

SEC CO., LTD.

# SNE-1500M

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## User Manual

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## Scanning Electron Microscope

### SNE-1500M

#### User Manual

Issued on October 1, 2007

**Revised on April 7, 2008**

SEC Co., Ltd.

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## Appendix 1. Drawing



## I. Mini-SEM Introduction

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## 1. General

The Scanning Electron Microscope (SEM) is used for observing the surface structure of a sample. The column is made up of an electron gun that generates a stream of electrons. The stream passes through apertures and an electronic lens system that controls the flow of electrons. The electron stream then passes through scan coils that raster the beam over the sample. Secondary electrons are emitted from the sample and are then collected by the secondary electron detector. The secondary electron signal is digitally captured, processed and ported through a USB connector to a PC for viewing. The PC software also controls the column settings. The column settings are the magnification, high voltage, condenser lens, vacuum and other microscope setting.

The microscope was designed with an intuitive easy to use software interface. Automatic and manual operations are completely software driven. The only manual adjustment is changing and aligning the filament. Also cleaning the column liner and replacing the apertures.

The Mini-SEM has a 3 axis manual stage that is controlled by the three knobs on the stage door.

## 2. Features

### Features:

- . Fast and easy to use electronic microscope
- . Table-top size
- . Automatic and manual adjustments
- . Fast sample exchange: At 3 minutes after sample exchange, image observation is ready..
- . Intuitive Graphic User Interface
- . Providing images of high resolution and high depth

### Application

- . Life Science
- . Food
- . Cosmetics
- . Healthcare
- . Pharmaceuticals
- . Textiles
- . Materials Science
- . Semiconductor
- . Education

### 3. Basic Principles of Scanning Electron Microscopy

#### Optical Microscope Limitations

An Optical Microscope is an analytical tool that uses visible light and a system of lenses to magnify and view the sample. Our eyes obtain visible light from the sun during the day to see, and we use electricity indoors to power lamps and lighting fixtures to see in dark areas. Most optical microscopes use an adjustable light source to control the brightness of the viewed image. Optical microscopes have a long history in the analytical sciences and are very useful in low magnification conditions. The resolution of a typical optical microscope is limited to the lens system and the wave length of visible light which is 400nm to 700nm. The maximum magnification is around 1500x and at this magnification the depth of field is very small. In comparison the naked eye has a resolution of approximately .1mm. A typical optical microscope resolution is approximately 200nm or .2um. The resolving power of the Mini-SEM is approximately 8nm or .008um at 20kv. The reason for the increase in resolution is the Mini-SEM has an electron source which emits an electromagnetic wave or beam of electrons which is much smaller in frequency than light. This huge increase in resolution means a much higher magnification > 20,000x and a larger depth of field. The Mini-SEM is positioned as an alternative to a high end optical microscope with greater resolving power and the ability of using different detectors such as Backscatter or X-ray.

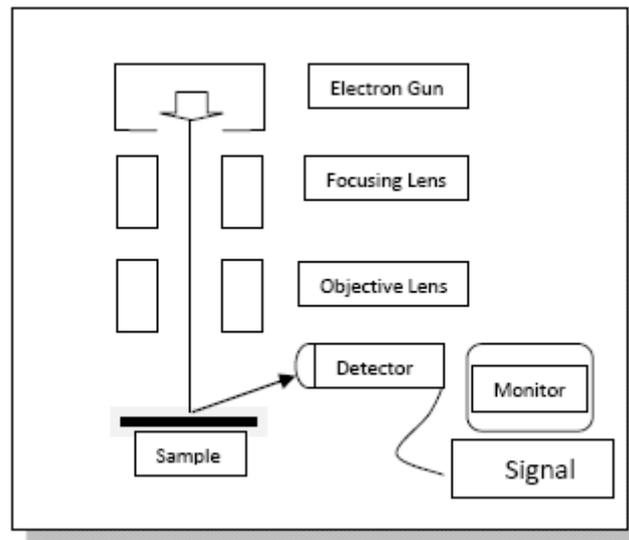
#### Electron Microscope Features

The electron microscope creates a beam of electrons by thermionic emission. A tungsten filament is heated to approximately 1800K in a high vacuum. An electrostatic field is used to pull the electrons from the heated filament. In order to achieve this, a high voltage is placed on the filament and the Anode is held at ground. As the electrons leave the filament tip the Wehnelt cap is used to focus the beam towards the anode. A hole in the anode plate allows the beam to travel down the column liner towards the sample. A series of apertures and electromagnetic lenses refine the beam to a small diameter. The beam is then shaped by Focus and Stigmator coils which reduce it to a finely focused dot. A set of scan coils control the X & Y raster on the sample. When the electron beam hits the sample a few things happen. Some of the electron beam gets scattered back out of the sample as backscattered electrons. Some interact with the surface of the sample they are called secondary electrons. These electrons are too weak and must be pulled away from the sample with a high voltage attached to the secondary detector. The electrons then hit a phosphor plate which converts them to light. The signal is amplified and used as a display signal. This signal is then adjusted with brightness and contrast amplifiers then digitized for viewing on a PC.

## Scanning Electron microscope structure

Scanning electron microscope is made up the figure shown as Figure 1. Electron that was accelerated by electron gun is made to small spot through focused lens and vector is adjusted to go to the specific point of time through object lens.

Electron that reached to sample generated various signals by colliding to sample. Detector to detect Second Electron (SE) in the signals is attached to “SNE-1500M”. The signal passed through detector is displayed on monitor being converted to the image to be seen by people through signal processor.



**Fig. 1 SEM Schematic View**

## Generation an Electron Beam

The Mini-SEM comes standard with a Tungsten filament. The filament is part of a gun assembly which consists of a filament, Wehnelt cap and an anode plate. An electron beam is produced through thermionic emission. The filament is heated in a vacuum and a high voltage from 1kv to 30kv is applied. The filament heat is increased until the electrons can overcome the work function energy barrier ( $E_w$ ). This allows the electrons to leave the filament wire and head towards ground. The Wehnelt cap controls the flow and focuses the beam towards the Anode. The beam travels down the column liner tube where an assortment of electromagnetic lenses and spray apertures reduce and refine the beam into a very small spot.

## Generation of a Secondary Electron

When the accelerated electron collides with the sample an inelastic scattering of the electron in the sample occurs. All of these interactions are very close to the surface of the sample. Some of these secondary electrons scatter towards the surface. If the energy of these electrons is stronger than the energy binding them to the sample they may leave the sample as secondary electrons. These secondary electrons are weak in energy and need to be pulled away by a high voltage on the secondary detector. The secondary electrons carry with them a lot of surface detail and are the main viewing signal on the Mini-SEM.

## How to detect Secondary Electron Detection

The desktop Mini-SEM uses an E-T secondary detector for image acquisition. The detector was developed by Everhart – Thornley in 1960. It is capable of detecting secondary and backscattered electrons. In the secondary mode a positive bias voltage is placed on the Faraday cage of the detector. This draws the weak secondary electrons to the detector and to the phosphor plate. The electrons that collide with the phosphor plate generate a small light signal that is amplified and converted to an electrical signal. The backscatter mode allows the collection of a backscatter electron signal by removing the positive voltage from the Faraday cage. Due to the position of the E-T detector and its fixed geometry and the fact that the stage cannot tilt towards the detector the backscatter mode is limited. Special 45 degree sample stubs and geometries need to be aligned with the detector to view a backscatter image.

#### 4. Mini-SEM Description



**Fig. 2 Front of Mini-SEM SNE-1500M**

**Power Switch:**

This is the main power on / off switch. Push the red button to apply power to the unit when operating. Push the button again to shut the unit down.

**Exchange Switch:**

This is the main vacuum switch

OFF - Vacuum is released, the column is at air.

ON – The column is under high Vacuum

Slow flickering – Column is pumping down.

Fast flickering – Release vacuum.

**Vacuum LED:**

This indicates the degree of vacuum in the chamber.

**Chamber Door:**

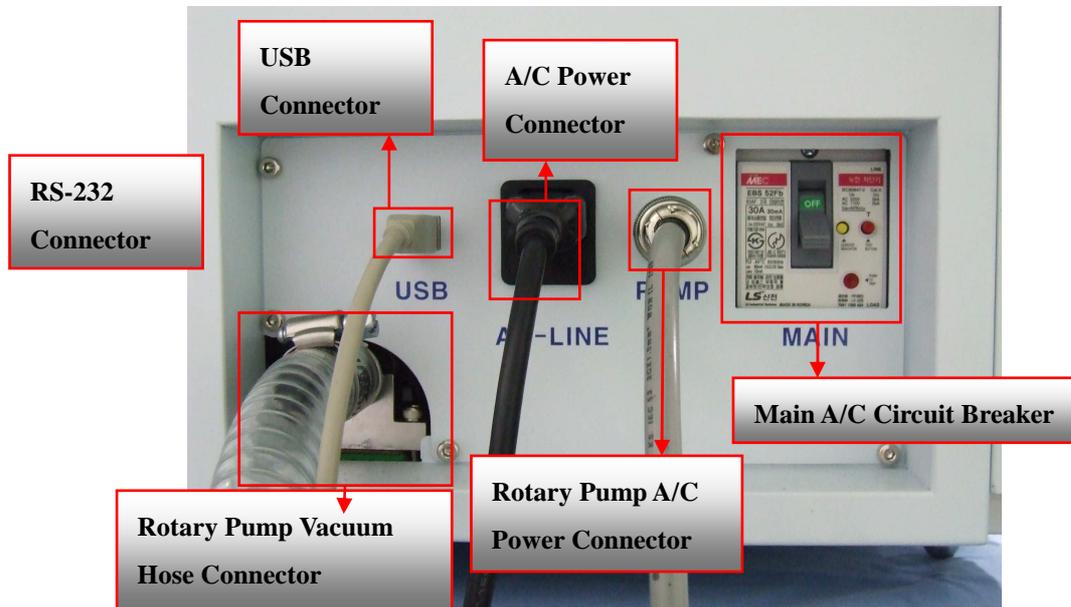
Pull open the door when the column is at air to change the sample. To view the sample, close the door, pump down the column and turn on the beam.

**Stage Control Knobs:**

Manual stage controls in X-axis, Y-axis and sample Rotation.

**Filament Exchange Cover:**

Remove this cover if replacing a filament or if gun alignment is necessary.



**Fig. 3 Back of Mini-SEM SNE-1500M**

**Main A/C Circuit Breaker:**

A 220 VAC main circuit breaker with ground fault protection controls the power to the Mini-SEM

**Power Connector:**

This is connected to 220 VAC power outlet

**Rotary Pump Vacuum Hose Connector**

This connects the rotary pump to the back end of the turbo molecular pump.

