

The
Great
PQC
Electron Microscope
Handbook

Chapter One

The SEM in All Its Glory

While the optical microscopes we use in PQC are state-of-the-art, they are limited in their capabilities to resolve high magnifications. We cannot get a clear view of a defect or its effect upon the wafer unless we use one of the scanning electron microscopes in the fab to get a better look.

Light microscopes use light reflected from the sample through a series of magnifying and focusing lenses to provide a magnified image of the sample. These are limited in their resolving power. SEMs, on the other hand, use a beam of electrons focused by magnetic fields and reflected from the sample to obtain an image. This provides useful magnifications of up to 150,000x!

Some of the material presented here has been lifted nearly unchanged from Larry Patterson's excellent treatise on the 6000 series SEMs. His work, however, is unfortunately somewhat outdated and rather bulky for our purposes, otherwise I would have just made a lot of copies and handed those out.

basic sem principles

There are six SEMs in the fab at the present time. Three are of the 6000 series, and these are used for CD measurements because of their advanced measuring capabilities. We use these the most because of their ease of operation. However, they are limited in their capabilities. There is no tilt, no electron dispersive spectrography system, and no way to look at anything other than an unbroken wafer.

The Hitachi S-806c in IQA is much more difficult to use, but it can rotate and tilt a sample, and both it and the S-900 are equipped with the electron dispersive spectrography attachment. The main visible difference between the 806 and the S-900 is that the 806 will accept whole wafers in its specimen chamber, while the S-900 will only accept approximately 3x5 mm samples. The advantage of the latter is that the specimen chamber is very small, which allows for a much better resolution. The sixth SEM, the S-570, is usually used for inspecting wire bonds and other applications that don't require a high magnification, but better resolution than a light microscope is able to attain.

Using electrons instead of photons requires entirely different equipment. The SEM must be pumped out to a high vacuum, otherwise the electrons would rebound off the air molecules, and loss of image would result. A complex system of valves and pumps accomplishes this. (The 6000 series SEMs are fully automatic. On the other SEMs, the specimen exchange operations must be performed manually.)

Instead of a light bulb, a cold field emission SEM produces an electron beam from a tungsten tip measuring 30 angstroms in diameter, a first anode, and a second anode. An accelerating voltage is applied across the anodes, and this causes an extraction voltage between the tip (the cathode) and the first anode. In turn, this causes electrons to be drawn from the cathode and accelerated past the anodes into the magnetic lenses, which form the electrons into an ordered beam. After some more shaping and focusing, the electrons strike the sample, where they are either absorbed (and since electrons are negatively charged, they cause a negative charge within the sample; this is the effect commonly referred to as charging-up), cause secondary electrons to be emitted, or scattered back off the sample. A detector senses these and sends a signal that is digitized and displayed as an image on the monitor.

the S6000 series

These SEMs are very easy to set up and use. They are some of the best SEMs in the world, and we have the advantage of owning three. For simple defect review, they are unparalleled. Their disadvantages are that the stage cannot tilt, which is sometimes useful to peer beneath a defect to see what effect it is having on the pattern, and there is no EDS system.

If the SEM is properly tuned, using it is a snap. First of all, make sure of the wafer number and the slot that it resides in. There are few things more frustrating than being unable to locate defects, and

then discovering you loaded the wrong wafer. Double-checking may save you a great deal of time and trouble.

Place the cassette on the stage. There is some slight movement possible when it is correctly seated, so check to make sure that the cassette is flat on the stage and that upper edge is aligned with the edge of the stage.

On the SEM, open the lower drawer with the keyboard. The screen ought to display an asterisk:

*

If it does not, press ESC. This will always work to return you to the asterisk prompt if you get yourself in a mess, so don't hesitate to use it. Nothing will be lost. The only place this doesn't work is if the screen shows the E> prompt, and we'll deal with this problem later.

Type

*WNO

and press return. This stands for Wafer Number, and it will allow you to select the slot number of the desired wafer. On the 6000 and the 6100, you'll just see this:

NO :

Just type the slot number. On the 6200, you get a full graphical representation of the wafer cassette. Use the cursor keys to move the purple bar up or down, to the slot containing the wafer you wish to load. Press "E", and the slot will turn yellow. Press return.

Type N for the disk-save question, and you will be back at the asterisk. Here, you can either just type RUN, or press F2.

*RUN
EXECUTE OK (Y/N) ?

What the SEM is really asking you is *Do you wish to move the wafer?* If the wafer is in the chamber already, it will unload. If you have already loaded your wafer and you don't want to go through all that trauma again, type N, and you can go ahead entering the rest of the data without unloading your wafer. This is useful if you have made an error in data entry, so you don't have to go through the wafer exchange procedure every time you enter the data.

Type Y and press return. The loading sequence will begin, and you will be able to enter the rest of the data.

Take a moment now and watch the loading sequence, as this will be helpful later when working with the 806 and the S-900. The load lock vents first, and then the door lifts open. If you look behind the stage where the cassette is, you will see a long box with a round window on its top, through which a worm gear is visible. This is the specimen exchange chamber, or S.E.C., valve. It separates the vacuum of the specimen chamber from the load lock, which can vent to atmosphere. After the wafer loads, the door will shut and the lock will pump out. When an acceptable level of vacuum has been achieved, the S.E.C. valve will open, and the stage will enter the specimen chamber carrying the wafer. The 806 works exactly the same way, except you get to do it all manually. The S-900 has a slightly different mechanism, due to its small specimen chamber, but the principle is the same.

While the wafer is loading, you can continue setting up the data. The next step again differs somewhat between the 6000/6100 and the 6200. On the 6100, you need to enter the recipe in the middle of the inspection data, while on the 6200 you do it afterwards. In either case, none of the inspection data needs to be entered, so just press return through it. At the end you will see

DATA IN OK? (Y/N)

and you will press Y, of course. If you are using the 6200, it will then prompt you for the recipe name.

After you have entered that, wait for the loading sequence to finish. The SEM will move the wafer to an approximate position close to the alignment point, and prompt you to align the first point. Use the trackball to position the cross on the corner of the die for SRAM devices and everything using MAX880 coordinates. Use the cross in the corner of the die for KLA-inspected DRAM wafers. Press the REG button when you have got it. It is a good idea to go up to 50 or 60KX to align the point, since the better you align it, the easier it will be to find the defect. After you have pressed REG, the stage will move to the second point, and you will repeat the process. The stage will then move to the center die, and the screen will say

Press continue switch when ready.

