SUE
MODEL 615
UHV EVAPORATOR

OPERATION MANUAL

March 2019

NOTE:

Information and data in this manual are subject to periodic amendments, revisions and additions. Please consult factory for the most current information and revision.

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NOTATIONS, SYMBOLS & WARNINGS!!

NOTATIONS AS USED IN THIS MANUAL.

WARNING!!

WARNINGS ARE DISPLAYED IN BOXES WITH THE WORD **WARNING!!** WRITTEN IN BOLD RED AND THE MOST CRITICAL INFORMATION UNDERLINED. WARNING BOXES ARE NOT INDENTED.

IMPORTANT

Important notes are displayed in indented boxes with all text underlined and headed by the word **IMPORTANT** underlined and written in bold black.

NOTE: General Notes are displayed in indented boxes with the bold word **NOTE:** at the left side.

TIP: Optional Tips are displayed in indented boxes with the bold word **TIP:** at the left side.

I: SAFETY

READING ALL MANUALS – REQUIRED FOR INSTALLATION, OPERATION & MAINTENANCE:
IT IS IMPERATIVE THAT EACH USER OF THIS EQUIPMENT READ AND UNDERSTAND ALL ASSOCIATED MANUALS PRIOR TO OPERATION AND MAINTENANCE THEREOF. FAILURE TO PROPERLY INSTALL, OPERATE OR SERVICE THIS PRODUCT CAN RESULT IN PRODUCT DAMAGE, ELECTROCUTION, BURNS, EYE INJURY, PHYSICAL INJURY OR DEATH. IMPORTANT: PLEASE EXERCISE EXTREME CAUTION IN OPERATION OR MODIFICATION OF THIS EQUIPMENT AND BE CERTAIN ALL PERSONNEL COMING INTO CONTACT WITH THE EQUIPMENT READ THIS MANUAL AND THE MANUALS (AND HAZARD WARNINGS) OF THE INDIVIDUAL COMPONENTS. MANUALS FOR EQUIPMENT NOT SUPPLIED BY AJA SHOULD BE OBTAINED BY THE END USER.

PLEASE BE AWARE OF THE FOLLOWING HAZARDS:

DANGER HIGH VOLTAGE: DO NOT WORK ALONE
BEFORE OPERATING OR SERVICING THIS EQUIPMENT, READ THIS MANUAL AND ALL THE ASSOCIATED AJA SUE 615 POWER SUPPLY MANUALS, PAYING SPECIAL ATTENTION TO **ALL SAFETY PRECAUTIONS AND RECOMMENDATIONS.**

THE HIGH VOLTAGE USED BY THE EVAPORATION SOURCE CAN BE **IMMEDIATELY FATAL**. ADDITIONALLY, BECAUSE THE INTERNAL CAPACITANCE IN THE POWER SUPPLY,
THIS VOLTAGE WILL PERSIST AFTER THE POWER SUPPLY HAS BEEN TURNED OFF.
BEFORE ENTERING THE CHAMBER: FIRST MAKE SURE THAT THE POWER SUPPLY IS TURNED OFF, WAIT AT LEAST 10 MINUTES (THE NATURAL DISCHARGE TIME OF THE POWER SUPPLY) THEN USE A GROUNDING HOOK ON THE HIGH VOLTAGE LEADS FROM THE AJA SUE 615 TO DISCHARGE ANY PERSISTANT VOLTAGE TO GROUND. (IF YOU DO NOT HAVE ACCESS TO A GROUNDING HOOK, CONTACT AJA SALES FOR A QUOTATION).

HEAT HAZARDS:
THE SOURCE FILAMENT, AND EVAPORANTS BECOME VERY HOT DURING PROCESSING. A MINIMUM COOLING PERIOD SHOULD BE USED BEFORE DIRECTLY HANDLING THE EMITTER ASSEMBLY, OR ANY RECENTLY USED EVAPORANT. AFTER VENTING, WAIT AT LEAST 5 MINUTES TO ALLOW METAL EVAPORANTS OR THE FILAMENT TO COOL. WAIT FOR 20 MINUTES OR MORE FOR SUBLIMING MATERIALS OR INSULATORS IN CRUCIBLE LINERS.

PINCH POINT:
WHEN SLIDING THE AJA SUE 615 BACK INTO THE CHAMBER FROM THE SERVICE POSITION, USE CAUTION TO AVOID THE PINCH POINT BETWEEN MATING FLANGES.

HAZARDOUS DUST:
HAZARDOUS DUST MAY BE FORMED WHEN EVAPORATING. THEREFORE, WHEN OPENING THE CHAMBER OR HANDLING AN AJA SUE 615, BE SURE TO USE THE PROPER PERSONAL PROTECTION AS REQUIRED BY THE MSDS FOR THAT MATERIAL.

SAFETY continued.

RETURN OF CONTAMINATED EQUIPMENT:
NEVER SHIP OR RETURN SOURCES OR SOURCE COMPONENTS CONTAMINATED WITH HAZARDOUS MATERIALS TO AJA INTERNATIONAL. **ALL** RETURNS REQUIRE FULL DISCLOSURE OF MATERIALS USED AND THE POTENTIAL HEALTH RISKS THEREOF, PRIOR TO THE ISSUANCE OF A RETURN AUTHORIZATION NUMBER.

STRONG MAGNETIC FIELDS – PACEMAKER & ELECTRONICS RISK!!!!:
ELECTRON BEAM EVAPORATION SOURCES ARE FITTED WITH STRONG PERMANENT MAGNETS WHICH MAY ADVERSELY AFFECT **PACEMAKER** OPERATION AND WHICH MAY ERASE OR CORRUPT THE MEMORY IN ELECTRONIC DEVICES RENDERING THEM NON-FUNCTIONAL.

SAFETY LABELING:
ALL AJA SUE 615s ARE SUPPLIED WITH THE FOLLOWING SAFETY LABELS.

Figure 1: The AJA SUE 615 System Safety Label

II: AJA SUE 615 PRODUCT DESCRIPTION AND BASIC OPERATING INFORMATION

A. AJA SUE 615 Product Description

1. The **AJA SUE 615** is essentially a 6 pocket, UHV, linear, electron beam deposition source with 15 cc crucible capacity. It is also designed to accommodate **in-situ crucible exchange** for 4 pockets when installed in an e-beam evaporation system with a properly located mini crucible exchange load-lock. Its crucible block is indexed using a full size, lead screw bellows that can be easily converted between manual and motorized operation. It is also compatible with the AJA atmosphere side **access slide** to allow quick, safe source removal without lifting. When retracted from the vacuum chamber, access to all source parts for service, cleaning and loading is facilitated. It is typically fitted with a 12" CF UHV flange but is also available on an ISO 250 flange with quick-lock, swing clamps for more frequent access. All AJA SUE 615 sources can be built as right or left hand version to optimize emitter orientation.

B. Basic Operating Information

1. The **AJA SUE 615** utilizes a high voltage filament to generate electrons via thermionic emission from its cathodic emitter assembly. Electrons are accelerated away from a grounded anode plate into a permanent magnetic field that directs the electrons into a water-cooled crucible containing "source material". Approximate impact location and beam geometry are determined by the emitter configuration, the permanent magnet assembly and the filament voltage (beam energy). Since the permanent magnetic field is fixed, beam location (front to back) is determined by the negative voltage potential on the filament – the higher the voltage, the higher the beam energy to overcome the magnetic field, the further the beam will locate past the crucible and vice versa. Shunt bars are available to adjust the permanent magnetic field in discreet increments. Fine beam steering adjustments are made using a small electromagnetic coil assembly. The final beam location can be randomized or rastered on the source material by modulating this electromagnetic coil. This is called "beam sweeping". The coil is generally referred to as a "sweep coil". Since the source material can be easily heated to temperatures as high as 3400 C, it is common to utilize beam sweeping for source materials with poor thermal characteristics to allow stable, uniform heating and prevent "spitting".

2. In normal operation the source material is either melted/evaporated or sublimed in a vacuum chamber at pressures anywhere from 5×10^{-8} Torr up to about 3×10^{-4} Torr. Higher pressures are common when utilizing ion beam assist so as to operate in a pressure regime where the ion source can maintain a plasma and have a reasonable beam current/energy. The evaporated or sublimed material is generally emitted above the crucible in a cosine distribution, onto a "substrate", and at a working distance of between 350 mm and 1 m. Evaporated/sublimed material will <u>always</u> arrive at the substrate at thermal energy (<1eV) making ion beam assist interesting for some applications. Substrates are often heated, cooled, rotated, subjected to planetary motion, etc. to achieve specific results.

III. AJA SUE 615: GENERAL FEATURES

Do not attempt to disassemble the AJA SUE 615 in order to familiarize yourself with the source. This should not be undertaken without factory approval and unless a source problem or a desired modification warrants it. Any attempt to disassemble the AJA SUE 615 without factory approval and factory consultation will void the warranty on this product.

The standard AJA SUE 615 source mates to the system via 1) an SS 12"-CF UHV flange or 2) an SS ISO 250 flange with 4 quick-lock swing clamps as depicted in Figure 4. The design features separate cooling loops for the 6-pocket crucible, and the hearth.

