QNFCF

Quantum Nano Fabrication
and Characterization Facility

Standard Operating Procedure (SOP): SÜSS Microtec SB6 GEN2 wafer bonder

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	Rev2: New logo and document style, added more pictures, added information about force unit conversion in Appendix

Summary:

This document summarizes the safe operating practices to be followed when working with the SÜSS SB6 GEN2 wafer bonding system.

Important:

This equipment is capable of applying a force up to 20 kN. Any particle may damage the bonding head, the closed fixture or the quartz plate. As it is a vacuum system, please adhere to best practices for cleanliness of vacuum systems. Do not handle substrates and the closed fixture with bare hands or gloves that have been significantly contaminated.

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1. EQUIPMENT DESCRIPTION

The SB6 wafer bonder is capable of fusion, anodic, thermocompression and eutectic bonding of 2 substrates in vacuum. The system has the following characteristics and options:

- Temperature up to 550°C
- 500 N to 20 kN force
- Turbopump for high vacuum operations (as low as 5e-5 mbar)
- Tooling plates, clamps and spacers for 75 mm (3") and 100 mm (4") wafers
- Closed fixture
- Quartz clamping plate for pieces of 10 mm x 10 mm to 75 mm in diameter.
- Anodic bonding up to 2000 V
- Pre-alignment of the 2 substrates with the SÜSS MA6/BA6 aligner in bond-align mode
- Substrate stack thickness of 4 mm and 6 mm maximum with and without the substrate clamps respectively

1.1. GENERAL LAYOUT & FEATURES

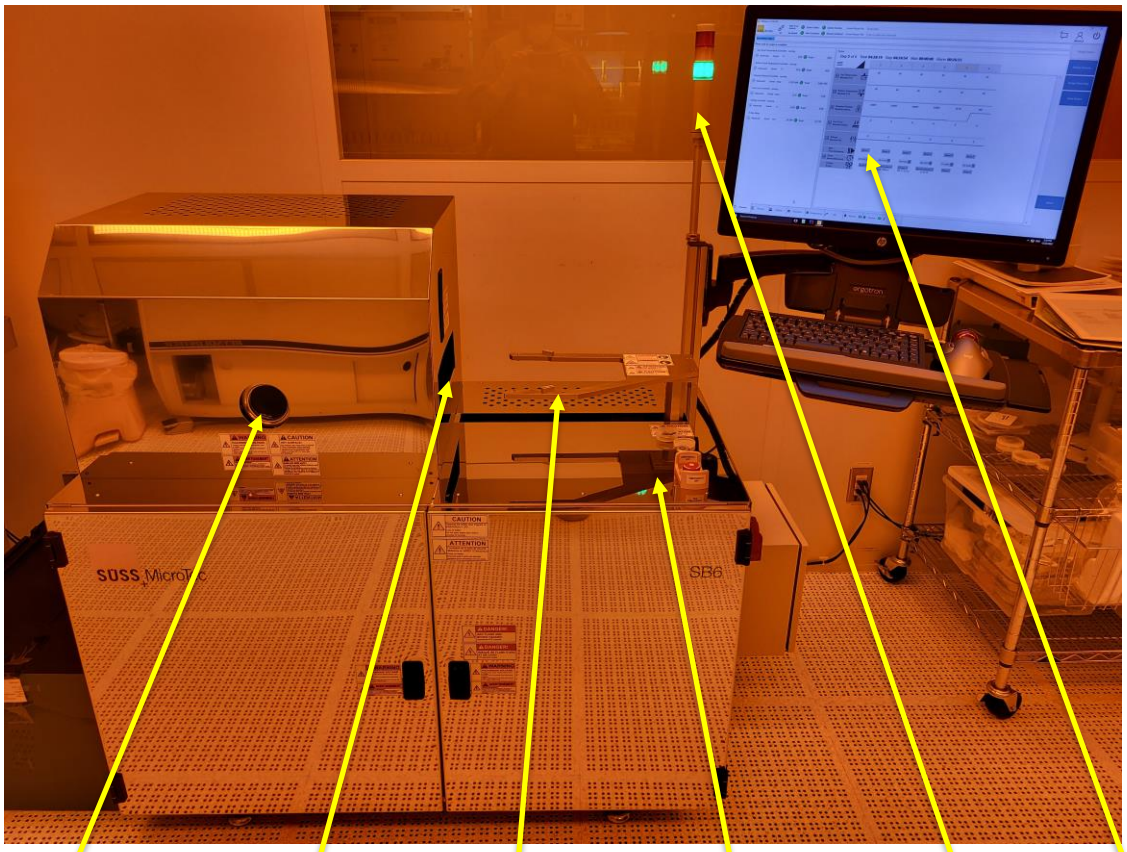
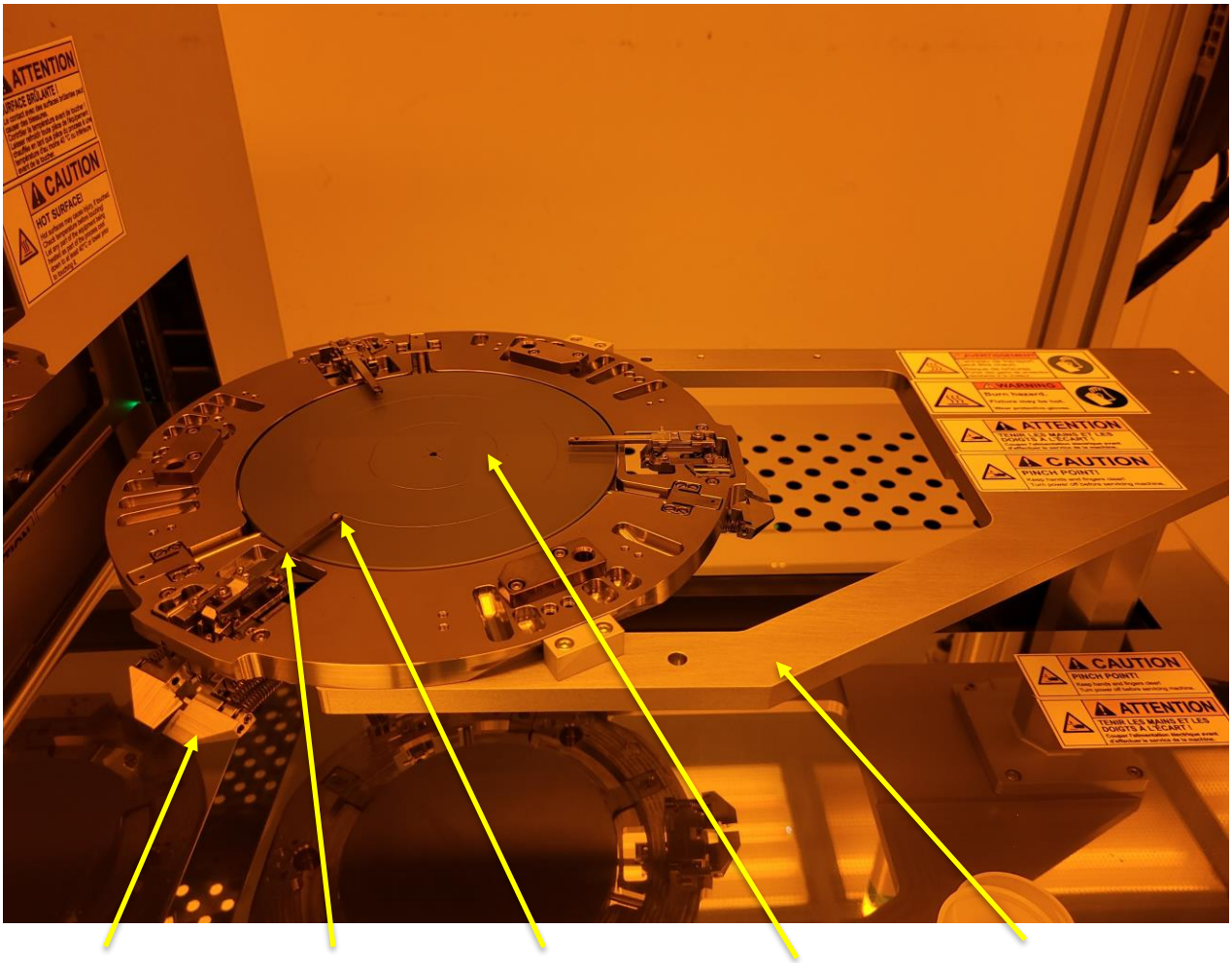