Don't press it. Instead, press ESC for the asterisk prompt. Type

*WMS

This will give you a map of the wafer on the screen. It is not really necessary, but sometimes it is helpful to see where the stage is going as compared to the defect location on the wafer map.

Now let's go find some defects. Type

*MVC

Chip (X, Y) :

The coordinates you should have about you somewhere from the KLA or the WIPAS cannot be used as they are. A conversion factor must be applied before they will match the SEM coordinates. The 6100/6200 spec (which you ought to have read already--if you haven't, stop and go read it first) contains this information. Once you have the correct coordinates, type them in and press return.

Defect (X, Y) :

These coordinates can be used as they appear, without converting them to anything. Just round them to the nearest whole number.

The stage will now move to the location you specified, and hopefully your defect will pop right up, which usually they do. If for some reason you can't see anything except unbroken pattern, there are a few tricks to help you out. You've already checked that the wafer you've loaded is the right one, so now make sure you've entered the right coordinates. Next, go up to a high mag, around 60 or 70K, and make sure the magnification rate button in the drawer is set on Fine. Go down an increment at a time, and examine the edge of the picture. Eventually your defect ought to appear at the edge of the screen.

If you haven't even come this far and you're still stuck aligning the wafer because you can't see anything at all, there's still hope! Press ESC if necessary to get the asterisk, and type

*ALP

There is a square of cloth glued to the stage that is very useful if the beam gets out of adjustment. You can get a rough adjustment here, and then fine-tune it over the wafer pattern. You should see a grid pattern at the moment. Go up to 20,000x or so, and press the Wobbler button. Press the button next to it marked "1". The screen will show a white circle and a square, in which the circle should be centered. If it

is not centered, use the X-Y knobs on the drawer to center it. This is the beam as it would appear if you were looking up at it from the sample.

Next press the "2" button. The beam is controlled by magnets that need to be aligned in order for the beam to be of the proper "shape". You will see movement of the image on the screen. This is due to the magnets pulsing so that you can align the beam. Use the X and Y knobs to remove all motion.

Once you've gotten the image to stay still, press the button in the upper left hand corner with the three lights (X stigma, Y stigma, and AFC). The first light will come on, and the image on the screen will likely begin to move again. As before, use the X and Y knobs to remove the motion. Then press the button again, and the second light will light. Repeat this process until you've gone through all three lights.

Focus the image as best you can. If the image appears to be "smeared" and will not focus well, then the stigmatism needs to be adjusted. Find the X and Y stigmator knobs just above the focus knob. Only turn one at a time, until you have the best focus, and then try the other. Try adjusting the focus during this as well--it will take a little practice to do it well. You are bound to get lost in the woods of stigmatism at least once or twice, so take the time to practice this.

If the SEM has been recently flashed, it will take up to two hours to completely stabilize. During this time, the beam current will continually drop. This is especially apparent on the 6200, since its beam current is 10 uA, while the 6100 is only 3. The SEM will operate at a very low beam current, so there is no need for any corrective action. It is a good idea, however, to press the HV ON/EMISSION ADJUST button before aligning the beam, since the alignment goes out every time the beam adjusts. The 6200 will automatically bring it up if it falls below a preset level, usually 7.5 uA, but it will wait until you are unloading the wafer to do it.

You can check the time the last flashing occurred by typing DFLN at the asterisk.

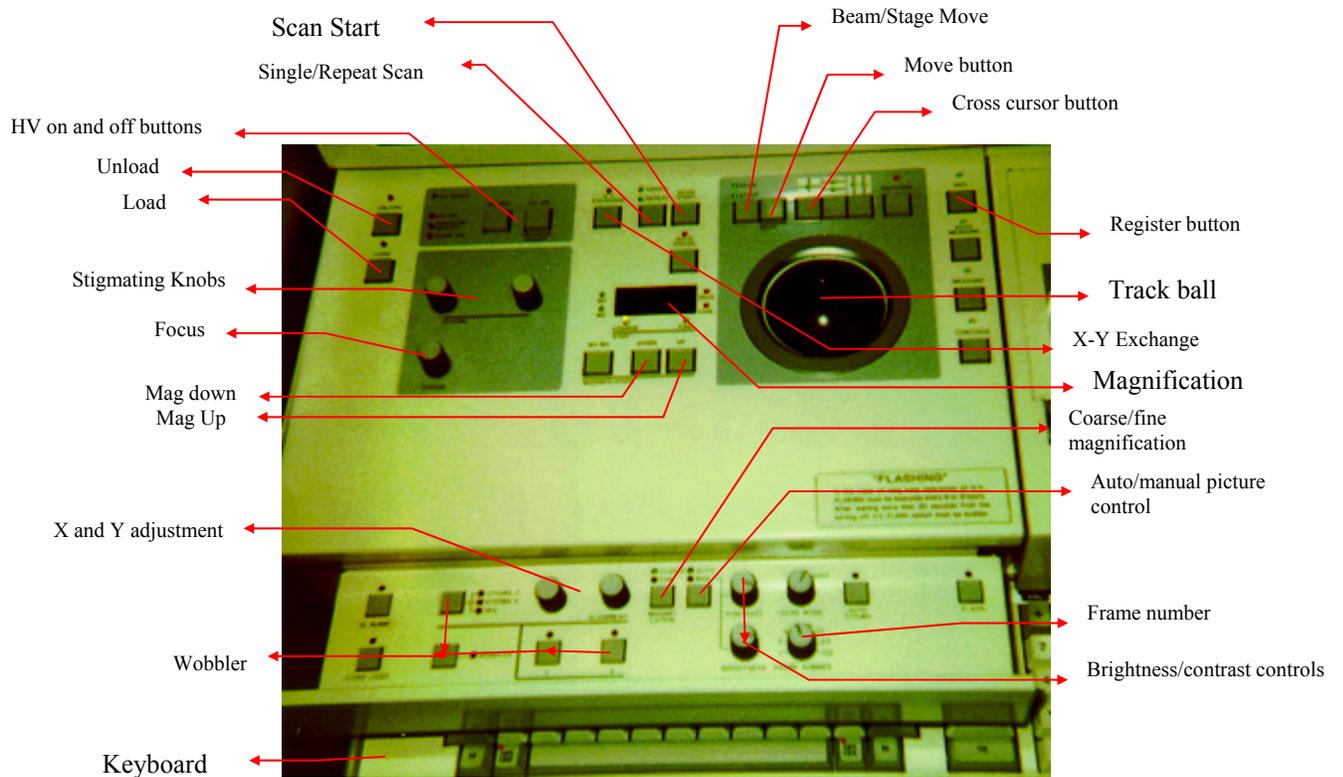


Figure 1: The 6000 series SEM control panel.

