0°.
- 7) Click the **Go To Eucentric Z** button. The specimen stage moves to the coordinates displayed in the **Eucentric Position Z** column.
- 8) Click the **Close** button in the upper right hand of the Eucentric Calculation subwindow.

15.3. Focus Adjustment and Stigma Correction

- 1) The beam condition **View** in the Focus/Stigma window is displayed in green. (If you have not marked the **View Adjust** check box in the Setting subwindow of Base Adjust tab, the beam condition starts from UFine. In this case, the beam condition **UFine** is displayed in green.)
- 2) Turn the **MAG** dial on the operation panel, and set the Image Scale numerical value in the FIB control button area to 25µm. Click **3** on the Scan Speed button.
- 3) Turn the **FOCUS** dial on the operation panel while watching the image in the image display area to focus the image. This is a focus adjustment.
- 4) Turn and adjust the **STIG-X** and **STIG-Y** dials on the operation panel when focusing does not work using the **FOCUS** dial. This is a stigma correction.
- 5) Click the **Next** button. This saves the degree of focus adjustment and stigma correction. The word "UFine" changes to green after the message "Beam Condition is changing" appears to the right of the beam condition.
- 6) For the beam condition, repeat the procedures outlined in steps (3) through (5) in the following order: UFine→Fine→Mid→Rough→URough.
- 7) Click the **Next** button when the focus adjustment and stigma correction of URough are complete. The Beam Position tab appears, and the View is displayed in green.

Note: Clicking the Abort button stops the operation, and the beam condition adjustment data is not saved. When starting the operation over, go back to step (1) and start again. When the Prev. button is clicked the beam condition returns to the previous condition. (Example: When the Prev button is clicked with the beam condition in Mid, it returns to Fine, and the beam condition adjustment data of Mid is lost.)

15.4. Adjustment of Beam Position

- 1) Select a location that will serve as a mark on the image in the image display area in the Daily Adjust window, and click that location. The clicked position moves to the center of the screen.
Note: Click the **Mark** button if you cannot find any location that will serve as a mark. This marks a hole that will become the beam position mark in the center of the current screen. When marking is complete, the color of the word "Mark" will change from green to black.
- 2) Click the Beam Position - Start button. The Beam Position tab appears.
- 3) Click the mark and then **Next** button. This saves the amount of beam position adjustment. The beam condition UFine change to green after the message "Beam Condition is changing" appears. (If you do not check the View Adjust in the Setting subwindow of Base Adjust tab, the beam condition starts from UFine. In this case, the beam condition Fine is displayed in green.)
- 4) Click the displayed mark with respect to UFine. The marked position moves to the center of the screen.
- 5) Repeat steps 3) and 4), and adjust the beam position in the following order, Fine→Mid→Rough→URough, for each beam condition.
- 6) Click the **Next** button when the URough beam position adjustment is complete. The Beam Position tab closes.
Note: Clicking the **Abort** button stops the operation, and the beam condition adjustment data is not saved. When starting the operation over, go back to step (1) and start again. When the **Prev.** button is clicked the beam condition returns to the previous condition. (Example: When the Prev button is clicked with the beam condition in Mid, it returns to Fine, and the beam condition adjustment data of Mid is lost.)

15.5. Probe Current Measurement

- 1) Click the **Probe Current – Start** button. The Probe Current tab appears. The specimen stage moves, and the Faraday cup appears in the image display area.



Figure 15-5 Probe Current Tab

- 2) Click the **Probe Measure** button. The button changes to green.
- 3) Click the hole in the Faraday cup. The values appear in Preset and Now. The value in Preset shows the previous setting of the probe current, and Now shows the probe current that is presently being measured.
- 4) Click the **Next** button. The value in Now overwrites the Preset condition. Also the beam condition changes from View to UFine.

Note: Click the **Abort** button if you do not want to overwrite. If you do not check the View Adjust in the Setting subwindow of Base Adjust tab, the measurement starts from UFine

- 5) Repeat the procedures in steps 3) and 4) in the following order, UFine→Fine→Mid→Rough→URough, for the beam condition.
- 6) Click the **Next** button when you reach URough. The Probe Current tab closes.

Note: If the value in Now is large compared to the value in Preset, the warning message appears. Call the Staff and follow the troubleshooting.

16. Degassing

Caution

Be sure to execute degassing before using gas injector. Once a day is sufficient. If gas is discharged without degassing, the vacuum degree in the main chamber decreases, and the optical system power supply may shut down.

- 1) Click the **Degas-Start** button. The button changes to green and degassing starts.
- 2) When the button turns black, degassing has finished.

17. Specimen Positioning

There are five (5) methods listed below for deciding the ion beam irradiation position of the specimen.

(1) Using Stage Controller subwindow

This method is used when the ion beam irradiation position is clear.

(2) Using Position Memory subwindow

This method is used when the position information image has already been recorded.

(3) Using Search subwindow

This method is used when searching for the location that the ion beam irradiates while observing the actual specimen image.

(4) Using Wafer Map

This method is used when using the ion beam to irradiate the intended chip, and the position of the chip or die on the wafer is already known.

(5) Using Linkage Function [Option]

This method is used when using the ion beam to irradiate a defect or a foreign object on the wafer detected in another wafer inspection equipment.

In methods (1) and (3), it is necessary to perform accurate positioning of the image in the image display area, after determining the specimen position.

In methods (4) and (5), it is necessary to perform focusing, stigma correction, and specimen height positioning by loading the specimen beforehand.

17.1. Using Stage Controller Subwindow

- 1) Click the **Beam Condition—View** button in the FIB control button area. The View button changes to green.
- 2) Click the **Large View** button in the application button area. The Large View window appears.

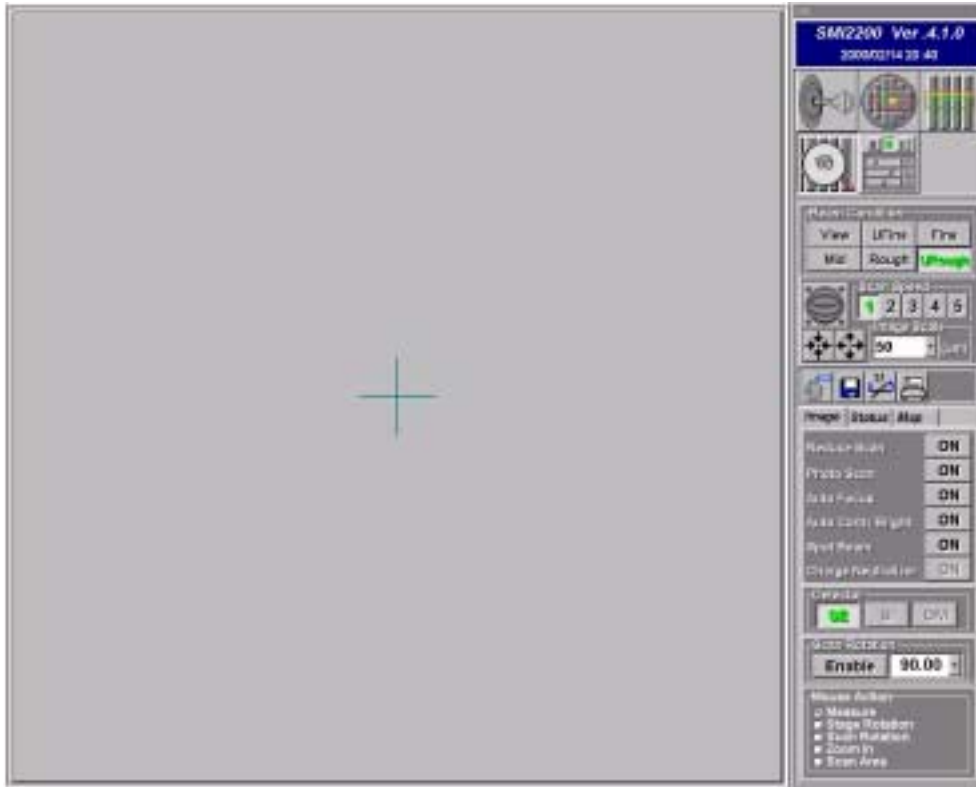


Figure 17-1 Large View Window

- 3) Select the Status tab in the tab switch area to display the SMI window Status tab, then click the **Stage Ctrl—Open** button. The Stage Controller subwindow appears.



Figure 17-2 SMI Window Status Tab

- 4) Move the cursor to the irradiation position in the wafer map area in the Stage Controller subwindow, and click. The specimen stage moves in the direction of X-Y to make the ion beam irradiate that position. While the stage is moving, the background of X (mm) and Y (mm) coordinates changes to green, and the values change. When the movement is complete, the coordinate values appear in white.



Figure 17-3 Stage Controller subwindow

- 5) Click the **Scan** button in the FIB control button area. The Scan button changes in open eye status, and the image appears in the image display area.

17.2. Using Position Memory Subwindow

- 1) Click the **Beam Condition—View** button in the FIB control button area. The View button changes to green.
- 2) Click the **position memory** button on the toolbar. The Position Memory subwindow opens and displays the position information images already been recorded.

Note: Change the beam condition from View to UFine or Fine if the contrast of the displayed images is low.

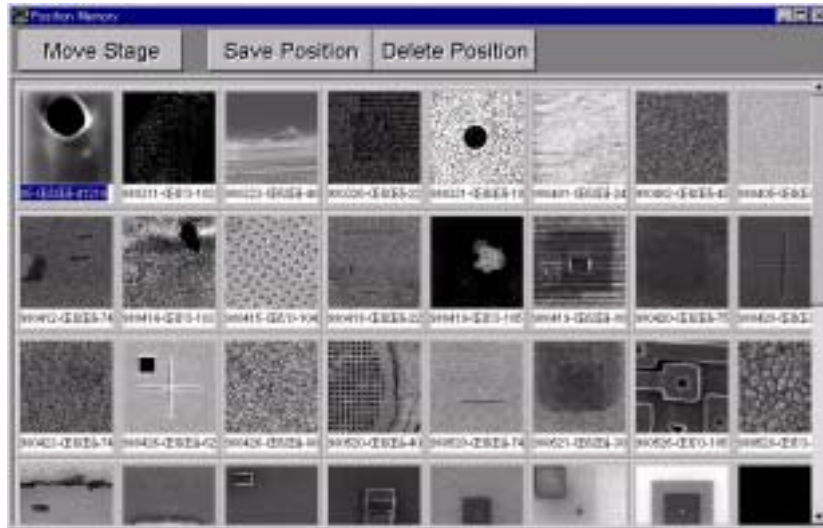


Figure 17-4 Position Memory Subwindow

- 3) Select the corresponding image from the position information images, and double-click. The specimen stage moves to the position coordinates recorded on the image.
- 4) Click the **Close** button in the Position Memory subwindow.
- 5) Click the **Scan** button in the FIB control button area. The Scan button changes in open eye status, and the image appears in the image display area.

17.3. Using Search subwindow

- 1) Click the **Beam Condition—View** button in the FIB control button area. The View button changes to green.
- 2) Click the **Large View** button in the application button area. The Large View window appears.
- 3) Click the Status tab in the tab switch area to display the SMI windows Status tab, and then click the **Search—Open** button. The Search subwindow appears.

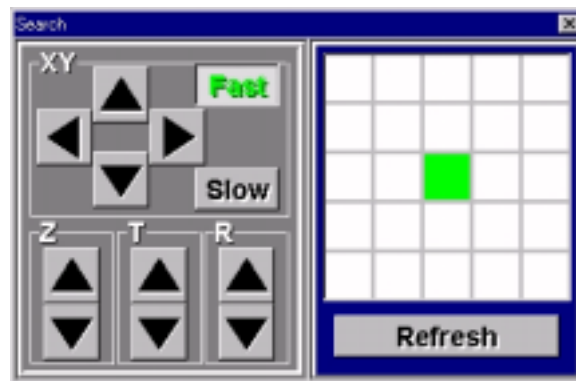


Figure 17-5 Search Subwindow

- 4) Click the **Scan** button in the FIB control button area. The Scan button changes in open eye status, and the image appears in the image display area.
- 5) Click the **XY jog** buttons in the Search subwindow until the image reaches the irradiation position. The specimen stage moves each time that the button is clicked.
 Note: The specimen stage moves at a high speed while the Fast button at the upper right of the XY jog button lights up.
- 6) Click the **grid** at the irradiation position if you use the search grid in the Search subwindow. The specimen stage moves to this position and the clicked grid lights in green.
 Note: For each movement of the grid, the specimen stage moves only the distance indicated in the Image Scale in the FIB control area.
- 7) Click the **Refresh** button in the Search subwindow. The clicked grid moves to the center of the search grid.
- 8) Click the **Close** button on the upper right of the Search subwindow.