Figure 1: SÜSS SB6 GEN2 wafer bonder

Closed fixture and quartz clamping plate



Clamp actuators | Substrate clamp | Sapphire roller | Closed Fixture | Loading slide

Figure 2: Closed fixture placed on the loading slide

Error! Reference source not found.shows a picture of the closed fixture placed on the fork of loading slide. The loading slide is used to load and unload the process chamber with the fixture containing the substrate stack for bonding. The substrates are locked in the fixture with a set of 3 clamps with sapphire rollers on the end of each clamp. There are separate sets of clamps for 75 mm and 100 mm wafer substrates. Any substrates smaller than 75mm will also use the 75mm clamps with an adapter plate (figure 4). The fixture must be handled with care to prevent damage to the sapphire rollers and the graphite pad for anodic bonding on the backside (cf. Figure 3).

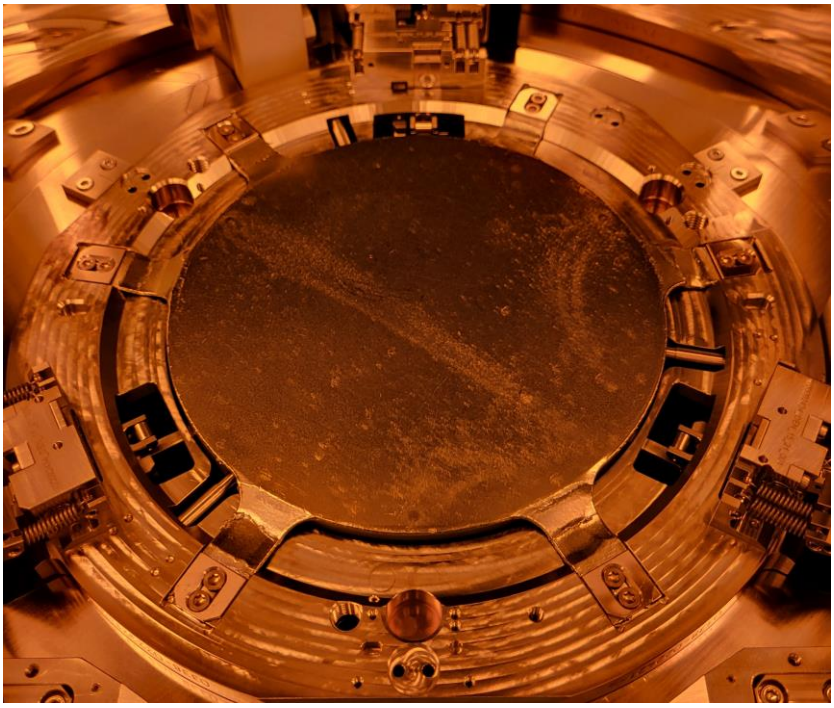


Figure 3: Backside of the fixture with graphite pad for anodic bonding

For pieces of 10 x10 mm up to 75 mm in diameter, a quartz clamping plate is needed to keep the stack in place. The quartz plate is 4 mm thick and needs to be accounted for your stack height.

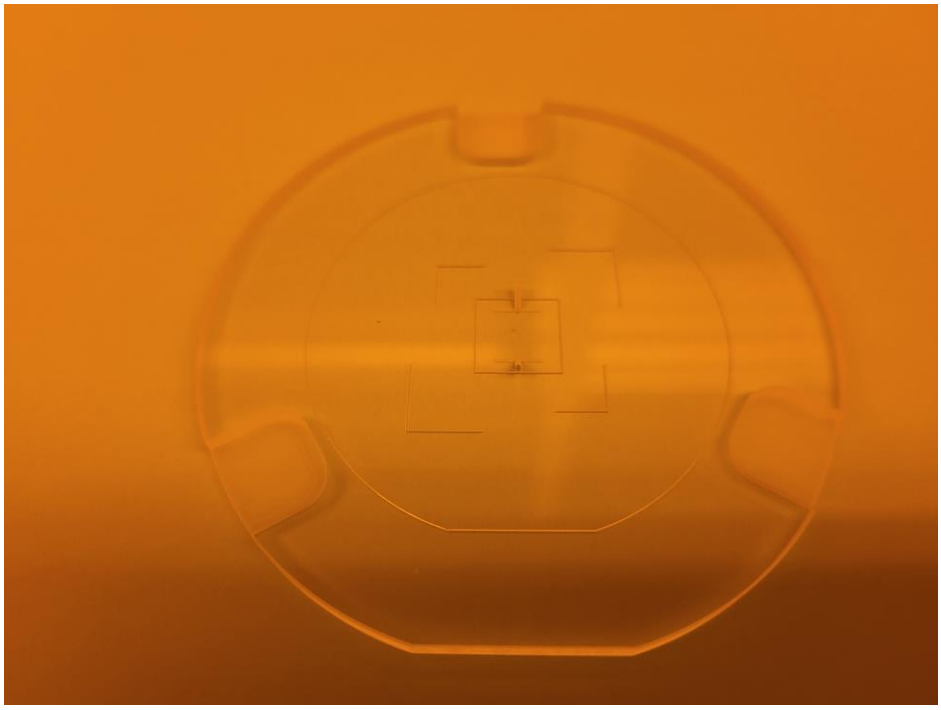


Figure 4: 75 mm quartz clamping plate for pieces

2. REFERENCE DOCUMENTS

- Safety data sheet (SDS) for chemicals to be used. SDS are located in the labeled binders by the cleanroom entrance. Electronic copies are also available in the QNFCF website (login required) https://qnfcf.uwaterloo.ca/data/safety-data-sheets
- Cleanroom Safety Protocols listed online (login to your account first): https://qnfcf.uwaterloo.ca/policies/safety-policies
- Emergency contact numbers listed online (login to your account first): https://qnfcf.uwaterloo.ca/data/general/safety-policies/emergency-phone-list
- Process recipes for the chemical solution needed. These PROC documents are available online in the "*Process Info*" folder under each piece of equipment in the *Equipment Info* section.