Take a moment to examine the controls. Some of these you should not use, as they affect the basic operation of the SEM, and EES usually will take care of that. The ones you should worry about are the ones marked above.

After all is done, just press UNLOAD. When the wafer is back in the cassette and the SEM beeps, type LEV at the asterisk prompt to close and evacuate the load lock.

If a serious error occurs and the software displays the E> prompt, just type S and the SEM that you are on, such as "S6200" for the 6200, and press return. You will have to reload the program now as well, so at the asterisk type

```
*LOAD
DRIVE : ?
```

This will be Drive #1.

```
*LOAD
DRIVE : 1
FILE TYPE : ?
```

The file type is CP (for command path).

```
*LOAD
DRIVE : 1
FILE TYPE : CP
FILE NAME : HMU256P
```

Once you have typed that, press return, and then everything should work normally. You might also try loading this if the SEM doesn't respond as it should to your input.

The S-806c

The 806 is located in the Incoming QA lab. Since that room is rated as a Class 100 clean room, and the fab is Class 10, we can't take product wafers into IQA. They must first be scrapped.

The 806 has several advantages over the 6000 series, and several disadvantages. The disadvantages are that, while its basic operation is fairly simple, you have to perform everything manually! This is no big deal if you're just loading a wafer, but when you have to locate a certain defect, it becomes a huge impediment. You must count die in order to find the right one, divide the coordinates by 1000 and change the Y to -Y. And if you've managed to load the wafer perfectly straight and you didn't miscount die in the hazy image, you might see your defect!

The advantages are that, once you've found it (and we'll look at ways to improve your chances there), you have a couple of options available to you that the 6000 series don't offer. You can tilt the wafer at an angle to look at the defect. This sometimes reveals quite a lot about the action of the defect upon the pattern. Even more informative is the EDS system, which can tell you of what elements particles are made. As an analytical tool, the 806 is marvelous, but a paragon of user-friendliness it is not.

Look at the SEM. Standing in front of it, you will see the beam column and vacuum controls to the left, the display unit in the center, and the cameras and the image processor to the right. Mounted on the left side of the specimen chamber is a box with a round window in its top and a rod projecting out of its side. This is the load lock. On the front of the SEM below it are an array of buttons, switches, and lights. These are the vacuum and valve controls. The control panel beneath the twin monitors controls magnification, focus, stigmation, etc. The box with the joystick is for stage control.

The wafer fits in a round metal chuck. Usually it is kept inside the evacuated load lock to keep it clean, but occasionally you will find it on top of or behind the SEM, where someone has left it. If you can't find it right off, look through the round window in the top of the load lock. If you see a flat, shiny metal surface, that's it. You just have to get it out.

The first thing to do is to look at the stage controller. In the right side of the green display should be the letters LCK. This means that the stage is at the exchange position and you can continue. If you don't see it, either someone has forgotten to remove their sample or is still working on it. Find out before you do anything else. If the stage is not at the LCK position, and you try to load a wafer, the whole works will simply fall to the bottom of the specimen chamber.

Look at the front of the SEM, where the vacuum and valve controls are. Most of these we don't worry about, such as the ion pump switches and the vacuum gauges. The ones we do use are in a cluster on the right side.

Find the six LEDs by the Pirani gauge. The upper three are marked "S.C. Vacuum", and the lower three are marked "S.E.C. Vacuum. They are marked High, Low, and Air. The SC Vacuum should always be high.

Directly below is a switch marked SC/SEC. It should be set on SEC. At the bottom of the panel are three buttons marked Evac, Close, and Air. Press the button marked Air. You'll hear a hiss, and after a second or two the red Air LED should light up and the Pirani gauge will peg out. You've just vented the load lock.

Go around to it and wait for the drawer to open. When the pressure has equalized, it will slide open a few millimeters, and you can grasp the rod and open it all the way. Unscrew the rod from the chuck, if necessary, and remove it.

