University of Minnesota Nano Fabrication Center
Standard Operating Procedure

Equipment Name: Mini-Brute Furnace

Badger Name: mini-brute
Model: mini
Location: Area 1
Revision Number: 5
Revisionist: Tony Whipple
Date: 9 April 2020

1 Description
The Mini-Brute system is a horizontal tube atmospheric furnace system for oxidation, annealing, and alloying and is manually controlled by the user. The maximum wafer size is four inches or 100mm the wafers are loaded by manual transport. This research type of furnace has a three zone single element with an atmospheric quartz tube. This tube allows most material that are NOT allowed in the other furnaces.

2 Safety
The safety item beyond the normal electrical hazards, are the high temperatures as the system can go to 1150 degrees C. The gases that are normally used are nitrogen, and oxygen. Contact a MNC person about any problems. This system is a research tool, which means you are responsible for controlling the system. Forming gas can be used within the limits stated in this document, during limited hours, check with staff. Please contact staff before you need the forming gas, this will give them notice and help their schedule.

3 Restrictions/Requirements
Must be a qualified user on the Mini-Brute system.

ALLOWED Materials: See the list of allowed materials in section 8.

General Restrictions: Do not understand something ? ASK MNC staff person first!

- DO NOT load glass slides or cover slips or any other low melting material into the system.
- If the wafers have been processed in the mini Brute, they can not be processed through any other Tylan or ANY wet bench in Bay1.
- Wafer cleanliness: All wafers that are to be processed in the system MUST be clean and free of anything that is not allowed or will cause damage to the tube or make the system unusable to others. All resist needs to be cleaned from the wafer. Washing it off with solvents might not good enough. The cleaner the wafer, the better the film or reaction will be.
- Avoid touching the wafers with your hands or the quartz boats that are to be loaded into the system.
- Avoid writing on the back of the wafers with any type of the Magic marker, or Sharpie, use a diamond scribe to label your wafers if you need to.

See section 8 for more detail info on material limits.

4 Required Facilities
The system needs electrical power, nitrogen gas, other gases as needed.

5 Definitions
BOAT or WAFER BOAT = This is the Quartz or SiC item that the wafers sit in while in the system.
TUBE = This is the actual location of where the wafers are to be when ran in the system.
PICKUP Tool = The item that is used to load and unload the boat from the cantilever on each tube.
Door = This is the end plate that closes the tube which is used to load and unload wafers into the tube.

6 Setup

Check Badger to make sure no one has reservations for this system. Have your wafers ready before starting

7 Operating Instructions

Starting

Make sure that the system is available for the time you will need. Check the reservation time on Badger. Enter your data in the log book this helps others know you are using the system and what material has been ran in it.

Preparing to run wafers:

The size of the boat that holds the wafers are 4 inch (100mm) size. Smaller size samples can be ran in the system, put your small samples on the back of a wafer that is placed horizontally and load it that way lying flat on to the boat. Consult MNC staff on how this can be done if you have questions.