3. MINIMUM REQUIREMENTS BEFORE USE

Before using this equipment independently, you must have completed the "*Becoming a Lab Member*" requirements listed on the facility website, the major elements of which include:

- Completing and passing all required Safety & Cleanroom training
- Submitting a *Process Review Request* (one for each of your unique process flows)
- Submitting an *Equipment Authorization Request* (one for each equipment needed)
- Receiving one-on-one equipment training by an authorized staff member

Additional requirements specific to this equipment:

- Take the training on the SÜSS MA6/BA6 aligner if alignment is required.
- Reserve time on this equipment through the facility's Badger scheduler well in advance of your session. When you arrive to use the equipment you must remember to "enable" the tool prior to beginning work and "disable" the tool when you are done.
- Review and become familiar with the risks and the emergency response procedures listed in the *safety data sheets* (SDS) for the chemicals you plan to use.
- NOTE: Make sure there is another lab member with you in the cleanroom should you plan to also use any wetbench or fumehood. This person will be there to provide assistance or seek help in the event of an emergency.

4. HEALTH, SAFETY & ENVIRONMENT

Not applicable

4.1. MANDATORY PERSONAL PROTECTIVE EQUIPMENT (PPE)

No PPE for is required for this system, however a “double glove” policy is in effect for any items that enter the chamber. This means that a fresh and new set of gloves must be worn over your cleanroom gloves during “load in” and “load out” operations.

4.2. CHEMICAL WASTE

Not applicable

4.3. IN THE EVENT OF AN EVACUATION ORDER (FIRE ALARM, ETC.)

Leave the cleanroom immediately. Do not waste time removing your cleanroom gear.

5. MATERIALS & SUPPLIES NEEDED

You will likely need some combination of the following items when using this equipment:

- Wafer tweezers
- A pair of grey gloves

6. VERIFICATIONS BEFORE STARTING

- Verify the substrate thicknesses with a micrometer. A dedicated micrometer is available at the wafer bonder location.
- If alignment is required, check with staff that the bond-align adapter is installed on the SÜSS MA6/BA6 aligner.
- If spacers are needed for alignment of wafers, check with staff that they are installed on the closed fixture.
- Check with staff that the adequate bonding head and clamps (75 mm or 100 mm) are installed and the height of the clamps are set accordingly with your stack thickness.
- Green color lit on the signal tower light.
- The bonding chamber is under vacuum ≤ 5e-5 mbar
- Check that the fixture is inside the process chamber by turning the chamber light on and looking through the chamber viewport.

7. GENERAL OPERATING GUIDELINES

This section summarizes the following information about hardware and software features of the SÜSS wafer bonder.

Bonder control sofware

The software interface has the following subfields:

- Module information
- Login button
- Page window
- Main menu including **Process**, **Recipes**, and **Station** tabs

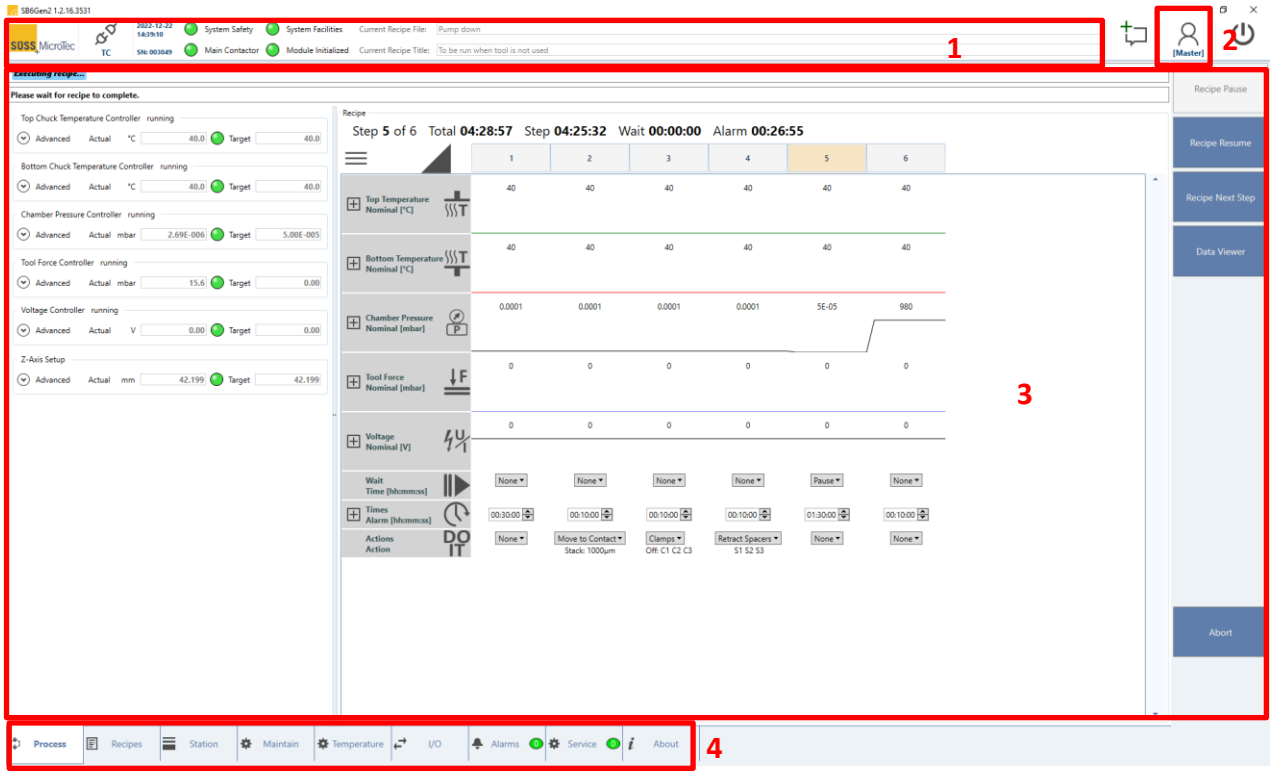


Figure 5: graphical user interface of the bonder control software. (1)Module area, (2)Login button, (3)Page window, (4) Main menu with pages.

The module area shows information about the current state of the system. Clicking the login button takes you to the login windows. Each qualified user will have their own account with operator authorization level, i.e **Process**, **Recipe**, **Station**, **Maintain** and **Alarms** pages are accessible and recipes can be run but no changes are possible.