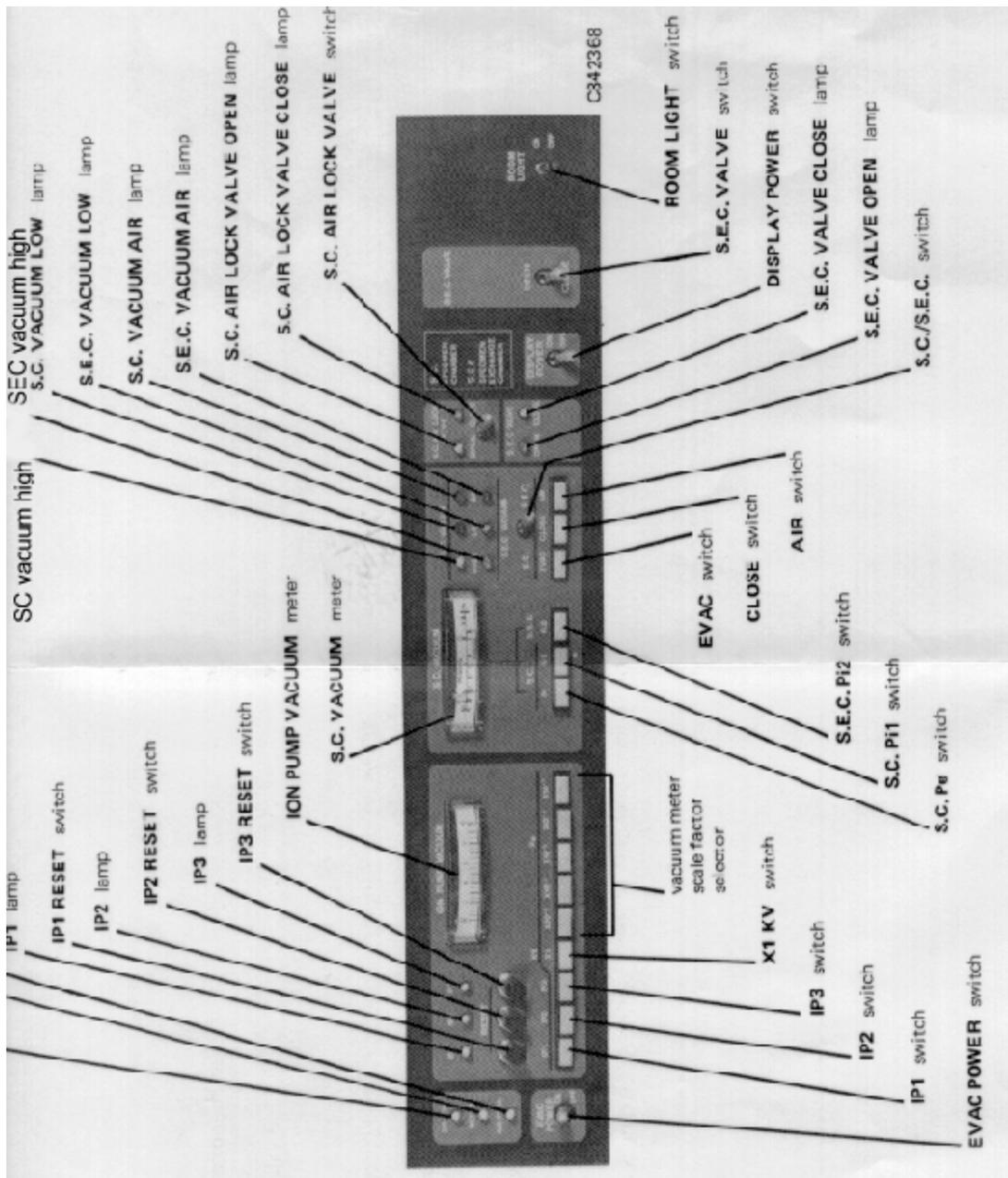


Figure 3: The S-806C vacuum control panel.

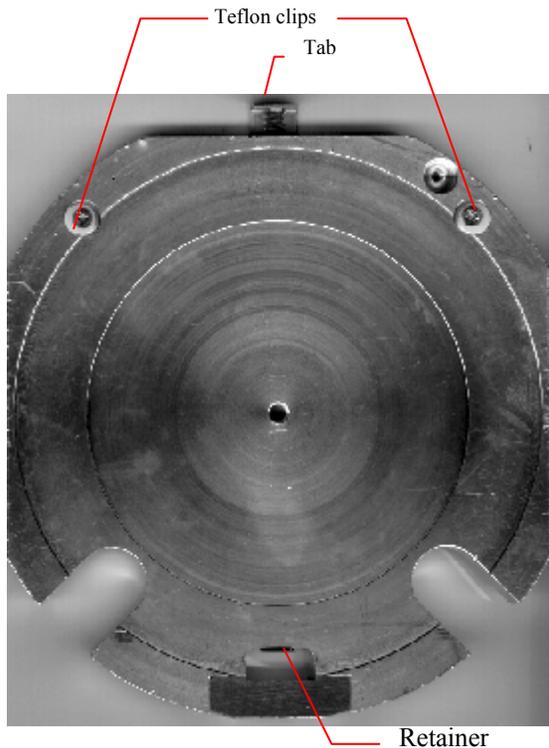


Figure 2: S-806 wafer chuck

The wafer chuck is a simple device, consisting of a large flat chunk of stainless steel and three clips. Hold it in one hand and use the index finger of that hand to press down on the tab at the top. This will move the retaining clip at the bottom down so you can insert the wafer. Do this now, making sure that it just fits under the two round Teflon holders at 10 and two o'clock. Once that's done and the wafer is flat on the chuck, let go the tab and the retainer will clamp onto the orientation flat of the wafer.

Look at the large notches in the stage at four and eight o'clock. Try and align the wafer using a scribe line and the edges of these notches. The straighter it is, the less trouble you'll have, so the more time spent the better.

Once it's aligned, set the chuck into the drawer so that it rests on the Teflon slides. The OF should be toward the rod. Push the chuck against the tip of the rod and screw it in a few turns. Then, close the drawer, and hold it closed with one hand while you press the Evac switch with the other. You'll hear a series of hums and gurgles as the chamber pumps out, and the Pirani gauge will drop slowly. Watch the progress of the LEDs--the red Low LED will light, and then the green High LED will light. The chamber is now pumped out.

Next to the vacuum switches is a switch by itself marked SEC Valve. The SEC valve separates the load lock from the specimen chamber (and as such, it obviously should be closed during the loading procedures.). You can see it against the side of the specimen chamber, right below the load lock. Watch it as you flip the switch. It will drop down, opening the specimen chamber to the load lock.

Push the chuck into the specimen chamber by pushing the rod in until it stops. Unscrew it and pull it back out, and look through the window to make sure you didn't pull the chuck out again. Then close the SEC valve, and flip the switch marked SC Valve. This opens the beamline to the specimen chamber, and you're ready to turn on the beam!

On the control panel below the monitors, the green ready button should be lit. Next to it is the HV ON/Emission Adjust button, just like on the 6200. Below that is a dial with three numbers. This is the beam energy control, and it should read 040. The first two numbers is the beam energy in KeV's, and the last number is the flashing voltage.

Once you've made sure of that, press the HV On button. The LED display and the beam current gauge to the left of the monitors will light and the beam will come up to 10 uA on the gauge.