**Rotary Pump Power Connector:**

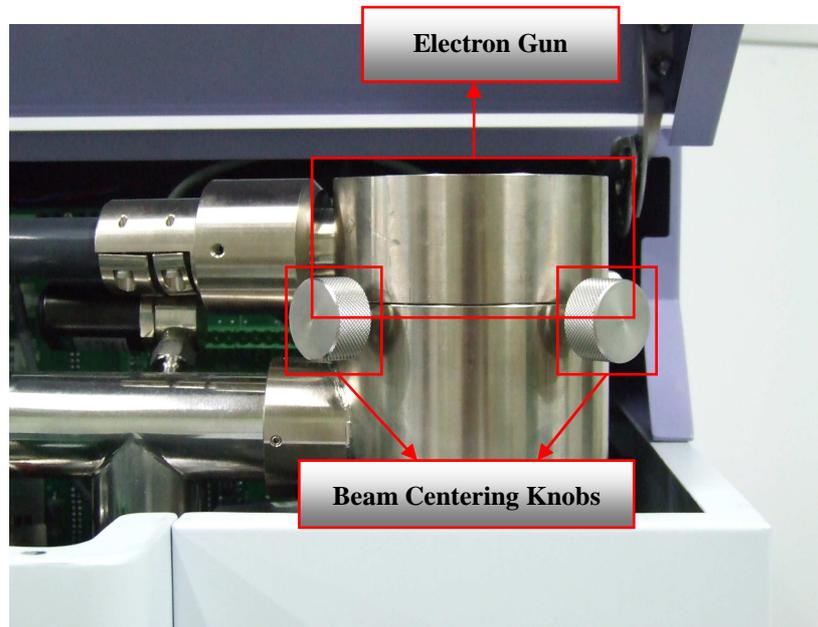
This is the power cable to the Rotary pump

**USB Connector:**

USB cable that transfers the video signal to the PC.

**RS-232 connector:**

Controls the column parameters to the Mini-SEM



**Fig. 4 Electron Gun Housing and Beam centering adjustments**

**Electron Gun:**

The electron gun assembly holds the tungsten filament. To access the electron gun open the Mini-SEM top cover. If a filament is blown and needs replacing vent the column to air and lift the electron gun to access the filament.

**Beam Centering Knobs:**

The four knobs control the centering of the beam to the Anode. This adjustment is critical for maximizing the beam signal down the column after a new filament is installed.



**Fig. 5 Rotary Pump**

**Vacuum Hose Connection:**

The rotary pump vacuum hose connects to the rear of the Mini- SEM. This pump is used as a rough pump for the column and the turbo molecular pump.



**Fig. 6 Laptop Computer**

**A/C Power Connector:**

This is the rotary pumps main A/C power connection and connects to the rear of the Mini-SEM labeled PUMP.

## II. Mini-SEM SNE-1500M Specification

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## 1. Standard Specifications

### Resolution

15.0nm (at accelerating voltage of 20kV, working distance of 8mm)

### Magnification

20x to 15,000x

### Electron Optics

<input type="checkbox"/> Electron Gun	- Thermo-electron emission type
<input type="checkbox"/> Accelerating voltage	- 0 to 20kV
<input type="checkbox"/> Lens system	- Electromagnetic lens reduction system
<input type="checkbox"/> Objective lens aperture	
<input type="checkbox"/> Stigmator coil	- Electromagnetic type
<input type="checkbox"/> Scanning coil	- Two-stage electromagnetic deflection
<input type="checkbox"/> Scanning rotation	- 360°

### Specimen Stage

① X movement	- 0 to 20 mm
② Y movement	- 0 to 20 mm
③ Rotation	- 360°
④ Maximum sample size	- 75 mm in Diameters
⑤ Maximum Sample thickness	- 12 mm

### Image Display

① Detector	- SE detector
② Display	- 17inch LCD
③ Scanning mode and speed	- Fast Scan: 0.1s (X=320lines, Y=240lines) - Slow Scan: 3s (X=640lines, Y = 480lines) - Fast Photo: 10s (X=1280lines, Y = 960lines) - Slow Photo: 30s (X=2560lines, Y = 1920lines)

- ④ Data display
  - Date
  - Time
  - Scale Bar
  - Accelerating Voltage
  - Magnitude

## Image Memory

- ① For Fast Display
  - 320 x 240 x 8bits
- ② For Display
  - 640 x 480 x 8bits
- ③ For High Resolution
  - 1280 x 960 x 8bits
- ④ For Ultra-High Resolution
  - 2560 x 1920 x 8bits
- ⑤ Memory functions
  - Image Integration (in Fast Scan mode)
  - Brightness control
  - Contrast control
- Memory Device
  - HDD of PC
  - Any recording medium in the PC
- ⑦ Image format
  - BMP, JPG, PNG, GIF

## Measuring Tool

- ① Length
  - Two Point length measuring
  - Multi Point length measuring
- ② Multi Point Area
- ③ Marking
  - Arrow Marking
  - Text Marking
  - Square Marking
  - Rectangle Marking

## Automatic Function

- Auto brightness and contrast
- Auto focus

## Operation support functions

- Operation Environment                    - Graphic User Interface
  - Simplified Menus
- Control devices                            - Power Switch
  - Vacuum Button
  - Dedicated Rotate Knob
- Condition registration                    - Pre-defined 6 conditions

## Vacuum System

- Ultimate vacuum                         - Electron gun:  $0 \times 10^{-7}$  Pa
  - Specimen chamber:  $0 \times 10^{-4}$  Pa
- Rotary pump                                - 100L/min x 1 unit
- Turbo molecular Pump (TMP)            - 70L/sec x 1 unit
- Vacuum gauge                            - Pirane gauge

## Control Unit (PC) Specification

- OS    - Windows® XP Professional SP2 (Korean)
- CPU                                         - Intel® Pentium® Core™ 2.0 GHz
- Memory                                    - 1GByte
- Interface connector                    - USB 2.0 and RS-232
- User Interface device                    - Keyboard
  - Mouse

## Dimension and Weight

- Main Unit                                 - 240(W) x 390(D) x 515(H) mm
- Control Unit (Laptop Computer)       - 178(W) x 280(D) x 515(H) mm
- Rotary Pump                             - 150(W) x 200(D) x 215(H) mm



### 3. Standard System Composition

**SNE-1500M**

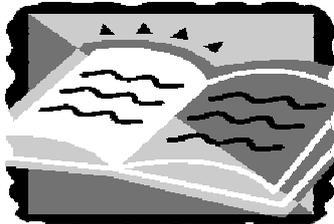
1unit

**Rotary Pump**

1unit

**PC**

1unit

**User Manual**

1copy

**USB Cable**

1unit

**Power Cable**

1unit

**Air Hose**

1unit

**Spare and consumable parts**

1set

**Standard tools**

1set

**Fig. 7 Packing List**

### III. Installation

---

## 1. Installation Requirements

### General

Mini-SEM SNE-1500M should be installed avoiding the following conditions since it is sensitive to surrounding vibration, electric power fields and magnetic fields.

- Do not place near a transformer.
- Do not place near an elevator.
- Do not place near equipment with a large consumption of electric power.
- Do not place the instrument where a high frequency field may be generated or near something that products an electrical spark discharge..
- Do not place near any chemical or gas that the possibly of corroding the instrument..
- Do not expose to direct sun light or wind.
- Do not place in an area that has unregulated temperature and humidity.
- Place the instrument on an isolated ground.
- Do not place in a location with large sound waves.

### Temperature and Humidity

Place in a temperature controlled, humidity controlled environment.

- Temperature: Maintain the temperature of the place where the unit installed at 15℃ ~ 30℃ at all times; do not exceed 5℃ in temperature change when the unit is being operated.
- Humidity: Maintain humidity of the unit installed place under 70% at all times.

### Electric Power

- Electric power for major equipments:  
Single phase 100~240V AC, 2kW, 60Hz
- Electric power for peripheral equipments:  
Single phase 100~240V AC, 1kW, 60Hz
- Supply electrical power in the fixed volume in using the unit. Do not exceed 10% of supplied electric power volume as the variation allowable value of electric power volume.

### Earth

- Apply the first degree earth.

## 2. Installation Configuration



**Fig. 8 Installation Configuration**

#### IV. Precaution

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## 1. Moving Precaution

- Do not carry or move the unit while power is on. The unit produces very high voltages and is a shock hazard. Also the turbo molecular pump spins at a very high speed and any sudden movements while it is spinning may cause the turbo to fail.
- The total weight of the unit is about 100kg. Care must be taken when carrying the unit to avoid a back injury or damage to the equipment. A service person or co-worker should help in any transportation.
- Provide a strong vibration free table for the instrument. Place the provided feet on each leg of the unit; this will give a firm resting position for the microscope.

## 2. Electric Power Precautions

- . Ensure there is proper power to the Mini-SEM. An A/C transformer that converts 110vac to 220vac will be provided. The transformer will provide a common ground to the Mini-SEM and PC.
- . Power down the Mini-SEM when opening the cover or replacing accessories.
- . Do not operate the Mini-SEM without a good earth ground. The system may malfunction and there is a chance of electrical shock.
- . To limit personal injury do not attempt any service without first contacting an EVEX service engineer.
- . Do not use any power supplies except for the one provided with the Mini-SEM . This may cause damage to the unit or start a fire.
- . Do not break down the high voltage tank in the Mini-SEM this may cause serious damage to the unit or electrical shock.
- . Avoid any undue stress on the electrical cord from the Mini-SEM. Do not apply too much twisting, bending or tension which may cause the cable to fail. A serious risk of electrical shock or a fire is possible.

### 3. Safety Precaution:

- Do not disassemble or service the Mini-SEM without first contacting an SEC service engineer. Due to the complexity of the unit, problems may occur including poor image quality, unit malfunction or damage..
- Do not use the PC for anything but controlling the microscope. Loading the PC with programs could have a serious effect on the quality and speed of the Mini-SEM. In some cases errors in the program or damage to the unit may occur.
- Rotary pump service is essential to a smooth running vacuum system. Periodically check the oil level every few months. Replace or refill the oil if discolored. If this is ignored a degrading vacuum will occur and the overall image quality will suffer. The possibility of permanent damage to the vacuum system is possible.
- Remove power from the Mini-SEM while changing the filament. The Mini-SEM creates very high voltages when in use as a precaution power down the unit.
- After replacing and saturating the filament, center the electron beam using the alignment knobs. This procedure increases the intensity of the beam on the sample. A poorly aligned beam will have a major impact on the quality of the image.
- Do not move the electron gun assembly or the cable after the high voltage has been turned on. The high voltage may be as high as 30kv and may cause serious injury or damage to the unit.
- If a vacuum problem has occurred do not keep pumping on the column. This will only wear out the rotary and turbo pumps. Look for the source of the leak (i.e. Dirty O- ring) and then retry the vacuum system. If there is still a problem, call your SEC service engineer.
- Do not modify any hardware or software on the Mini-SEM without permission from SEC. Electrical shock or permanent damage to the unit may occur.
- Do not open the cover except in the case of replacing a filament. This will limit any possibility of injury due to electrical shock.
- If the need arises that you think you need to open the cover please contact an SEC service engineer first.