In the **Process** page, one can:

- Initialize the module
- Search for a recipe
- Select the current recipe to be run
- Run, pause, resume and abort the running recipe
- Display the run data

In the **Recipes** page, one can:

- View the list of recipes
- View the recipe steps

In the **Station** page, one can:

- Initialize the module
- Load and unload the fixture manually
- Run and abort the current recipe

In the **Maintain** page, one can:

- Check the current status of the system
- Display the chamber pressure overview
- Turn on and off the chamber light
- Open the run data

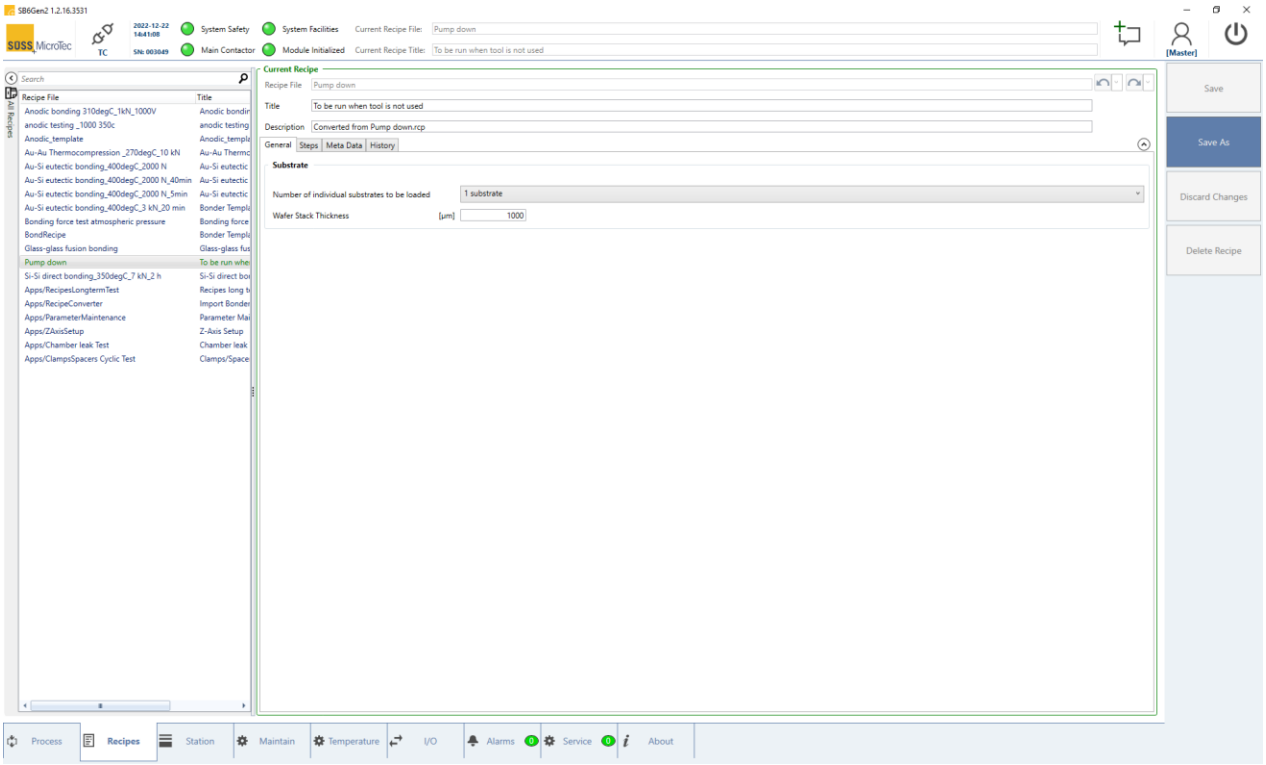


Figure 6: Recipes page.

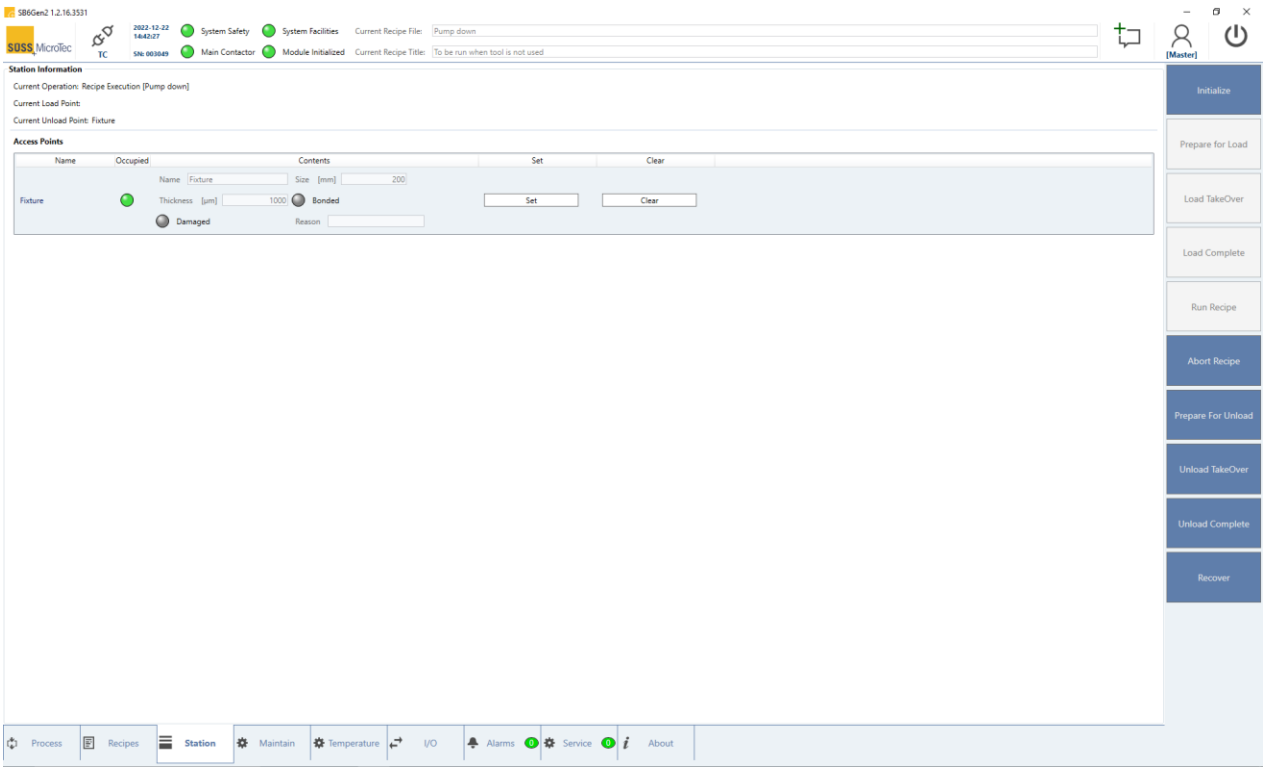


Figure 7: Station page during process run.