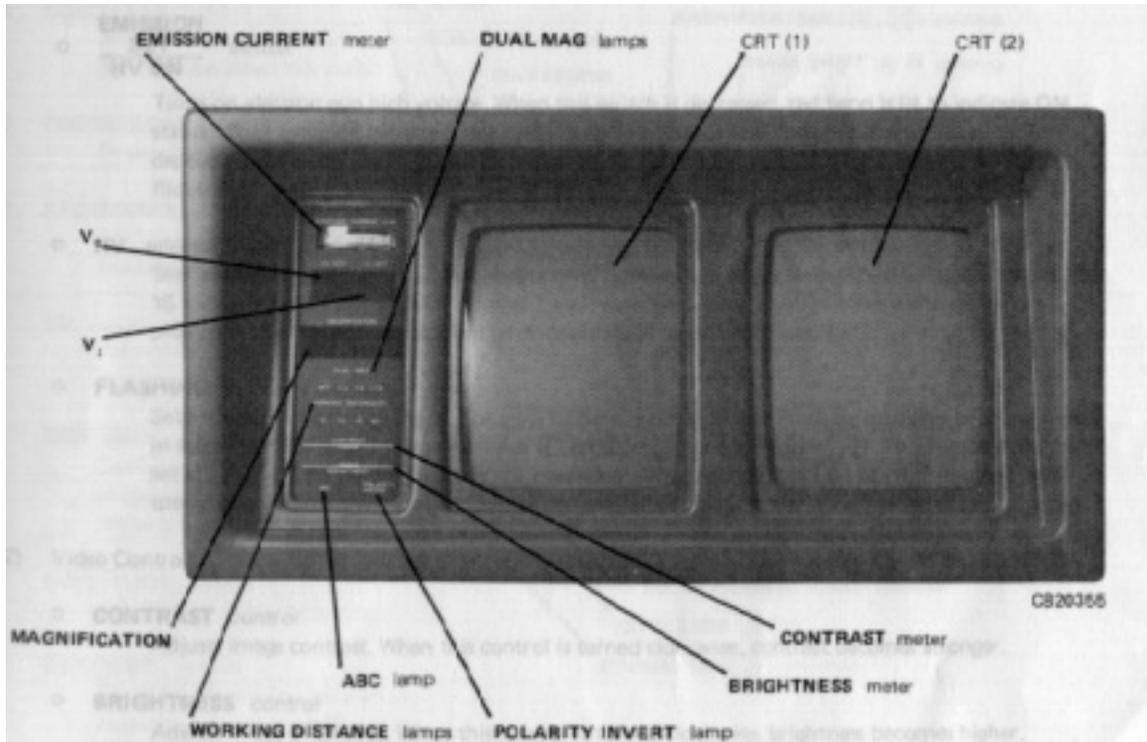


Figure 3: The S-900/806c monitors.

If at any time while you are using the SEM and you see the beam monitor control button (BMC) flashing, press it.

Now, find the button marked ABC. This is the automatic brightness/contrast control. Press it, and the SEM will scan the screen for a few seconds, and then set the brightness/contrast levels. You can set them yourself by moving the switch next to the button to Manual, and then using the knobs below to adjust the video levels.

The double row of buttons to the right are for different display modes. The top row controls types of display, and the bottom row controls the scan rate. Right now, press the first button in the bottom row and then press ABC. You ought to be able to see a faint image of some kind.

On the stage controller, find the button marked Location/Command. Press it so that the Command LED lights up. On the green display you ought to see only two slashes, like these:

/ /

Type “21” on the keypad and press enter. This is the command to set the stage speed, which can be either 1, 2, or 3. 1 is the slowest, and 3 is the fastest. You’ll see a listing of the settings now—the one that you need to change is the X,Y setting. Z and T ought always to be 1. Press 3 and press enter.

Move the joystick slowly down until you see the location numbers begin to change on the display. After a second you should see the edge of the chuck pass by. Press ABC again and move the stage until you can see the edge of the wafer. If you’re not sure that you’re looking at the edge of the wafer, follow it around in one direction until you can see one of the round Teflon clips, with the Phillips-head screw. (Make sure the magnification is set on 40X.)

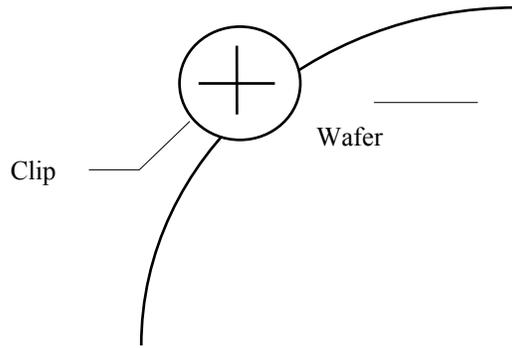


Figure 4: Teflon clip in relation to wafer.

The edge of the wafer is a good place to set the focus and stigmatism. Get as sharp an image as you can, and then move into the wafer until you see the pattern. Find a scribe line and follow it up to the top row of die, and then find the leftmost whole die.

The best technique I have found for finding smaller defects is to take the wafer to the 6200 first. Locate the defect with the KLA coordinates, and then move a couple of microns away from the defect and then just leave it there and let it charge up. Go do something else for several minutes, until you have a nice, large dark spot on the wafer. It'll stay there for a while, so when you go to the 806 it will be readily apparent where the defect is--right next to the big dark spot.

You still have to find the correct die, though, so press ABC again and move the stage slowly to the right. Count the number of die in the top row and compare it to the KLA wafer map. You will probably have two extra--these are dummy die. Draw them in on the map so that your reference will be correct. Start from one end of the top row and count die over and down to the die with the defect. Watch the monitor carefully as you move the stage, and count die until you reach the die with the defect. Go to its lower left-hand corner, and move it into the center of the monitor.

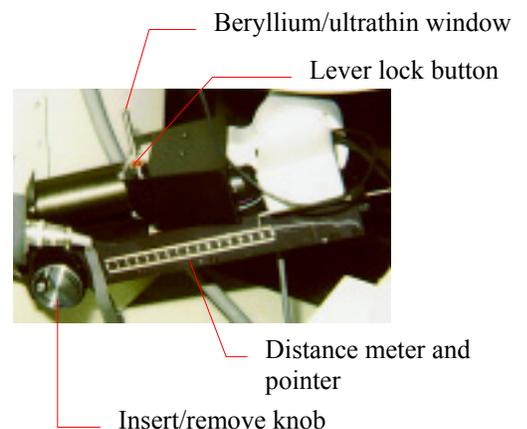
On the stage controller, write down the location numbers as a reference point that you can return to if it is necessary.