#### 4. General Precautions

- Refer to the proper section in the manual for any maintenance that will be performed. Call your service engineer if any questions arise.
- Customers should only attempt the below repairs on the Mini-SEM. Any other service should be performed by a trained & qualified SEC service engineer:
  - Filament replacement
  - Wehnelt Cap cleaning and polishing
  - Cleaning and polishing the anode and sleeve
  - Changing apertures
  - Cleaning and replacement of Chamber door O-ring
  - Change rotary pump oil
- Keep the column under vacuum if not in use. Do not install the Mini-SEM in an area with high humidity or large temperature swings. Keep the Mini-SEM where it was installed.
- Try to keep the Mini-SEM under vacuum. If the system is not used for an extended period of time recycle the vacuum. This will keep the column clean and dry.

## 5. Sample and Chamber Precautions

- Be careful in choosing different types of samples to use in the SEM. Some samples, especially powders may contaminate the chamber. The electron beam may react with the sample and oxidation may occur. This oxidation may contaminate the column and can react with the column walls causing corrosion. This contamination will also affect the apertures, secondary detector scintillator and other parts of the column degrading the image quality.
- Pay attention to the size of the sample. Do not allow the sample to contact the column pole piece, secondary detector or the EDS detector (if an EDS detector is installed). Major problems can occur with the column or the EDS detector if the sample hits them.
- Ensure the chamber door is closed completely before evacuating the column.

## V. Program Configuration

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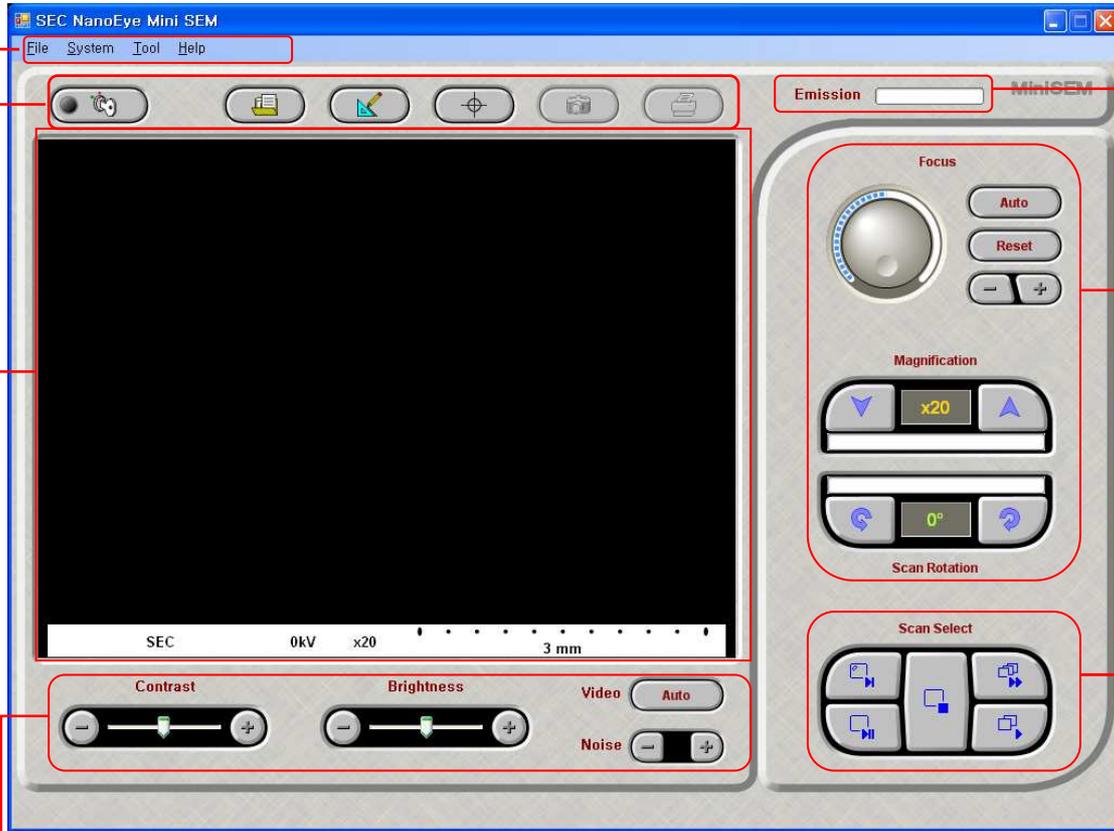


Fig. 9 Main Screen

**Image adjustment**

Adjusting light and shade, brightness of screen

**Image Window**

Image acquisition area

**Tool Bar**

Start Scanning, Open Image, Cross Point, Image Acquisition, Print

**Main Menu**

Configuration: Sets High Voltage, Secondary Detector Parameters & Beam Alignment  
Tools: Cross Point, Measurements, Microscope and Scanning Adjustments

**Scan Select**

Adjusts scan rate and size

**Magnification:**

Adjusts image Magnification and Electronic Scan Rotation

**Focus:**

Manual and Automatic Image Focus

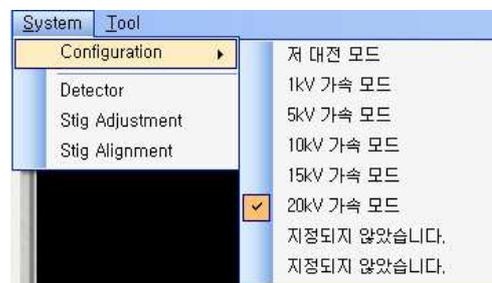
**Filament Information**

Emission Current Meter

## 1. System Menu

### □. Configuration

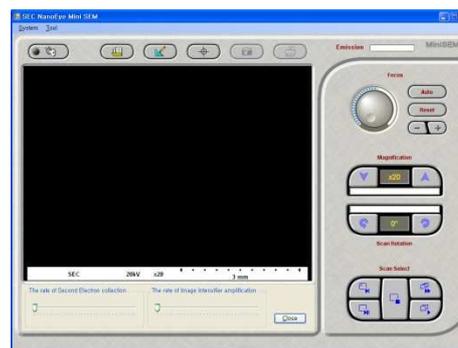
Left click on the configuration menu to select the predefined acceleration voltage that best fits your samples requirements. If the acceleration voltage is changed several set points are also changed that define that acceleration voltage such as the filament current and emission current. Lowering the acceleration voltage will reduce charging but will also reduce the beam resolution and intensity. Increasing the acceleration voltage will give a stronger image and higher resolution but a well grounded sample is needed.



**Fig. 10 System Menu**

### □. Detector

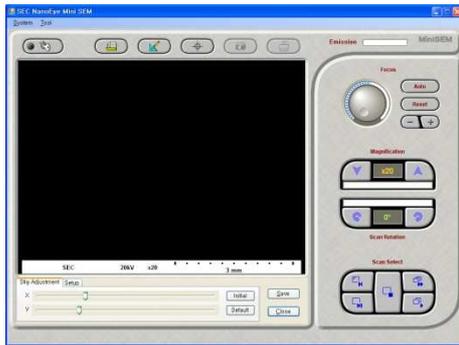
Selecting the detector menu item will allow you to change the secondary detector parameters. There are two slide bars that control the rate of collection and the amplification or gain. The rate of electron collection is controlled by adjusting the scintillator high voltage. The amplification is adjusted by changing the gain of the preamp.



**Fig. 11 System - Detector**

### □. Stig Adjustment

It corrects astigmatism of electronic magnetic lens. Using it, wrong image due to the distortion of electron beam can be corrected. It can regulate the spot phenomenon of electron beam.



**Fig. 12 System- Stig. Adjustment**

**Stig adjustment:**

Regulate astigmatic pencil to X-axis or Y-axis.

**Initial:**

Set it to 0.

**Default:**

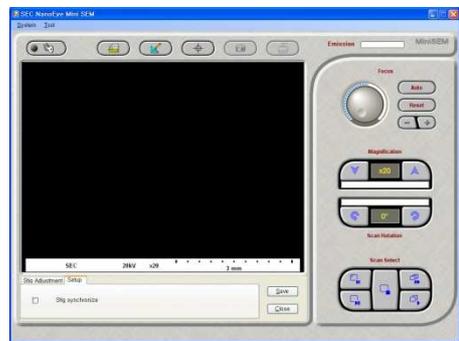
Recover to basic value.

**Save:**

Set present value to basic value.

**Close:**

Close the present window.



**Fig. 13 System – Stig. Adjustment: Setup**

**Stig. Synchronize:**

It is used for adjustment of astigmatism.

□. Stig Alignment

Align stigmatism. Adjustment may be required after exchanging filament or Aperture.



**Fig. 14 System – Stig Alignment**

**X•Y Alignment:**

Select X, Y array.

**Sympathy:**

Operate Wobble function.

**Adjust:**

Open or close Wobble adjustment window.

**Default:**

Call basic value.

**Initial :**

Set it to 0.

**Save:**

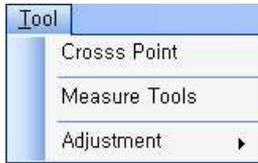
Set present value to basic value.

**Close:**

Close the present window.

## 2. Tools

The Tool menu contains various tools for image column adjustments.



**Fig. 15 Tool**

### Cross Point:

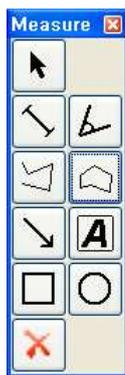
Indicates the center position of the image inside the image window. When adjusting the magnification or rotation the new image will center on this point.

### Measure tools:

This menu option enables various tools for measuring and image annotation.

#### □. Measure Tools

The measurement tool contains various tools for measuring image features including size and angle measurements. There are also useful image annotation tools for drawing on the image or writing text.



**Fig. 16 Tool – Measure tools**

-  Select measuring tool.
-  Measure the distance between tow points.
-  Connect three point and measure the angle between the points.
-  Measure the length of several line segments.
-  Measure the area.
-  Draw the arrow to point specific point.
-  Draw text tool.
-  Draw rectangle on image.
-  Draw circle on image.
-  Delete all measuring .

## 2. Tool Bar

The tool bar that is located just above the image window contains all the basic functions for acquiring an image, opening an old image, displaying the measurement tool, defining the center of the image, saving the image and printing the image.



**Fig.17 Tool Bar**



**High Voltage On /Off:** This button toggles the high voltage on and off. Clicking the button enables the high voltage and produces an image in the image window. Clicking the button a second time will shut off the high voltage.