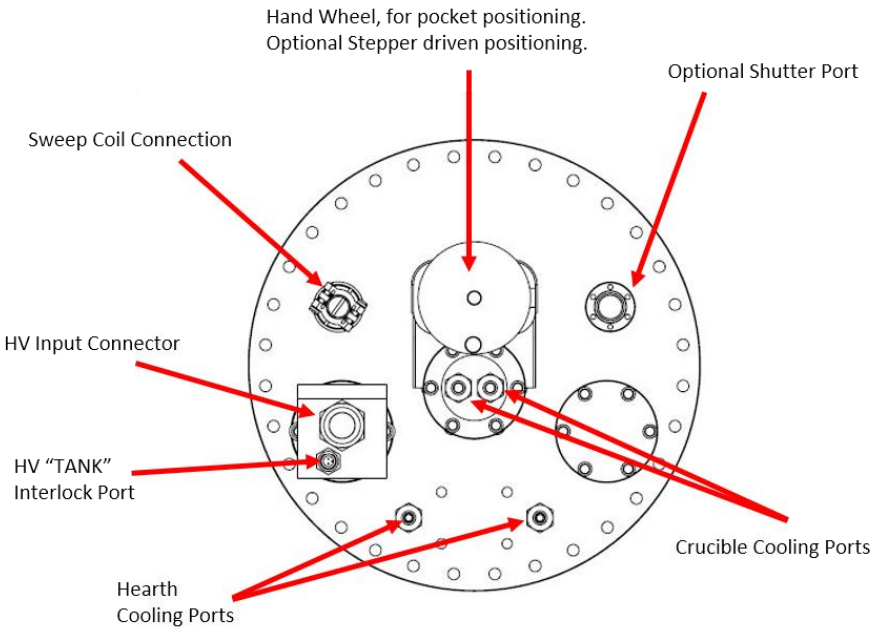


Figure 2: AJA SUE 615 atmosphere side view of 12" CF Flange

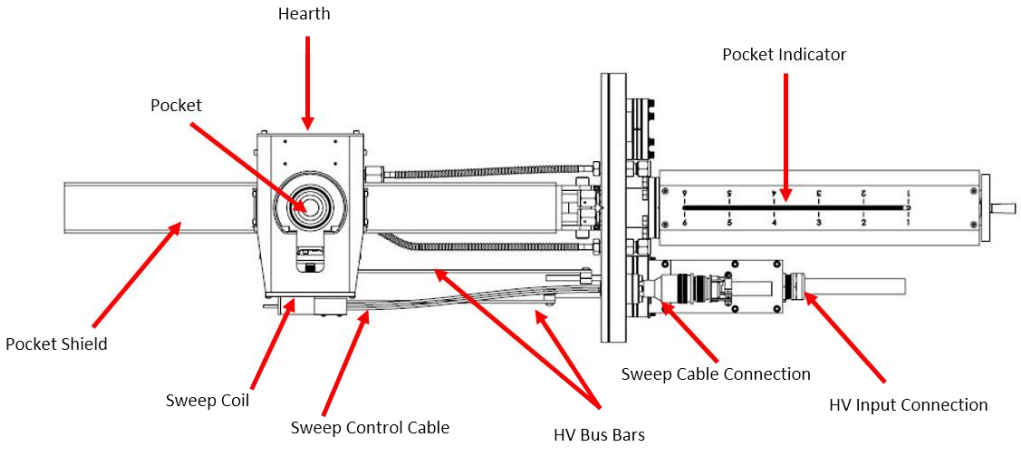


Figure 3: TOP VIEW OF THE AJA SUE 615

A. USEFUL SPECIFICATIONS:

1. Maximum Bakeout Temperature: 150˚C
2. Maximum Power: 6 kW
3. Acceleration Voltage (HV): 4-10 kV
4. Operating Pressure Range:
    a. Maximum 5×10^{-5} Torr
5. Beam Deflection: 270˚
6. Sweep Lateral Coil: +/- 3 A
7. Sweep Longitudinal Coil: +/- 3 A
8. Cooling Water:
    a. Maximum Temperature: 25˚C
    b. Flow Rate: 1.0 GPM (2X)
    c. Min. Pressure Differential: 45 psi
9. Crucible Volume: 15cc.

NOTE: The AJA SUE 615 operating pressure range is typically from 5×10^{-5} Torr and below, consult with factory regarding your pressure requirements.

IV. SLIDING THE AJA SUE 615

WARNING!!

HIGH VOLTAGE:
THE HIGH VOLTAGE USED BY THE EVAPORATION SOURCE CAN BE IMMEDIATELY FATAL. ADDITIONALLY, BECAUSE THE INTERNAL CAPACITANCE IN THE POWER SUPPLY, THIS VOLTAGE WILL PERSIST AFTER THE POWER SUPPLY HAS BEEN TURNED OFF. BEFORE ENTERING THE CHAMBER, FIRST MAKE SURE THAT THE POWER SUPPLY IS OFF, WAIT AT LEAST 10 MINUTES (THE NATURAL DISCHARGE TIME OF THE POWER SUPPLY) THEN USE A GROUNDING HOOK ON THE HIGH VOLTAGE LEADS FROM THE AJA SUE 615 TO DISCHARGE ANY PERISTANT VOLTAGE TO GROUND.

STRONG MAGNETIC FIELDS – PACEMAKER & ELECTRONICS RISK!:
ELECTRON BEAM EVAPORATION SOURCES ARE FITTED WITH STRONG PERMANENT MAGNETS WHICH MAY ADVERSELY AFFECT PACEMAKER OPERATION AND WHICH MAY ERASE OR CORRUPT THE MEMORY IN ELECTRONIC DEVICES RENDERING THEM NON-FUNCTIONAL.

A. THE AJA SUE 615 ON SLIDING RAILS

1. Each system is equipped with rails and a guiding carriage assembly that allows for easy removal from the system, service and maintenance. These are depicted in Figures 4 & 5 below.

B. HOW TO SAFELY SLIDE THE AJA SUE 615:

1. Preparing the source for maintenance or loading.
    a. Manually turn off the high voltage power supply to the source.
    b. Make sure that the source shutter (if equipped) is in the closed position.
    c. Perform the proper procedure for venting your system to atmosphere.

NOTE: The vacuum interlock circuit provided with the AJA SUE 615, will disable all power sources while the system is vented to atmosphere, and accessible to users. The interlock will NOT prevent stored energy from remaining accessible at the high voltage feedthrough or bus bars in the evaporation source.

WARNING!!

HEAT HAZARDS:
THE SOURCE FILAMENT, AND EVAPORANTS BECOME VERY HOT DURING PROCESSING. A MINIMUM COOLING PERIOD SHOULD BE USED BEFORE DIRECTLY HANDLING THE EMITTER ASSEMBLY, OR ANY RECENTLY USED EVAPORANT. AFTER VENTING, WAIT AT LEAST 5 MINUTES TO ALLOW METAL EVAPORANTS OR THE FILAMENT TO COOL. WAIT FOR 20 MINUTES OR MORE FOR SUBLIMIMG MATERIALS OR INSULATORS IN CRUCIBLE LINERS.

PINCH POINT:
WHEN SLIDING THE AJA SUE 615 BACK INTO THE CHAMBER FROM THE SERVICE POSITION, USE CAUTION TO AVOID THE PINCH POINT BETWEEN MATING FLANGES.

    d. Unfasten the AJA SUE 615 flange from the main chamber.
    e. Carefully slide the AJA SUE 615 away from the chamber, until it reaches the carriage stop (see Figure 5), While making sure NOT TO TOUCH THE HIGH VOLTAGE FEEDTHROUGH OR BUS BARS.
    f. Use a grounding hook, to discharge any persistent high voltage, by touching BOTH high voltage connections and buss bars.
    g. Wait an appropriate amount of time, to allow components or materials to cool.
    h. Proceed with your maintenance activity.

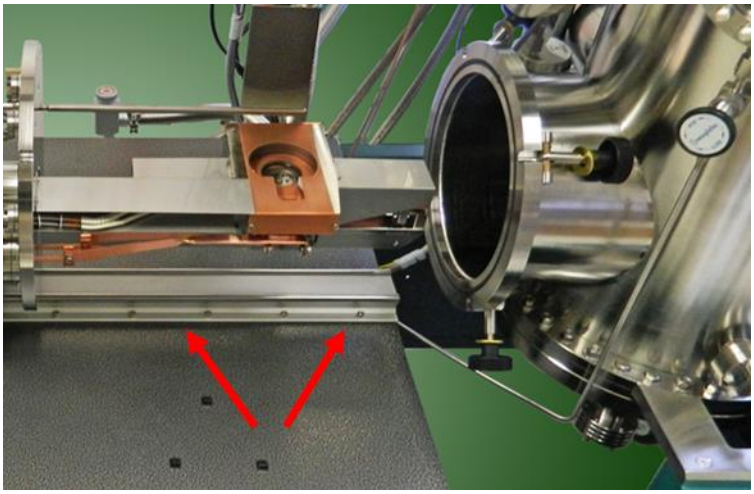


Figure 4: The AJA SUE 615 on Sliding Support Rail (Depicted with 12" ISO Flange Option)

NOTE: It is recommended to re-grease the support rails annually. Do not clean with any type of alcohol.

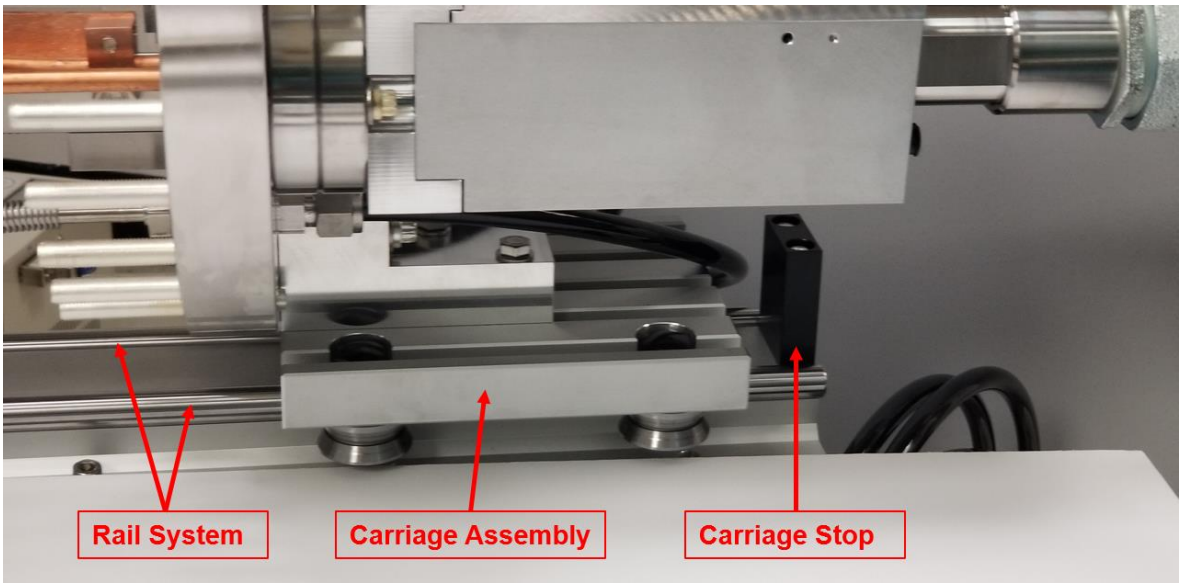


Figure 5: The AJA SUE 615 Sliding Carriage System

C. LOADING MATERIAL

NOTE: Do not overfill the crucible or crucible liner in the AJA SUE 615. Overfilling can cause cross contamination of evaporants, or jamming of the pocket indexing. Crucibles or liners can usually be filled between 60% and 80% by volume, however there are some specific materials that require special considerations. Contact AJA for advice. NEVER RUN THE SOURCE WITH AN EMPTY CRUCIBLE.