Type Command-02 (for relative move.) Divide the KLA coordinates by 1000, and enter the result. Change Y to -Y by pressing the "-" key before entering the coordinates. Press Enter, and if you have the right die, you ought to see the black spot appear. If you don't see it, check that you entered the coordinates correctly. If you did, return to the reference point you noted earlier, the corner of the die, and began checking the surrounding die. Most of the time, this will reveal the defect. If you still can't find it, go back to the top row and count die again to the defect die.

Once you've found the defect, the hard part is over. Now we can explore some of the more interesting features of the 806. On the stage controller, type Command-05. This is the tilt function. At no time should you tilt the wafer more than 55 degrees. Do not tilt it at all if the EDS detector is in the chamber, because it might be struck by the tilting wafer, and the result would probably cause you a great deal of embarrassment.

For the tilt angle, enter 55 degrees. Press enter, and quickly zoom out so you can keep the dark spot of your defect in the screen. It will meander around quite a bit as the stage tilts. If it goes off the screen, don't worry. Just remember which way it went because it won't go far. Once the tilt has finished, go and find it, and zoom in again. You will be surprised at how much different it looks. This is often useful to look at how the defect is affecting things beneath it. Enter a tilt angle of 0 to return the wafer to its original position.

Figure 5: EDS controls.



The large juglike apparatus attached to the side of the SEM, and the computer terminal on the other side, are the components of the electron dispersive spectrography system, or EDS, or EDAX, which is a brand name that rolls off the tongue better. Look at the base of the jug.

Bolted to the side of the SEM, directly by the monitors, is a small box with three lights. One says "Beryllium window"; one says "Ultrathin window", and the other says, "On". The beryllium light should be lit. Press down on the red lever lock button, and pull the window lever toward you. Release the button. Now, the red ultrathin window light will be lit.

Turn the crank clockwise to insert the detector into the specimen chamber. When you feel it stop, back off about a quarter turn.

On the SEM, find an area of the particle that is clear of residual material or pattern. Zoom in on it and press the scan mode button marked Position Set. You will see a small scanning bar on the screen, with a crosshair in it. Use the X-Y position set knobs to move the crosshair over the area you selected on the particle. Then press

the scan mode button marked Spot. The screen will show just a small, bright point.

On the EDS, we need to check the parameters now. Press Acquire, and choose "Check PHA status" by either pressing its number on the keyboard, or scrolling to it using the paddle. Once it's highlighted, press the RUN button. All the parameters must be green. Check the LN2 level--it should read OK. Look at the Counts In/Counts Out reading. The counts out should be at least 50 or so. A lower number will work, but it will be much slower.

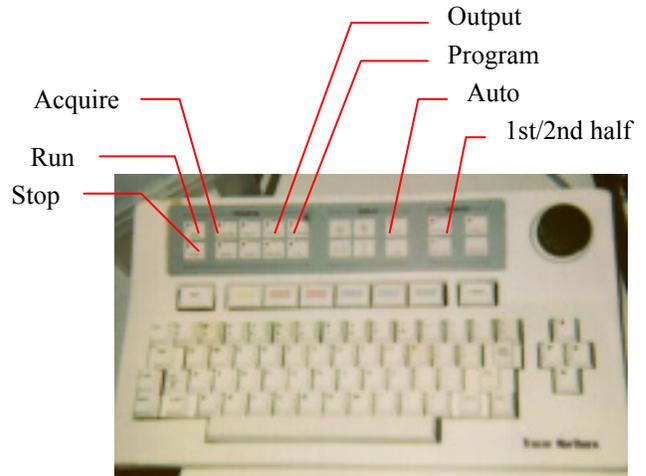


Figure 6: the EDS Keyboard

Check the beam current on the SEM to make sure it hasn't dropped off. It may be possible to increase the beam energy from 4 KeVs to 10 KeVs, but this should be done with care. Ask your lead.

If the PHA status is satisfactory, press STOP. Now, you need to choose the memory half where your spectrum will be stored. Press the First Half button, and make sure that the Auto button is lit. This is the automatic zoom function.

Now you're ready to take a spectrum! Press Acquire again, and choose Acquire X-Ray Spectrum. Press RUN, and sit back.

You will see a graph forming on the screen. This is a plot of the acquired X-rays' energy by the number of X-Rays. Since each element gives off X-rays of a specific energy when bombarded with electrons, the computer can identify separate elements and their ratios to each other by plotting such a graph. The X-rays' energy is limited by their beam energy, in this case to 4 KeVs, so we will only see light elements.

Let the acquisition run for sixty seconds. If it doesn't stop automatically, stop it by pressing STOP. Press Program, and choose Identify Spectral Peaks. Press Run. The computer will attempt to identify the peaks. It is usually successful at this, but you can also do it manually if necessary. However, this is an involved procedure that takes practice, so ask your lead for assistance.

To print your spectrum, press Output, and choose Plot Spectrum. When you've finished using the EDS, return the lever to the beryllium window position and rotate the sensor out of the specimen chamber until the distance indicator passes the number 14 on the scale.

The S-900

The S-900 is almost exactly like the 806, except that it is designed for better resolution at a higher magnification. It requires some sample preparation, however. The sample rod will only hold a sample measuring about 3x5 millimeters.

Before you use the SEM, you must fill the cold trap and the cold finger reservoirs with liquid nitrogen. The cold trap is located on the left rear side of the SEM, just beside the bottom of the column. Use a funnel to fill the reservoir. When it is full, you'll see nitrogen vapor coming out of the vent at the bottom of the back panel of the SEM. The cold finger reservoir is the canlike attachment on the front of the column. Twist it a quarter-turn to get it off, and remove the copper braid that feeds into it. Fill the container, and replace the braid. Be careful, since the braid will displace some of the nitrogen, especially when screwing the container back into its holder.

Preparing the sample requires practice, and is rather beyond the scope of this manual. Once you have it prepared, set it into the sample holder you plan to use.

Insert the rod into the chamber until it stops. Do not rotate it, just press and hold until you hear a loud click. Turn the switch below the chamber to EVAC, and wait until the green LED above the switch lights up. Turn the sample rod clockwise about 45 degrees, until it stops, and push it farther into the chamber. When it stops again, turn it clockwise another 15 degrees and finish seating it in the chamber.