**Open file:** Opens a directory dialog box for selecting and viewing previously stored images.



**Display measurement tool:** Opens the measurement tool for measuring features and annotating the image.



**Display Cross Point:** Defines the center of the image for zooming in and scan rotation.



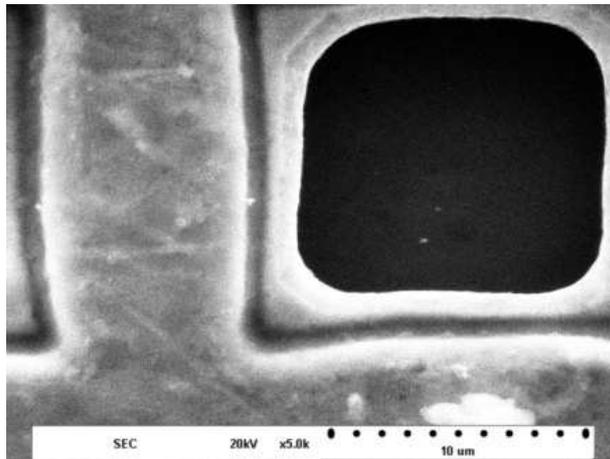
**Save:** Opens the Save File Dialog box. Images are saved as (.jpg) or (.tif) files.



**Print:** Output the image to the defined printer.

### 3. Image Window

This is the main viewing area of the Mini-SEM software. It holds the acquired image and a status bar. When the high voltage is turned on the microscope will automatically adjust to provide a low magnified previewed image. The image adjustments like magnification, focus, contrast and brightness will have an immediate effect on the display. The viewing area on the LCD is approximately 640 \*480 pixels. This is only for initial viewing; the acquired image resolution is much higher.



**Fig. 18 Image Window**

**Status Bar:** The status bar contains the user information, high voltage and micron bar.

## 4. Image Adjustment

This area controls the Focus, Magnification and Scan Rotation of the image.



**Fig. 19 Image Adjustment**



**Focus Control Knob:** Manual focus control by left mouse click and dragging the mouse left or right.



**Auto Focus:** Allows computer control of the image focus.



**Reset:** Sets focus to mid scale.



**+ / - Buttons:** Allows for very small focus adjustments.



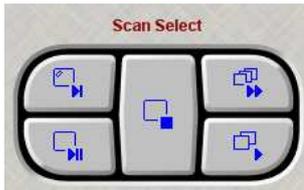
**Magnification Arrows:** Controls the image magnification up or down from 20x to 25,000x. Left click the magnification arrows to increase or decrease your image magnification.



**Scan Rotation:** Controls the electronic image rotation. Left clicking the CW or CCW arrow buttons will cause the image to rotate by 1 degree. The rotation degrees will be displayed in the center window. This should not be confused with stage rotation.

## 5. Scan Select

The select scan buttons control the rate and resolution of the preview and acquired images.



**Fig. 20 Scan Select**

	Fast Scan	Acquires a small (320 * 240) pixels High speed preview. This mode is used when modifying the image focus or contrast and brightness
	Slow Scan	Acquires a higher resolution image of (640 * 480) pixels. The pixel time is the same as the fast scan.
	Stop	This button stops the preview and freezes the image. This is mainly used with the measurement tool.
	Fast Photo	Acquires a high resolution (1280 * 960) pixel image.
	Slow Photo	Acquires the highest resolution (2560 * 1920) pixel image.

## 6. Image Adjustment

The image adjustment slide bars control the contrast and brightness of the image. These controls are applied to the acquired image and do not change the secondary detector levels. This is merely a software adjustment of the 8 bit gray scale. The internal hardware has a 0 to 4096 histogram that the image can shift around in. The 0 to 256 image can shift up or down using the Brightness slide bar or can expand or retract using the Contrast slide bar. Clicking the auto button will allow the computer to set the video levels.



**Fig. 21 Image Adjustment**



**Brightness Control:** Left click and drag the slide bar up or down will increase or decrease the Brightness or offset of the image. Left click on the plus or minus signs will change the brightness by a very small amount.



**Contrast Control:** Left click and drag the slide bar up or down will increase or decrease the contrast or gain of the image. Left click the plus or minus signs will change the contrast by a very small amount.



**Auto:** Clicking on the auto button allows the computer to adjust the contrast and brightness of the image. The 256 gray scale image can be multiplied and shifted within a 0 to 4096 window.



**Noise:** Left click on the noise filter to increase pixel averaging. This filter will lessen the noise by taking multiple reads at each pixel then averaging the data to that pixel.

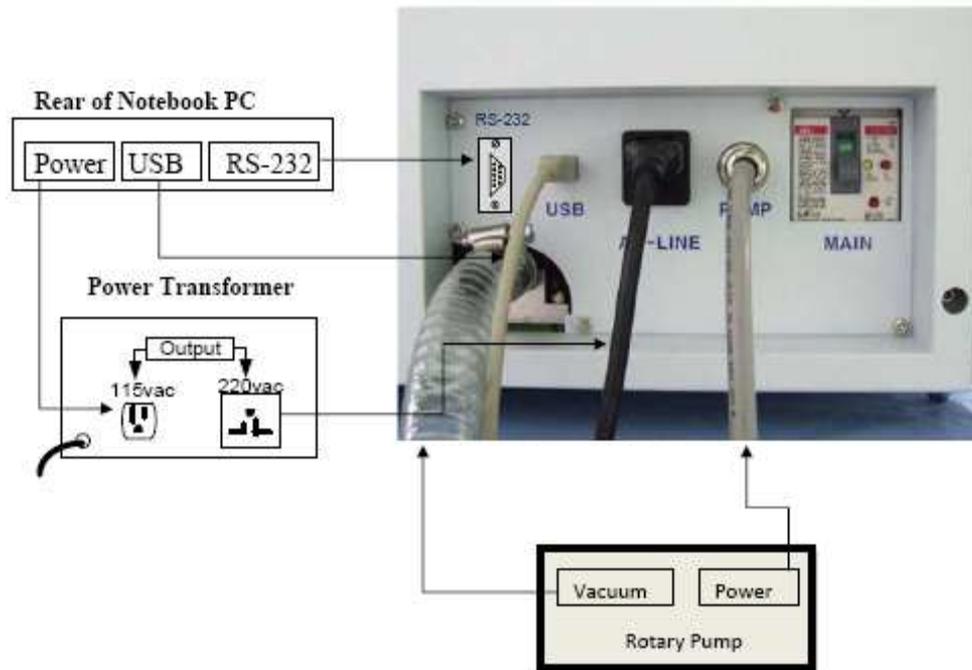
## VI. Installation Instructions

---

## 1. Installation Configuration

- . Install the unit on a strong table top to reduce any vibration.
- . Install the rotary pump on the floor as far as possible from the column.
- . Install the PC to the right of the column leaving access to the chamber door.
- . Do not put any device that generates vibration or electromagnetic waves near the unit.

## 2. Connection of the Unit



**Fig. 22 Components Connection**

1. Connect the A/C power cable from the back of Mini-SEM to the Power Transformer.
2. Connect the supplied vacuum hose to the vacuum hose nipple on rear of the Mini-SEM. The other end of the hose goes to the rotary pump.
3. Connect the power cable of the rotary pump to Mini-SEM connector marked "Rotary Pump".
4. Connect the USB cable from the back of the Mini-SEM to the USB port on the PC.
5. Connect the RS-232 cable from the rear of Mini-SEM to the RS-232 port on the PC.

## VII. Operation

---

## 1. System Description

### Caution before operating:

- . Make sure there is no object or device that can generate vibration or electromagnetic fields in the area.
- . Check that all cables and hoses are connected.
- . Check the chamber door o-ring is clear of any debris. This may cause a vacuum leak.

### Caution while operating:

- . Do not bang on the Mini-SEM.
- . Do not cut off electric power while running the Mini-SEM.
- . Do not try to open the door by force. This may cause a quick change in pressure and rupture the X-ray detectors thin window if one is installed.
- . Close the door after a sample exchange this will keep the chamber free of dust.

## 2. Electric Power

(1). Main Circuit Breaker: The system is equipped with a main circuit breaker on the rear of the Mini-SEM. Switch the circuit breaker to the ON position. This is 220vac GFI breaker. This will allow the main power button in the front of the Mini-SEM to control the system power. Switch the circuit breaker off if the unit is not in use for long periods.



**Fig. 23 Rear of Mini-SEM**

### 3. Vacuum Control and Maintenance

For acquiring image, fix sample on the sample stage and then set vacuum in the unit. It takes time to set and release vacuum. Setting and releasing vacuum can be made by pushing Vacuum button at the front of “SNE-1500M”.

Like a standard SEM, the Mini-SEM has an advanced turbo controlled high vacuum system. The SEM should always be kept under vacuum except when changing a sample. When the unit is powered up the rotary pump evacuates the chamber and pulls on the base of the turbo pump. The LED bar graph on the front of the Mini-SEM displays the vacuum level in the chamber. When the bar graph is at its limit the system will beep indicating it is OK to turn on the high voltage. This process takes about 2-3 minutes. When the system is powered off the chamber will stay under vacuum.

Pressing the exchange button will vent the column allowing for a sample change. Mount the sample on a standard pin stub with proper grounding techniques. Use Carbon tape or paint to adhere the sample to the stub. If the sample is not conductive, sputter coat the sample with Gold, Carbon or Palladium. This will increase the conductivity of the sample which will prevent the sample from charging. Charging occurs when there is a buildup of electrons on the surface of the sample which cannot discharge to ground. The symptoms are very bright or dark areas on the acquired image. Using proper sample preparation techniques will dramatically increase the quality of the image.

Close the door and push the exchange button again. This time the column will start to pump down and the vacuum gauge bar graph will start to rise. When the system beeps the high voltage is ready to be turned on.

Poor vacuum as a result of column contamination or a vacuum leak will affect the quality of the image and shorten the life of the filament. Try to keep the chamber and column as clean as possible. Always check the chamber door o-ring for any dirt or debris. Have your column serviced once a year by SEC service engineer.

## 4. Sample Exchange

1. Preparing the sample: Due to the nature of the SEM the sample should have a good electrical ground to the stage. This prevents charging and the quality of the secondary image is increased. The sample should be mounted on the Evex provided sample stubs. There are two diameter stubs a 15mm diameter for smaller samples and a 25mm diameter for larger samples. The stubs sit inside the sample holder that is screwed down to the stage.



**Fig. 24 Sample Stubs (Top)**

**Fig. 25 Sample Stubs (Bottom)**

2. Vent the chamber by pressing the exchange button. This will power off the turbo pump and rotary pump and leak the chamber to air. After the chamber is vented open the front door by pulling on the handle. Do not force the door open prematurely this may rupture a detector window if the SEM is equipped with an x-ray system.

3. The microscope was shipped with a tool that measures the height of the sample. The height is approximately 8mm from the bottom of the pole piece.



**Fig. 26 Sample Height jig**

**Fig. 27 Adjusting Sample**

**Fig. 28 Sample on Stage**

4. Insert the sample holder onto the stage then tighten. Slowly slide the door closed and push the exchange button again. This will start the pump down cycle which takes 2 to 3 minutes. When the vacuum gauge on the front of the unit reaches its highest level the unit will beep and the system high voltage can be turned on.

