Tech Note 03-018:

Photo-Cathode Preparation in Load-Locked Gun

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April 2003

Introduction

Cathode preparation in the Load-Locked Gun in the Injector Test Stand at Jefferson Lab consists of several distinct phases. The wafer is first mounted on a puck, loaded into the system, hydrogen cleaned, heated, activated and moved to the high voltage chamber. This document will outline the procedures and provide a baseline for certain times and temperatures.

Mounting

The first step to prepare a cathode for use in the load locked gun is to prepare the GaAs wafer (properly diced to 15.5 mm x 15.5 mm, wet chemical processed, anodized, etc.). Once the GaAs wafer is prepared, it should be mounted on the puck. If the puck has a wafer on it, it must be removed by pulling the Tantalum cup off using the scribe/awl to push the edges up and the clean pliers to pull the cup completely off. If the cathode is attached using Indium, the puck must be heated to melt the indium. This is accomplished by putting clean Aluminum foil on the hot plate, putting the puck on the hot plate, and monitoring the temperature. The hot plate should be turned to a level of 3 and the temperature reading will be approximately 200ºC when the indium melts.

A square of Indium foil approximately 1 cm by 1 cm can be laid on the hot puck and the GaAs is gently set down, making sure to get the corners of the wafer into the recessed area of the puck.

The puck can be removed from the hot plate using the clean pliers and set on the heavy block of aluminum, which is covered with clean aluminum foil to cool.

Once cool, an Tantalum cup is put on the puck to hold the wafer in place. The cup should be set onto the puck and pressed gently on by hand. Care should be taken to ensure that the cup goes onto the puck evenly without any edges sticking up. The puck cup pressing tool should then be used to finish pressing the cup onto the puck.

Loading

1. Tape a glove bag to the loading flange and start a dry nitrogen purge.
2. Set up a table for tools.
3. Load the necessary materials into the glove bag.

- New gasket
- Puck with wafer (in clean wipes)
- Gasket puller
- Gasket pusher
- Wrench

4. Hook up a nitrogen line for the chamber vent port.
5. Close the valve to the prep chamber
6. Close the turbo pump valve and turn off the turbo pump.
7. Turn off the ion pump.
8. Vent the chamber to atmosphere with dry nitrogen.
9. Remove the flange and load/unload the puck.
    - Make sure that the puck is in the proper orientation, with the GaAs facing the hydrogen cleaner.
10. Replace the flange and seal the gasket.
11. Turn off the purge to the chamber.
12. Open the turbo pump vent (with the turbo off)
13. Turn on the turbo – the turbo's backing diaphragm pump will rough down the chamber.
14. Once the pressure on the convectron gauge reads zero, the ion pump can be started (do not leave the ion pump on at currents more than ~3 mA)

Heat cleaning

To heat the puck in order to liberate hydrogen and other contaminants, a heat cycle of ~520ºC as measured by the thermocouple (roughly equivalent to 675ºC on the stalk heaters) can be used.

1. Insert the ceramic heater into the back of the puck, pushing the puck the whole way onto the mount then withdrawing the heater to the marked spot on the micrometer.
2. Attach the current supply leads to the terminals on the heater flange (red to the isolated terminal and black to the copper terminal)
3. When the ion pump pressure is low (~10-15 uA), the heat cycle may be started.
4. Retract cooling fingers if necessary and insert thermocouple (make sure thermocouple reader is on 1º rather than 0.1º scale to read over 200ºC.

Desired process	Temperature	Typical Current	Time at Temperature
Heat before hydrogen	350-500ºC	13A to start, then drop to 5A	15 minutes
Hydrogen clean	200ºC	5-6A	15 minute clean
Heat after hydrogen	520ºC	12.1A – 13.3A	2 hour
Frost wafer (BAD)	540ºC	13.3A?	

5. To start heating for any process, the current is typically turned on to 13A. The ceramic will degas before the temperature goes up on the thermocouple, leading to an increase in ion pump pressure.

6. Ion pump pressure ideally should stay under 100uA. If the heating is to rapid, this threshold will be exceeded.
7. For more rapid cooling, the copper cooling finger can be inserted at temperatures as high as 400ºC. Higher temperatures are not recommended as the chamber is warm and it is undesirable to have the cathode as the coolest surface in the chamber.

Hydrogen cleaning

1. Adjust the temperature to be between 200-220ºC.
2. The turbo pump must be on and the turbo valve must be open (do not cycle this valve while the cathode is hot since a burst of gas will be liberated and can harm the cathode)
3. Pressure should be ~10-20 uA on the ion pump.
4. Make sure that there is adequate hydrogen pressure in the line (p>5 in Hg) by briefly opening the valve and regulator on the hydrogen bottle, then open the leak valve for hydrogen until the Convectron gauge reads a pressure of 35-40 mTorr. The ion pump will read about 2-5 mA at this pressure.
5. Attach the RF lead to the hydrogen cleaner and turn on the RF power. Resonance is at about 80-100 MHz and typical values for input and reflected power are 100+W incident power and 95W reflected power. The glow should be pink rather than blue. Turn up the flow of gas or adjust the frequency if the discharge is weak.
6. Typical hydrogen cleaning is for 15 minutes.
7. After hydrogen cleaning, turn off the RF and hydrogen flow, and let the vacuum recover for at least 15-20 minutes before starting a heat cycle to liberate the hydrogen (pressure should be <30 uA).
8. Let the puck cool to at least 40ºC before moving it to the prep chamber or opening/closing any valves.