1. Cleanliness is critical to creating high quality thin films. Before loading a new material into a crucible, make sure to thoroughly clean out all of the previous material by use of an abrasive pad, followed by vacuuming of any particulates, and wiping with a clean room wipe and IPA.

2. There are several ways to load evaporant into the AJA SUE 615, whether your process allows the direct placement of material in the crucible, or the use of a crucible liner. The six crucible pockets can be indexed by manually rotating the hand wheel (Figure 2), or if so equipped, by stepper motor.

    a. By Sliding: As depicted above, full access to the crucible is available when the AJA SUE 615 is in the service position.

    b. Chamber Lid/Hoist Access: Most AJA systems will have this feature, allowing the main chamber lid to be opened with a hoist mechanism. In these cases, the crucible pocket can be up to 900 mm below the lid opening. Loading material can be performed by using a clean, clear length of rigid tubing, with an OD smaller than the pocket diameter, to guide single pellets of evaporant into the crucible. In this way the user maintains the best control over the load process.

    c. (if equipped) Via Main Chamber Loading Access Port: Main chambers, depending on design, can feature a load access port, located near, and aligned to the exposed E-beam pocket. This would allow tube loading of evaporant, for the expense of a small gasket.

    d. (If equipped) Via In-situ Crucible Exchange System: This is the only available option to load evaporant while maintaining main chamber vacuum. In brief, it makes use of a load lock, and transfer mechanism to deliver and retrieve crucible liners, in and out of the system, partially depicted in Figure 6 below.

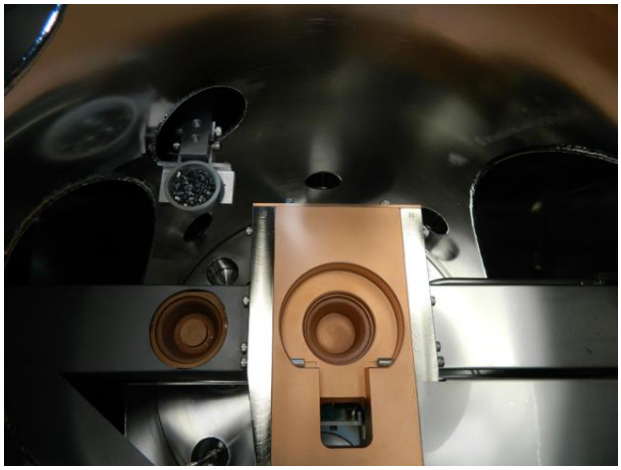


Figure 6: In-situ Crucible Exchange System

    e. Loading Magnetic Evaporants: Magnetic pellets should only be loaded into the active pocket a small amount at a time, because they can be drawn out of the pocket by fields within the system. Larger pellet sizes of material will help to keep the evaporant in the active pocket. Also, magnetic materials should not be indexed to another location until melted into a single solid ingot, to prevent pellets drawn from the pocket from jamming the transfer. Melting will also exceed the Curie point of the material.

D. SERVICE AND INSPECTIONS.

1. SERVICE:
    a. Once the AJA SUE 615 is out on its rails, and safely grounded, it is ready for service. Latter sections of this manual will outline procedures for user serviceable items such as sweep coil and emitter assembly replacement. See sections VII-IX for more information.

    b. † AJA SUE 615 Service Policy is to send a replacement emitter assembly to resolve most emitter or filament issues, saving the researcher valuable time and effort, troubleshooting, cleaning, and performing the fine alignment required to successfully refurbish an emitter assembly. Contact AJA at either aaaservice@ajaint.com or call: +1-781-545-7365 for instructions.

2. INSPECTIONS:
    a. After every venting to atmosphere the following inspections should be made, to help maintain a functioning system, and prevent unwanted downtime.
        i. Inspect each of the 6 crucible pockets for either a minimum fill of 50% for materials you wish to continue evaporating, or residue from materials you no longer need. Fill and clean as necessary.
        ii. Examine the entire source for evaporant debris or flakes that may have accumulated during processing. Pay special attention to the emitter assembly, High Voltage leads and feedthroughs, as debris buildup can lead to short circuits in these areas. Vacuum away all loose material.

V. THEORY OF OPERATION

The **AJA SUE 615** Evaporation Source, generates a stream of energetic electrons, by passing a large (up to 50A) ac current, through a Tungsten filament placed at the front of the hearth. The filament heats, allowing thermionic emission of electrons to occur. The filament is also brought to a high negative potential, from 4 to 10 kV dc. The electron stream is accelerated away from the filament, and toward a grounded Anode. A beam former is placed between the cathode and anode, to shape the beam.

A high strength permanent magnet is placed toward the rear of the hearth. The magnetic field produced, is shaped by pole pieces to provide parallel field lines along the latitudinal (side to side) axis, as shown in Figure 7. The effect of the magnetic field on the beam of electrons emerging from the port shown below, is to steer the beam through a 270-degree arc, in accordance with the “right hand rule”. The beam is focused by the placement of pole extensions.

For a fixed magnetic field strength, the point of impact of the beam along the longitude (front to back) is determined by the acceleration voltage (HV) applied to the cathode (kV dc). The higher the HV applied, the further along the longitude, the beam will travel. In order to locate the point of impact in the center of the crucible pocket, at reasonable high voltages, shunt bars (0.060” thick each), can be mounted below the permanent magnet. The application of one shunt bar will reduce the magnetic field strength enough to allow the reduction of the HV by 1 kV, to maintain the same point of impact. 4 shunt bars are provided.

Once the point of impact is located in the center of the crucible pocket along the longitudinal axis, all additional beam steering is provided by 3 additional electromagnets, combined into one component, called the sweep Coil. The u-shaped sweep coil is located in the front of the hearth, above the emitter assembly (filament), and around the beam access port. By applying currents from +/- 4 A, the electromagnets can further steer the beam across the pocket, in any direction.

Safety limits can be established, in units of milliamps of electromagnet current, that define the boundaries of the crucible pocket. Given these limits, sweep patterns can then be programmed (see the EBC manual for further instructions on how to program sweep functions) to raster the beam across the pocket in order to better manage the heating of the evaporation material in the pocket.

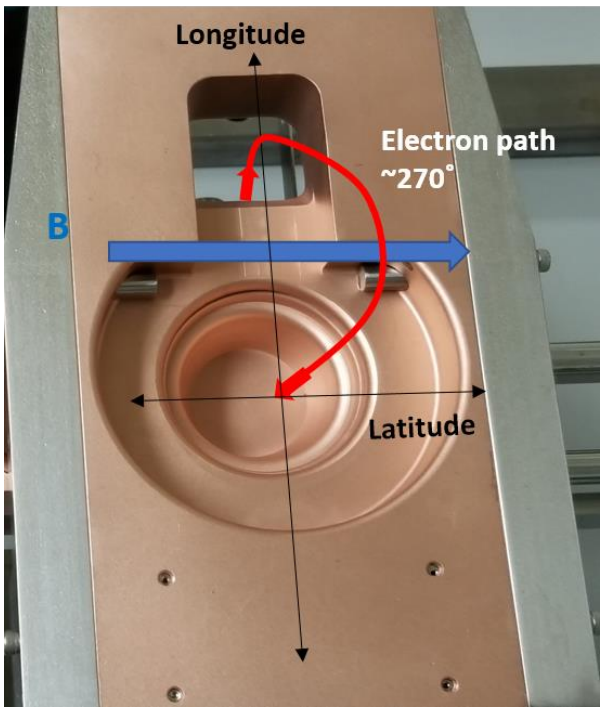


Figure 7: Permanent Magnetic Field Steering Electron Beam to the Pocket.

The kinetic energy of the electrons is transformed into thermal energy as the particles in the beam impact the evaporant in the pocket. Temperatures greater than 3400 degrees Celsius can be achieved with ease, allowing for the vaporization of most materials. Due to these achievable temperatures, the 6-pocket linear crucible is independently water cooled. In order to better manage the loss of thermal energy by cooling (among other considerations), many combinations of evaporant and mating crucible liners have been developed (Contact AJA for crucible liner suggestions for your evaporant). The AJA SUE 615 is compatible with 15 cc crucible liners.

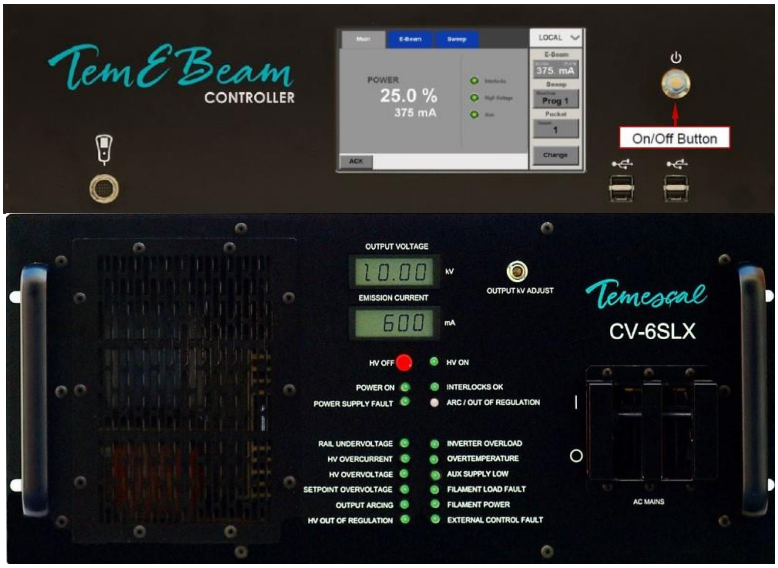
By the mechanism above, the evaporant is vaporized by evaporation or direct sublimation. The emitted vapor from the source roughly follows a cosine distribution in trajectory, generally toward the substrate, located 350 mm to 1 m away, with thermal energies less than 1 eV. Since the thermal energy is so low, the pressure in the chamber must be below the point where the mean free path is longer than the distance between the source and the substrate. This pressure is typically around 0.3 mTorr or lower.

VI. LOCAL EVAPORATOR OPERATION

A. POWER SUPPLY FUNCTIONS:

1. The **AJA SUE 615** is powered by the CV-6SLX Power Supply and the Temescal TemEbeam Controller (EBC). This section will outline how to perform a manual process with these supplies. For more in-depth information about the controller and power supply, please consult the OEM manuals.
2. Turn on the EBC with the switches on the front and rear of the device. To turn on the CV-6SLX, use the breaker on the front panel.