## 5. Mini-SEM Application

### **Loading the Software**

1. Check that both the USB and RS-232 cables are connected to the computer and the Mini-SEM.
2. Turn on the PC
3. Double click the “Mini-SEM” icon, the application will load
4. Select SEM high voltage settings from the System, Configuration menu.
5. If the SEM is under high vacuum, left click on the HV on / off button.
- 6 After a few seconds an image will appear inside the image viewing area.

At this point the microscope saturated the filament, adjusted the condenser lens, focused the image, adjusted the contrast and brightness and is scanning the image at a low magnification.

These are only basic setting to get you started. You have full manual control of the stage and microscope parameters to achieve a beautiful high quality digital image.

## 6. Quick Guide

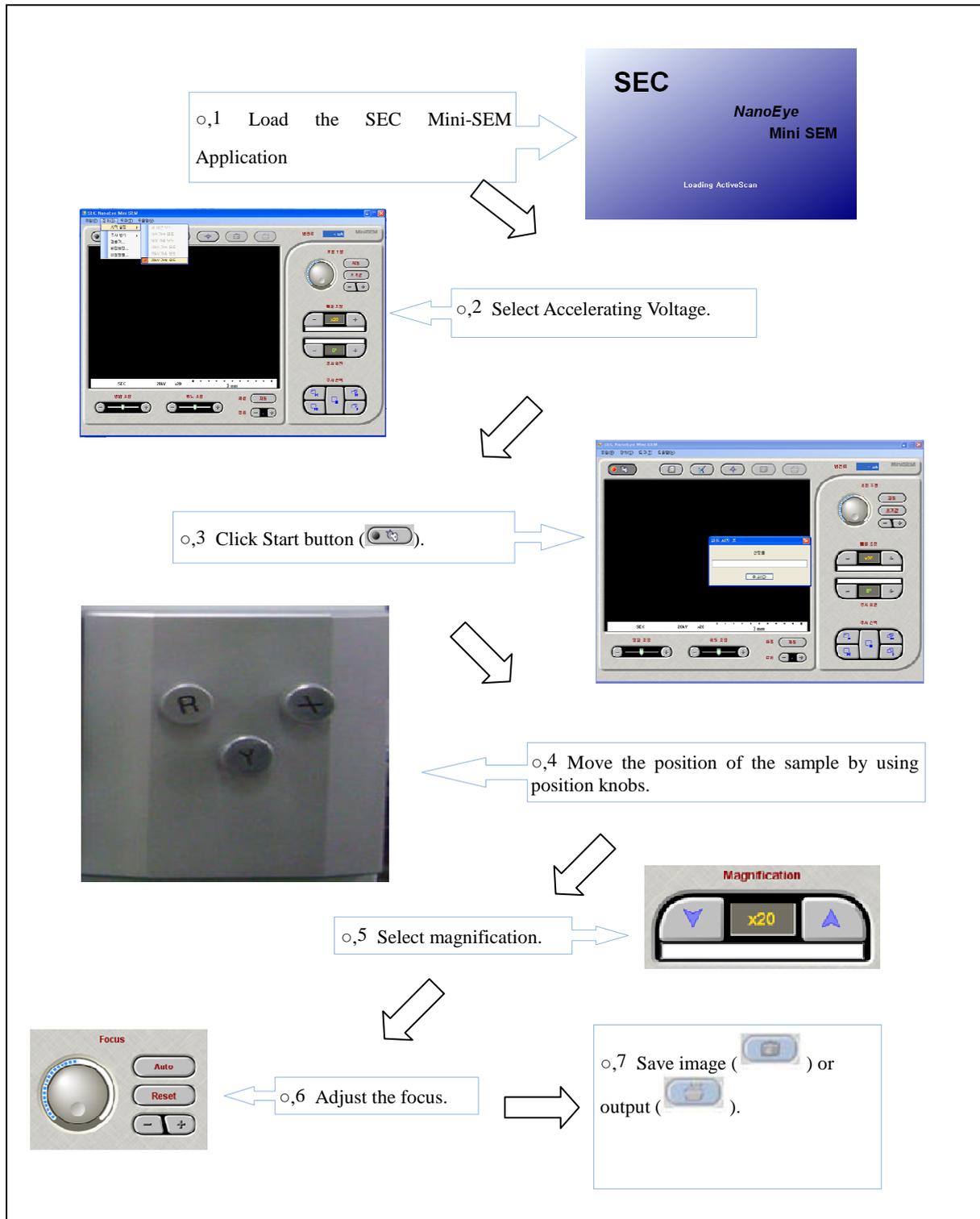
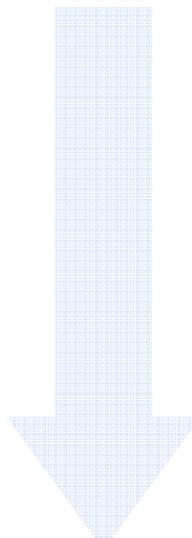


Fig. 29 Quick Guide

Searching Image area



 **Select Scan Mode by "Slow Scan".**

 **Search the area to look by rotating X/Y-axis Handle of Door.**

 **Rotate image un the use of R-axis Handle of Door, if necessary.**

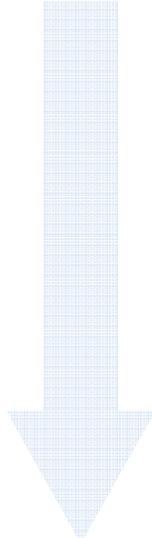
 **If more precise rotation is necessary, rotate it in the use of scanning rotation in program.**

Fig. 30 Image Searching

Image improvement

□. In case of not being in complete focus:

Push "Auto Focus" () button. If not being in complete focus after Auto Focusing, execute the following procedures:



 **Select Scan Mode to "Fast Scan".**

 **Lower magnification if image is entirely not seen.**

 **Make edge of image seen clearly in the use of Focus button.**

 **Adjust it so that the edge can be seen clearly up to the magnification one step bigger than those to look actually.**

 **In the magnification one step bigger than those to look, make minute adjustment in the use of precision focus button.**

 **Observe image by changing the magnification to desired magnification.**

Fig. 31 Focus Adjustment

- . In case that image is too dark or bright:

Click “Auto” button. () If it is not fully improved after clicking “Auto”

button, adjust brightness () and contrast ()

## 7. Filament Replacement



Break Vacuum.



Turn off power of front.



Turn off circuit breaker at the back.



Exchange Filament and open exchange cover



Break down Electron Gun.



Replace Filament.



Assemble Electron Gun.



Exchange Filament and close exchange cover

**Fig. 32 Filament Replacement**

## Image adjustment after replacement



Open Filament exchange cover.



Turn on main power circuit breaker at the back.



Turn off power in the front.



Set vacuum.



Run program.



Adjust Electron Gun Centering handle looking the image for best image.



Exchange Filament and close exchange cover.

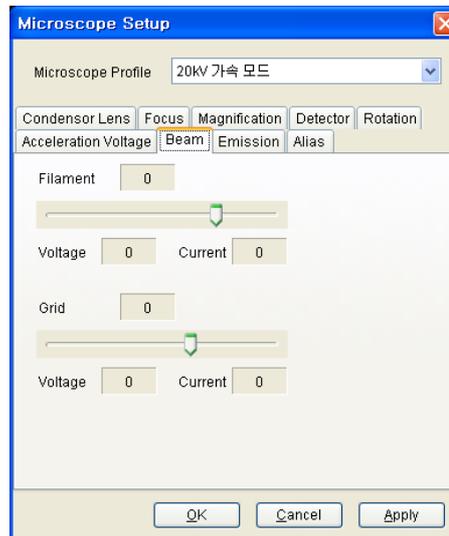
Fig. 33 Filament Correction

### Cautions in replacing filament:

- Do not contact filament immediately after putting off electron beam; it may be dangerous against burn because of high temperature.
- In releasing filament and grid that covers filament, use vinyl gloves in spare parts to prevent contamination.
- In replacing to another filament in reserve stocks, check if tungsten hairpin of filament is arrayed in the middle of grid.
- The inside and outside of grid that were being used for long time is discolored on the surface because of electron gun with high temperature. Wash them by metal compound of spare parts to maintain cleanness and use it.
- As much emission of gas is generated in the exchanged filament and in the column and chamber that are opened to the air after replacing filament, set vacuum by sufficient time.

### Caution in image adjustment after replacement:

- In arraying optic axis by Electron Gun Centering Handle, pair facing Centering Handle and rotate to the same direction and then search the point where the brightest image is displayed on image window of PC.
- Set emission in Emission located at Program Tool  Adjustment  SEM.



- . Electron beam is generated by heating tungsten filament (Approx. 1800K). Radiation volume of electron beam is controlled by increase/decrease of heating current of filament. Increasing heating current, emission current is also increased but passing over heating current in the fixed level, emission current is not increase any more. Such current area in the fixed level is called saturation area. Set emission current value at nearing the point where saturation area is started, and use it.
  - Setting emission current value over saturation area, filament is overheated so the life is shortened; setting emission current value under saturation area, emission is unstable so good image cannot be obtained.
- . Put emission in the minimum, increase it slowly, and look at the image displayed on image window for setting emission current value to the unit. The brightness of screen is gradually increasing and it becomes not being changed any more passing a certain point, consider the area to saturation area and set the emission current value.

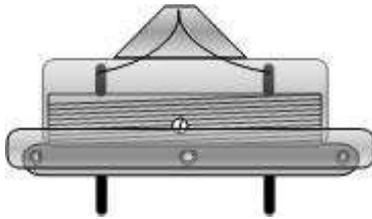
Assembly Order of filament and grid



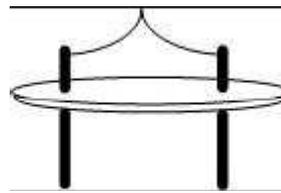
**Fig. 34 Assembly order of Filament and Grid**

## Filament Replacement

**Overview:** There is only so much life in a filament and eventually you will have to replace it. When the filament dies the tungsten wire opens and the ability to heat the filament is lost. The emission current will be at 0 and the current meter will show a minimum amount. Evex gives you two options on replacing the filament cartridge. You can order from Evex pre centered filament cartridges. These cartridges are cleaned, polished, aligned and the Wehnelt cap height is set for you. Or you can order standard filaments and adjust them yourself. I will explain the how to center the filaments below.



Filament Cartridge



Tungsten Filament

**Remove the Filament Cartridge:** Power off the Mini-SEM high voltage and press the “Exchange Button” to vent the column. Power the unit off, for safety and let the blown filament cool for a few minutes. The tungsten filament is heated to approximately 1800 degrees Kelvin or 2780 degrees Fahrenheit. **Be careful it can be very hot.** Loosen the gun adjustment knobs and remove the gun from the column. Unscrew the filament retaining ring and remove the filament cartridge. You may have to rock it back and forth but it should pull right out of the gun. Once you have the filament in your hand put the gun back on the column and pump the column down. This will keep the gun area clean.