17.4. Adjusting Specimen Height Position

- 1) Click the **Eucentric Calculation** button on the toolbar after deciding on a specimen position using one of the methods described in sections 17.1 through 17.3. The Eucentric Calculation subwindow appears. Then carry out steps (4) through (9) in section 15.2 to adjust the position of the specimen height.

17.5. Determining Specimen Position

- 1) Point the hand-shaped cursor with the irradiation position of displayed image, and double-click. The specimen stage moves to that position, and the irradiation position moves to the center of the screen.
- 2) Turn the **MAG** dial on the operation panel to reduce the view size of the image.
- 3) Perform step (1) on the magnified image again, then determine the correct position.

17.6. Using Wafer Map

The following conditions are necessary to determine the specimen position using the wafer map.

- ① The specimen has been loaded into the main chamber.
- ② Focusing of the image, stigma correction, and positioning the height of the specimen have been completed, and
- ③ The wafer die pitch is already known.

- 1) Click the **Wafer Map** button in the application button area. The Linkage window appears.

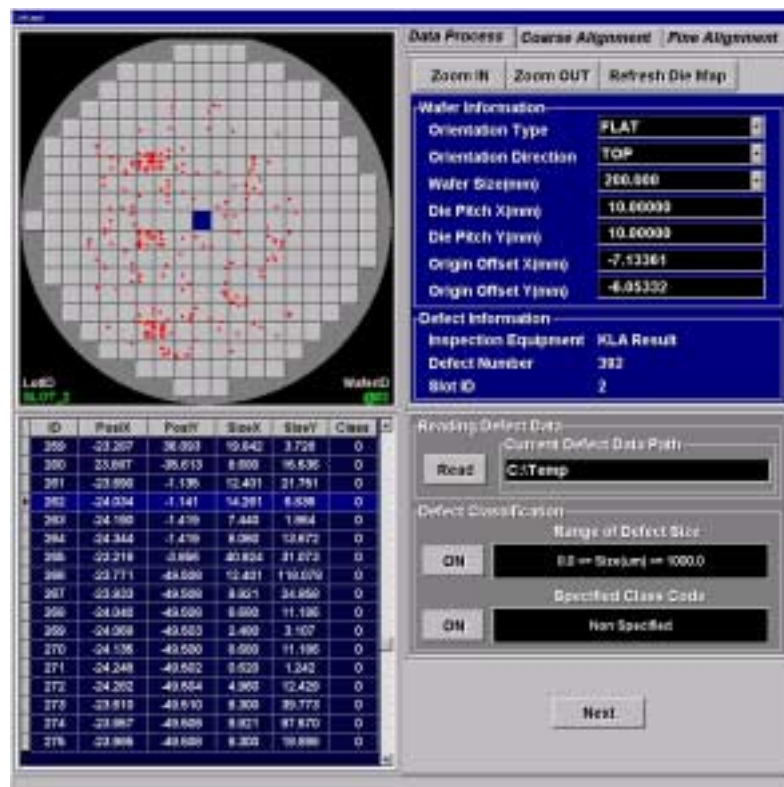


Figure 17-6 Linkage Window

- 2) Click the **Refresh Die Map** button. It clears the defect data red points that were used previously from the wafer map.

- 3) Enter the observation data of the wafer to be observed into each column of Wafer Information area in the Data Process tab. There are the columns of Orientation Type, Orientation Direction, Wafer Size, Die Pitch X (mm), and Die Pitch Y (mm).
- 4) Click the **Next** button. The Linkage window Coarse Alignment tab appears.



Figure 17-7 Coarse Alignment Tab

- 5) Click the **Auto** button in the control area, and then click the **Start** button. Confirmation of the five points along the wafer periphery begins. The Start button is displayed in green during confirmation, and the images of the five (5) positions appear in the image display area one by one. The Start button turns black when the position confirmation is complete.
- 6) Click the **Next** button. The Fine Alignment tab appears.

17. Specimen Positioning

- 7) Click the **Auto** button and then the **Start** button. The selection dialog for the standard template observation image appears.

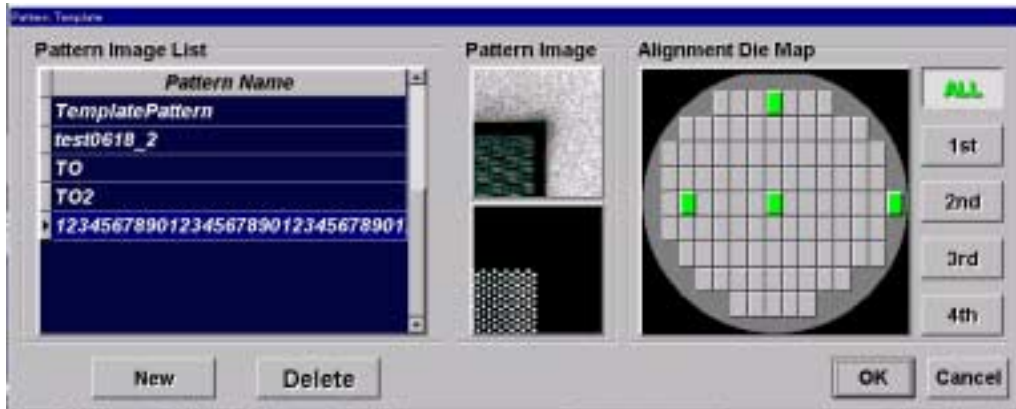


Figure 17-8 Selection Dialog for Standard Template Observation Image

- 8) Click the **New** button. The Input Dialog subwindow appears.

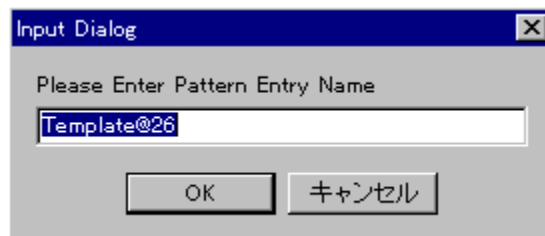


Figure 17-9 Input Dialog Subwindow

- 9) Enter the pattern name (40 characters or less) into the Please Enter Pattern Entry Name column.
- 10) Click the **OK** button. The pattern name is registered, and the Input Dialog subwindow closes. When the OK button is clicked, the specimen stage automatically moves to the origin of first chip that was saved in template (displayed in yellow in the wafer map area), and the image at the original position appears in the image display area.
- 11) Turn the **MAG** dial display on the operation panel, and set the value of the Image Scale column in the FIB control button area to 1500 μ m.
- 12) Look at the image at the origin of the chip. If it is not suitable as the point of origin, move it to another chip by following the procedures described below.
 - a) Click the right button of the mouse on a certain position in the wafer map area. The pull-

down menu appears.

- b) Point the cursor at **Move To**, and then click the **Die Reference**. The cursor shape in the wafer map area changes to a square.
- c) Move the square cursor to another chip that will serve as the new origin, and click. The specimen stage moves, and the image of that chip is displayed in the screen.
- 13) Point the hand cursor on the origin of image displayed in the image display area, and double-click. The origin position moves to the center of the screen.
- 14) Click the **Start** button in the control area. This saves the image at the origin.
- 15) Set the value for the Image Scale column in the FIB control button area to 150 μ m by using the **MAG** dial on the operation panel.
- 16) Click the **Start** button again. This saves the magnified image.
- 17) When the message "Get Die Reference 1" appears at the very bottom of the Linkage window, click the **Start** button again. This aligns the coordinates of first chip origin saved in the template and the actual specimen's current chip origin.
- 18) The message changes to "Get Die Reference 2" when the coordinate alignment is complete, and the specimen stage moves to the second chip origin in the template.
Confirm that the value in the Image Scale column is 150 μ m, perform step (14), and move the origin of the second chip to the center of the screen.
- 19) Click the **Start** button to perform coordinate alignment for the second chip origin.
- 20) Hereafter, perform coordinate alignment of the origin for the third and the fourth chips of the template. This will complete coordinate alignment of the wafer map data and the current specimen.
- 21) Click the right button of the mouse at a certain position in the wafer map area. The pull-down menu appears.
- 22) Point the cursor on **Move To**, and then click the **Die reference** on the newly appeared pull down menu. The cursor shape in the wafer map area changes to a square.
- 23) Point the cursor on the desired chip, and click. The specimen stage will move.

17.7. Using Linkage [Option]

The following conditions are necessary to determine the specimen position using the linkage.

- ① The specimen has been loaded into the main chamber. and
- ② Focusing of the image, stigma correction, and positioning of the specimen height have been completed.

- 1) Click the **Wafer Map** button in the application button area. The Linkage window appears.
- 2) Insert the data floppy disk into the floppy disk drive in the PC.

- 3) Click the **Read** button in the coordinates defect list area. The Select Defect Data Path subwindow appears.

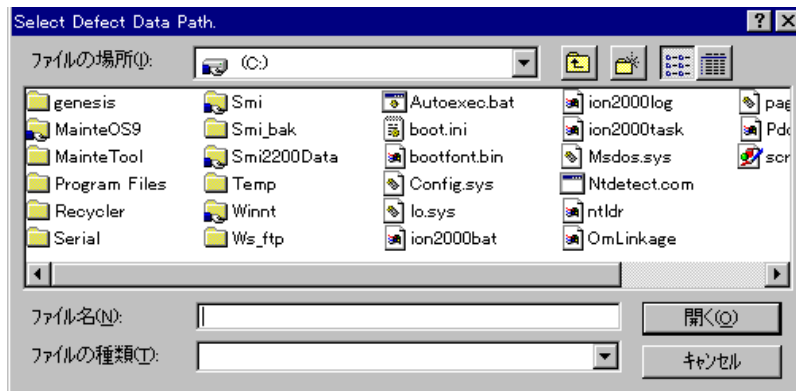


Figure 17-10 Select Defect Data Path Subwindow

- 4) Click ▼ in the file location column, and select the A drive (3.5-inch FD). The file list appears.
- 5) Select the file for the specimen loaded in the main chamber and click the **Open** button. The message "Covering..... Please Wait" and the bar chart appears. When the bar chart reaches 100%, the defect locations are displayed in red dots on the wafer in the wafer map area.



Figure 17-11 Wafer Map

- 6) Hereafter, follow the procedures described in steps (4) through (19) in section 17.6 "Using Wafer Map."
- 7) Hereafter, perform the coordinate alignment for the origin of third and the fourth chips in the template. This will complete coordinate alignment of the floppy disk data and the current specimen.
- 8) Click a defect number from the coordinate defect list area in the Linkage window, or click the red dot on the wafer map. The specimen stage moves to the defect coordinates, and this determines the specimen position.
- 9) Click the **Scan** button in the FIB control button area. The image appears in the image display area.

18. Image Observation

Observation of the microscope image by FIB (Focused Ion Beam) is performed after the specimen position described in sections 15 through 17 is determined, and each adjustment is completed.

18.1. Displaying Image

- 1) Click the **Large View** button in the application button area. The Large View window appears.
- 2) Click the **Beam Condition-View** button in the FIB control button area. The View button changes to green.
- 3) Click the **Scan** button in the FIB control button area. The Scan button changes in open eye status, and the image appears in the image display area.

Note: If the image is not clear, adjust it with Focus and Stigma X and Y in the operation panel, or use the adjustment support functions in the Focus & Stigma Checker subwindow (Refer to the Operation Screen Reference Manual.)

- 4) Determine the view size of the image by using the **MAG** dial on the operation panel.

18.2. Rotating Image

The image displayed in the image display area can be rotated during observation and at the time of saving. There are two methods for image rotation: ① Stage rotation and ② Scanning rotation. If you do not need to rotate the image, go to section 18.3.

18.2.1. Stage Rotation

This is the method to rotate the image by rotating the specimen stage.

- 1) Confirm that the Scan button is in open eye status.
- 2) Click the **Image tab** in the tab switch area with the image displayed in the Large View window. The SMI window Image tab appears.



Figure 18-1 Image Tab

- 3) Mark the **Stage Rotation** check box in the Mouse Action area.
- 4) Write a green line, which will be horizontal after the rotation, on the image by dragging the mouse.

Note: The length of the line is arbitrary.

- 5) Release your finger from the mouse after dragging. The Stage Rotation subwindow appears. The degree of the angle until the green line comes to horizontal appears in the Rotation (deg) column.