Moving to Prep chamber

1. Retract the thermocouple (this interferes with the springs on the transverse manipulator).
2. Close the valve to the turbo pump.
3. Attach a mirror or camera to the load chamber window so that the puck can be seen during the grab, or have another person to help with the alignment of the manipulators.
4. Record the pressure in both the load and prep chambers, then open the valve between the two chambers and note the pressure again.
5. WARNING: PULLING ON THE MANIPULATORS CAN CAUSE VACUUM LEAKS – KEEP AN EYE ON THE PRESSURES AS YOU DO THE NEXT STEP.
6. Move the transverse manipulator in until it touches the puck. The alignment between the two manipulators can be quite bad so note the direction of misalignment and gently (do not jerk the manipulator) pull on the end of the

manipulator until the puck can be grabbed. Keeping this pull on the manipulator, start to withdraw the puck from the loading cradle, making sure that the puck is not twisting as it is withdrawn (if it does start to twist, put it back in the cradle – a combination of the cold finger and the heater can sometimes be used to straighten out the puck – be careful though as the heater's mechanical contact is quite fragile).

7. Once the puck is on the transverse manipulator, smoothly pull it into the prep chamber. The springs don't hold it adequately so do not make any sudden movements. Before closing the valve (which vibrates the chamber), keep the puck from rolling off the manipulator by putting it against the longitudinal manipulator.
8. Close the valve between the prep chamber and load chamber, again noting the pressures.
9. Insert the longitudinal manipulator into the back of the puck – do not engage the wings of the manipulator into the back of the puck or it will be impossible to leave the puck in the HV chamber.
10. Retract the puck to the stop at the back of the longitudinal manipulator for activation.

Activation

1. Bias the ring anode (using output labeled "postivive/anode" of the battery bias box) at a voltage of at least 150 V (first click is currently 284V).
2. Insert the Cesiator (using control box) and attach the current leads
3. Monitor the photocurrent on the picoammeter using either a chart recorder or striptool program.
4. Turn on light using either the white light source or the laser (laser may be more desirable due to large background current from photoemission from metal surfaces with the white light). Be sure to follow LSOP for aligning lasers since this laser is not enclosed.
5. Turn on the Cesium to a current ~5A and monitor the photocurrent.
6. After the first Cs peak, turn on the NF3 – it currently requires ~4 turns to get the NF3 to a pressure of 2 –3 uA on the prep chamber ion pump.
7. Repeat cycles until the photoresponse at the top of the cycles starts to roll over.
8. Remove the battery bias
9. Withdraw the cesiator
10. Shut the NF3 valve tightly

The photocurrent may drop rapidly after activation since the Cs may still be warm and is quite close to the cathode. Several cycles of NF3 applied typically regain much of the QE after the activation.

Moving to HV chamber

1. Make sure that the load/prep valve and the first beamline valve are closed.
2. Make sure that the QE scan battery bias is not being applied to the high voltage chamber.

3. Note the orientation of the slots for the wings in the puck. Orient these vertically so that it will be easy to find the slots when the puck needs to be withdrawn.
4. Open the valve between the prep and HV chambers.
5. Move the puck smoothly into the HV chamber. The entrance to the chamber through the valve is tight so be careful of scraping. (The manipulator should be lifted slightly to avoid scraping at the moment.)
6. Move the puck in until you hit the back of the sapphire rollers. Press gently in until you feel the puck seat in the chamber. (Scribe marks are on the manipulator for the fully inserted position with the wings engaged and with the wings not engaged.)
7. Withdraw the manipulator and close the valve.

Removing from HV chamber

1. To remove the puck from the high voltage chamber, make sure the QE scan battery bias is not applied to the HV chamber.
2. Make sure that the first beamline valve and the load/prep valve are closed.
3. Open the prep/HV chamber valve.
4. Insert the longitudinal manipulator, with the ears of the manipulator vertical.
5. When the puck is contacted, gently press to try to get the ears into the puck. It may take several tries to get the alignment correct. Make sure to pull back at least an inch between tries so that the puck is not twisted as you rotate the manipulator.
6. When the ears slip into the back of the puck, turn about ¼ turn to engage them in the groove.
7. Withdraw the puck from the HV chamber, making sure to lift slightly and gently on the back of the manipulator to clear the valve.
8. Close the prep/HV valve.

Moving to Load chamber

1. Either set up a mirror or camera to see in the load chamber, or preferably, have someone available to help with alignment in the load chamber.
2. Grab the puck with both the longitudinal and transverse manipulators.
3. Twist the longitudinal manipulator while looking in the window until the ears are lined up with the slots.
4. Withdraw the longitudinal manipulator. It may be best to leave the puck with the slots at 10 o'clock and 4 o'clock to try to prevent it from rolling off of the manipulator.
5. Hold the puck on the transverse manipulator by pressing it against the side of the longitudinal manipulator.
6. Note the pressure in the load and prep chambers.
7. Open the valve to the load chamber, again noting the pressure.
8. Gently move the puck into the load chamber.
9. When the puck touches, the manipulator typically needs to be pulled toward the back of the gun (away from HV chamber) to get the alignment correct. Pull gently

and avoid jerking the manipulator to avoid opening leaks. Keep an eye on the pressure in the prep chamber as well.

10. Insert the heater to hold the puck on the load chamber dock.
11. Remove the transverse manipulator, making sure the puck does not twist (pull back and up typically).
12. Close the valve between the prep and load chamber.