Fig. 35 Remove Cartridge



Fig. 36 Loosen Filament

Rubber gloves should be worn to prevent the oils in your skin from contaminating the filament cartridge.

Remove the old filament: Loosen the 4 hex screws that hold the filament to the cartridge. Then remove the old filament from the bottom of the cartridge. Now is a good time to do a little maintenance.

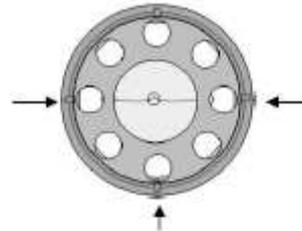
By the way, you can save the old filaments and get them rewired.



**Fig.37 Remove Filament**



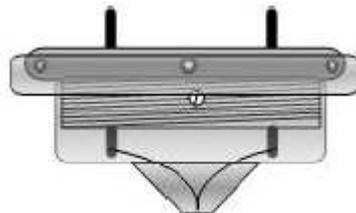
**Fig. 38 Blown Filament**



**Fig. 39 Filament with  
4 adjustment screws**

The quality of your image is partly based on the cleanliness of your column so before you replace the filament lets breakout the metal polish and polish all the components in the filament cartridge. This includes the Wehnelt Cap, Filament Retaining Ring and Filament holder. Rinse off all the pieces and sonicate them in a methanol bath. Blow them dry with compressed air and now you are ready to install the new filament

Installing the New Filament Cartridge: Remove the new filament from the box be very careful not to bend the wire. Turn the filament cartridge upside down and place the filament inside. Tighten the 4 hex screws and flip the cartridge over. Screw the Wehnelt cap onto the cartridge and with a magnifying glass slowly rotate the Wehnelt cap down onto the filament. If it looks like the filament is not centered in the Wehnelt cap hole you will have to adjust the 4 hex screws until it is centered. Then keep lowering the Wehnelt cap until the filament is flush and centered in the hold. Now rotate the Wehnelt cap until the filament is flush and centered in the hole. Now rotate the Wehnelt cap 1/2 to 3/4 of a turn counter clockwise to set the proper filament height. Tighten the Wehnelt cap set screw and replace the filament cartridge in the gun. Place the gun assembly back onto the column and press the “Exchange Button” to evacuate the chamber.



**Fig. 40 Properly Adjusted Filament**

## Filament Adjustments

**Overview:** The filament saturation point needs to be set to maximize the efficiency of the filament. If the filament is under saturated the image will be weak and noisy. If the filament is oversaturated the image may be strong but the filament life will be short. See the chart below. There is a happy medium called the saturation point.

**Saturation:** Saturation occurs when an increase in filament current does not produce an increase in beam current which is directly related to image brightness. To saturate the beam takes a little tweaking.

**Saturation Setup:** Select “Configuration in the “System” menu to set the configuration profile to 20kv. Under the “Tool” menu select “Adjustment” then “Microscope.” Enter the password “HBKIM” and a new form will be displayed labeled Microscope Setup. Left click on the “Microscope Profile drop down box” to select a profile to match the acceleration voltage you are using ( i.e. 20kv) see figure 54. Select the “Beam” tab in the 20kv profile and adjust the “Filament” slide bar to 0 and the “Grid” slide bar to midscale, see fig 55. Click “Apply” at the bottom of the form to accept those parameters. A Dialog box will appear “Configuration Saved,” close the dialog box. Click the High voltage “Key Switch” “On”, see fig 56. The high voltage will turn on and the Mini-SEM will use the “Microscope Parameter” page you just configured to setup the image. Since the filament slide bar was set to 0 the emission current will be very low on the emission meter and no image will appear in the preview window.

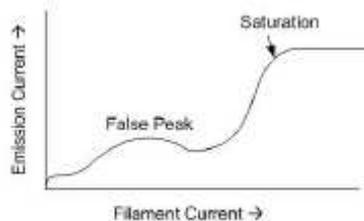


Fig 51: Filament vs. Emission Current



Fig 52: Configuration Profile

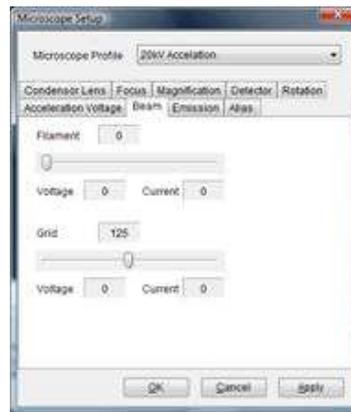


Fig 53: Microscope adjustments

**Heating the Filament:** With the high voltage on, slowly bring the filament slide bar up to around 20. Let the filament sit there for a minute. As you increase the slide bar the current through the filament will rise making the filament hotter. Increase the current slowly and watch the emission meter. When the Emission meter starts to increase an image may appear in the image area. If no image is seen and there is emission current then the beam is out of alignment. In order to saturate the filament you must first have an image. Follow the beam alignment procedure if necessary to find the Image. If an image is visible then adjust the gun alignment knobs (See fig 57 and fig 58) for the brightest image. To adjust the gun alignment knobs you must first loosen all of them. Then adjust them in pairs, Tighten one side and loosen the other of pair “A”, then switch to pair “B”. Adjust them while watching the image. Next increase the filament slide bar a little more. If the image goes dark move the slide bar to the previous position and take a smaller step in filament current. If the image goes dim then use the gun adjustment knobs to center the filament again. Repeat this process until an increase in filament current does not increase the image brightness. At this point the Gun is centered and filament is saturated.



**Fig. 44 Microscope Setup Alias tab**



**Fig. 45 Microscope Setup Beam Tab**



**Fig. 46 Microscope High Voltage Key Switch**

**Beam Alignment:** Before any adjustments are made a few things need to be checked. Check the contrast and brightness slide bars, the image area should be grey with just background noise in the preview window. Set the condenser lens slide bars to 0 and set the magnification to 20x. Adjust the centering knobs until an image appears. When you do get an image go back to the Filament heating section and saturate the filament.

**Beam Alignment:** When the filament is replaced or your notice a drop in image intensity you should check the beam alignment. The first thing to look at is the emission meter. Even if the filament is blown there will be a background current seen on the meter. The Emission meter will display 000 uA when the high voltage is off. When the High voltage is on and the filament slide bar is at 0 the meter should read 40uA. A properly saturated filament should read around 80uA at 20kv. Basically if you have an emission current above 40uA at 20kv then there should be some type of image on the display.

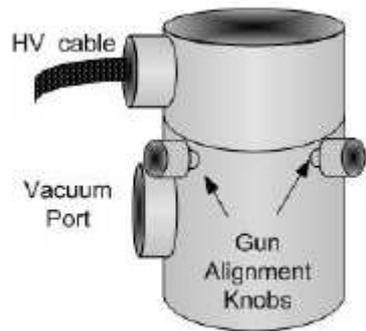


Fig 57 Gun Alignment knobs

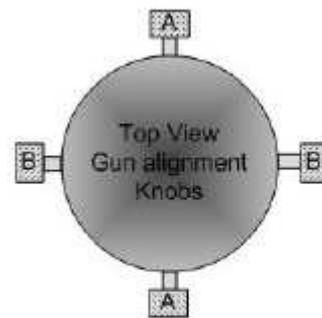


Fig 58 Gun Alignment knobs top view.



Fig 59 Emission Meter

HV off: Emission meter reads 000uA

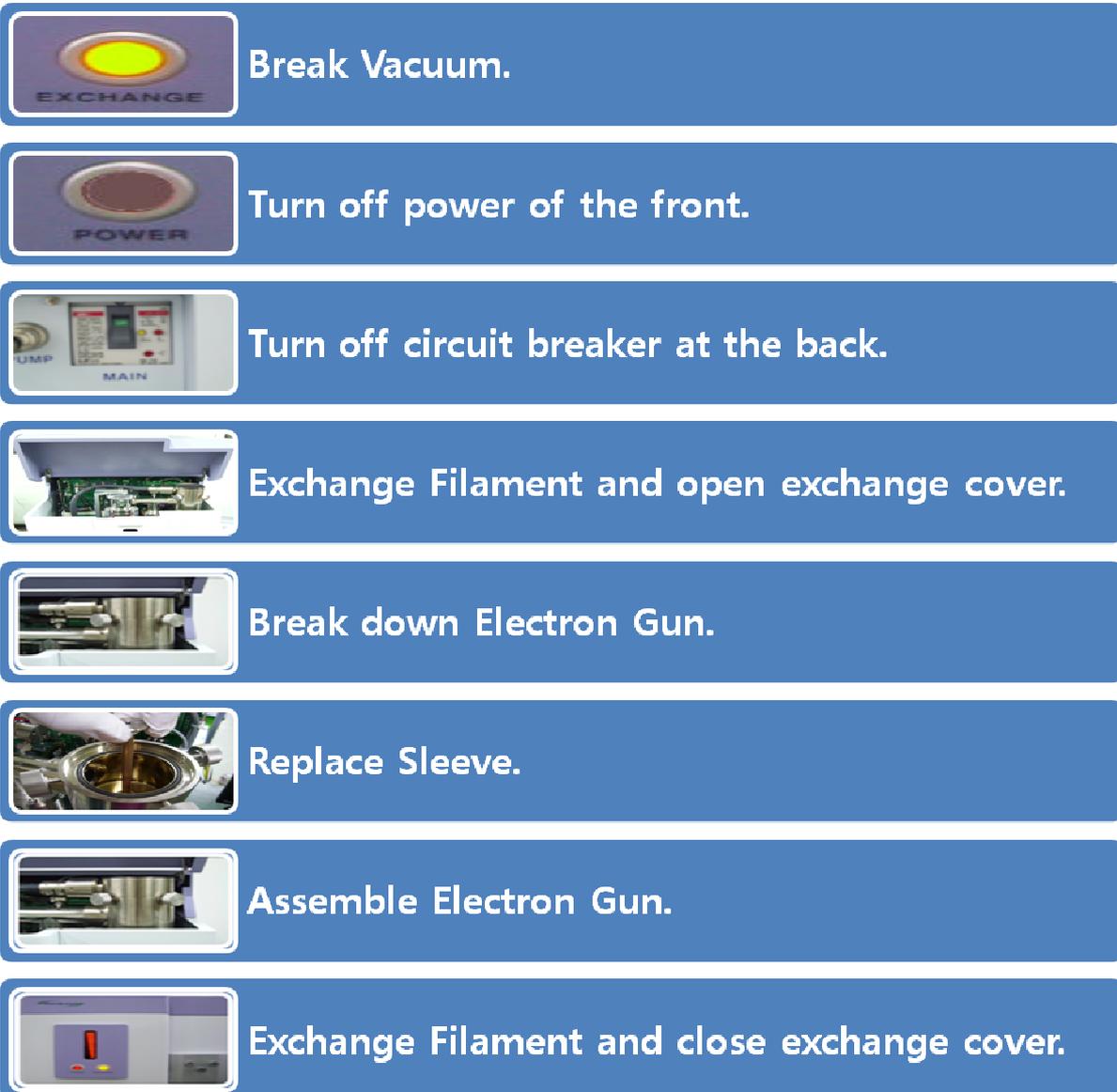
HV on, Filament not saturated: Emission meter reads 40uA

HV on, Filament Saturated at 20kv: Emission meter reads approximately 80uA

## 8. Checkup and Replacement of Anode, sleeve, Aperture

Anode and sleeve are optical distance of electron beam. Contaminated matter may be evaporated in vacuum by high energy. In case of critical pollution, the parts should be replaced but in ordinary cases, they can be used by washing after checkup. Aperture is contaminated by evaporation colliding to electron through long time using. Contaminated Aperture can be identified by naked eye since the hole in the center of it is blocked up or the circumference of hole is discolored.