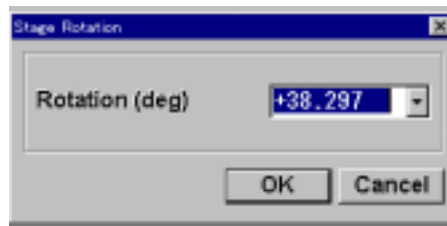


Figure 18-2 Stage Rotation Subwindow

- 6) Click the **OK** button. The specimen stage starts rotating. The Stage Rotation subwindow closes automatically when the rotation is complete.

Note: If the position of the object moves off the screen due to rotation of the specimen stage, you may return the object to the center of the screen by reducing the image magnification one degree to display the object, and by double-clicking the hand-shaped cursor on the intended part.

18.2.2. Scan Rotation

This is the method to change the scanning direction of the ion beam instead of rotating the specimen stage.

- 1) Confirm that the Scan button is in open eye status.
- 2) Click the **Image tab** in the tab switch area with the image displayed in the Large View window. The SMI window Image tab appears.
- 3) Mark the **Scan Rotation** check box in the Mouse Action area.
- 4) Write a green line, which will become horizontal after the rotation, on the image by dragging the mouse. Note: The length of the line is arbitrary.
- 5) Release your finger from the mouse after dragging. The scanning direction of the beam changes, and the rotated image appears. At the same time, the word the Scan Rotation— Enable button changes from black to green, and the right column shows the degree of the angle until the green line comes to horizontal.

Note: Click the **Enable** to cancel the scan rotation. The image returns to the condition before rotation, and the Enable button turns black.

18.3. Saving the Image

The quality of image to be saved is improved, as the scanning speed of the ion beam slows. The larger the Scan Speed tab number (buttons 1 to 5), the better the quality will be.

Note: Slowing the scanning speed increases the time that the ion beam irradiates the specimen, and the effects of sputtering intensify.

To obtain the best image quality, click the **Photo Scan** button on the Image tab. The ion beam will scan at a very low speed, and this will display a clear image.

- 1) Confirm the Scan button is in open eye status.
- 2) Select a speed from the Scan Speed tab 1-5 and click it to change the scanning speed of the ion beam, or click the **Photo Scan-ON** button. The image to be saved appears. While scanning, the number button or the Photo Scan-ON button changes to green.

Note: When selecting Photo Scan, click the **Scan** button first to close the eye, and then click the **Photo Scan-ON** button.

When scanning is complete, the Scan button changes in eye close status, and the image is left displayed in the image display area in the Large View window.

- 3) Click the **Disk** button on the toolbar. The Image Index subwindow appears.

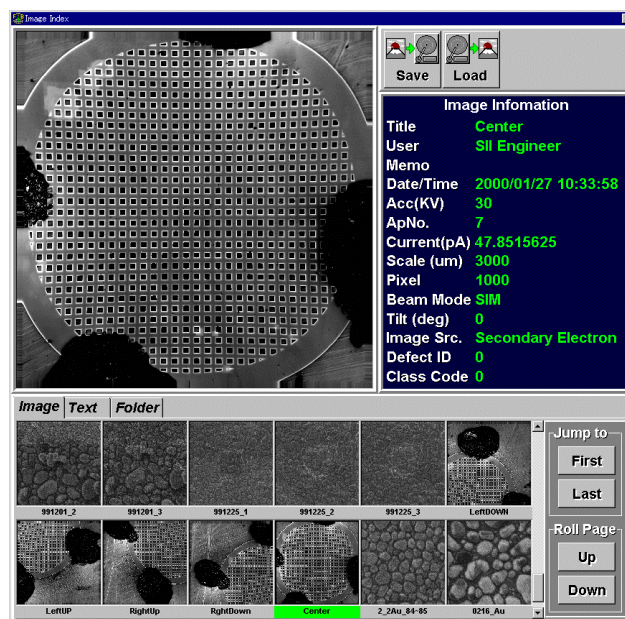


Figure 18-3 Image Index Subwindow

18. Image Observation

- 4) Click the **Save** button. The Input Image Title & Memo subwindow appears.

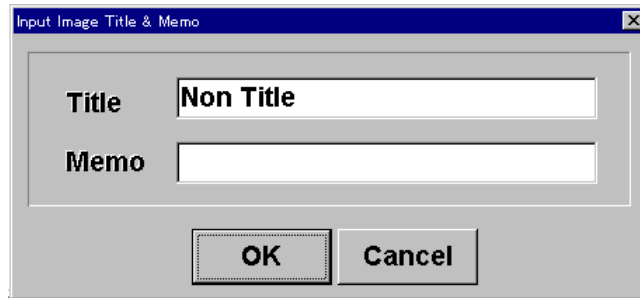


Figure 18-4 Input Image Title & Memo Subwindow

- 5) Delete the characters displayed in the **Title** column, and enter the title.
Note: The characters that can be used are limited to normal-width alphanumeric characters.
- 6) Enter information in the **Memo** column, if necessary.
Note: The characters that can be used are limited to normal-width alphanumeric characters.
- 7) Click the **OK** button. The image is added to the Image tab in the Image Index subwindow, and the Input Image Title & Memo subwindow closes.
- 8) Click the **Close** button on the Image Index subwindow. It returns to the Large View window.

18.4. Print

- 1) Click the **print** button on the toolbar while the image is displayed on the screen in the Large View window. The Print subwindow appears.
- 2) Click the **OK** button. Printing begins.

19. Processing

Processing includes the basic processing and application processing. Basic processing includes etching, deposition, and slope cutting. Application processing is the processing performed by the combination of etching and deposition and includes cross section processing, TEM specimen preparation, and cutting and formation of integrated circuit wiring. Since the processing data model has already been saved for section processing and TEM specimen preparation, access the model to begin processing. The user determines the conditions for integrated circuit wiring cutting and formation by combining the basic processing procedures.

To begin processing, specimen position determination described in sections 15 through 17 along with each adjustment must be completed. Also the specimen stage height positioning using an actual specimen must be carried out. The specimen stage height positioning is especially important.

19.1. Basic Processing

19.1.1. Etching

19.1.1.1. Setting Processing Frame

- 1) Click the **Process View** button in the application button area. The Process View window appears.

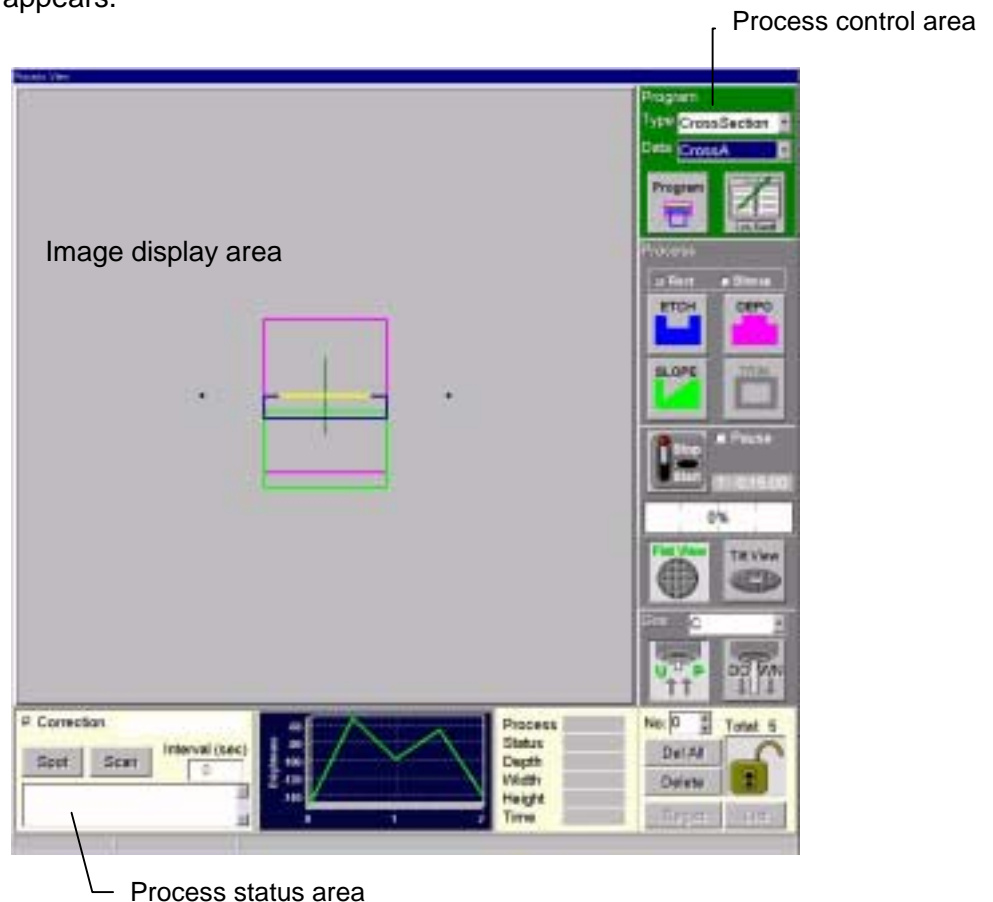


Figure 19-1 Process View Window

- 2) Click the **Beam Condition—UFine** button in the FIB control button area. The word “UFine” changes to green.
- 3) Click the **Scan** button in the FIB control button area. The Scan button changes in open eye status, and the image is displayed in the image print area.
- 4) Double-click the location on the screen for processing. The object location moves to the center of the screen.
- 5) Select the view size by using the **MAG** dial on the operation panel, and click the **Scan** button. The Scan button changes in eye close status.
- 6) Click the **ETCH** button in the process control area. The background of the button brightens.
- 7) Click an arbitrary point within the processing range, and drag the mouse diagonally. The processing frame appears as a rectangular blue line.

19.1.1.2. Correcting Processing Frame Size

The size of the processing frame can be corrected by the following two methods.

(A) moving the side of the processing frame.

(B) changing the values for the dimensions of the processing frame.

(A) Moving the side of the processing frame

- 1) Point the cursor with the yellow dot in the middle of the side to be corrected, and move this side by dragging. When the mouse starts to drag the side, the color of the processing frame line changes from blue to red, and then returns to blue when completed.

(B) Changing the numerical values for the dimensions of the processing frame.

- 1) Click the right button of the mouse in an arbitrary location in the image area. The Properties pop-up menu appears.

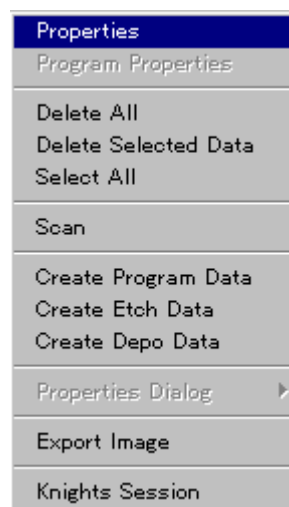


Figure 19-2 Properties Pop-up Menu

- 2) Click the **Properties** on the pop-up menu. The Process Data Properties subwindow Etch tab appears.

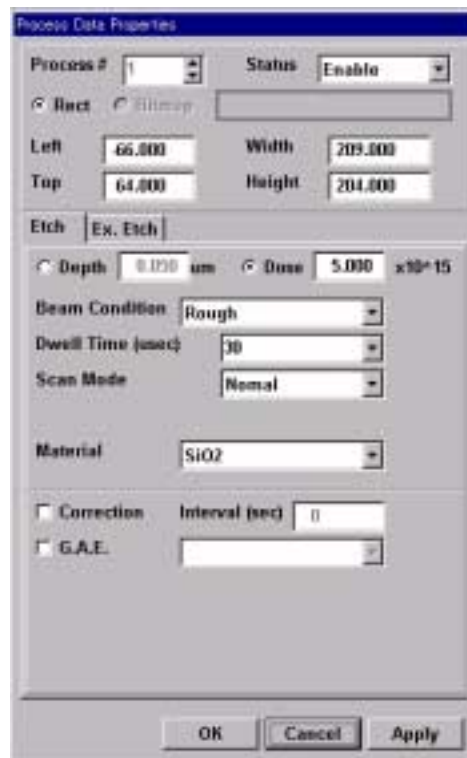


Figure 19-3 Process Data Properties Subwindow Etch Tab

- 3) Enter the values to be set in the Width and Height columns using the keyboard. (Unit: μm)
- 4) Click the **OK** button. The processing frame changes to a rectangular shape with the set width and height. The Process Data Properties subwindow Etch tab closes.

19.1.1.3. Correction of Processing Frame Position

- 1) Click on the processing frame line, and drag the processing frame interior.