Figure 8:
Temescal Power Supply and TemEBeam (EBC) Sweep Controller



B. INITIAL SETUP:

1. Check the configuration screens (Figure 9).
   a. Navigate from the main menu to the configuration mode.
   b. Review the CONFIG\MAIN, CONFIG\E-BEAM, and CONFIG\SWEEP screens shown below.
      i. On the CONFIG\MAIN (1) screen, confirm that the E-beam and Sweep modules are set to Local.
      ii. On the CONFIG\E-Beam screen, confirm the HVPS Type, kV Control, and Emis Control are set as shown. Emis Scale will be set according to your system usage.
      iii. On the CONFIG\SWEEP (1) screen, setting the Sweep Interlock Limits will be described below. The Enable/Disable button is located on this screen. You must set Disable to set new sweep limits, and set Enable to process.

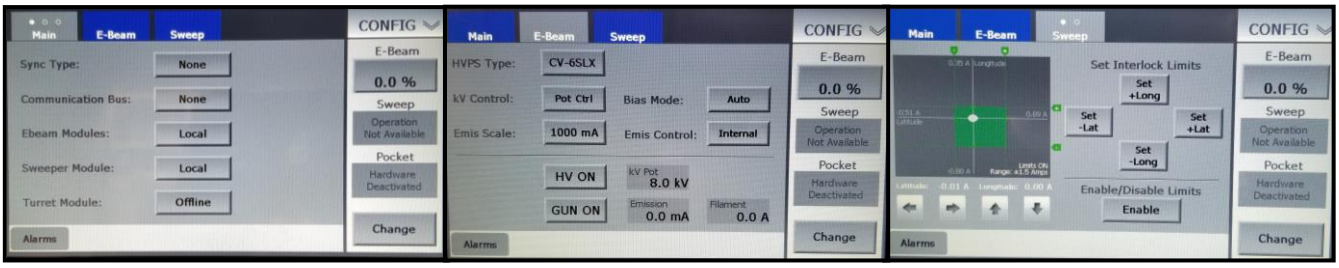
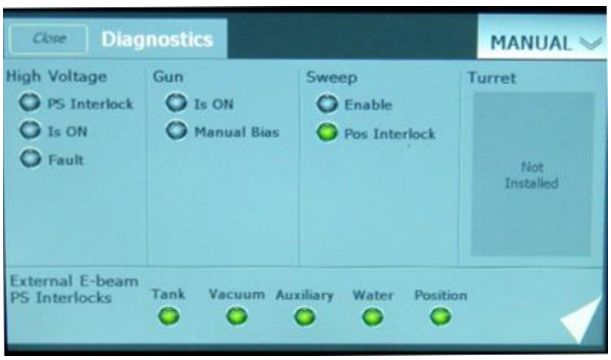


Figure 9: Initial Configuration settings for AJA SUE 615

2. Initial Conditions: System Interlocks/ Diagnostics.
To use the AJA SUE 615 safely, the 4 major protective interlocks must be satisfied.

Figure 10:
The Diagnostics Screen is accessible from most EBC Screens, and shows the status of the interlocks: Tank, Vacuum and Auxiliary.



a. Tank: Shown in Figure 2, this interlock disables output power from reaching the AJA SUE 615 if the power connector is open, and the high voltage contacts are accessible.

b. Vacuum: This interlock is activated by a relay triggered by the high vacuum gauge on the system. The threshold value is typically set to 5 x 10^{-5} Torr, low enough to establish the appropriate mean free path for the system, and assure in-chamber access to hazards are denied.

c. Auxiliary: This interlock is used if the AJA SUE 615 is equipped with a motorized crucible indexer. Upon power up, this interlock will not be satisfied until the motor is homed. (See Figure 11, for the HOME button on the main screen of the software). The interlock will also not be satisfied when the indexer is "not in position" as it travels in-between pocket positions.

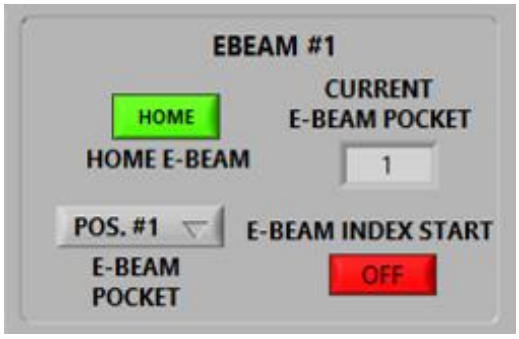


Figure 11: Screen shot of motorized pocket indexer, Home Button.

d. Water: Two, 1 GPM flow switches in series, on the output side of the E-beam cooling flow circuit are closed to complete the interlock circuit. As long as the minimum flow is present, the minimum flow will be indicated by a lit green LED in the cooling circuit relay rail. This interlock supersedes the one shown is Figure 10 above, in that it will deactivate the power to the entire system, including the EBC. (The water and position interlocks in Figure 10 are bypassed.)

3. High Voltage (HV) and longitudinal (front to back) centering.
The AJA SUE 615 will be pre-set at the factory with an HV between 7-8 kV.
This voltage may need to be adjusted from time to time.

a. Select a pocket with a metal load, Ti preferably. This will provide a good reflecting medium, that will aid visualizing the beam.
   i. Manually: Rotate the hand wheel (Figure 2) until the pocket Indicator is aligned with the chosen pocket.
   ii. Motorized: Select the pocket on the AJA Software main screen, from the pull-down menu, and push "E-Beam Index Start". (See Figure 11).

b. On the AJA Software Main Screen, open the E-beam shutter.

NOTE: If the E-beam shutter is not opened during use, the beam can over time, damage the shutter, and potentially contaminate your process.

c. Visualize the beam.
In order to adjust the beam, you must first be able to see it. A good view of the pocket and surrounding areas is crucial. This is done by turning on the HV, and then slowly increasing the emission current to a low setting (<=20mA).
   i. On the EBC CONFIG\E-Beam screen, turn on the HV and GUN, as shown in Figure 12.
   ii. On the hand-held controller, select the power adjust button, and use the joystick to increase the emission current, while looking in the chamber for the first visible sign of the beam. Stop increasing the current when you can just see the beam. (Expect a few second delay while the filament warms up).

WARNING!!

VISIBLY BRIGHT SOURCE AND UV EXPOSURE:
DO NOT ATTEMPT TO VIEW THE BEAM WITH THE NAKED EYE WITHOUT A POLARIZING FILTER. THE E-BEAM-MATERIAL INTERACTION CAN EMIT VERY BRIGHT VISIBLE LIGHT AND UV RADIATION, WHICH MAY CAUSE PERMANENT AND SERIOUS EYE DAMAGE OR BLINDNESS. PYREX TYPE GLASS VIEWPORTS ARE USED ON AJA SYSTEMS UNLESS OTHERWISE SPECIFIED. IT IS NOT FULLY UNDERSTOOD IF THESE VIEWPORTS COMPLETELY FILTER HARMFUL UV RADIATION THEREFORE, IT IS RECOMMENDED TO ONLY VIEW THE E-BEAM INTERACTION THROUGH THE SUPPLIED POLARIZING FILTERS.

NOTE: If your system is equipped with a camera and screen, for pocket visualization, this process may be iterative. Optimizing the camera focus, camera position, mirror angle and screen contrast may take several attempts to maximize. DO NOT INCREASE EMISSION CURRENT ABOVE 20 mA DURING THIS STEP.

d. Adjust the High Voltage.
Using a small flat head screw driver, make small adjustments to the potentiometer on the front face of the CV-6SLX labelled “Adjust”, until the beam spot is centered in the pocket from front to back.

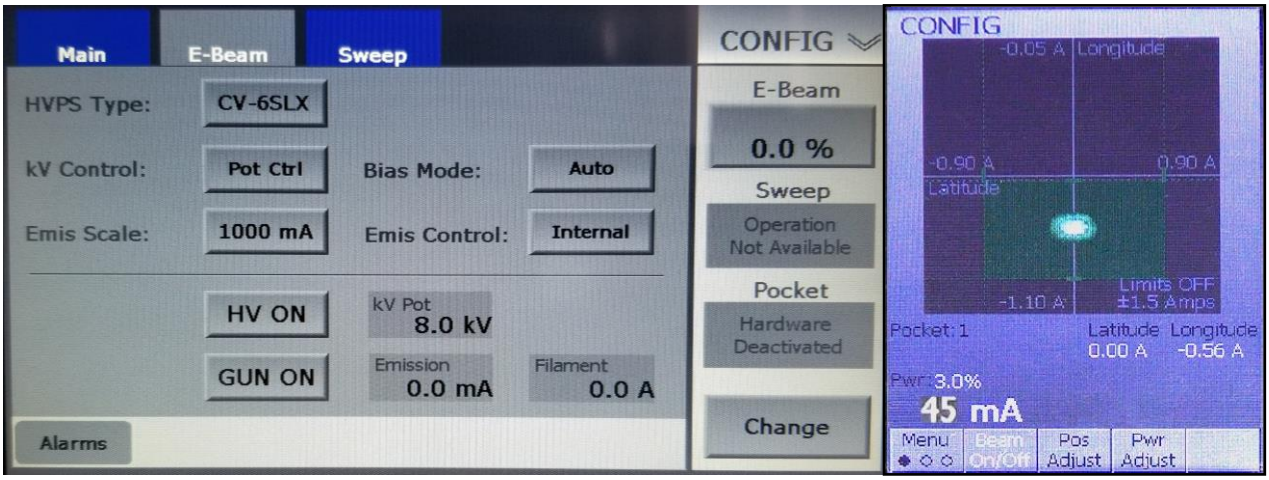


Figure 12: EBC CONFIG\E-Beam screen, and Hand-Held Remote Control. (Characters turn white when a button is turned on.)