### Replacement of Anode, Sleeve, and Aperture



- 
**Break Vacuum.**
- 
**Turn off power of the front.**
- 
**Turn off circuit breaker at the back.**
- 
**Exchange Filament and open exchange cover.**
- 
**Break down Electron Gun.**
- 
**Replace Sleeve.**
- 
**Assemble Electron Gun.**
- 
**Exchange Filament and close exchange cover.**

**Fig. 50 Replacement of Anode, Sleeve, and Aperture**

### Assembly of Anode, Sleeve, and Aperture

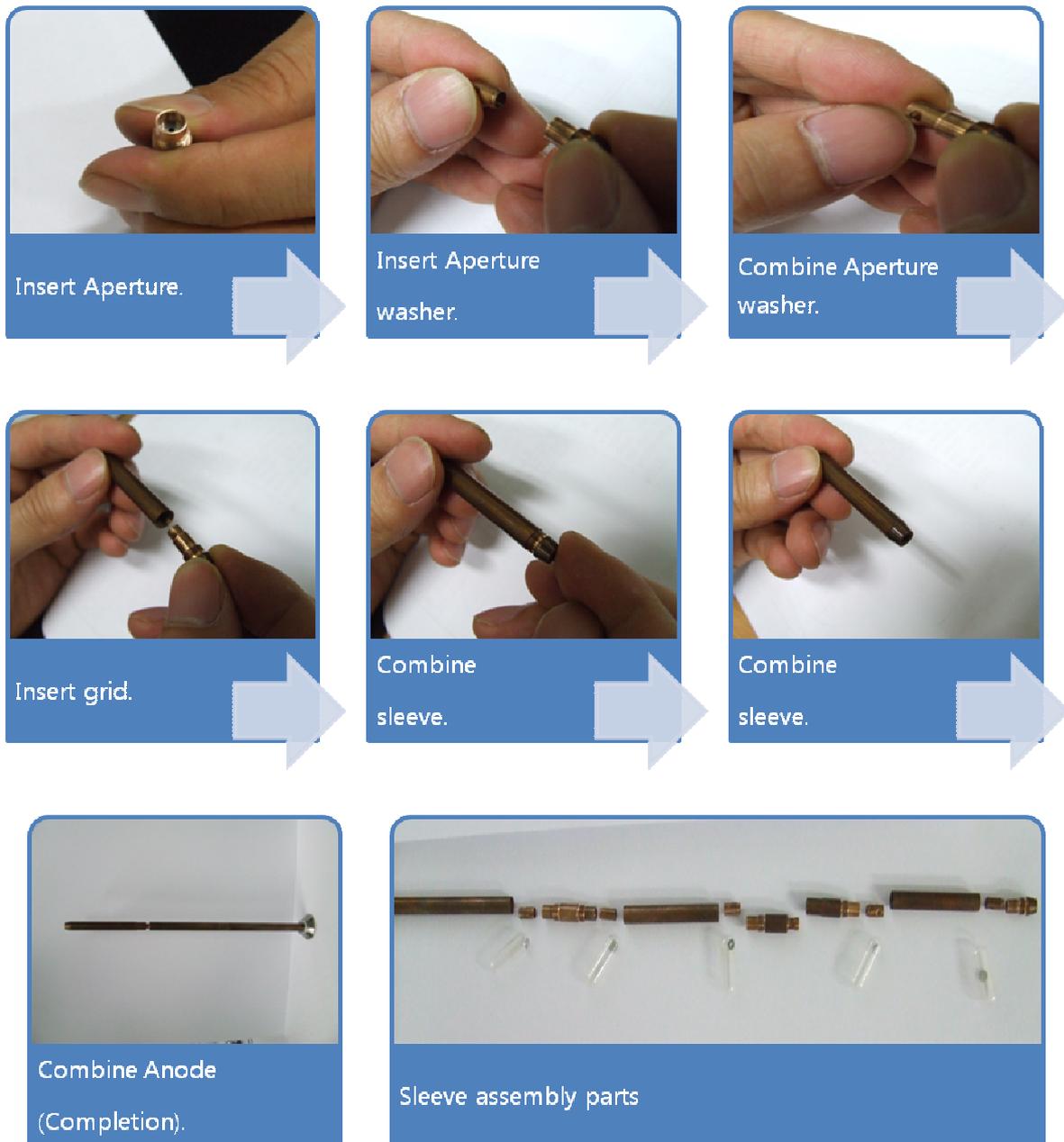


Fig. 51 Assembly of Anode, Sleeve, and Aperture

## 9. Inspection of Vacuum system

### Checkup and replacement of O-ring

O-ring in the inside of chamber or gun has high exposure frequency due to sample exchange or filament replacement. So, vacuum sealing may be deteriorated because of dust or pollution. Execute periodical washing and maintenance:

- Pull out O-ring out of attachment groove. Do not use metal tool at that time; occurring scar or deformation on the surface of attachment groove or O-ring, it may be the cause of vacuum defect.
- Remove dust or contaminated matter from pulled out O-ring in the use of gauze soaked with ethanol in small amount. Do not touch skin or cloth in which contaminated matter may exist with once wiped O-ring.
- Check if there is minute dust or scar in O-ring fully. Replace O-ring with scar or deformation and attach new one.
- Smear Vacuum grease in small amount and spread evenly overall O-ring.
- Wash O-ring attachment groove by ethanol.
- Insert Vacuum grease spread O-ring into attachment groove and turn it to the original state.

### Checkup and replacement of Rotary pump oil

Lack of Rotary pump oil amount or deterioration and discoloration of oil lowered the vacuum exhaust capability, so periodically checkup and replacement are required:

- Refill:
  - Refill oil in case that oil is not deteriorated, oil is less the fixed level when it is not discolored.
  - Refill oil through oil inlet looking at Rotary pump oil gauge.
- Exchange
  - Exchange oil in every 6 months or 1 year periodically or in case that color of oil seen at Rotary pump oil gauge is changed.
  - Break down Air hose and oil mist that are connected to main body of the unit.
  - Break down Disjoin Drain bolt and pull out oil.
  - If waste oil is completely exhausted, tighten drain bolt and fill new oil into oil inlet. The bottom limit of Rotary pump oil gauge and 2 to 3/4 of the top limit are appropriate amount.
  - Tighten main body of the unit and Air hose, oil mist.

## VIII. Fault Diagnosis

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## 1. Fault Repair

In case of occurring in trouble in the middle of using the unit, take an action according to the instruction mentioned in this chapter. In case of occurring in fault not being mentioned in this chapter, stop operation of the unit and contact SEC Co., Ltd.

- ※ Checkup of fault repair should be executed by the person who is aware of the danger matters of system and educated for them.
- ※ If not wearing proper protection device during checkup of fault repair, death accident or severe injury may occur; wear protection device by all means before checking up for fault repair.
- ※ Turn off power before fault repair.
- ※ Review the cautions before fault repair. If it is uncertain what action should be taken in fault repair, do not progress any more and contact SEC Co., Ltd.

## 2. The Fault of the Unit

### System power breakdown

Phenomenon

System is not operated since power is not supplied to system after turning on front power switch in “SNE-1500M”, not putting on the lamp.

Cause

Power is not supplied to 220V plug for power supply.

E.L.B (leakage circuit breaker) switch turns off due to overload of “SNE-1500M” inside.

Action

Check if 220V plug for system power supply is pulled out.

Check if E.L.B (leakage circuit breaker) switch at the back of “SNE-1500M” is ON or not.

- If ON is certain and not turning OFF artificially, do not turn ON and ask serviceman for it.

### **Caution**

In case of being pulled in power cord, if E.L.B(Earth Leakage Breaker) switch is ON, power is supplied to SMPS and the other apparatus; be careful of it specially.

## PC Booting and Running Defect:

### Phenomenon

Power of PC is not turned on or nothing is displayed on screen.

It is not being progressed any more in the middle of PC booting.

Program is not normally run.

### Cause

Power is not supplied to PC.

Trouble occurred in S/W since system was not successfully ended.

Cable between PC and "SNE-1500M" is not correctly connected.

### Action

Check if plug for power supply in PC is pulled out from socket.

Check if battery in PC was discharged.

Check if cable connection between PC and "SNE-1500M".

Check if "SNE-1500M" turns on.

Check if unnecessary program is being run.

Check if PC is infected by virus.

## Vacuum system Defect:

### Phenomenon

Beeps are sounded without stop from board in the middle of vacuum setting.

### Cause

Air Hose between Rotary pump and "SNE-1500M" is not correctly connected.

There is trouble in Rotary pump.

There is trouble in turbo pump.

Door is not fully closed.

### Action

Check Air Hose connection between Rotary pump and "SNE-1500M."

Firmly Close the Door.

Replace oil in Rotary pump.

### 3. In case of requiring maintenance and repair

#### Filament snap

Phenomenon

Image is not displayed and noise is heard after running program.

Cause

Filament was snapped.

Action

Replace filament.