19.1.1.4. Etching

- 1) Click the right button of the mouse at a certain point in the image area. The Properties pop-up menu appears.
- 2) Click the **Properties** on the pop-up menu. The Process Date Properties subwindow Etch tab appears.
- 3) Click **Etch-Depth**, and enter the etching depth (unit: μm) into the right column using the keyboard.

- 4) Click ▼ in the **Beam Condition** column, and select the beam condition.
- 5) Click the **OK** button. The Process Data Properties subwindow Etch tab closes.
- 6) Click the **Start/Stop** button in the process control area. The switch lever icon for this button drops to the Start side, the green LED lights up, and processing starts. Processing status appears in the processing frame.
- 7) Processing is complete when the bar graph located under the Start/Stop button reaches 100%. The switch lever icon of the Start/Stop button moves up to the Stop side when processing is complete, and the LED turns off.

Note: To interrupt processing during operations, click the Start/Stop button.

When the Start/Stop button is clicked again, processing restarts at the place of interruption.

19.1.2. Deposition

Caution

Be sure to execute degassing before performing deposition processing for the first time each day. If gas is discharged without degassing, the vacuum degree in the main chamber decreases, and the optical system power supply may shut down. If degassing has been carried out in Daily Adjust, it is unnecessary to execute.

19.1.2.1. Degassing

- 1) Confirm that the Scan button in the FIB control button area is in eye close status. If not, click this button to close it.
- 2) Click the right button of the mouse on Gas Injector in the process control area. The words "W Degas" or "C Degas" appear.
- 3) Click the mouse when the background changes to blue by pointing the cursor on the word. The confirmation window "W Gas Injector Degas OK?" or "C Gas Injector Degas OK?" appears.
- 4) Click the **OK** button. The ion optical system control power supply is cut off and the gas discharges. At this time, the error message "Main Chamber Vacuum Interlock error" sometimes appears. Few seconds after the completion of gas discharge, the ion optical system control power supply restores automatically.
- 5) Click the **Close** button in the error message window. The error message disappears.

19.1.2.2. Lowering Gas Injector Nozzle

- 1) Click the **Gas Injector-DOWN** button. The gas injector nozzle lowers, and when this finishes, the characters “DOWN” change to green.
- 2) Click the **Scan** button in the FIB control button area so that the Scan button changes in open eye status. The image appears once again in the image display area. After the image is updated, click the Scan button in the FIB control button area so that it changes in eye close status.

Note: The image needs to be updated because the image moves off when the nozzle lowers due to the change of electric field and beam shift.

19.1.2.3. Setting Processing Frame

- 1) Click the **DEPO** button in the process control area. The background of the button brightens.
- 2) Click an arbitrary location within the processed range, and drag it diagonally. Pink rectangular lines display the processing frame.

Note: Refer to sections 19.1.1.2 and 19.1.1.3 to change the size or position of the processing frame.

19.1.2.4. Deposition

- 1) Click the right button of the mouse at an arbitrary location on the screen. The Properties pop-up menu appears.
- 2) Click the **Properties**. The Process Data Properties subwindow Depo tab appears.

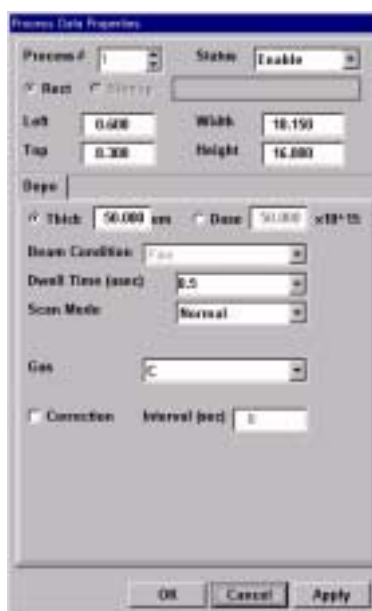


Figure 19-4 Process Data Properties Subwindow Depo Tab

- 3) Mark the **Depo-Thick**, and enter the deposition thickness (unit: μm) in the right column using the keyboard.
- 4) Click ▼ in the **Beam Condition** column to display a list of beam conditions. The recommended conditions for deposition are displayed in dark characters. Select the condition with largest current value.
- 5) Click the **OK** button. The selected beam condition is set and Process Data Properties subwindow Depo tab closes.
- 6) Click the **Start/Stop** button in the process control area. The switch lever icon of Start/Stop button lowers to the Start side, the green LED lights, and processing starts. The processing condition appears in the processing frame. The progress of the processing is shown in the bar graph under the Start/Stop button, and the processing ends when the bar graph reaches 100%. At the same time processing finishes, the valve closes and the gas discharge stops. The switch lever icon of the Start/Stop button moves up to the Stop side when the processing ends, and the LED turns off.
Note: To interrupt processing during operations, click the **Start/Stop** button. When the Start/Stop button is clicked again, processing restarts at the place of interruption.
- 7) Click the **Gas Injector-UP** button. The gas injector nozzle rises, and the word "UP" changes to green.

19.1.3. Slope Cutting

19.1.3.1. Setting the Processing Frame

- 1) Click the **SLOPE** button in the process control area. The button background brightens.
- 2) Click an arbitrary location within the process range, and drag it diagonally. Green rectangular lines display the processing frame.

Note: Refer to sections 19.1.1.2 and 19.1.1.3 to change the size or position of the processing frame.

19.1.3.2. Slope Cutting

- 1) Click the right button of the mouse at an arbitrary location on the screen. The Properties pop-up menu appears.
- 2) Click the **Properties**. The Process Data Properties subwindow Slope tab appears.



Figure 19-5 Process Data Properties Subwindow Slope Tab

- 3) Click ▼ in the **Slope-Direction** column, and select Top.
 Note: If the specimen is not horizontal to the processing frame, perform stage rotation so that the upper side of the screen can be bored deeper. (Refer to section 18.2.1.)
- 4) Click ▼ in the **Beam Condition** column to select the beam condition.
- 5) Click the **OK** button on the Slope tab of the Process Data Properties subwindow. This window closes.
- 6) Click the **Start/Stop** button in the process control area. The switch lever icon of this button lowers to the Start side, the green LED lights up, and processing starts. The processing status appears in real time in the processing frame.
- 7) Processing progress appears in the graph under the Start/Stop button, and processing ends when the bar graph reaches 100%. The button's switch lever icon moves up to the Stop side when processing ends, and the LED turns off.
 Note: To interrupt processing during operations, click the Start/Stop button. When the Start/Stop button is clicked again, processing restarts at the place of interruption.

19.2. Drift Correction

The processing position drifts slightly by various reasons. Using the drift correction correct such drift automatically at regular intervals. First making a spot for drift correction, then memorize the image at that position using image recognition, and start processing. To carry out the drift correction, the Drift Correction check box in the Type Properties window and Correction check box in the Program Properties or Process Data Properties condition setting must be marked beforehand. This setting must be done by Staff.

- 1) Set the processing frame and then click the **Spot** button at the lower-left of process status area. The button turns to green.
- 2) Click a position where the correction mark to be made. It must be outside of the processing frame. The clicked position is surrounded by a square-shaped dotted line.
- 3) If a hole already exists, the message of "Spot already exists. Continue?" appears. Click the **OK** button. When the software recognizes the image, the Spot button turns black. Go to step (5).
- 4) If no hole exists, spot-making process and image recognition start. Wait till the Spot button turns black.

Note: If the spot-making process takes too much time (it is displayed as a Spot Time), click the Stop button when a certain time has passed. The spot-making process is interrupted. Click the Spot button again and then the center of the said square-shaped dotted line. Go back to step (3).

- 5) Mark the **Correction** check box in the Process Data Properties and input the correction time interval manually. In general, a number between 30 and 60 is appropriate.
- 6) When you start the processing, the area inside the square-shaped dotted line is scanned, position correction is carried out, and then actual processing starts. Drift correction is carried out at the intervals set at step (5).

19.3. Application Processing

Application processing is the combination of etching and deposition processes. Application processing includes cross section processing, TEM specimen preparation, integrated circuit wiring cutting, and integrated circuit wiring formation.

The SMI2200 saves the processing data models for cross section processing and the TEM specimen preparation. When determining the processing procedure for individual specimens, read the existing processing data models, and modify and save it as the new processing data. The processing data models do not exist for integrated circuit wiring cutting and formation. For these processing procedures, the user should perform processing using the actual specimen, and save the process as processing data.

Note: Staff executes saving of processing data.

19.3.1. Determining Processing Process

19.3.1.1. Cross Section Processing and Observation

(A) Setting Processing Frame

- 1) Click the **Process View** button in the application button area. The Process View window appears.
- 2) Click ▼ in the **Type** column in the process control area, and choose Section.
- 3) Click ▼ in the **Data** column. The list of processing data saved in Cross Section appears. Select the most suitable processing data for the cross section processing to be executed.
- 4) Click the **Program** button. The processing frame processing data appears above the image.
- 5) Drag the yellow bar handle in the processing frame, and determine the position and the width of the processing frame.
 - Determining the position: Point the cursor at the center of the yellow bar handles in the processing frame, and drag it. The entire processing frame moves.
 - Determining the width: Point the cursor with either end of the yellow bar handle and drag. The width of the processing frame expands or contracts to the right or left.

(B) Setting Processing Conditions

(1) Setting General Conditions

- 1) Click the **Program Data Properties** button in the process control area.
The Program Properties subwindow appears.



Figure 19-6 Program Data Properties button



Figure 19-7 Program Properties Subwindow

- 2) Enter a value that is larger by 1~2 μm than the cross section depth to be observed as the temporary value in the General-Depth column.
- 3) Click ▼ in the **MATERIAL** column, and choose the material that corresponds to the specimen.
- 4) Click ▼ in the **Angle (Deg)** column, and select the observation angle.
You can select from among 30°, 45° or 60°. This setting determines the size of the vertical dimensions of the green processing frame.
- 5) Click ▼ in the **Direction** column, and choose **Top**.

(2) Setting Rough Boring Conditions

Note: Setting of rough boring conditions must be carried out by Staff.

Start where the Program Template subwindow Cross General tab appears.



Figure 19-8 Program Template Subwindow Cross General Tab

1) Click the **Rough** tab. The Program Template subwindow Cross Rough tab appears.

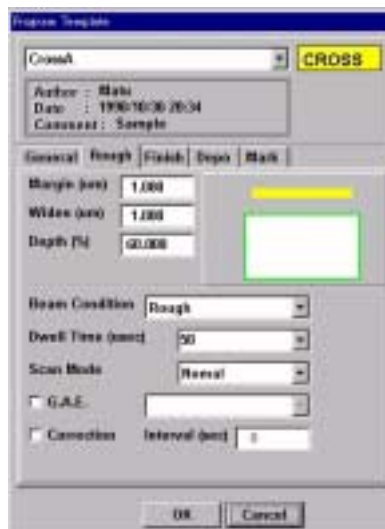


Figure 19-9 Program Template Subwindow Cross Rough Tab

2) Click ▼ in the **Beam Condition** column, and choose **Rough** or **URough**.

(3) Setting Conditions for Finish Boring

Note: Setting of Finish boring conditions must be carried out by Staff.

- 1) Click the **Finish** tab. The Program Template subwindow Cross Finish tab appears.

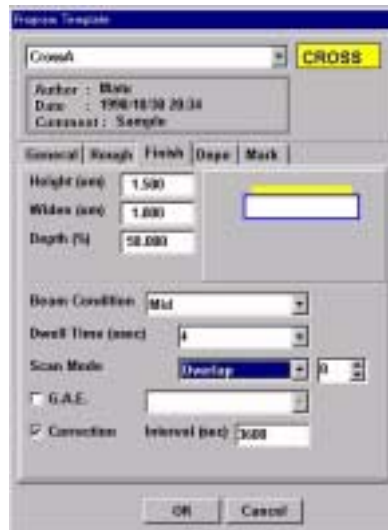


Figure 19-10 Program Template Subwindow Cross Finish Tab

- 2) Enter the value **30** in the **Depth (%)** column. It will appear in the Depth (%) column as 30.000.
- 3) Click ▼ in the **Beam Condition** column, and choose **Mid or Fine**.

(4) Setting Deposition Conditions

Note: Setting deposition conditions must be carried out by Staff.

- 1) Select the **Depo** tab. The Program Template subwindow Cross Depo tab appears.