NOTE: Processes using photoresist are typically heat sensitive, and will blister if too much heat is delivered to the substrate. Heating can be reduced by decreasing the HV. This can be done while maintaining the front to back beam centering by proportionately increasing the number of shunt bars used to reduce the permanent magnets field strength. An increase of 1 shunt bar, allows the reduction of the HV by 1 kV. (See Figure:13)

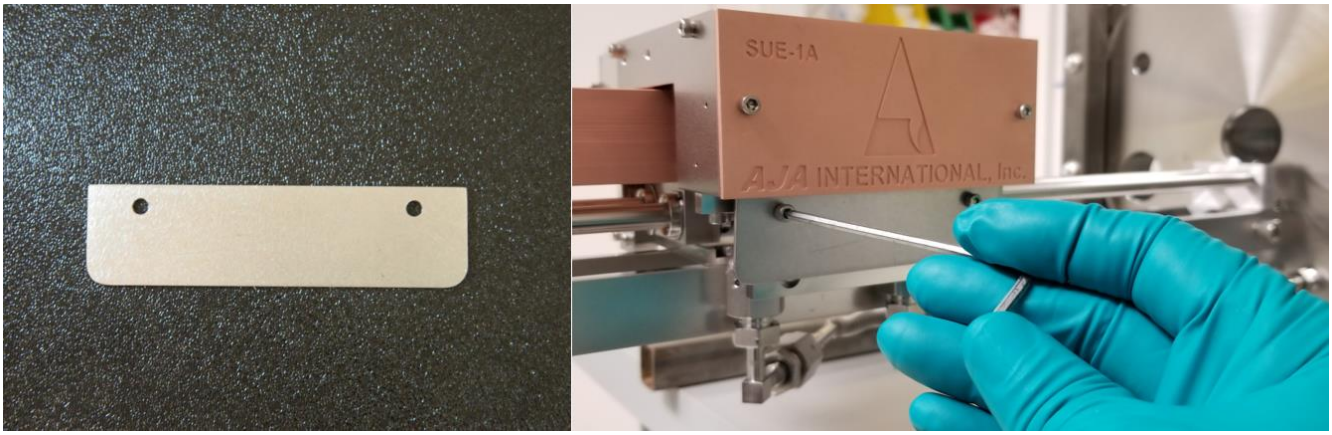


Figure 13: Shunt Bar and Shunt Bar installation, on the rear side of the AJA SUE 615.

4. Defining Pocket Boundaries

The next step is to define the pocket boundaries. These boundaries are actually current limits for the sweep coil electromagnets, that once set, will turn the beam off when a boundary is reached. The limits should be chosen so that the beam will not impact the bare pocket/crucible or liner wall directly, at any time during setup or processing. This step is also performed in the EBC Configuration mode.

NOTE: Pockets and crucible liners have tapered walls. It is important to understand how the material will react during processing, and as the material is evaporated, and set the pocket boundaries accordingly, to protect the source. The material reaction will also determine processing parameters, such as emission current ramp rate, and sweep frequency. Contact AJA for advice.

a. Return to the CONFIG\SWEEP screen from Figure 9, to disable limits.

b. Using the EBC remote, as shown in Figure 14 below, select the second menu by pressing the “Menu” button twice.

c. While observing the beam spot position, use the joystick to bring the beam to the safe, negative longitude limit, and press the “Set -Long” button. (For reference, this is the limit furthest from the filament).

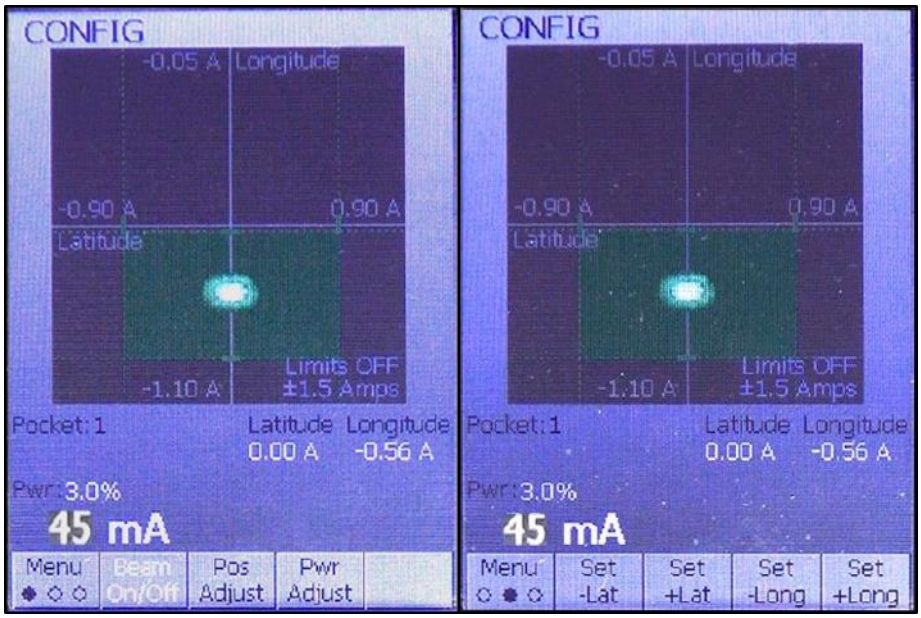
d. Repeat the above process for the remaining three limits.

e. The extent of the scannable pocket will be depicted in green.

f. Return to the CONFIG\SWEEP screen, to enable limits.

g. Test the newly set boundaries by using the joystick to move the beam beyond the limits. The beam should turn off, and the green extent, should turn red, as shown in Figure 15 below.

Figure 14:
EBC Remote Control screens for setting the Pocket Boundaries or Sweep Limits.



NOTE: Pocket boundaries should be changed if evaporants are to be used with a crucible liner, instead of directly placed into the pocket/crucible. These boundaries will be smaller, to keep the beam spot placed safely within the liner limits.

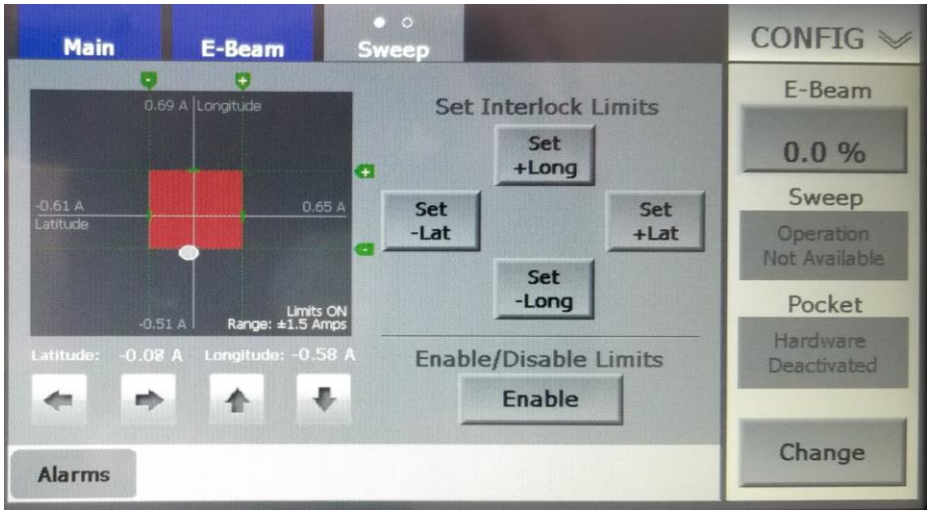


Figure 15: CONFIG\SWEEP screen showing the Sweep area and Alarm, when the Beam is moved outside the Sweep Boundaries.

C. MANUAL EVAPORATION

1. Setting a simple sweep function: circle

    a. Return to the manual mode on the EBC by selecting the upper right-hand corner CONFIG\CHANGE MODE\MANUAL. (Note that changing modes of operation will cause the HV and GUN to turn off.)

    b. Navigate to the MANUAL\E-Beam screen, to turn on the HV and GUN, and slowly raise the emission current until you can see the beam again.

    c. Select the sweep tab, as shown in Figure 16 below.

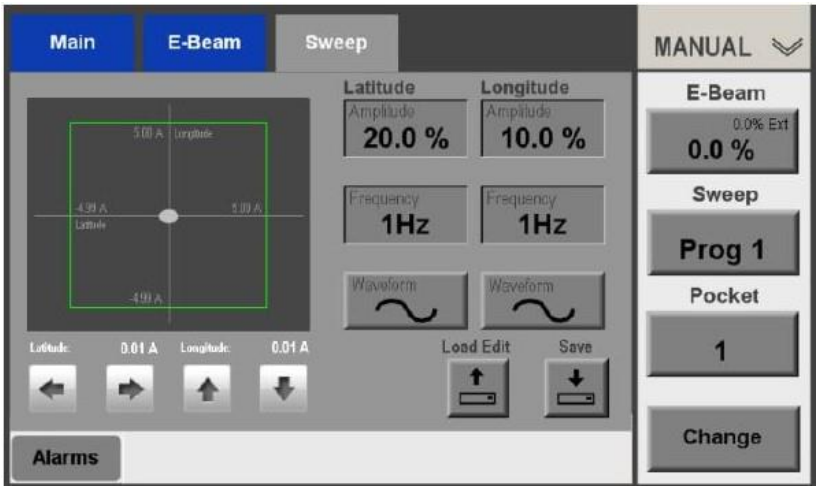


Figure 16: The MANUAL\Sweep Screen

    d. A circle sweep pattern is defined by equal amplitudes and frequencies of sine waves.
        i. Select each frequency, and set the same value.
        ii. Select each amplitude, and set the same value. (This is a percentage of the sweep limits defined above)
        iii. Set each waveform to sine wave.
        iv. Press the sweep button to start the pattern. (Press again to stop)

NOTE: There is a wide variety of sweep options available. For further information, consult the OEM manual.

    e. While observing the beam, adjust the amplitude, so that the circle fits inside of the pocket or liner smallest diameter (bottom). Increasing the amplitude will widen the circle, and decreasing will reduce it.

    f. While observing the beam, adjust the frequency. Higher frequencies will travel faster.

    g. When the adjustments are complete, “save” the sweep program, by pressing the SAVE button.

        i. Define the sweep program by entering a pocket # and program #
        ii. Provide information in the description section.

2. Prepare the system Deposition Controller

    a. Setup to measure the specific evaporant in use. These controllers typically require the density and z-factor for your evaporant material.

    b. See the controller manual for further details.

3. Establish Deposition Rate

    a. Select the MANUAL\ E-Beam Tab (Figure 17: below)

    b. Select the emission current, and increase slowly (allow periodic soaking) while monitoring the deposition rate (angstroms per second) reported from the deposition controller.

    c. Stop increasing emission current when a reasonable rate is measured for the evaporant.

Figure 17: EBC Manual E-Beam Screen

    d. Calculate how many seconds of exposure will produce the film thickness you want to deposit.

4. Deposit.

    a. On the AJA software Main Screen, open the substrate shutter.

    b. Start timing the deposition run.

    c. Close the substrate shutter when the time has elapsed.

5. Turn off the AJA SUE 615.

    a. Ramp down the emission current as necessary for your specific evaporant.
    b. On the EBC MANUAL/E-Beam screen, Turn off GUN, then HV.
    c. Exit to the MAIN MENU.
    d. Turn off the EBC, and CV-6SLX.