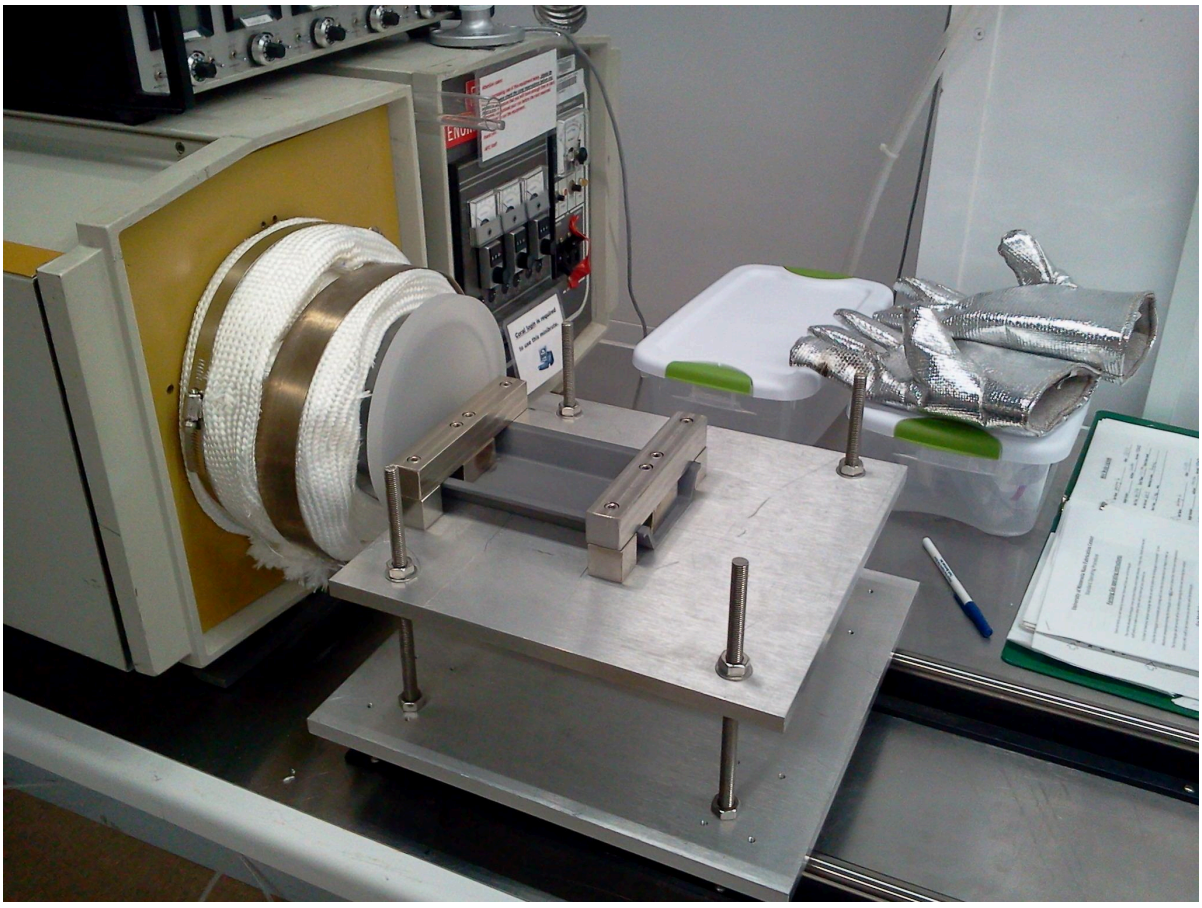

Fig. 1 This is the mini-brute system.

Check Status of tube:

Check the status of the tube by checking reservation time on Badger, and looking at the system to see if it is running. If you are planning to use the forming gas remember that there are limits of when this can be

used. The normal allowed forming gas times are from 9:00 until 4:30 but check with MNC staff before to make sure other factors will not interrupt your planned run.

Check to see that the cooling water is on, if not, contact MNC staff person and do not run until they solve this problem.

Fig. 2 Confirm the water is flowing before starting, the metal indicator should be in the middle of gauge.

Start the process:

You will need to select the gas flows, ramping up in temperature, time at temperature, and the ramping down rate which are normally programmed items in a computer controlled system.

Loading the sample :
Load your wafers into the system. This can be a hard thing to do depending on your sample.
If you do not need to have the system at the operating temperature, you can load you sample before turning on the heating element. Use caution during this step if the tube door and quartz ware are hot. Touching the hot quartz ware could result in injury. Handling hot quartz could also induce contamination if it is not handled safely. If you need to purge the chamber to remove the air to avoid air reacting with your, it is best to do this while the tube is still cold (room temperature).

Fig. 3 Opening the door with the door support tool, notice the heat gloves are being used.

Open the door fixture, and place the wafers and boat into the tube and push them into the tube by using a push rod. Make sure the wafer samples are in far enough from the door area. Place the push rod in the holder section to cool down, as it will be hot. Make sure you use the Mini-Brute heat gloves while doing this if the tube has been heated up. Make sure the door is placed against the tube end

Fig. 4 Loading the samples should be done with this quartz rod. Do not handle the hook end, keep it clean.

Controlling the Gas flow:

The three gas sources that can be used, they are: N2, O2, and Forming Gas – which is 5% H2 and 95 % N2. See the section on the limits of running with the forming gas.

The system has N2 as the normal gas that is connected, and if you need some other gas connected you will need MNC personal to do the change over for you. The gas flow can be adjusted with the flow meter. For the Oxygen gas the main cylinder is always on, so only the small knob to the side of the flow meter and the flow meter itself only needs to be turned on.