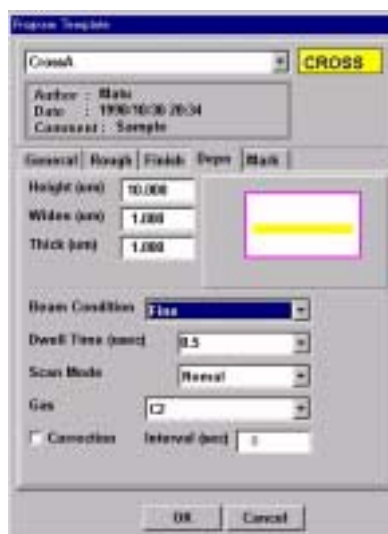


Figure 19-11 Program Template Subwindow Cross Depo Tab

- 2) Move the cursor to the **Thick (μm)** column, and enter the value **0.5**. It will appear in the Thick (μm) column as 0.500.
- 3) Perform steps 5)-8) in section 19.1.2.4, and set the beam condition in the Beam Condition column.
- 4) Click the **OK** button. All of the conditions from (A) to (D) are finalized, and the Program Template subwindow closes. The set processing frame now appears on the screen.

(C) Executing Cross section Processing

- 1) Click the **Gas Injector-DOWN** button in the process control area. The gas injector nozzle lowers, and the word "DOWN" changes to green when lowering is complete.
- 2) Click the **Start/Stop** button in the process control area. Processing begins, the button's switch lever icon lowers to the Start side, and the green LED lights. The processing appears in the processing frame. Processing progress appears in the bar graph under the Start/Stop button, and the processing ends when the bar graph reaches 100%. The valve closes at the same time the processing finishes, and gas discharge ends. In addition, the switch lever icon of the Start/Stop button moves up to the Stop side, and the LED turns off.
 Note: To interrupt processing during operations, click the Start/Stop button. When the Start/Stop button is clicked again, processing restarts at the place of interruption.
- 3) Click the **Gas Injector-UP** button. The gas injector nozzle rises. The word "UP" changes to green when it stops rising.

(D) Cross Section Observation

- 1) Click the **Beam Condition-View** button in the FIB control button area.
- 2) Click the **Tilt View** button in the process control area. The specimen stage tilts at the angle set in the **Angle (Deg)** column of Program Type Properties.
- 3) Click **Scan** button in the FIB control button area. The ion beam scanning of image observation begins, and the Scan button changes in open eye status.
- 4) Focus the image using the **FOCUS, STIG-X** and **STIG-Y** dials on the operation panel.
 Note: The adjustment amount for FOCUS, STIG-X, and STIG-Y at this time is not saved. Follow the procedures in section 18.3 to save it.
- 5) If proper processing results were not obtained as a result of cross section observation, correct the Depth value (μm) (step 2 in section 19.3.1.1(B) (1)), the Depth value (%) (step 2 in section 19.3.1.1 (B) (3)), and the Thick value (μm) (step 2 in section 19.3.1.1(B) (4)), which were set as temporary values, and perform reprocessing.
 Note: Each value shown above differs, depending on the specimen.

(E) Registering Cross section Processing Data

Cross section processing data can be registered as a data program processing type Section described in the section 19.3.2.

Note: Setting of cross section data must be carried out by Staff.

- 1) Click the right button of mouse at an arbitrary location in the image display area while the image appears. The Properties pop-up menu appears.
- 2) Click the **Program Properties** on the pop-up menu. The Program Properties subwindow Cross General tab appears.
- 3) Click the **New** button. The Program Data sub window appears.



Figure 19-12 Program Data Subwindow

- 4) Enter the data name into the Name column, using normal-width alphanumeric characters (13 characters or less).
- 5) Click the **OK** button. The processing data is registered, and this windows closes.
- 6) Click the **OK** button of Cross General tab in the Program Properties subwindow. Cross section appears in the Program -Type column in the process control area, the newly registered data name appears in the Data column, and this window closes.

(F) Printing Image

- 1) Follow the section 18.4.

19.3.1.2. TEM Specimen Preparation

There are two (s) methods for TEM specimen preparation: pick-up method and dicing method.

In pick-up method, a thin specimen for TEM observation is made in a wafer first and then cut by spatter etching. The cut thin specimen is picked up from the wafer with using the manipulator microscope for FIB (Option).

In dicing method, a material block which has already been cut from the wafer using dicing machine for preparing TEM specimen is processed as a specimen for TEM observation.

19.3.1.2.1 Pick-up Method

Refer to the instruction manual for the optional Manipulator Microscope for FIB.

19.3.1.2.2 Dicing Method

The material block, which has been processed using the dicing machine to make a TEM specimen, must be affixed to the mesh and fixed to the dedicated holder [Option]. The specimen positioning including the specimen loading and specimen height positioning needs to be carried out before following procedures.

(A) Posture Adjustment

For the three-dimensional specimen such as a material block for TEM specimen, the posture of the specimen need to be adjusted by tilting the specimen stage so that an incident angle of ion beam becomes perpendicular to the processing position.

- 1) While an image is displayed in the image display area, adjust the view size until the whole image of specimen is displayed by using the **MAG** dial.

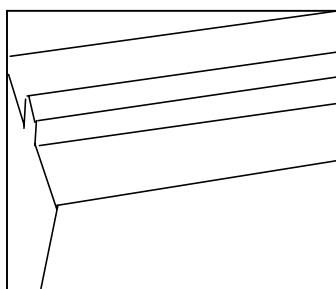


Figure 19-13 View Size Adjustment

- 2) Confirm that the Scan button is in open eye status and click the **Status** tab in the SMI window tab switch area to display the SMI window Status tab. Then click the **Search-Open** button to display the Search subwindow.

- 3) Adjust the tilt angle until the specimen can be viewed from the top by using **T jog** buttons.

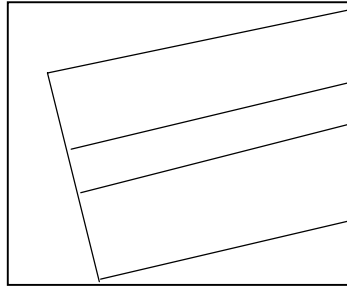


Figure 19-14 View Size Right Angle Adjustment

- 4) Click the **Image** tab in the SMI window tab switch area to display the SMI window Image tab.
- 5) Click the **Mouse Action - Scan Rotation**.
- 6) Write a green line, which will become horizontal after the rotation, on the image by dragging the mouse.
- 7) Release your finger from the mouse after dragging. The scanning rotation starts and the level is adjusted.



Figure 19-15 View Size Level Adjustment

(B) Determining Processing Frame

- 1) Click the **Process View** button in the application button area. The Process View window appears.
- 2) Click the **Gas Injector - Down** button and lower the gas injector nozzle.
- 3) Click the **Scan** button in the FIB control area to change it in open eye status.
- 4) Click ▼ in the **Program-Type** column in the process control area, and select **TEM**.
- 5) Click ▼ in the **Data** column. A list of the processing data saved as TEM appears. Select the most suitable processing data for preparing the TEM specimen.
- 6) Click the **Program** button. The processing frame of processing data appears above the image.

- 7) Drag the yellow bar handles in the processing frame to determine the position and the width of the processing frame. To carry out the procedure, refer to step (5) in section (A) 19.3.1.1). In addition, determine the size of the processing frame in the vertical dimensions, as described below. Click the red dot in the center of the top or the bottom line of the multiple processing frames displayed, and drag it vertically when the red dot changes to yellow.

(C) Setting Processing Conditions

(1) Setting General Conditions

- 1) Click the **Open Program Data Properties** button. The Program Template subwindow TEM General tab appears.



Figure 19-16 Program Template Subwindow TEM General Tab

- 2) Enter a value that is 1~2 μm larger than the cross section to be observed as a temporary value into the **General-Depth (μm)**.
- 3) Click ▼ in the **Material** column, and choose a material that corresponds to the specimen.
- 4) Move the cursor to the **Leave (μm)** column, and enter the value **1**.
- 5) Click ▼ in the **Direction** column, and choose **Horizon**.

(2) Setting Rough Boring Conditions

Note: Setting of rough boring conditions must be carried out by Staff.
 Start from where the TEM General tab of the Program Template subwindow appears.



Figure 19-17 Program Template Subwindow TEM General Tab

1) Click the **Rough** tab. The Program Template subwindow TEM Rough tab appears.



Figure 19-18 Program Template Subwindow TEM Rough Tab

2) Click ▼ in the **Beam Condition** column, and choose **Rough** or **URough**.

(3) Setting Finish Boring Conditions

Note: Setting of finish boring conditions must be carried out by Staff.

- 1) Click the **Finish** tab. The Program Template subwindow TEM Finish tab appears.

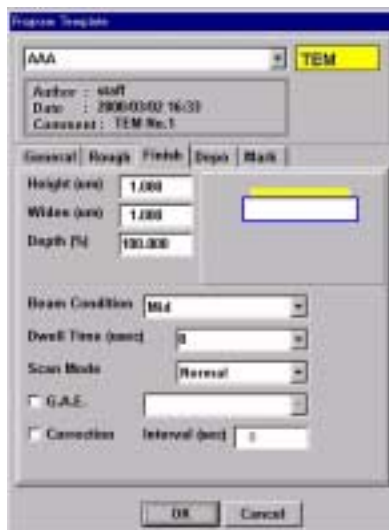


Figure 19-19 Program Template Subwindow TEM Finish Tab

- 2) Move the cursor to the **Depth (%)** column, and enter the numerical value **30** as a temporary value. It will appear in the Depth (%) column as 30.000.
- 3) Click ▼ in the **Beam Condition column**, and choose **Mid or Fine**.

(4) Setting Deposition Conditions

Note: Setting of deposition conditions must be carried out by Staff.

- 1) Click the **Depo** tab. The Program Template subwindow TEM Depo tab appears.

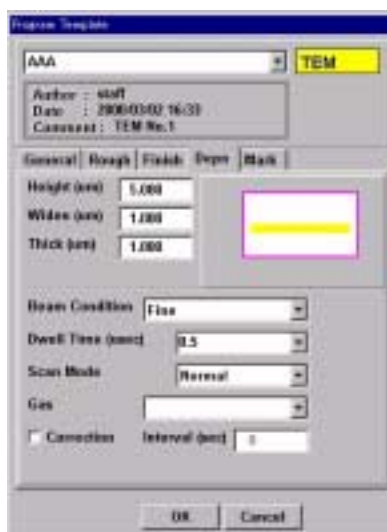


Figure 19-20 Program Template Subwindow TEM Depo Tab

- 2) Move the cursor to the **Thick (μm)** column and enter the numerical value **0.5**, as a temporary value. It will appear in the Thick (Vm) column as 0.500.
- 3) Perform steps (5) through (8) in section 19.1.2.4, and set the beam condition in the Beam Condition column.
- 4) Click the **OK** button. All of conditions from (A) to (D) are set, and the Program Template subwindow TEM Depo tab closes. The screen now displays the new processing frame that has been set.

(D) Execution of Processing and FIB Leaving Width Measurement

- 1) Click the **Start/Stop** button in the process control area. The button's switch lever icon lowers to the Start side, the green LED lights up, and processing starts. The processing status is displayed in the processing frame.
The bar graph under the Start/Stop button displays the processing progress, and processing ends when the bar graph reaches 100%. When processing finishes, the valve closes and the gas stops discharging. The switch lever icon of the Start/Stop button moves to Stop side and the LED turns off.
- 2) Click **▼** in the **Beam Condition** column, and select **UFine**. Click the **Scan** button to display the image after processing and then click the **Scan** button again. The button changes in eye close status.
- 3) Click the **Del All** button in the process status area to delete the processing frames for TEM specimen preparation processing.
- 4) Click the **Lock** button in the process status area. The button changes to the locked key status.
- 5) Select the **Mouse Action - Measure** in the SMI window.
- 6) Point the cursor at the upper end of TEM specimen, which is the leaving part between two holes made during TEM specimen processing, and drag it to its lower end to measure the width between upper and lower ends (i.e. FIB leaving width). The dragged line is displayed in green.
- 7) Stop dragging and release a finger from the mouse button. The measured length is displayed at the upper left corner of image display area. Since the vertical direction is measured, read the value in Y.
- 8) Click the **Gas Injector-UP** button. The gas injector nozzle rises
- 9) Click the **Lock** button to change it in open key status.

(E) Reducing Thickness of TEM Specimen

The FIB leaving width, which is the distance between two holes made during TEM specimen processing, is reduced by sputter etching.

- 1) Click the **Stage Ctrl - Open** in the SMI window. The Stage Controller subwindow appears.

- 2) Enter **+1** in the **T(deg)** column.