D. SHUTTING DOWN

1. Before venting the system, wait for 5 minutes to allow the filament to cool.

2. After venting the system, wait for at least 5 minutes to allow metal evaporants to cool, and Wait for 20 minutes or more when handling subliming materials, or insulators in crucible liners.

WARNING!!

HIGH VOLTAGE:
THE HIGH VOLTAGE USED BY THE EVAPORATION SOURCE CAN BE IMMEDIATELY FATAL. ADDITIONALLY, BECAUSE THE INTERNAL CAPACITANCE IN THE POWER SUPPLY, THIS VOLTAGE WILL PERSIST AFTER THE POWER SUPPLY HAS BEEN TURNED OFF. BEFORE ENTERING THE CHAMBER, FIRST MAKE SURE THAT THE POWER SUPPLY IS OFF, AND THEN USE A GROUNDING HOOK ON THE HIGH VOLTAGE LEADS FROM THE AJA SUE 615 TO DISCHARGE ANY PERSISTANT VOLTAGE TO GROUND.

STRONG MAGNETIC FIELDS – PACEMAKER & ELECTRONICS RISK!
ELECTRON BEAM EVAPORATION SOURCES ARE FITTED WITH STRONG PERMANENT MAGNETS WHICH MAY ADVERSELY AFFECT PACEMAKER OPERATION AND WHICH MAY ERASE OR CORRUPT THE MEMORY IN ELECTRONIC DEVICES RENDERING THEM NON-FUNCTIONAL.

VII. SWEEP COIL REPLACEMENT

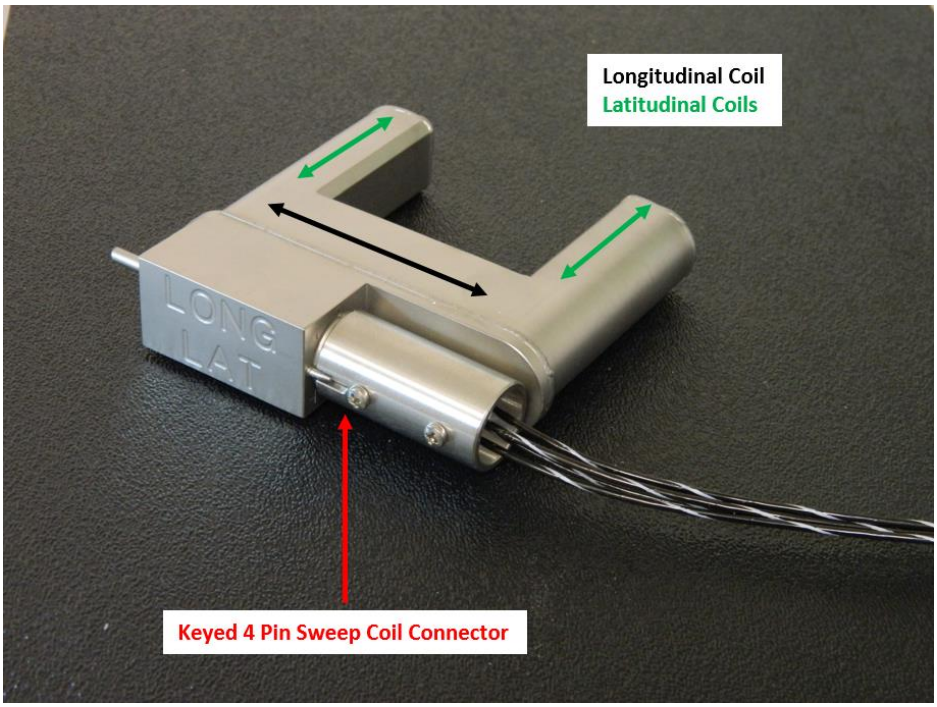


Figure 18: Sweep Coil Characteristics

WARNING!!

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A. PREPARE THE AJA SUE 615 FOR SERVICE.

1. Follow the steps provided in Section IV, to safely slide the AJA SUE 615 out of the main chamber for service.
2. The sweep coil is located above the emitter assembly, visible from the front face of the hearth.
3. You will require a 5/64” Allen (hex) wrench to perform this replacement.

B. PROCEDURE FOR REPLACING THE STEERING COIL.

1. As shown in Figure 18., the sweep coil is held in place by (2X) 6-32 x 3/8” BHCS. The one opposite the connector has a washer.

2. Disconnect the keyed 4 pin sweep coil connector, by sliding it toward the AJA SUE 615 flange. (Note: The sweep coil always orients its connector toward the flange)

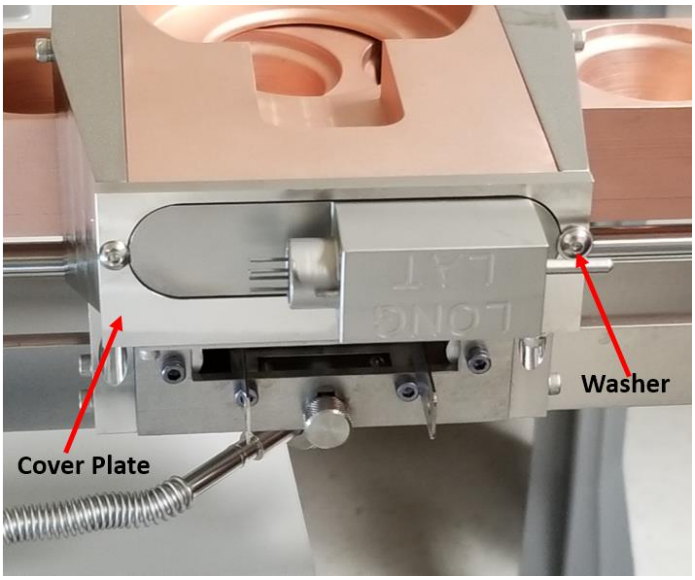

Figure 19: Initial Sweep Coil Configuration

3. While holding the coil cover plate, use the Allen wrench to remove the 2 BHCS, making note of which side the washer was on. Then remove the cover plate, leaving what is depicted in Figure 19.

NOTE: Attached to the bottom of the coil cover plate is an auxiliary plate, which supports the auxiliary magnets that are oriented as in Figure 20 below. These magnets are normally held in place by their own attraction. If they come out during this procedure, they will reorient N to S, and will need to be realigned before replacement.

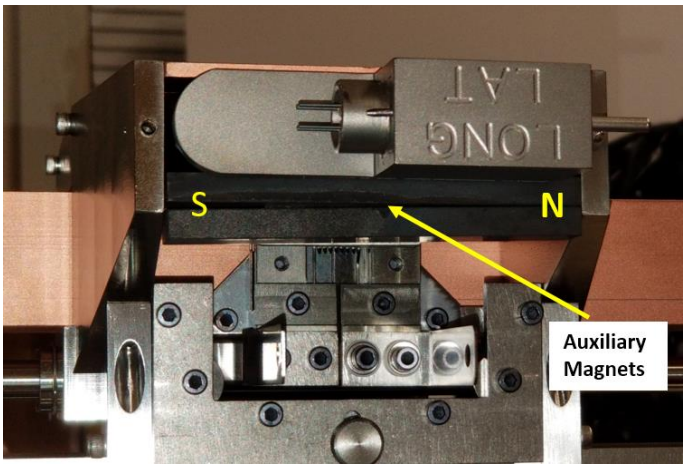

Figure 20: After Cover Plate Removal

4. Gently remove the sweep coil, by pulling it straight out toward you, as shown in Figure 21.

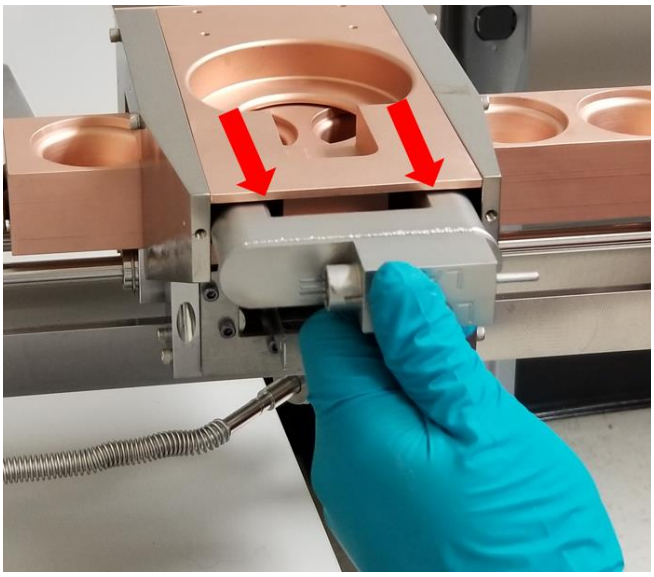

Figure 21: Final Removal of the Sweep Coil

5. Repeat these steps in reverse order to install the new sweep coil.

NOTE: All sweep coils may not provide exactly the same magnetic field for a given current (mA). It is recommended to redefine sweep boundaries when installing a new sweep coil.

VIII: EMITTER ASSEMBLY REPLACEMENT

WARNING!!

HIGH VOLTAGE: DO NOT WORK ALONE
THE HIGH VOLTAGE USED BY THE EVAPORATION SOURCE CAN BE IMMEDIATELY FATAL. ADDITIONALLY, BECAUSE THE INTERNAL CAPACITANCE IN THE POWER SUPPLY, THIS VOLTAGE WILL PERSIST AFTER THE POWER SUPPLY HAS BEEN TURNED OFF. BEFORE ENTERING THE CHAMBER: FIRST MAKE SURE THAT THE POWER SUPPLY IS TURNED OFF, WAIT AT LEAST 10 MINUTES (THE NATURAL DISCHARGE TIME OF THE POWER SUPPLY) THEN USE A GROUNDING HOOK ON THE HIGH VOLTAGE LEADS FROM THE AJA SUE 615 TO DISCHARGE ANY PERSISTANT VOLTAGE TO GROUND. (IF YOU DO NOT HAVE ACCESS TO A GROUNDING HOOK, CONTACT AJA SALES FOR A QUOTATION).

HIGH PERFORMANCE EMITTER ASSEMBLY COMPONENTS: (As seen in Figure 22 below.)