Figure 7: Specimen exchange chamber

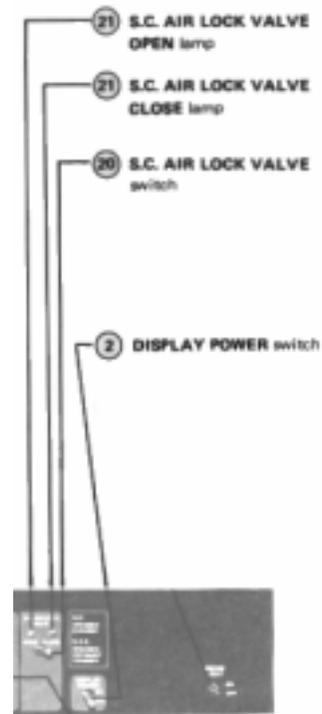
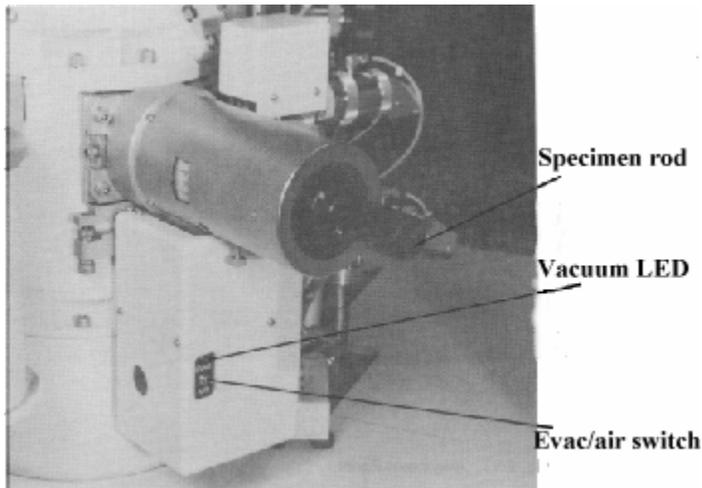


Figure 8: S-900 vacuum control.

Find the timer and set it for five minutes, to let the SEM pump out. Switch on the display power, if it is not already on, and check that the accelerating voltage is set to 154. Open the S.C. valve, and when the green HV READY light on the switch panel comes on, turn on the high voltage, and reduce the magnification down to 250X.

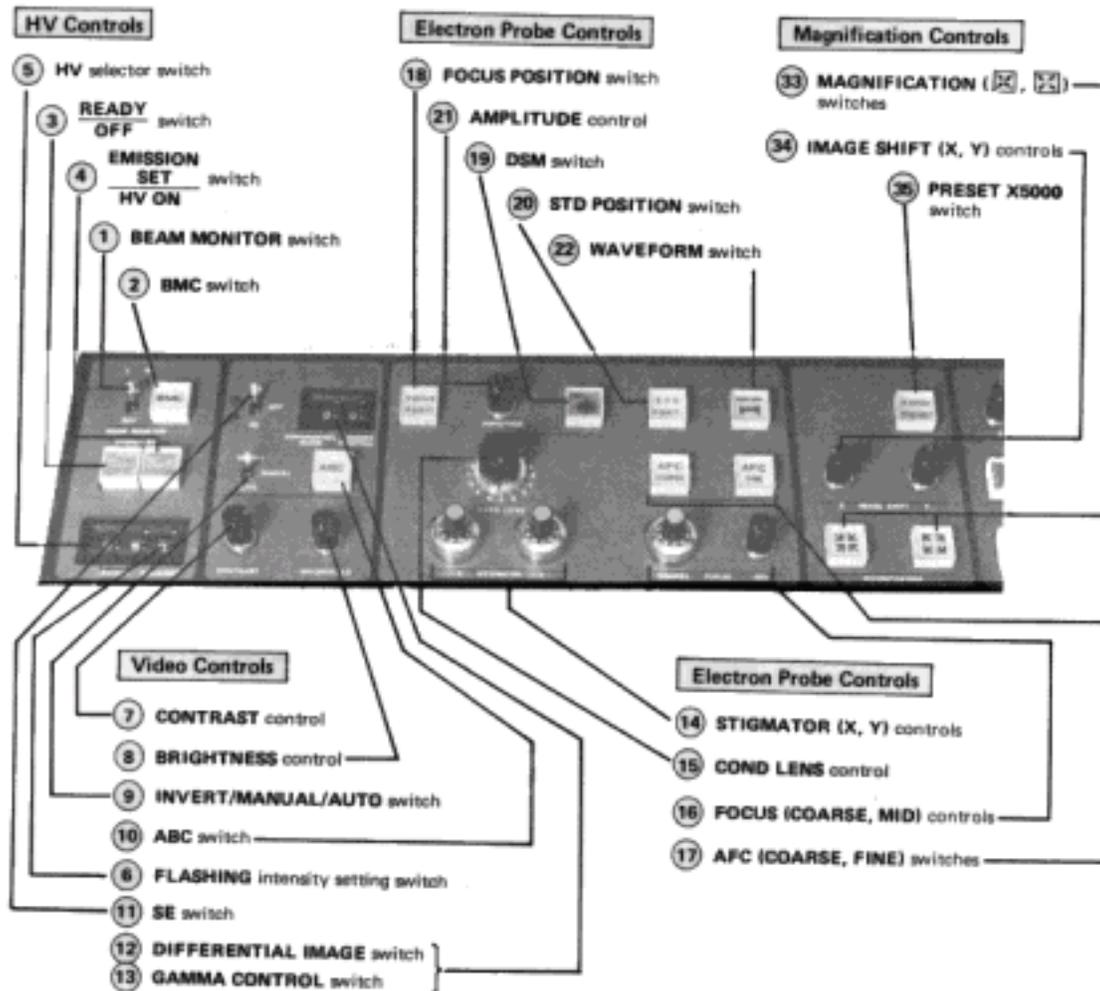


Figure 7: 806/S-900 control panel (left).