Note: When boring a hole by using FIB, the wall of the hole is not vertical but tilted. Since the ion distribution of FIB horizontal plane is a normal distribution, the entrance of hole at where the ion irradiate longer is sputter-etched deeper than the bottom of the hole. This taper angle is approx. 1° . Because of this, the specimen is tilted to 1°

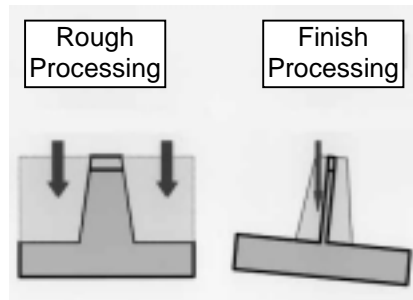


Figure 19-21 Status at Finish Processing

- 3) Click the **GO** button. The specimen stage starts tilting.
- 4) Click the **Scan** button to display the updated image. After updating the image, click the Scan button again and change it in eye close status.
- 5) Click the **Etch** button in the process status area. The processing frame appease.
- 6) Set the processing frame surrounding the lower part of FIB leaving width that is displayed in white.



Figure 19-22 Processing Frame Set

- 7) Click the right button of the mouse at an arbitrary location in the image display area. The Properties pop-up menu appears.
- 8) Select the **Properties**, and Process Data Properties subwindow Etch tab appears.
- 9) Enter the width of TEM specimen in the **Depth** column.
- 10) Select the **Rough (1.3nA)** in the **Beam Condition** column.
- 11) Click the **OK** button. Process Data Properties subwindow Etch tab closes.
- 12) Click the **Start/Stop** button to start the processing.
- 13) When the bar graph shown below the Start/Stop button reaches **20%**, click the **Start/Stop** button and stop processing.
Note: Since the end face etching speed is five-times faster than that of boring a hole, processing must be stopped at 20% stage.
- 14) Enter **-2** in the **T(deg)** column in the Stage Controller subwindow.
- 15) Click the **GO** button. The specimen stage starts tilting.
- 16) Select the **UFine** in the **Beam Condition** column and then click the **Scan** button to display the updated image. After updating the image, click the **Scan** button again to change it in eye close status.
- 17) Set the processing frame surrounding the lower part of FIB leaving width that is displayed in white.
- 18) Click the right button of the mouse at an arbitrary location in the image display area. The Properties pop-up menu appears.
- 19) Select the **Properties**, and Process Data Properties subwindow Etch tab appears.
- 20) Click ▼ in the **Status** column and select the **Enable**.
- 21) Select the **Rough** in the **Beam Condition** column.
- 22) Click the **OK** button. Process Data Properties subwindow Etch tab closes.
- 23) Click the **Start/Stop** button to start the processing.
- 24) When the bar graph under the Start/Stop button reaches **20%**, click the **Start/Stop** button and stop processing.
- 25) Enter **+1** in the **T(deg)** column in the Stage Controller subwindow.
- 26) Click the **GO** button. The specimen stage returns to level and TEM specimen becomes vertical.
- 27) Select the **UFine** in the **Beam Condition** column and then click the **Scan** button to display the updated image. After updating the image, click the **Scan** button again to change it in eye close status.
- 28) Carry out the steps (4) to (7) in the section (C) "Execution of Processing and FIB Leaving Width measurement" to measure the FIB leaving width, and then read the Y value.
- 29) Repeat the steps (2) to (28) above until the Y value becomes approx. **0.5µm**.

(F) Making Thin TEM Specimen

After cutting the bottom part, TEM specimen is etched with FIB to make a thin specimen having a desired thickness.

- 1) Enter **+1** in the **T(deg)** column in the Stage Controller subwindow.
- 2) Click the **GO** button. The stage starts tilting.
- 3) Click the **Scan** button to display the updated image. After updating the image, click the **Scan** button and change it in eye close status.
- 4) Click the right button of the mouse at an arbitrary location in the image display area. The Properties pop-up menu appears.
- 5) Select **Propaties**. The Process Data Propaties subwindow Etch tab appears.
- 6) Click ▼ in the **Status** column and select **Enable**.
- 7) Enter the TEM specimen width in the **Depth** column.
- 8) Click ▼ in the **Beam Condition** column and select **Fine (48pA)**.
- 9) Enter **0.3** in the **Height** column.
- 10) Click the **OK** button. The Process Data Propaties subwindow Etch tab closes.
- 11) Click the **Scan** button to display the updated image.
- 12) Move the processing frame to the lower part of FIB leaving width.
- 13) Click the **Start/Stop** button to start processing.
- 14) When the bar graph below the Start/Stop button reaches to **20%**, click the **Start/Stop** button to stop processing.
- 15) Enter **-2** in the T(deg) column in the Stage Controller subwindow.
- 16) Click the **GO** button. The specimen stage start tilting.
- 17) Click the **Scan** button to display the updated image. After updating the image, click the **Scan** button and change it in eye close status.
- 18) Click the right button of the mouse at an arbitrary location in the image display area. The Properties pop-up menu appears.
- 19) Select **Propaties**. The Process Data Propaties subwindow Etch tab appears.
- 20) Click ▼ in the **Status** column and select **Enable**.
- 21) Click the **OK** button. The Process Data Propaties subwindow Etch tab closes.
- 22) Click the **Scan** button to display the updated image.
- 23) Move the processing frame to the upper part of FIB leaving width.
- 24) Click the **Start/Stop** button to start processing.
- 25) When the bar graph below the Start/Stop button reaches to **20%**, click the **Start/Stop** button to stop processing.
- 26) Enter **+1** in the **T(deg)** column in the Stage Controller subwindow.
- 27) Click the **GO** button. The specimen stage returns to level and the TEM specimen becomes vertical.
- 28) Select the beam condition of **UFine** and click the **Scan** button to display the updated image. After updating the image, click the **Scan** button again and change it in eye close status.
- 29) Carry out the steps (4) to (7) in the section (C) "Execution of Processing and FIB Leaving Width measurement" to measure the FIB leaving width, and then read the Y value.

30) Repeat the steps (1) to (29) above until the Y value becomes desired value.

Note: Then unload the specimen from the main chamber (see the Section 20), and use it as a TEM specimen.

19.3.1.3. Integrated Circuit Wiring Cutting

(A) Preparation

- 1) Click the **Process View** button in the application button area to display the Process View window.
- 2) Click ▼ in the **Program-Type** column in the process control area, and choose **Normal**.

Note: This step is necessary to register an integrated circuit wiring cutting process as processing data. Be sure to perform this step.

- 3) If the wiring on the integrated circuit is running diagonally, perform scanning rotation (Refer to section 18.2.2).

(B) Wiring Cutting

- 1) Set the processing frame wider than the width of the wiring to be cut. Refer to section 19.1.1.1 for the procedures to set processing frames.
- 2) Click **Fine** for the beam condition in the FIB control button area.
- 3) Click the **Start/Stop** button in the process control area. The wiring cutting procedure begins by etching in the processing frame.
- 4) Observe the image in the processing frame, and end the processing by pressing the **Start/Stop** button when all of the wiring has been completely removed (when the inside of the processing frame changes from white to dark), and after the insulated film has been removed.

Note: If the image in the processing frame does not whiten 2~3 minutes after starting the etching process, press the **Start/Stop** button to stop etching. Then change the beam condition to **Mid**, and perform reprocessing at different location. (This occurs because the etching speed is too slow in Fine.)

- 5) Read the percent value displayed in the bar chart under the Start/Stop button.
- 6) Click the right button of the mouse at an arbitrary location in the image display area in which the image appears. The Properties pop-up menu appears.
- 7) Click the **Properties** from the pop-up menu. The Process Data Properties subwindow Etch tab appears.

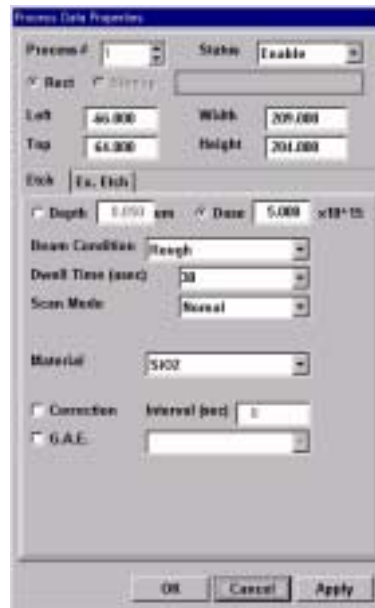


Figure 19-23 Process Data Properties Subwindow Etch Tab

- 8) Using the formula below, determine the thickness of the wiring to be removed (i.e. processing depth).

$$\text{Processing depth} = \frac{\text{Value set in Depth } (\mu\text{m}) \times \text{Value displayed in bar graph}}{100}$$

- 9) Enter the processing depth sought in step (8) into the Depth (μm) column.
 10) Click the **OK** button. The change in depth is set, and the Process Data Properties subwindow Etch tab closes.

(C) Registering the Integrated Circuit Wiring Cutting Data

The integrated circuit wiring cutting processing data is registered as a data for the program processing type Normal described in the section 19.3.2.

Note: Only staff can register the integrated circuit wiring cutting data.

Register the integrated circuit wiring cutting data according to the procedures described in section 19.3.1.1 (E). When the OK button is clicked in step (6), Normal appears in the Program-Type column, and the name of newly registered data appears in the Data column.

(D) Printing Image

Follow the procedures in section 18.4.

19.3.1.4. Integrated Circuit Wiring Formation

(A) Preparation

- 1) Click the **Process View** button in the application button area. The Process View window appears.
- 2) Click ▼ in the **Program-Type** column, and choose **Normal**.
Note: This step is necessary to register the integrated circuit wiring formation process as program data.
- 3) Lower the gas injector nozzle (Refer to section 19.1.2.2).
- 4) Perform scanning rotation so that the line between two points where new wiring is connected becomes horizontal (Refer to section 18.2.2).

(B) Etching to Remove the Insulation Coating Film

- 1) Set the processing frame at one side of the connection where the new wiring is to be connected to the existing wiring. Refer to section 19.1.1.1.
- 2) Click beam condition **Fine** in the FIB control button area.
- 3) Click the **Start/stop** button in the process control area. The etching process in the processing frame begins.
- 4) After the green line on the Brightness monitor in the process status area fades out once, it abruptly comes on. Stop etching by pressing the **Start/Stop** button when the line comes on completely.

Note: If the green line on the Brightness monitor does not come on within 2-3 minutes since the etching has started, stop the etching operation by pressing the Start/Stop button, change the beam condition into Mid, and perform re-processing. (This occurs because the etching speed is too slow in Fine.)

- 5) Read the percentage displayed in the bar graph under the Start/Stop button.
- 6) Click the right button of the mouse at an arbitrary location above the image

display area where the image appears. The Properties pop-up menu appears.

- 7) Click the **Properties** on the pop-up menu. The Process Data Properties subwindow Etch tab appears.
- 8) Using the formula below, determine the thickness of the wiring to be removed (i.e. processing depth).

$$\text{Processing depth} = \frac{\text{Value set in Depth } (\mu\text{m}) \times \text{Value displayed in bar graph}}{100}$$

- 9) Enter the processing depth sought in step (8) into the Depth (μm) column.
- 10) Click ▼ to the right of the **Status** column, and select **Disable**.
- 11) Click the **OK** button. The change in the Depth is set, and the Process Data Properties subwindow Etch tab closes.
- 12) Set the processing frame to the other position on the existing wiring where the new wiring is to be connected (Refer to section 19.1.1.1).
- 13) Access the Process Data Properties subwindow Etch tab, and enter the value obtained in step (8) in the Depth column. In addition, set the Beam Condition to Fine in the column (the same as step 2).
 Note: If the beam condition was changed to Mid as a result of etching in step (4), select Mid instead of Fine.
- 14) Click the **Start/Stop** button, and remove the other wiring's insulation coating film.
- 15) Click ▼ in the **Status** column, select **Disable**, and click the **OK** button. This sets Disable, and the Process Data Properties subwindow Etch tab closes.

(C) New Wiring Formation Deposition

- 1) Click the **Process-DEPO** button in the process control area.
- 2) Set the processing frame that connects the two locations where the insulation-coating film was removed by etching (Refer to section 19.1.2.3).
- 3) Perform the operations in steps (6) and (7) in section 19.3.1.4. (B) to display the Process Data Properties subwindow Depo tab.