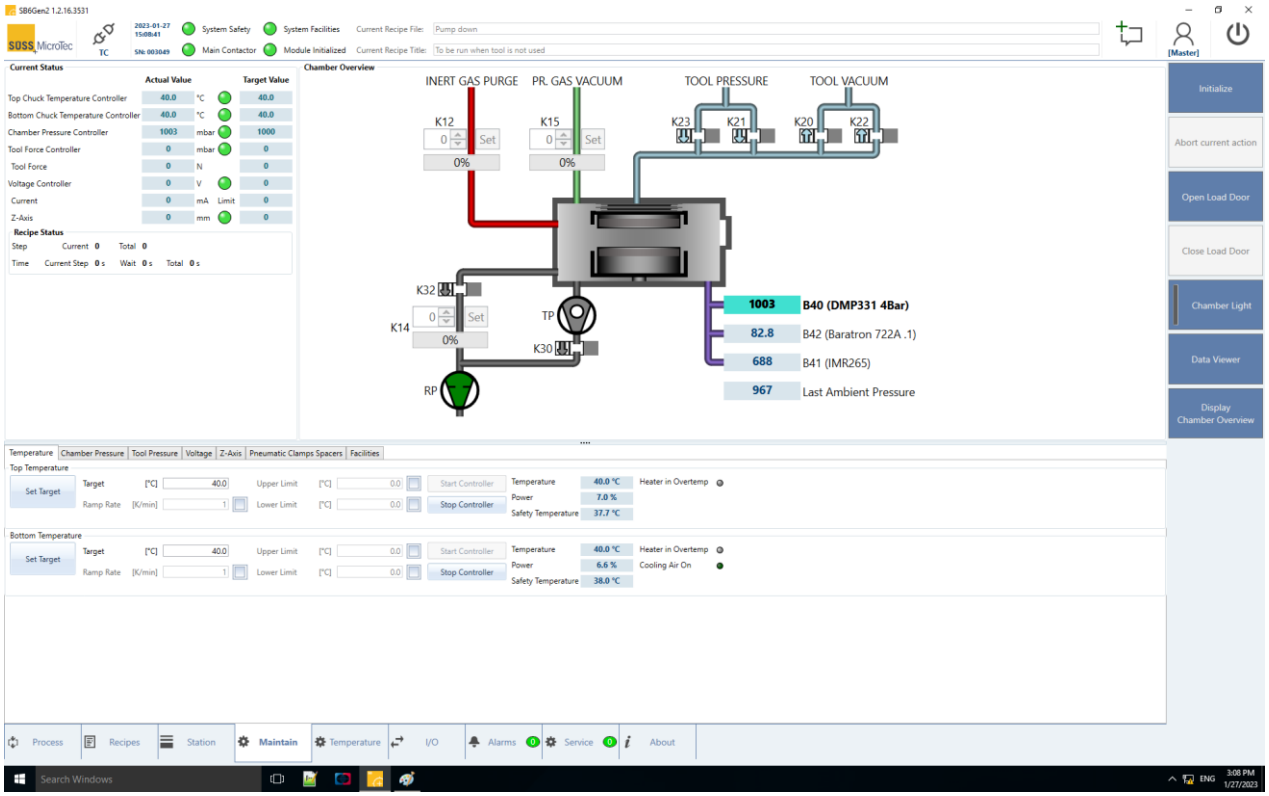


Figure 8: Maintain page.

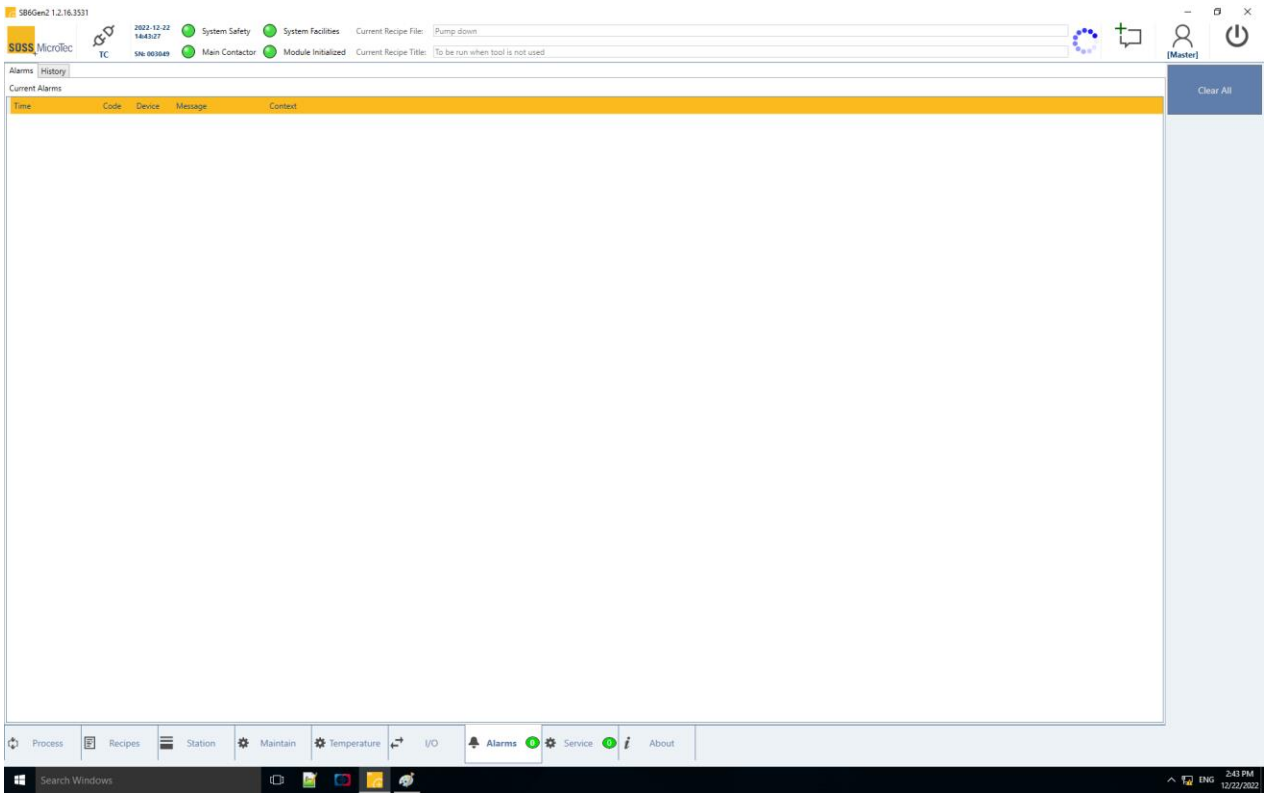


Figure 9: Alarms page.

Signal Tower Light

The tool is equipped with a signal tower light to indicate its operating states. It is located directly behind the monitor. The operating status of the tool is indicated by the three colors green, yellow and red. To inform the operator of an alarm, a horn is also attached to the alarm lamp.

- Continuous red light + alarm horn = alarm
- Yellow continuous light = tool in idle mode
- Yellow flashing light = process completed
- Green continuous light = machining process running

8. STANDARD OPERATING PROCEDURE

Typical operation of this equipment can routinely be divided into the following steps.