Depending on your process needs you may need to run the gas flow several minutes to make sure the tube is purged out enough before turning on any heat. This will help remove any room air from the tube before you have the tube gets heat added. You must have forming gas flowing 15 min before applying heat.

Applying heat:

Watch the system as it runs, this system can not be left for very long, without supervision since it is manually controlled equipment. Control power does system power, Element switch powers the elements.

Fig. 4 Main power Control & Element switches.

Fig. 5 Temperature readout display – black thin line

Turn on the Control Power switch up, then the Element switch up. Then set the center knob to the power value that you want. The left and the right control knobs should be set to 500 which means it will match the center knob value. You might want to wait for the temperature to reach a middle or halfway set point, before increasing to a final target temp. See the chart for an approximate value listing.

The numbers on center zone are the temperature and the 000 value is what starts at 400 C. But use the chart to get better temperature values to start with. Adjust as the process continues to run, make notes for yourself for future runs.

Fig. 6 Main temperature controls for the three adjustment knobs.

Remember that you need to select the ramping up in temperature, gas flows, time at temperature, and the ramping down rate, so plan ahead.

Start by recording the time at a set event, and this can be your time at temperature, anneal time, or called soak time. You can set a timer to track time, also write this in the log book for future records.

Once the required time is completed, then it can be cooled down. Adjust the setpoint temperature value on the center knob to a lower value. This can be to a slightly smaller knob value and as the tube display temperature goes down the knob value can also decree. This takes longer but the ramping down rate is slower which you might need.

Other processes might need the samples to cool at the fastest rate, turn the center knob to zero and turn off the Element switches down to off. While this is the fastest, it will still take a while to cool down.

Some users might set the values to a middle value and cool part way before turning everything off.

Letting it cool as much as you can before unloading is best, if your process can allow it. These choices are up to you, this makes the system great for doing research, the flexibility in how the process is ran, but you must control it and be safe.

Unloading the sample :
The unloading the sample can also be hard to do, as the door might still be hot. Unload the door first by sliding the door pickup tool into the top openings and lift the door away from the tube and place it on the cooling supports. Be careful as it is still hot. Use the heat gloves to protect your hands. Pull the sample or the wafer boat out, slowly using the push/pull rod. The next part is to transition the sample to the cooling support area. Return the push/pull rod back in its stored position. Put the door back on the tube

Shutting the system down :

The system can be shut down by making sure that if Oxygen or other gas was used that it is shut off, so as to not waste the gas. Or if forming gas was used that staff is contacted to have them disconnect it. Then enter into the log book all the final data that needs to be entered such as the ending time.

8 Problems/Troubleshooting

Mistake – glove or sleeve touch something and was burned or melted, now what?
Do NOT close the tube with the burnt part inside, leave the tube open and contact MNC staff. If the burnt part is the boat or baffle leave it out, and allow the tube to close.

Turn the switch to **RED** and also log the equipment down in Badger, so the stop light shows **RED**.

Allowed and prohibited processing and materials

Items NOT allowed in the Mini-Brute tube:
- If wafers are planned to be ran in the Tyaln tube they should not be ran in the Mini-Brute tube. Contact MNC staff to get a better understanding of this.
- If your wafer or other material on it might burn or be explosive or have a reaction it should not be ran.
- If the sample has a material that will melt and cause it to leave debris in the tube , do not run.
- The sample can cause bad byproducts such as gases; do not run in the tube.
- Low temperature melting glass as in glass slides or cover slips, DO NOT melt items in the system !

Forming Gas operating instructions:

There are limits you will need to remember these each time you run with Forming Gas.

The normal allowed forming gas times are from 9:00 until 4:30 Monday – Friday only.
Check with MNC staff before to make sure other factors will not interrupt your planned run.

It is best to load your sample and purge the tube out with N2 before the forming gas is connected.
~ 15 min
Once the forming gas is connected and running wait 5 min then the temperature can begin to heat up.

Maximum temperature during the forming gas run is **450 C** and not above that, watch your temperatures!

The forming gas can be turned off while the sample is cooling down or after it is cooled down.

Make sure the forming gas is off for 5 min before opening the door and removing your sample.

Contact MNC staff to let them know you are done with the forming gas.