Figure 19-24 Process Data Properties Subwindow Depo Tab

- 4) Enter the numerical value **1** in the Thick column. It will appear in the Thick column as 1.000μm.
- 5) Perform calculations similar to steps (5) through (8) as outlined in section 19.1.2.4, and set the necessary beam condition for the **Depo-Beam Condition** column.

Note: Calculate the area of the processing frame set in step (2).

- 6) Click the **OK** button. This sets the beam condition, and the Process Data Properties subwindow Depo tab closes.
- 7) Click the **Start/Stop** button in the process control area. Processing begins, and this button's icon switch lever moves to the Start side, and the green LED lights up. The processing condition is displayed in the processing frame.

The bar graph below the Start/Stop button displays the processing status. The processing ends when the bar graph reaches 100%. When processing finishes, the valve closes, and the gas stops discharging. The switch lever icon of the Start/Stop button moves to the Stop side, and the LED turns off.

Note: Click the Start/Stop button when you want to interrupt operations while processing. When the Start/Stop button is clicked again, the processing restarts from the point of interruption.

- 8) Click the **Gas Injector-UP** button. The gas injector nozzle rises, and the "UP" characters change to green.
- 9) Click the right button of the mouse on an arbitrary location of the image display area. The Properties pop-up menu appears.
- 10) Click the **Properties** on the Properties pop-up menu. The Process Data Properties subwindow Depo tab appears.
- 11) Select **Enable** by clicking ▼ in the **Status** column.

- 12) Click the **OK** button. This sets Enable, and the Process Data Properties subwindow Depo tab closes.
- 13) By clicking ▼ in the **No.** column located in the process status area, you can change from the currently displayed value to a value that is smaller by 1.
- 14) Hereafter, repeat steps (9) through (13) up to the value 1 in the No. column.

(D) Registering Integrated Circuit Wiring Formation Data

The integrated circuit wiring cutting processing data is registered as data for program processing type Normal described in the section 19.3.2.

Note: Only Staff can register the integrated circuit wiring formation data.

Register the integrated circuit wiring formation data by following the procedures in section 19.3.1.1 (E). When the OK button is clicked in step (6), Normal is displayed in the Program-Type column, and the name of newly registered data appears in the Data column.

(E) Printing image

Follow the procedures in section 18.4.

19.3.2. Program Processing

Program processing accesses the processing data that have been registered for cross section processing, TEM specimen preparation, integrated circuit wiring cutting, and integrated circuit wiring formation, and it executes processing by determining the process saved in the data. For program processing, the program must determine the processing process as defined in section 19.3.1, and this data must be saved as the processing data prior to the start of processing.

19.3.2.1. Selection of Type and Data

- 1) Click the **Process View** button in the application button area. The Process View window appears.
- 2) Click ▼ in the process control area **Program-Type** column, and select the type of the processing to execute.

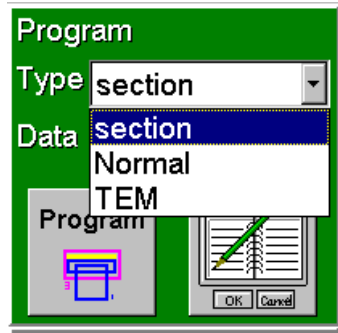


Figure 19-25 Type List

- 3) Click ▼ in the **Data** column. The processing data registered in the type selected in step (2) appears. Select the processing data appropriate for the processing that will take place. The selected data appears in the Data column.
- 4) Click the **Program** button in the process control area. The processing data processing frame appears. The number of processing frames is displayed in the **Total** column in the process status area.
- 5) When the pink deposition frame is seen in the processing frame, lower the gas injector nozzle following the procedures described in section 19.1.2.2.
- 6) Click the **Scan** button in the FIB control button area to display the image. The Scan button changes in eye close status.
Note: Click the Scan button even if the image has already been displayed. In addition, click the Scan button even if the deposition frame is not displayed in step (5).
- 7) When the image appears again, click the **Scan** button to changes it in eye close status.

19.3.2.2. Processing Frame Size and Position Correction

(A) Cross Section Type

- 1) To correct the processing frame position, move the cursor to the center area of the yellow bar handle in the processing frame, and drag it.
- 2) To correct the width of the processing frame, drag the mouse at either the left or right end of the yellow bar handle. The processing frame expands to the left or right.

(B) Normal Type

- 1) To correct the processing frame position, move the cursor to an arbitrary location in one of the processing frames displayed, and drag it. All of the processing frames move while their relative positions remain the same.
- 2) To correct the processing frame size, move the cursor to the yellow dot located in the center of one of the four sides (top, bottom, right and left) of one of the processing frames, and drag it. The location of the selected side for all of the frames changes simultaneously.

(C) TEM Type

- 1) The procedure to correct the processing frame position is the same as (A) (1), above.
- 2) The procedure to correct the size of the processing frame in the horizontal direction is the same as (A) (2) above.
- 3) To correct the size of the processing frame in the vertical direction, click the red dot located in the center of the top or the bottom outside of the displayed processing frames so that the color changes to yellow, then drag it vertically.

19.3.2.3. Processing Execution

- 1) Click the **Start/Stop** button in the process control area. This button's switch lever icon lowers toward the Start side, the green LED lights, and processing starts. The processing status appears in real time in the processing frame.
- 2) During processing, processing progress appears in the bar graph under the Start/Stop button. Processing ends when the bar graph reaches 100%. The lines of processing frames that have been completed change to brown. The Start/Stop button switch lever icon moves up to the Stop side when the processing ends, and the LED turns off.
 Note: Click the Start/Stop button if you want to interrupt the processing. When the Start/Stop button is clicked again, the processing restarts from the point of interruption.
- 3) Click the **Gas Injector-UP** button if you have performed deposition. The gas injector nozzle rises, and the "UP" characters change to green when it finishes rising.

19.3.2.4. Observation After Processing

After the program processing is complete, observe the processing surface image, save the image, and print it out, if necessary.

(A) Cross Section Observation

For cross section processing, follow the procedures described in section 19.3.1.1 (D). For TEM specimen preparation, follow the procedures described in section 19.3.1.2 (D).

Note: Operators can perform re-processing by correcting the processing conditions (refer to the step 5 in section 19.3.1.1(D)) using the cross section observation results. Data re-processed after correction cannot be saved, however.

(B) Surface Observation

Follow the procedures described in section 18 for image observation after integrated circuit wiring cutting and integrated circuit wiring formation.

(C) Saving the Image

Follow the procedures described in section 18.3 for saving the image after processing.

(D) Printing Image

Follow the procedures described in section 18.4 for printing the image after processing.

19.4. Grain Observation

Grain observation is used to display metallic film crystal grains on the material surface (for instance, wiring for the integrated circuit) as an image.

To perform grain observation, the ion beam in following conditions is irradiated to the metallic film.

- ① Beam Condition: Mid
- ② Image Scale: 30 μ m

The actual optimal irradiation conditions differ depending on the specimen.

Soon after irradiation begins, the insulation coating film on the metallic film surface is removed by etching, and the metallic crystal grain image appears.

Focus the object by using the FOCUS, STIG-X and STIG-Y dials on the operation panel. If necessary perform Eucentric Calculation to display a clear image.

After the crystal grain image appears, lower the probe current by Beam Condition in order to increase the resolution of the image.

Follow the procedures described in sections 18.3 and 18.4 for saving and printing the grain image.

20. Unloading Specimen



CAUTION

Do not place your hand in the sub-chamber while parts in the sub-chamber are operating. The moving parts can injure your hand.

Open and close the sub-chamber cover carefully. If the cover drops, it can injure your hand.

Be sure to wear gloves before loading the specimen. The vacuum in the main chamber could deteriorate by skin oils if the specimen or the specimen holder come into direct contact with the hand.

20.1. Transferring to Sub-chamber

- 1) Click the **Start-up** button in the application button area to display the Start-up window after Login.

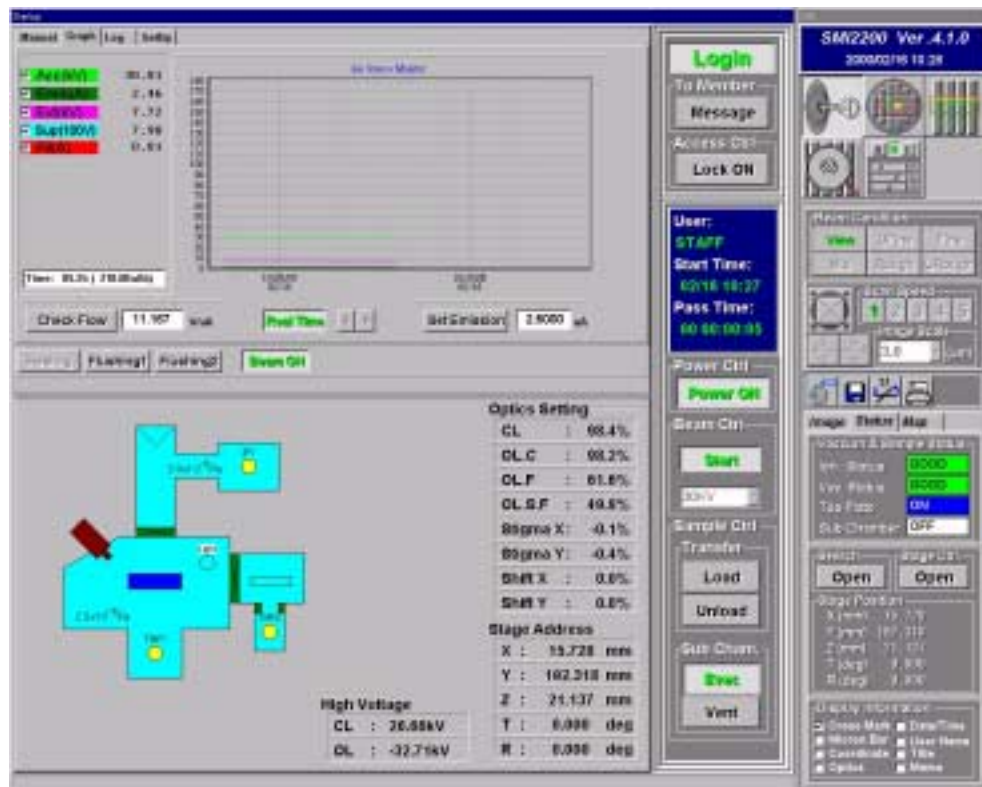


Figure 20-1 Startup Window After Login

20. Unloading Specimen

- 2) Click the **Transfer-Unload** button. The Unload button starts blinking, and the specimen is transferred from the main chamber to the sub-chamber. When transfer is complete, the Unload button stops blinking and changes from green to black.

The progress of transferring from the main chamber to the sub-chamber can be monitored by the animation in the vacuum status display area.

20.2. Unloading from Sub-chamber

When transfer from the main chamber to the sub-chamber completes, the Vent button automatically start blinking. When it stops blinking and turns to green, the sub-chamber is at atmospheric pressure.

- 1) Open the sub-chamber cover by hand, and unload the specimen holder.

20.3. Unloading Specimen from Specimen Holder

Push the knob on the back of the specimen holder, move the lock nail on the top surface of the specimen holder outward, and detach the semiconductor wafer from the specimen holder.

20.4. Storing Specimen Holder in Sub-chamber

- 1) Set the specimen holder in the sub-chamber, while hanging the hook on the backside of the specimen holder on the pin located at the transfer arm tip in the sub-chamber.
- 2) Close the sub-chamber cover by hand.
- 3) Click the **Sub Cham. - Evac** button in the Startup window after Login. Evacuation of the sub-chamber begins, and the Evac button start flashing. It stops flashing and changes to green when the evacuation is complete.

Note: While the SMI2200 is not being used, set and store the specimen holder in the sub-chamber. If you have several specimen holders, be sure to store unused specimen holders in the desiccators.