8.1. PREPARATION

8.1.1. CHAMBER VENTING AND FIXTURE UNLOADING

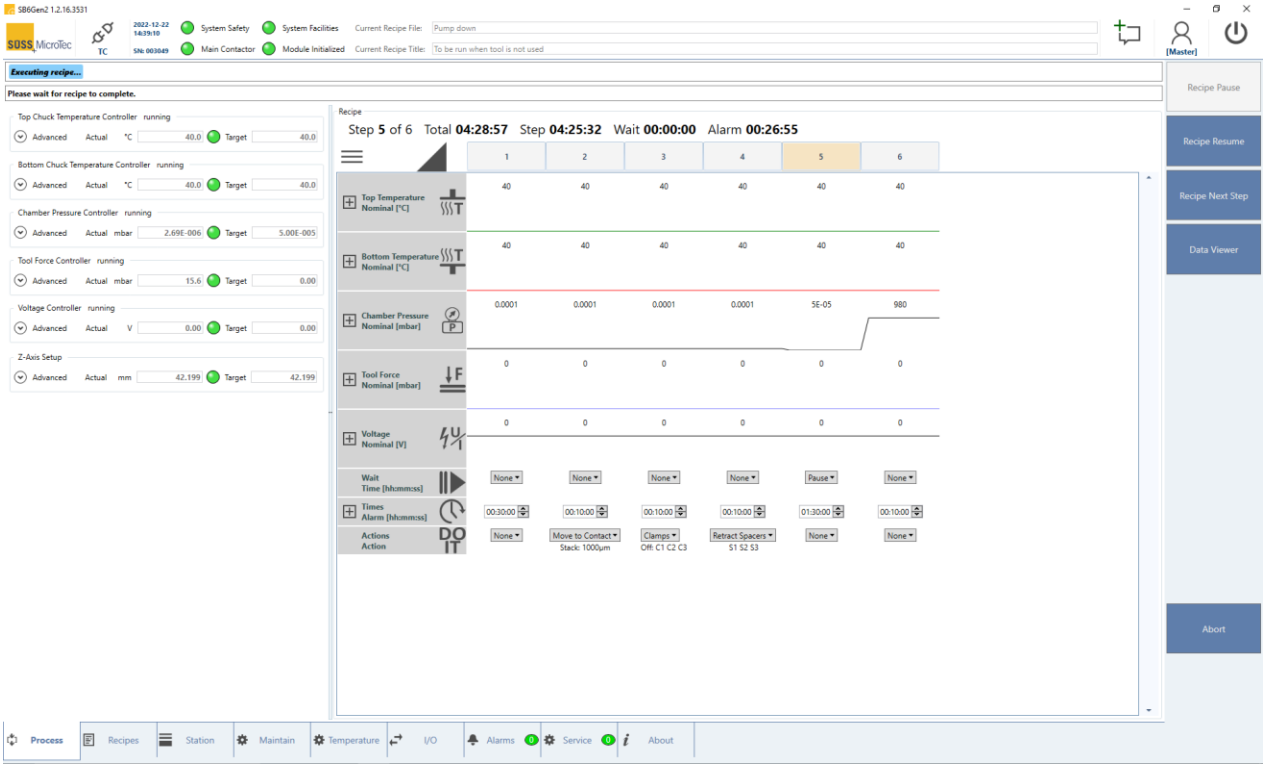


Figure 10: Process page with "pump down" recipe running.

1. Click the **Login** icon, select your account and enter your password.
2. In the **Process** page, click **Recipe Next Step** button to vent the chamber and wait until the **Station** page is displayed.
3. Click **Prepare for unload** button. The chamber door will open shortly.
4. Push the loading slide into the chamber up to its limit stop. Hold the slide until it is locked by the pneumatic cylinder. An audible click can be heard from the cylinder actuating when slide is in place.
5. Press the **Unload takeover** button. Wait until the slide is released.
6. Pull the loading slide out of the chamber fully to its home position
7. Click Unload complete button.
8. Inspect the fixture, the clamps and the spacers. Any damage must be reported in Badger or to staff immediately.

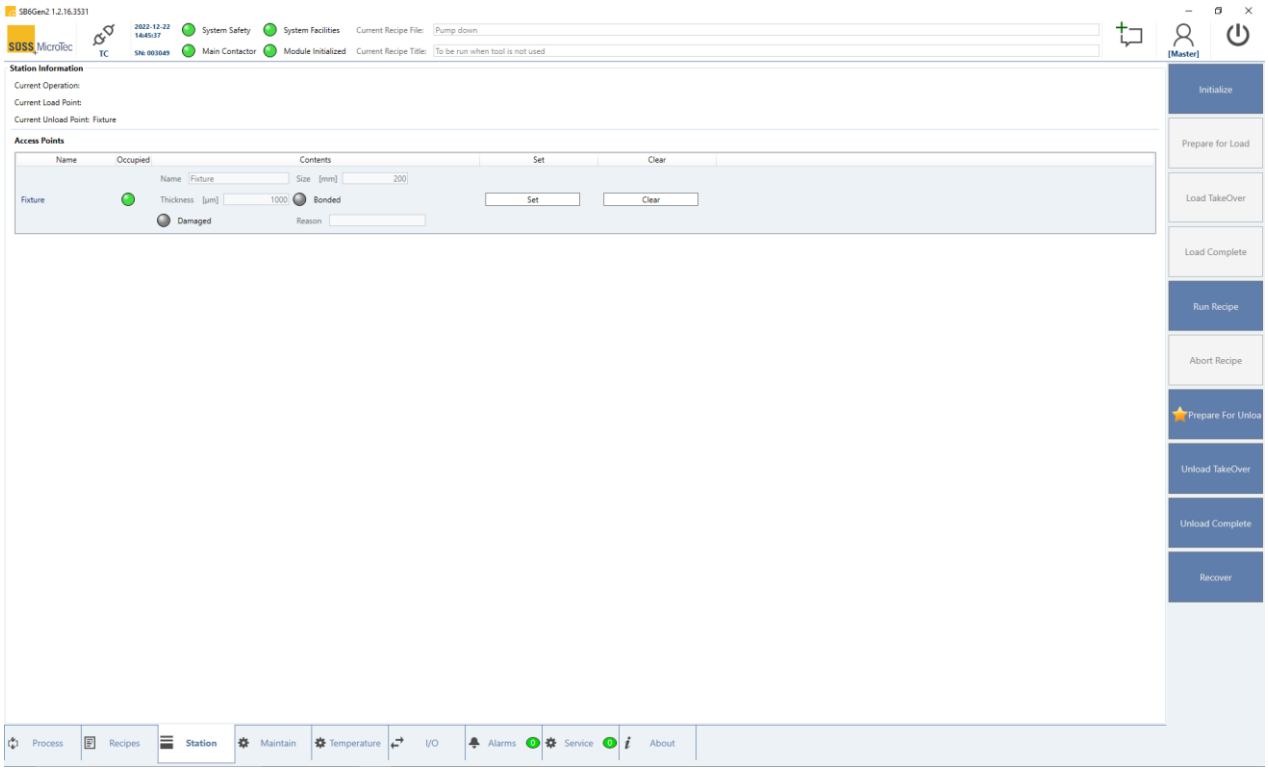


Figure 11: Station page with buttons for unloading the fixture on the right.

8.1.2. LOADING OF THE SUBSTRATES ON FIXTURE

The 2 substrates can be loaded with 2 methods.

Method 1

Alignment of the 2 substrates is needed. The MA6/BA6 aligner will automatically place the spacers between the wafers and clamps the wafers after alignment. Please refer to the SOP for the Süss BA6 aligner.

Method 2

No alignment is needed or coarse alignment can be done by hand. The 2 wafers are loaded manually on the fixture. There is no need to remove the fixture from the loading slide. Note: for anodic bonding, the glass wafer must be placed on top of the silicon wafer.

1. Put on a second pair of gloves.
2. Place the first wafer with the side to be bonded facing up
3. Optional: insert the 3 spacers by lifting the corresponding levers
   Warning: make sure that the spacers do not bend when inserted.

4. Place the second wafer with the side to be bonded facing down (Figure 12)
5. Push the 3 clamps onto the wafers by lifting the corresponding levers slowly and carefully (Figure 13).
   Warning: lifting the levers too fast may damage the sapphire rollers.