1. **Emitter Anode**
2. **Filament**
3. **Filament Clamps**
4. **Retaining Thumbscrew Slot**
5. **Filament Bus Bars**
6. **Filament Alignment Hole**
7. **Beam Formers**

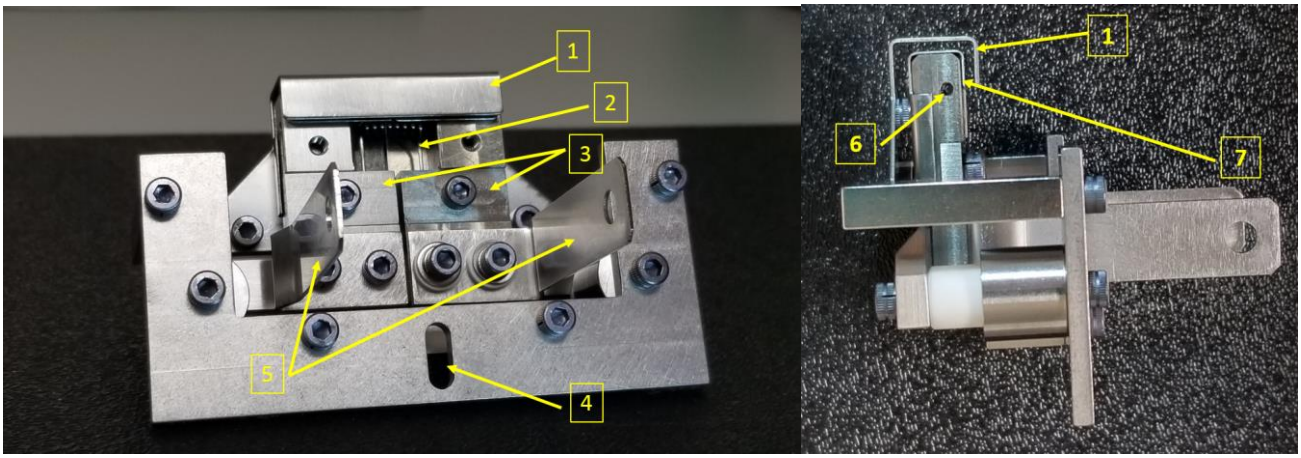

Figure 22: Front and Side Views of the Emitter Assembly

WARNING!!

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ELECTRON BEAM EVAPORATION SOURCES ARE FITTED WITH STRONG PERMANENT MAGNETS WHICH MAY ADVERSELY AFFECT PACEMAKER OPERATION AND WHICH MAY ERASE OR CORRUPT THE MEMORY IN ELECTRONIC DEVICES RENDERING THEM NON-FUNCTIONAL.

A. PREPARE THE AJA SUE 615 FOR SERVICE.

1. Follow the steps provided in Section IV, to safely slide the AJA SUE 615 out of the main chamber for service.
2. The emitter assembly is located below the sweep coil, visible from the front face of the hearth.
3. You will require: 5/32” and 1/8” Allen (hex) wrenches, and 1/2" and 5/16” open ended wrenches, to perform this replacement.

B. PROCEDURE FOR REPLACING THE EMITTER ASSEMBLY

1. As shown in Figure 23, the first step in removing the emitter assembly for replacement is to disconnect the High Voltage straps. Use a 5/32" Allen (hex) wrench and 5/16" open ended wrench to remove the 10-32 x 3/8 SHCS, 2 washers and 5/16" hex nut, connecting the HV straps to the filament bus bars. Perform this step for the most accessible strap first.

WARNING!!

CARE MUST BE TAKEN WHEN WORKING WITH HIGH VOLTAGE FEEDTHROUGHS, STRAPS AND BUS BARS.
THESE CONNECTIONS MUST CARRY HIGH VOLTAGES AND CURRENTS. THEY ARE RIGID, AND CAN APPLY TORQUE ON CERAMIC ISOLATORS IF MISHANDLED. DAMAGED OR BROKEN ISOLATION CAN MAKE LETHAL HIGH VOLTAGE ACCESSIBLE. USE 2 HANDED TECHNIQUES WHEN CONNECTING OR REMOVING THESE COMPONENTS TO MINIMIZE THIS RISK.

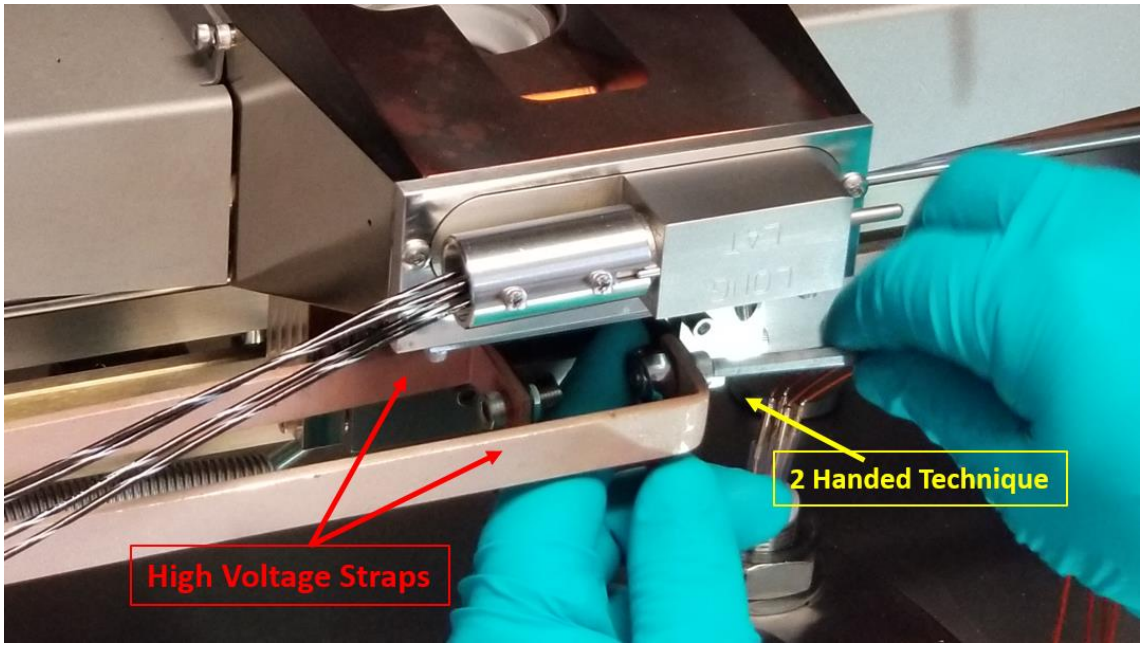

Figure 23: Step 1, High Voltage Strap Removal using 2 Handed Technique.

2. Before moving to disconnect the second HV strap, finish disconnecting the first strap, by using a 1/2" open ended wrench and 1/8" Allen (hex) wrench, to remove the strap from the HV feedthrough, as shown in Figure 24. below. Make use of a 2 handed technique again, to minimize damage to the HV feedthrough.

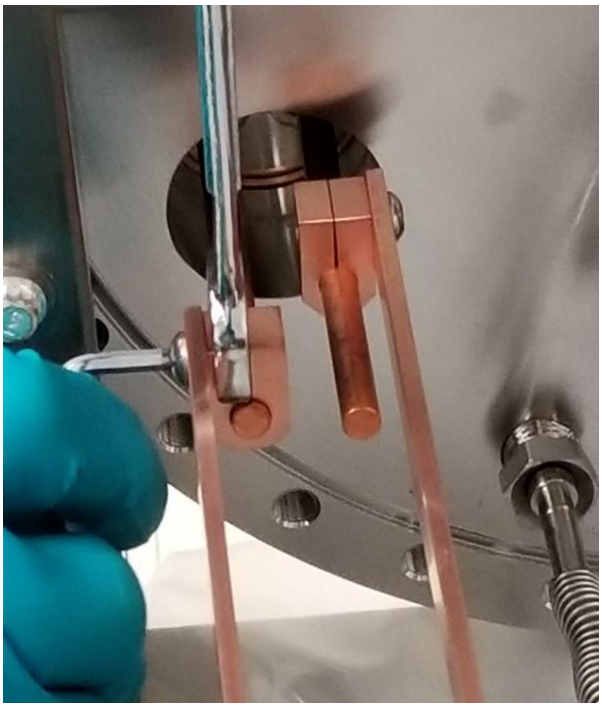

Figure 24: Step 2, 2 Handed Removal of HV Strap from HV Feedthrough.

3. Repeat steps 1 & 2 above for the second HV strap.
4. Release the knurled thumbscrew holding the emitter assembly in place. Then gently pull toward you, and downward, to remove the assembly from the hearth, as depicted in Figure 25.

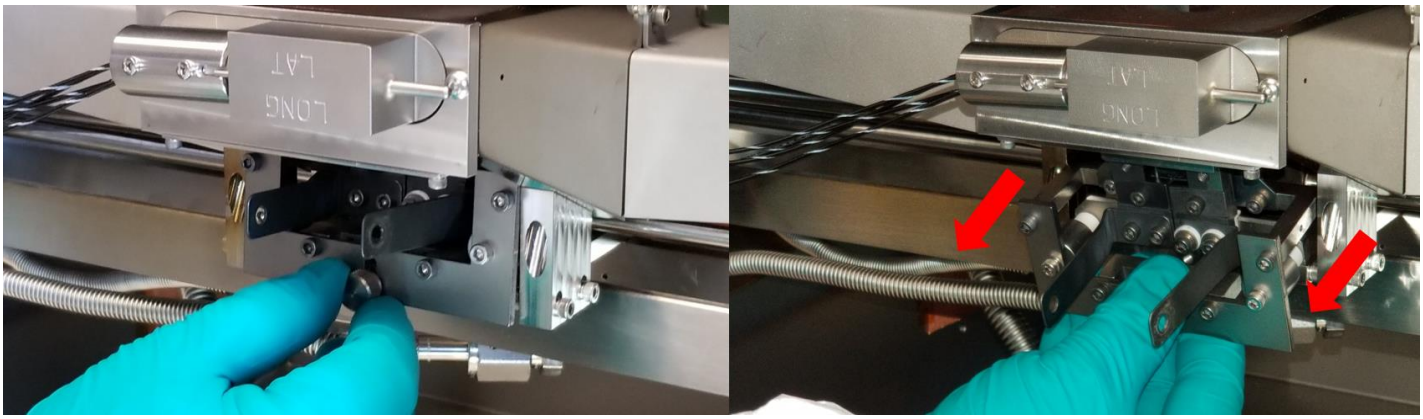

Figure 25: Step 3, Removal of Retaining Thumbscrew and Gently pull out and down.

5. To replace the emitter, follow the above steps in reverse order.

WARNING!!