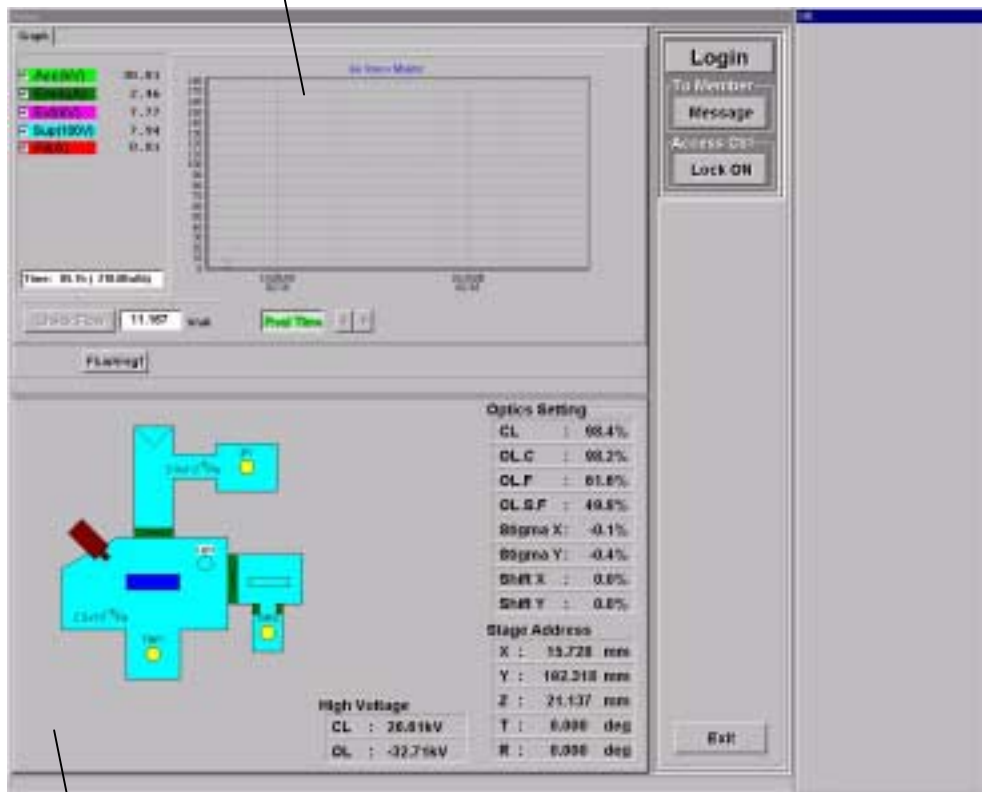
21. Log-out

21.1. Log-out

- 1) Click the **Start-up** button in the application button area. The Start-up window after Login appears.
- 2) Click the **Login** button. The screen changes to Start-up window before Login.

Note: Maintain the SMI2200 in the log-out condition when the day's operations are not complete, but processing and observation of specimen are complete. Ion beam emission, the gas injector heater power supply, and the ion optical system controlled power supply continue operating.

Ion source tab switch area



Vacuum status display area

Figure 21-1 Startup Window Before Login

21.2. Re-use Following Log-out

- 1) Execute login according to the procedures in section 13.1.

21. Log-out

22. Refreshing Ion Source

When the ion emission time indicated in the Time column in the ion source function tab switch area exceeds 24 hours, a message requiring refreshing appears. (in the event the message appears during the middle of processing, time is extended until processing is complete). Carry out refreshing procedures.

- 1) Confirm that the Scan button in the FIB control button area is in eye close status. If not, click the button to close it.
- 2) Click the **Start-up** button in the application button area. The Start-up window after Login appears.
- 3) Click the **Beam Ctrl-Start** button. Ion beam emission stops, and the button changes to black.
- 4) Click the **Start** button again, and carry out ion beam emission. (Refer to section 13.2).
- 5) Adjust the beam according to the procedures in section 15.

23. Procedures for Managing Image Noise

Sometimes noise appears in the image display area when the SMI2200 operates continuously. This phenomenon arises when the ion source has deteriorated, or when there are large emission current fluctuations. In such cases, carry out flushing.

- 1) Confirm that the Scan button in the FIB control button area is in eye close status. Click the button if the eye is in open status.
- 2) Click the **Start-up** button in the application button area to display the Start-up window after Login.
- 3) Click the **Flushing 1** button on the ion source function switch tab, and perform flushing of the ion source. The Flushing 1 button lights up during flushing, and change to black when flushing ends.

Note: Contact staff if the image noise does not improve after flushing.

24. Daily Shutdown

24.1. Ion beam Shutdown

To shut down ion beam emission after the day's operations are complete, the following conditions are necessary.

- (1) The specimen has been unloaded from the main chamber.
- (2) The Start-up window after Login appears.

- 1) Click the **Beam Ctrl – Start** button. The ion source high voltage power supply is cut, ion beam stops emission, and the Start button turns black.
- 2) Click the **Power Ctrl - Power ON** button. The ion optical system control high voltage power supply is cut and the Start button turns black.

24.2. Log-out

- 1) Log-out according to the procedures described in section 21.1.
- 2) Click the **Exit** button. The Exit button changes from black to green, and then go back to the initial Windows screen.

24.3. SLEEP Switch ON

- 1) Click the **start** button in the initial screen of Windows, and then click the **shutdown** button. The shutdown window appears.
- 2) Click the **Shut down the computer (S)** button, and click the **Yes** button. The computer's shutdown window soon appears.
- 3) Press the **SLEEP** switch on the operation mode panel under the operation table. The PC screen blacks out without cutting off the main electric power supply. Operation conditions continue, and the READY LED, GAS TEMP LED and POWER LED of VACUUM (ION), and VACUUM (MAIN) controls on the maintenance panel remain lit.



Figure 24-1 SLEEP Switch

Note: Maintain the sleep switch in the ON position without turning off the main power supply after finishing the day's operation. For starting up the system next day, follow the procedures described in section 12.3.

25. Emergency Shutdown

Press the emergency shutdown switch if smoke or unusual noises occur while the SMI2200 is operating.

When the emergency shutdown switch is pressed, all power supply circuits, except the emergency shutdown circuit, are cut off.

After an emergency shutdown, Staff must contact SII service personnel, and follow their instructions.

To release the emergency shutdown switch, rotate the switch button in the direction of the arrow. The emergency shutdown switch is a push-and-lock type. After the emergency shutdown switch is released, the equipment will still not operate. Turn on the power supply to restart the system.

25. Emergency Shutdown

26. Complete Shutdown

Before cutting off the main power to the SMI2200, shut down the PC. (Refer to procedures (1) and (2) described in section 24.3.)

Turn the LINE switch in the transformer box to the OFF position after confirming the PC has been shut down.

Note: It is not necessary to turn off the switches of POWER 1 and POWER 2, at this time.

Users are required to turn off the line switch only before a long vacation, a power suspension for plant maintenance or the like.

If problems occur in the SMI2200, do not turn off the Line switch, and contact SII service personnel and follow their instructions.

26. Complete Shutdown

Appendix: SMI2200 Principle of Operation

Ion Source

Ion source is the source of ion beam. SMI2200 uses a needle-type, liquid metallic gallium as an ion source. The metallic gallium is stored in the coil in a liquid status and is supplied to a needle under the coil, and the surface tension of the liquid gallium causes it to adhere to the point of the needle.

The melting point of gallium is 29.75°C. Generally it is in the liquid status in the room temperature but it solidifies if the temperature decreases. To keep the liquid status, filament is used to heat the coil.

The extract voltage V_{EXT} is applied between the needle and extractor to make an electric field which is used to extract ions from the liquid gallium. The extractor has a negative potential and extracts the positive charge ions. The amount of ion emitted from the ion source is converted into the charge transfer rate per unit of time, and shown in current value. This current is called the emission current.

Contrary to the extractor, the suppressor has a positive potential V_{SUP} and controls to maintain the ion flow emitted from the needle at a certain rate. The potential difference between the needle and ground is 30kV and this potential difference creates the accelerated voltage V_{ACC} that expels the ion emitted from the needle toward the specimen.

The current density distribution of ion beam emitted from the ion source is a normal distribution, in which the density is highest at the tip of needle (= center axis) and gradually reducing as leaving from the center. The stationary aperture located under the extractor shuts the periphery part of ion beam at where the current density is low, and extracts only the high-density center part of ion beam from the ion source.

Ion Optical System

The ion beam emitted from the ion source passes through the ion column and is irradiated to the specimen. Some kinds of lens, aperture and electrode are built in the ion column to control the diameter, amount and irradiation position of ion beam being irradiated to the specimen. The ion amount reaches to the specimen is called the probe current.

The condensing lens is an electrostatic lens and controls the diameter of ion beam emitted from the ion source.

The blanking electrode has a shape of cylinder divided into two. The blanking electrode does not create the potential difference between electrodes while the ion beam is irradiated to the specimen. Consequently the ion beam passes the electrodes straightforward. On the other hand, it creates a large difference in the electric potential between the electrodes to generate an electric field, and bends the path of the ion beam so that the ion beam cannot pass through the movable aperture if the ion beam is unnecessary to be irradiated to the specimen.

The alignment electrode has a shape of cylinder divided into eight. It adjusts the path of the ion beam slightly with an electric field so that the ion beam passes through the center of the object lens.

The aperture has six (6) holes of different diameter and the ion beam coming from the alignment electrode passes through one suitable hole. The hole has a function of controlling the ion amount passing through the hole. The probe current of ion beam passed through the small hole is low while that of large hole is high. When the operator select an ion beam force (beam condition), the aperture moves to align a suitable hole to the ion beam path. The aperture also automatically adjusts its

positioning when the ion beam path is slightly deflected by the alignment electrode.

The stigmator has a shape of cylinder divided into eight. In order to utilize high functions of SMI2200, the cross section of ion beam should be a perfect circle. However, because of the dispersion of each electrode and lens, it never be a perfect circle, in other words, there are stigmata. The stigmator generates the electric field by applying the necessary voltage, and adjusts the cross section form of the ion beam closer to a perfect circle. The effect of stigmator can be checked by the clearness of focused image.

The object lens is an electrostatic lens. It focuses the ion beam, and aligns it with the focal point on the surface of the specimen.

The deflecting electrode has a shape of cylinder divided into four. It bends the path of the ion beam in the electric field generated by the voltage applied between electrodes, and determines the irradiation location on the specimen surface. The deflecting electrode scans the ion beam above the specimen by continuously changing the applied voltage. The SMI2200 changes the electric field of deflecting electrode continuously to move the ion beam irradiation position and function as a scanning ion microscope.

Sputter Etching

The gallium ions generated from the ion source have mass. When the ion crashed to the specimen, the kinetic energy expels atoms of material surface. This phenomenon is called sputter etching.

SMI 2200 increases the effectiveness of sputter etching by focusing ions into a small diameter beam having a high density before irradiating to the specimen. By setting the areas to where the ion beam irradiates, ion beam probe current and beam irradiation period to adequate values, you can make a rectangular hole in the specimen.

Deposition

When irradiating ion beams while spraying a specific compound gas on the specimen surface, the ion beam kinetic energy decomposes the compound into solid elements and gas elements. The solid elements are adhered to the specimen surface and accumulated. This phenomenon is called ion beam assisted deposition. The gas elements are exhausted outside of the main chamber by vacuum pump. SMI2200 uses phenanthrene or hexacarbonyl tungsten as a material gas. Phenanthrene is used for carbon deposition and hexacarbonyl tungsten is for tungsten deposition.

The ion beam having suitable current density must be used for deposition. If the kinetic energy of ion beam is too small, the atoms do not adhered to the specimen surface. If it is too large, then sputter etching takes place on the specimen surface. Therefore the suitable ion beam having the optimal current density for deposition must be selected.

By entering a type of deposition material, area and thickness of deposition, PC recommends a suitable beam condition having an adequate probe current. When the operator selects the beam condition and carry out deposition, rectangular-shaped carbon film or tungsten film is formed on the specimen surface.

Eucentric Calculation

The Z-axis position at where the ion beam focuses is fixed. In order to carry out scanning ion microscope observation, sputter etching or deposition, the height of the specimen surface shall be

aligned to the focusing point accurately.

Since the thickness differs from specimen to specimen, Z-axis of ion beam irradiation position must be adjusted to the ion beam focal point whenever a specimen is changed. Also, when the specimen stage is tilted, the height of specimen surface changes and the Z-axis of irradiation position needs to be adjusted to the ion beam focal point. However, the ion beam irradiation position must be maintained at the ion beam focal position when the specimen tilts.

The height of specimen surface is adjusted as follows. Select a certain point of specimen image displayed in the screen, and move that point to the center of screen. First tilt the specimen stage to 30° . If the height of the specimen surface is different from the ion beam focal position, the selected point in the image shifts from the center of screen. Move the specimen stage horizontally until the selected point moves back to the center of screen. Then tilt the specimen stage to 60° and move back the selected point to the center of screen. Finally set the tilt angle to 0° . The moving distances at tilt angles of 30° and 60° is used as data, the PC performs the prescribed calculation to obtain a shift of vertical direction between the specimen surface and ion beam focal point. The Z-axis is moved up and down according to these calculated values to adjust the ion surface to the ion beam focal point.

This calculation performed by the PC is called the Eucentric Calculation.