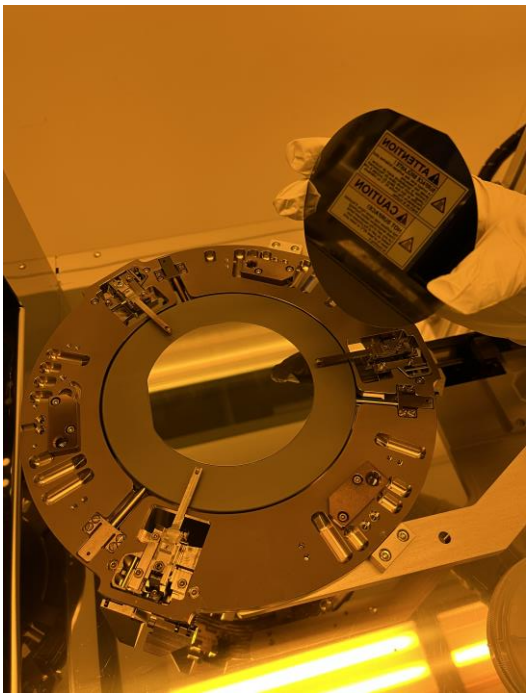


Figure 12: The lower wafer placed on fixture, bonding side face up and top wafer being placed onto the lower wafer by hand with the bonding surface being placed face down.

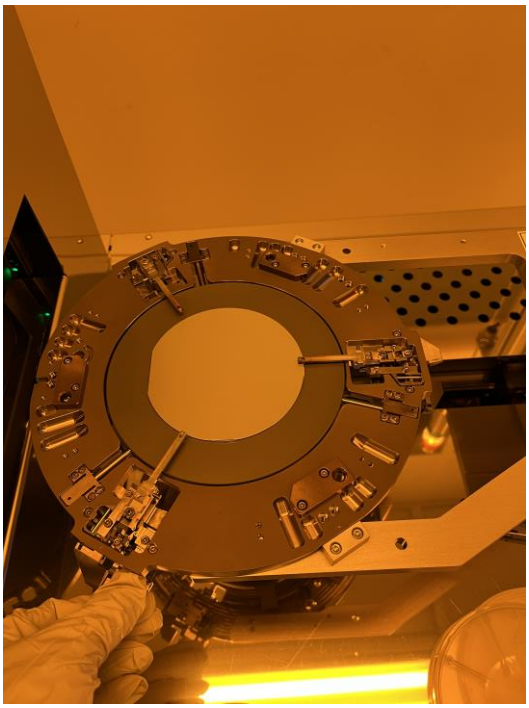


Figure 13: Wafers stacked together and the clamps are being manually actuated one at a time to hold the stack together.

8.1.3. LOADING OF FIXTURE WITH SUBSTRATE STACK

1. If the fixture was removed for alignment in the SUSS aligner, place it back carefully on the loading slide. The bottom of the fixture must be aligned with the 2 pins on the loading fork. The two flats with no notch must be against the alignment blocks. The fixture notch must face the chamber door.

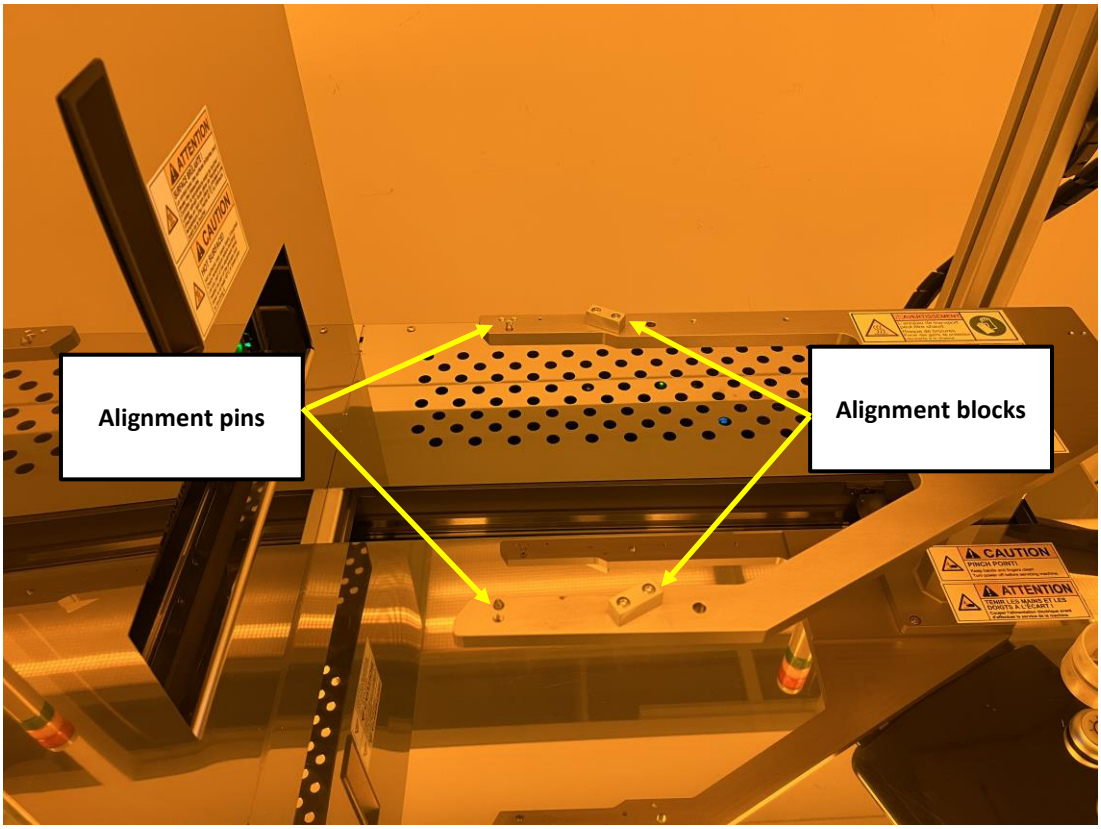


Figure 14: Loading slide without fixture.

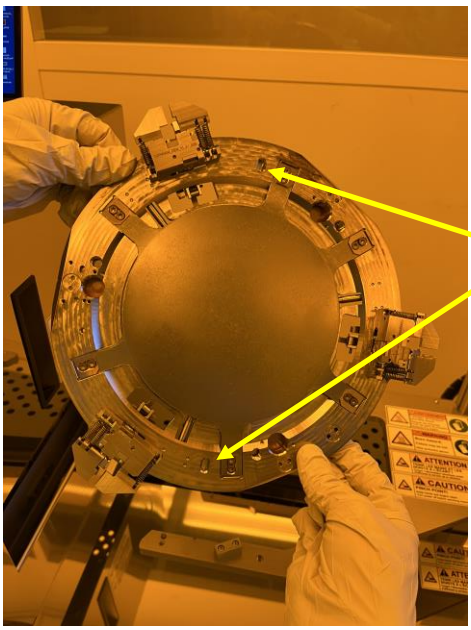


Figure 15: Holes for alignment pin found on the underside of fixture.