CARE MUST BE TAKEN WHEN WORKING WITH HIGH VOLTAGE FEEDTHROUGHS:
THESE CONNECTIONS ARE EASILY BENT, EVEN WHEN CARE IS TAKEN WHEN MAKING CONNECTIONS. ALWAYS CHECK THAT THESE CONNECTIONS ARE PARALLEL, AND NOT BENT TOO CLOSE TO ANY OTHER COMPONENT, AFTER MAKING OR BREAKING CONNECTIONS.

IX: TROUBLESHOOTING

† AJA SUE 615 Service Policy is to send a replacement emitter assembly to resolve most emitter or filament issues, saving the researcher valuable time and effort, troubleshooting, cleaning, and performing the fine alignment required to successfully refurbish an emitter assembly. Contact AJA at either aaaservice@ajaint.com or call: +1-781-545-7365 for instructions.

WARNING!!

HIGH VOLTAGE:
THE HIGH VOLTAGE USED BY THE EVAPORATION SOURCE CAN BE **IMMEDIATELY FATAL**. ADDITIONALLY, BECAUSE THE INTERNAL CAPACITANCE IN THE POWER SUPPLY, THIS VOLTAGE **WILL PERSIST AFTER THE POWER SUPPLY HAS BEEN TURNED OFF**. BEFORE ENTERING THE CHAMBER, FIRST MAKE SURE THAT THE POWER SUPPLY IS OFF, AND THEN USE A GROUNDING HOOK ON THE HIGH VOLTAGE LEADS FROM THE AJA SUE 615 TO DISCHARGE ANY PERSISTANT VOLTAGE TO GROUND.

STRONG MAGNETIC FIELDS – PACEMAKER & ELECTRONICS RISK!:
ELECTRON BEAM EVAPORATION SOURCES ARE FITTED WITH STRONG PERMANENT MAGNETS WHICH MAY ADVERSELY AFFECT **PACEMAKER** OPERATION AND WHICH MAY ERASE OR CORRUPT THE MEMORY IN ELECTRONIC DEVICES RENDERING THEM NON-FUNCTIONAL.

A. Symptom: Emission current is at maximum value, and filament current is normal, but there is no high voltage.
- **a. Source:** High voltage is shorted to ground.
  - i. **Remedy:** Check if insulators are broken or if the emitter, filament leads, or HV feedthrough, are shorted. †

B. Symptom: High voltage is normal, but there is no emission current.
- **a. Source:** Filament is broken or loose.
  - **i. Remedy:** Use an ohm-meter to check continuity between the filament bus bars (see Figure 22). Make sure the filament is seated correctly, and that the filament clamp screws are tight. †
- **b. Source:** Oxide buildup on the filament clamps causing the resistance between the bus bars to be too high.
  - i. **Remedy:** With an ohm-meter**,** test the resistance between the bus bars. Resistance should be 0.3Ω or less, if the resistance is greater, the filament must be replaced. †
- **c. Source:** There is a loose connection in the circuit supplying filament current.
  - i. **Remedy:** Check the connections between the e-beam power supply and the emitter assembly. ‡

C. Symptom: Zero filament current.
- **a. Source:** The filament is damaged.
  - **i. Remedy:** Measure continuity between the filament clamps. Replace the emitter assembly if the filament is discontinuous. †
- **b. Source:** A heavy oxide buildup occurred on filament mounting surfaces.
  - **i. Remedy:** With an ohm-meter, check the resistance between the filament bus bars. If the resistance is greater than 0.3 Ω, the filament must be replaced. †

D. Symptom: High voltage and emission current values rise and fall independent of controls, with visible arcing near the high voltage insulators.

- **a. Source:** One or both of the high voltage feedthroughs is losing its' insulating properties, by being either coated or fractured.
  - **i. Remedy:** Inspect the insulators on the high voltage feedthrough. If these are coated, they may be cleaned by bead blasting. If they are fractured or damaged, replace them.
- **b. Source:** The in-chamber high voltage leads are making intermittent contact, due to coating.
  - **i. Remedy:** Dismount and clean the leads by bead blasting, then reinstall.

E. Symptom: High voltage and emission current are normal, with filament current high.

- **a. Source:** 2 or more of the filament loops may be shorted.
  - **i. Remedy:** Carefully inspect the filament, if loops are touching, the filament must be replaced**. †**

F. Symptom: Emission current is limited to less than its maximum.

- **a. Source:** Flanged insulators may be heavily coated.
  - **i. Remedy:** Examine the 2 flanged insulators on the emitter assembly. If coated, replace them. †
- **b. Source:** The filament may be badly warped, or have loops shorted.
  - **i. Remedy:** Carefully inspect the filament, if loops are touching, the filament must be replaced**. †**
- **c. Source:** Poor connections in the High Voltage circuit.
  - **i. Remedy:** Inspect all connections in the circuit back to the transformer for loose connections or oxidized surfaces. Tighten loose connections, and sand or file oxidized surfaces. ‡

G. Symptom: Large drop in deposition rate.

- **a. Source:** Weak permanent magnet making the beam unable to be centered longitudinally.
  - **i. Remedy:** Check beam spot position at low power, and no coil current. If the spot is too far toward the back of the source, replace the permanent magnet.
- **b. Source:** Cooling is inadequate.
  - i. **Remedy:** Check that the cooling water is at the right temperature and flow rate. ‡

H. Symptom: Filament has short life

- **a. Source:** The vacuum system may not pump properly below 5 x 10^{-5} torr.
  - **i. Remedy:** Perform a He leak check on the system. Perform vacuum maintenance. ‡

I. Symptom: The emission current and/or HV rise or fall rapidly.

- **a. Source:** A flanged insulator may be cracked.
  - **i. Remedy:** Inspect the flanged insulators with a magnifier, replace any that have cracked. **†**

J. Symptom: Deposition rate decreases along with broadening of the beam spot.

- **a. Source:** The filament may have become warped.
  - i. **Remedy**: Carefully inspect the filament. If warped, it must be replaced. **†**

K. Symptom: High voltage, emission and filament currents are normal, but larger than normal longitudinal current is needed to center the beam in the pocket.

- **a. Source:** The incorrect value for longitudinal current is set.
  - **i. Remedy:** Make a correction adjustment to the longitudinal deflection current. ‡
- **b. Source:** The permanent magnet has weakened.
  - **i. Remedy:** Check beam spot position at low power, and no coil current. If the spot is too far toward the back of the source, replace the permanent magnet.
- **c. Source:** The longitudinal coil is internally, partially shorted.
  - i. **Remedy:** Measure the internal resistance of the longitudinal coil. If the resistance is not between 8 and 10 Ω, replace the coil.

L. **Symptom:** High voltage, emission and filament currents are normal, but the beam is not centered laterally.
   a. **Source:** The lateral deflection coil may be energized.
      i. **Remedy:** Check the status of the lateral deflection current, set to zero. ‡
   b. **Source:** One or both of the lateral coils could be shorted together, internally or to ground.
      i. **Remedy:** With an ohm-meter, measure the resistance across the 2 lateral control pins, and each pin to ground. Both should be open to ground, and measure between 2-4 Ω across the pins. Replace the coil if the resistance is wrong.
   c. **Source:** The filament midpoint is not aligned exactly to the center between the pole pieces.
      i. **Remedy:** Inspect that the filament position is correct, and not sagging or warped. †
      .

M. **Symptom:** Adjustment of the beam positioning controls has no effect in either direction.
   a. **Source:** Deflection currents are not reaching the coils.
      i. **Remedy:** The coil leads or connector are disconnected or shorted internally**.** Make sure, the cables are not shorted, and connected correctly.
   b. **Source:** No voltage appears at the coil terminals, or incorrect internal coil resistance.
      i. **Remedy:** Check that a voltage appears across both sets of coil connector terminals. ‡ If voltage is present, measure the coil resistances, and replace if they fall out The ranges listed below.
      Longitude: 8-10 Ω, Latitude: 2-4 Ω

N. **Symptom:** Unable to sweep the beam over the entire surface of the pocket.
   a. **Source:** The permanent magnet's field is too strong for this setup.
      i. **Remedy:** Install shunt bars as necessary to decrease the field in the pocket.

O. **Symptom:** The beam spot cannot be moved toward the back or rear of the source in the longitudinal direction.
   a. **Source:** This can happen if you choose to not use the full 10 kV of available acceleration Voltage (HV). ‡
      i. **Remedy:** Install shunt bars as necessary to decrease the field in the pocket.

P. **Symptom:** The beam spot is located too far toward the back or rear of the source.
   a. **Source:** The permanent magnet has become weakened.
      i. **Remedy:** Evaluate the beam position with no coil current. If too far to the rear, replace the magnet.
   b. **Source:** This can happen if unneeded shunts have been installed.
      i. **Remedy:** Remove excess shunts.
   c. **Source:** The acceleration voltage (HV) has been set too high.
      i. **Remedy:** Decrease the HV. ‡

Q. **Symptom:** The beam spot is located too far forward, toward the emitter.
   a. **Source:** This can happen if the HV is set too low.
      i. **Remedy:** Increase the HV. ‡

R. **Symptom:** Sudden loss in field strength of the permanent magnet.
   a. **Source:** The source may have been heated to more than its maximum bake out temperature of 150˚ C.
      i. **Remedy:** Evaluate the beam position with no coil current. If too far to the rear, replace the magnet.

‡ For solutions to issues external to the source hardware, please refer to either the OEM EBC or power supply manuals, or the AJA System Manual.

X: LIST OF CONSUMABLE PARTS

The parts listed below, are considered consumables or replacements, for the AJA SUE 615 system.

AJA SUE 615-General

- Replacement Emitter Assembly
- Replacement Sweep Coil
- Crucible Shields
- AJA SUE 615 Shunt Bar
- AJA SUE 615 Permanent Magnet
- AJA SUE 615 Shutter
- Emitter Thumbscrew
- High Voltage Feedthrough
- High Voltage Strap
- High Voltage Strap Clamp (and screws)
- Crucible Plug
- Crucible Plug Washer
- Crucible Plug Nut
- Linear Crucible Bearings (4X)

AJA SUE 615 with In-situ Crucible Exchange

- Lifters
- Crucible Shields
- Exchange Pocket Shutter

Hardware and Gaskets:

- 12-inch Cu CF Gasket
- ISO 250 Flange O-ring (Viton)
- 2.75-inch Cu CF Gasket
- 1.33-inch Cu CF Gasket

Process Materials: (Contact AJA for list of offerings)

- Evaporation Materials
- 15 cc Crucible Liners