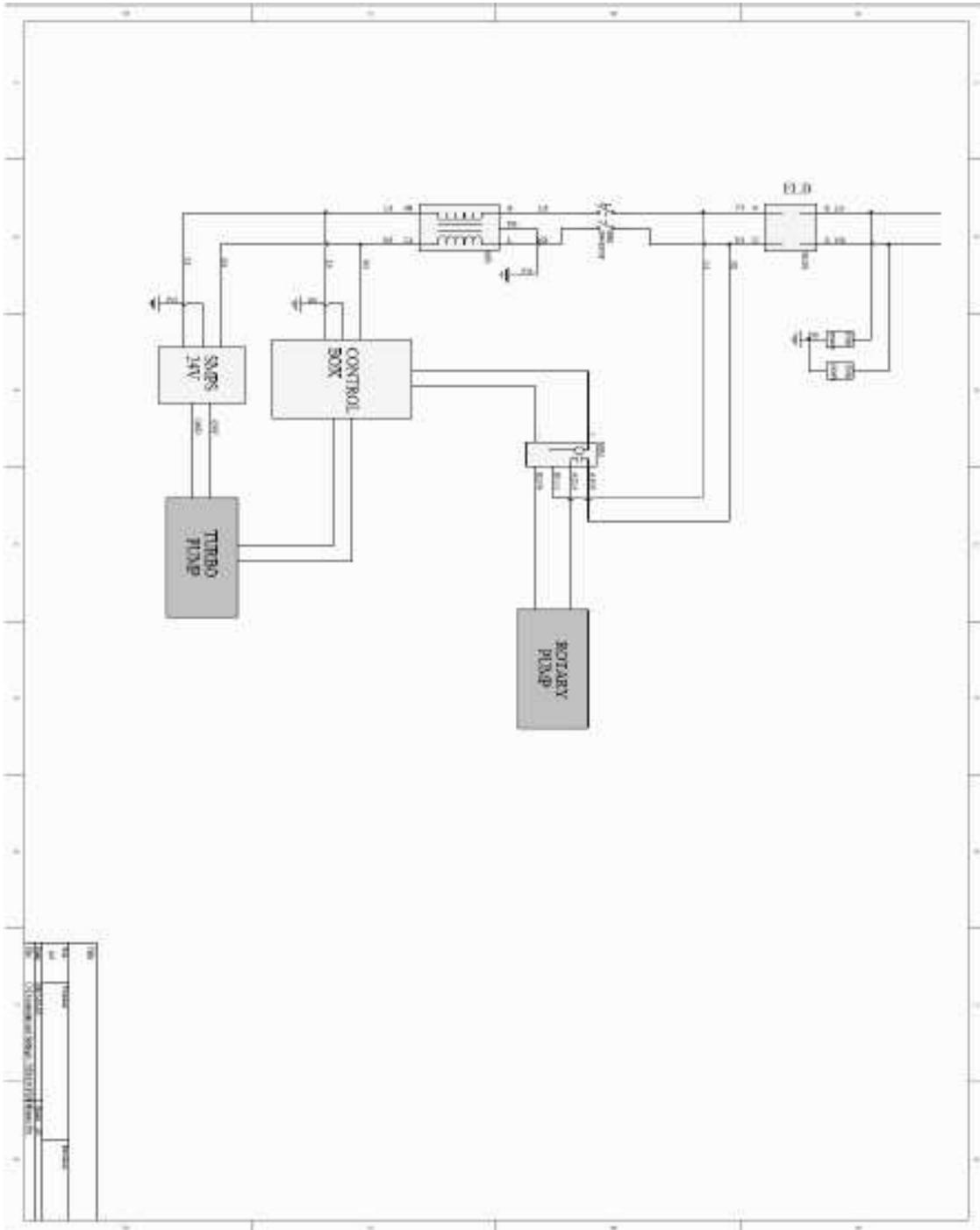
#### 4. Periodical Checkup List

UNIT	Item	Checkup and Repair Details	Checkup Period			
			Day	Week	Month	Year
Column	Filament Align	Screen		O		
	Aperture contamination	Screen			O	
Vacuum System	Rotary Pump	Abnormal noise, vibration	O			
		Pump Oil				O
	Turbo Pump	Abnormal noise, vibration	O			
Chamber	Door inside	Foreign matter	O			
Others	High voltage	Screen	O			
	Fuse short circuit	Power ON/OFF	O			
	Front lamp	Lighting	O			
	FAN	Abnormal noise, vibration			O	

## Appendix □. Drawing

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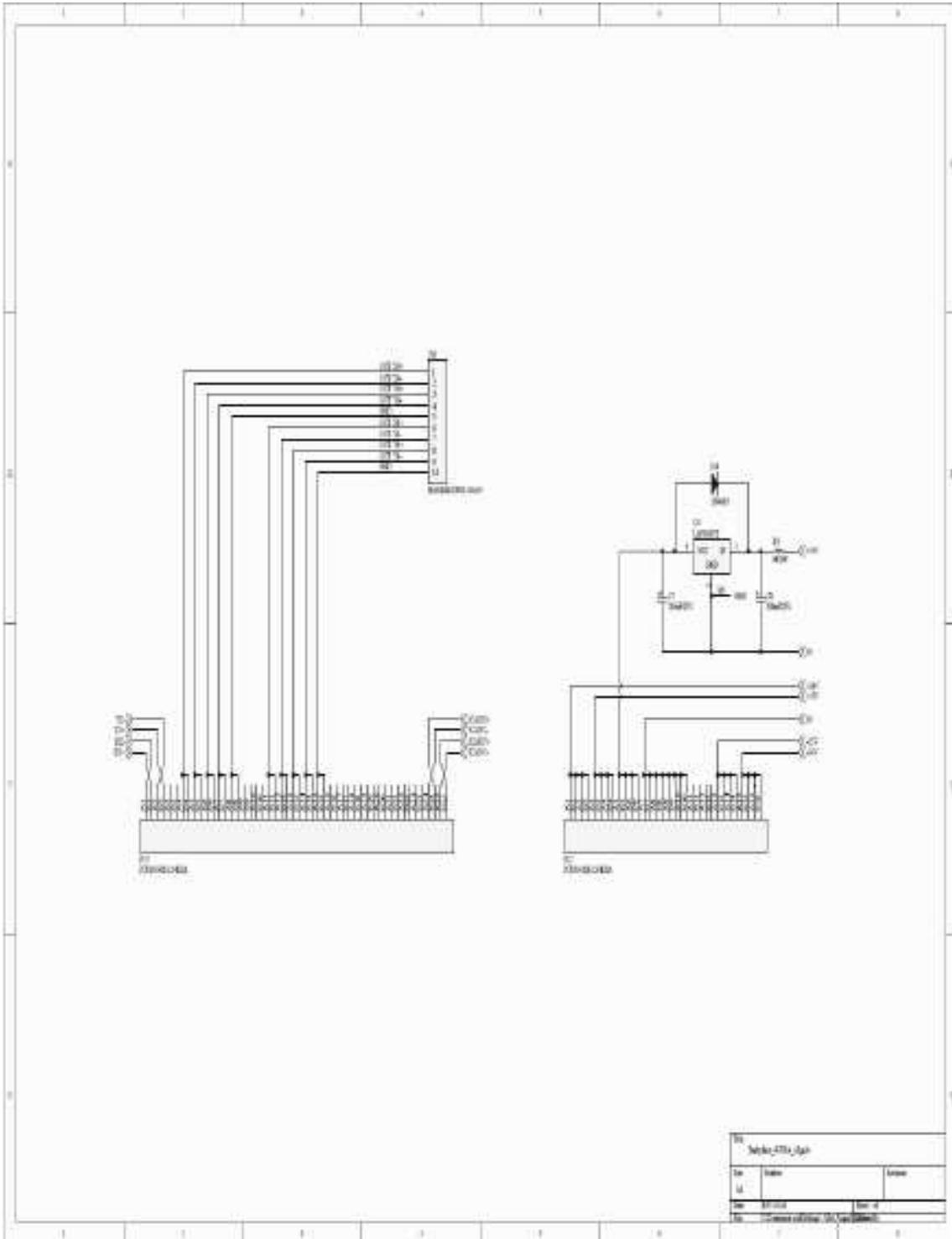
A. Power



Appendix 1 - 1 Power

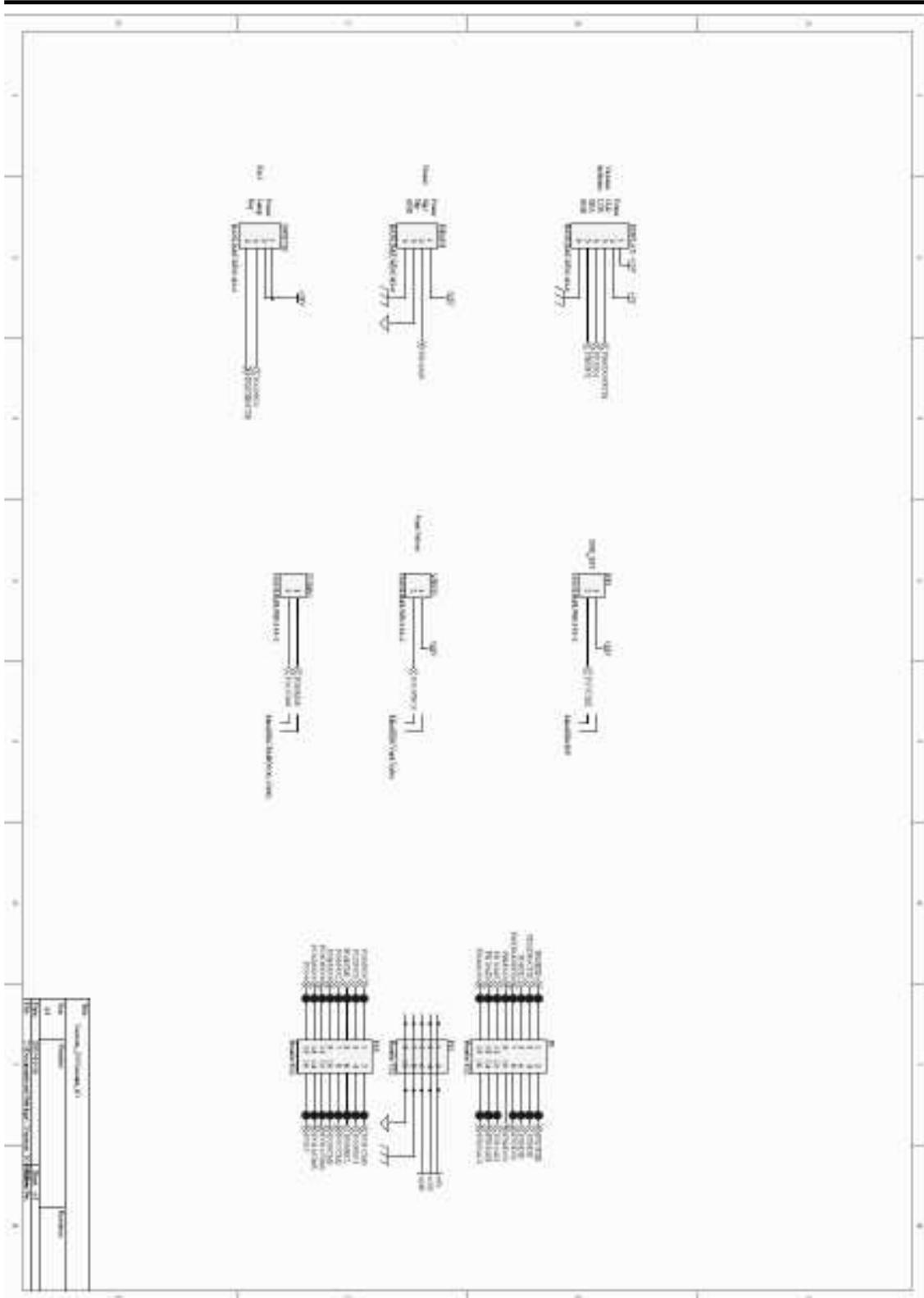


C. Back



Appendix 1 - 3 Back

D. I/O


**Appendix 1 - 4 I/O**