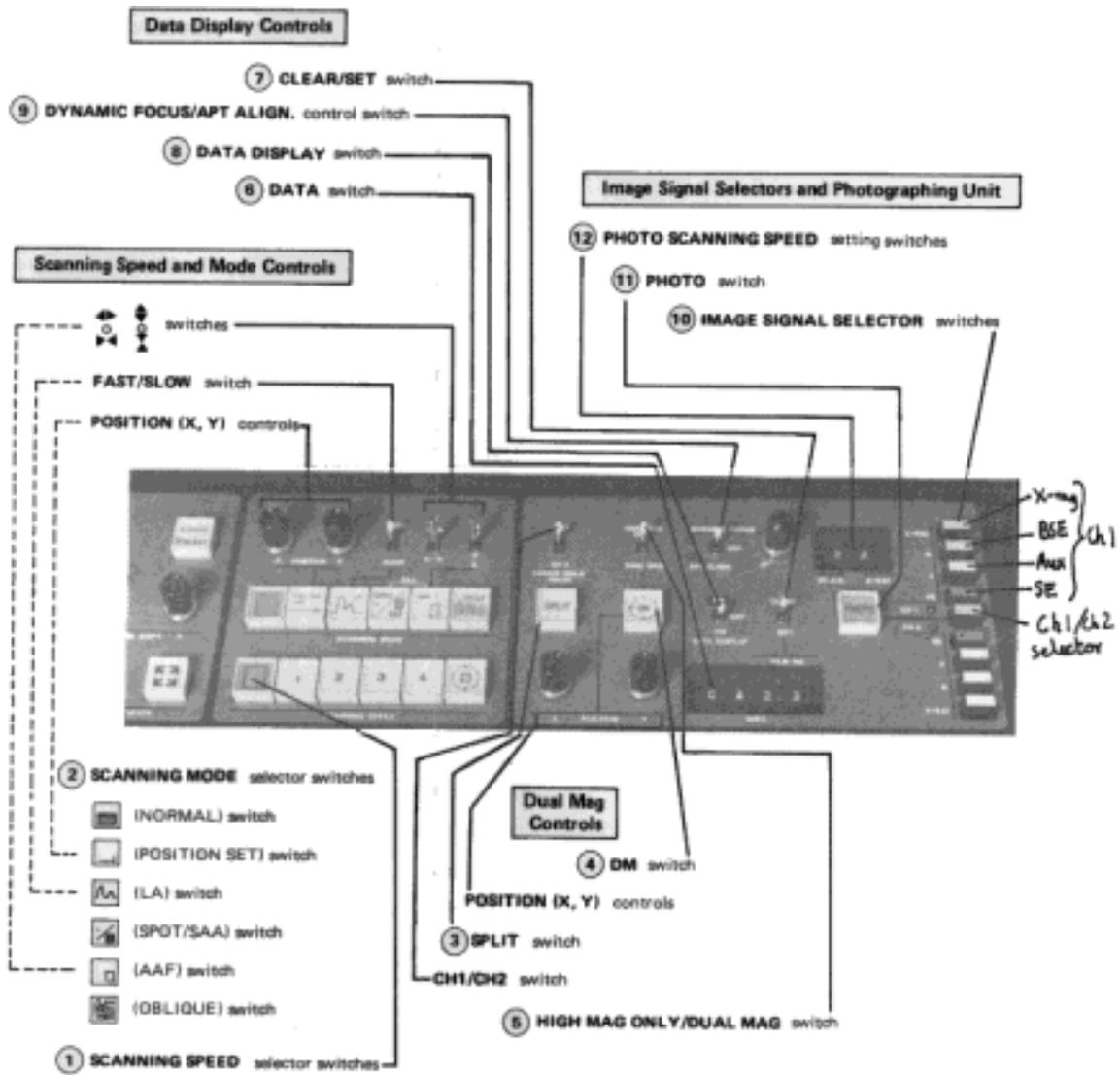


Figure 8: 806/S-900 control panel (right)

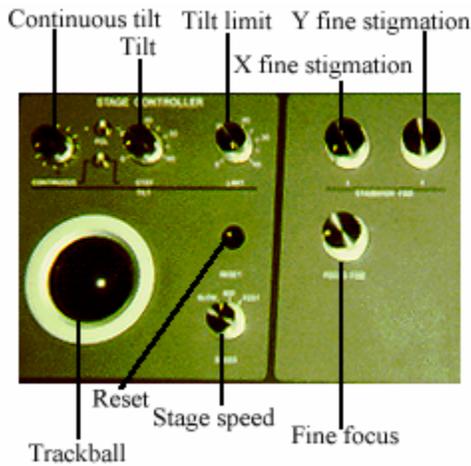


Figure 9: S-900 stage control panel.

When you are using the cross-section sample rod, where the sample is held on its edge, the first thing you will see on the monitors is half of a circular hole. If you don't see this, press the RESET button on the stage control panel to bring the sample back to its home position, and make sure that the magnification is reduced to 250x. Also, set the manual/auto brightness and contrast switch to auto, and press the ABC button.

Press the Normal scan speed button, and set the stage speed to Medium. The sample is “up” from the current position, so roll the trackball down to move the stage down. The bottom edge of the sample will appear first, then the top. Once you see the top edge, zoom in to about 20KX and adjust the focus and stigmation until you have a good image. A useful feature here is to select the #6 scan speed switch, which quarters the size of the image, but greatly improves the resolution. Once you have attained a good image, switch back to normal scan speed.

Once you're happy with the image, take a photograph. The camera works the same way as on the 806 and the 6200, and, in addition, the thermal printer works as well. Press Copy on the thermal printer, put film in the camera, ensure that the Start/Stop light on the image processor is lit, and press the red Photo button on the right side of the keyboard. When the scan is finished, develop the film, and tear off the printout.

To remove the sample from the SEM, return to 250K magnification. Switch off the high voltage, press the Reset button, and wait until the stage motors stop. Close the S.C. valve, and pull out the sample rod until it stops. Turn it to the left and pull again, until you see the peg appear in its slot in the chamber. Don't pull the rod all the way out until you turn the EVAC/AIR switch to AIR, and wait for the green light to go off. Once you've removed the sample, return the rod to the SEM, insert it, and leave it in. This prevents contaminants from getting on the rod and in the specimen chamber.