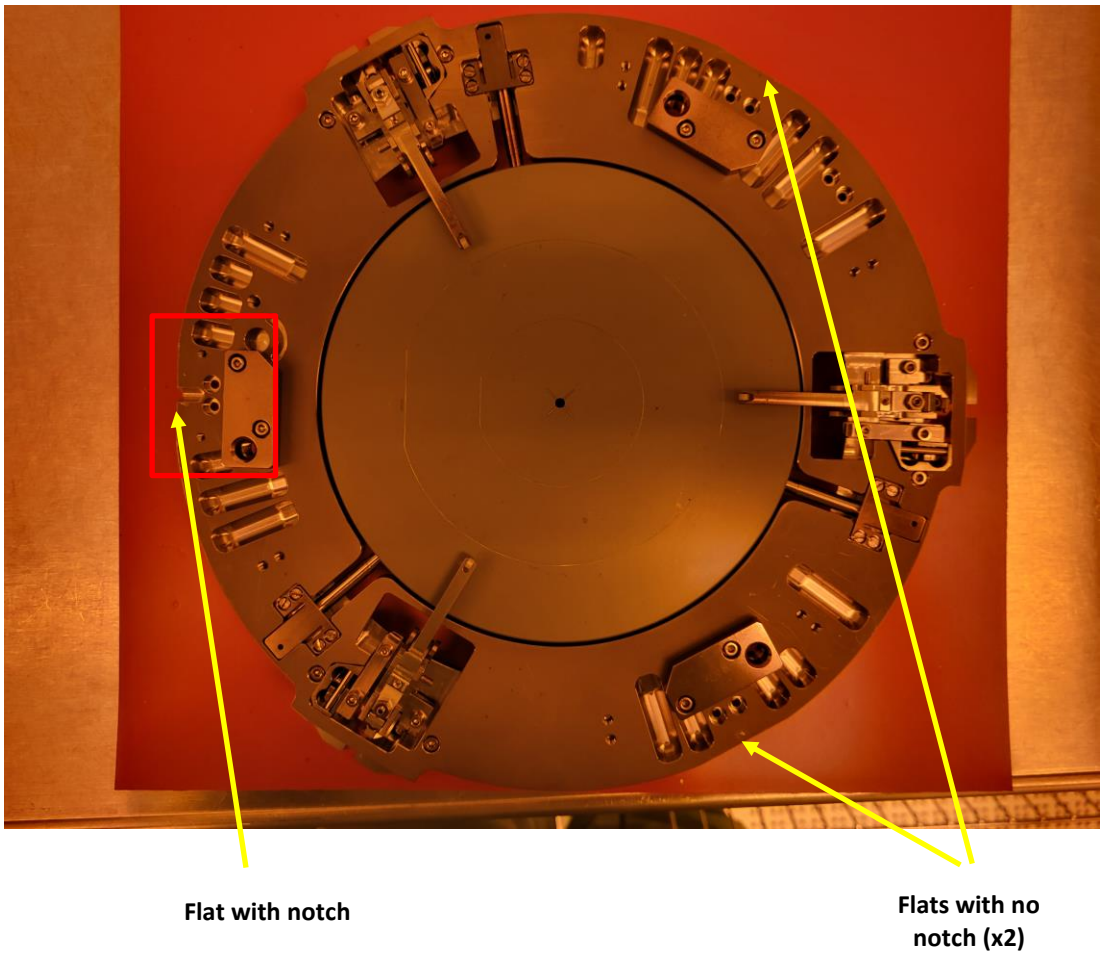


Figure 16: Flat and notch locations on fixture

Warning: Do not touch the actuator levers or the graphite pad (anodic bonding) on the backside of the fixture when you handle the fixture. A fixture not properly placed on the loading slide will damage the tool.

2. In the Station page: Click **Prepare for load** button. The chamber door will open shortly.
3. Push the loading slide into the chamber up to its limit stop. Hold the slide until it is locked by the pneumatic cylinder.
4. Press the **Load takeover** button. Wait until the slide is released.
5. Bring the loading slide to its home position outside of the chamber.
6. Click **Load complete** button.

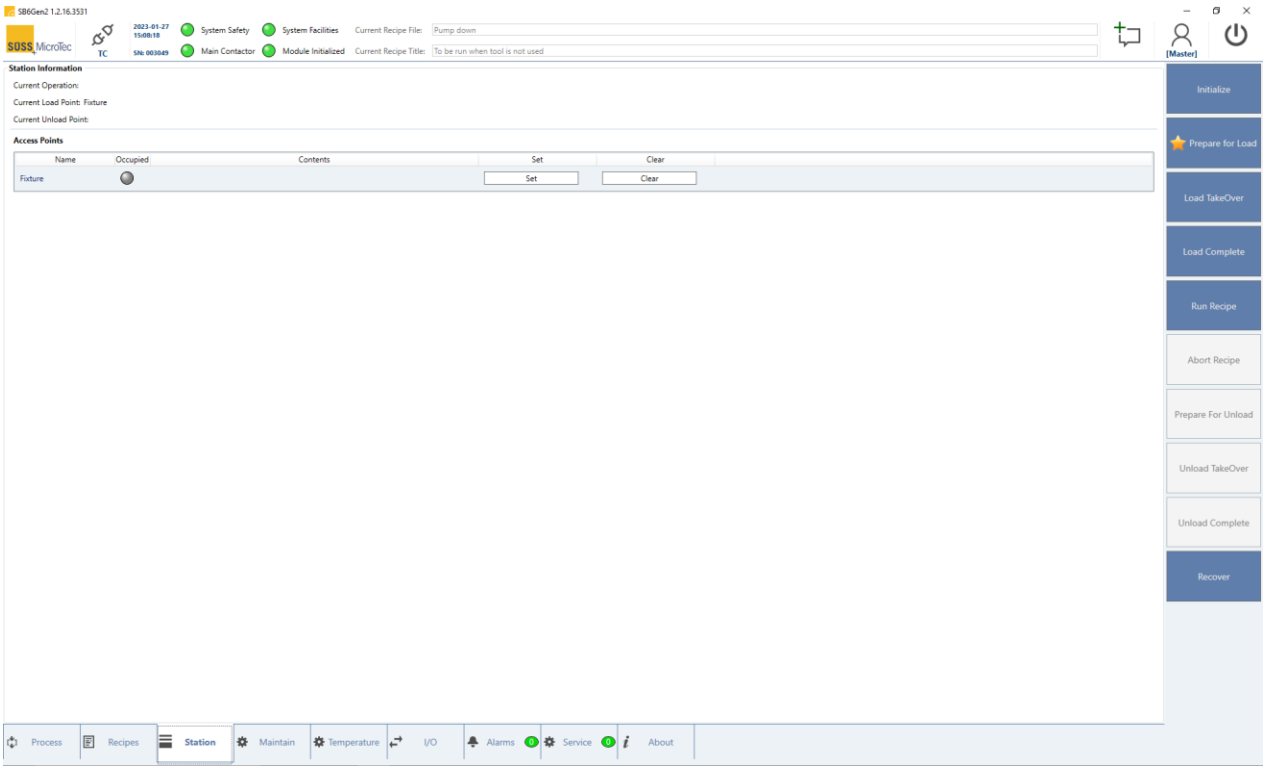


Figure 17: Station page with buttons on the right for loading the fixture

8.2.RECIPE SELECTION AND RUNNING

1. Check the stack thickness in the recipe:
   - In the **Recipe** page, select the recipe to be run and make sure that the substrate stack thickness is correct.

     Warning: improper stack thickness may damage the fixture, the bonding head and your sample. The thickness of the quartz clamping plate (4 mm) must be taken into account when pieces will be bonded.
2. Load and run the recipe:
   - Go to the **Process** page
   - Select the recipe to be run and click **Set as current recipe**
   - Click **Start.** The color for the tool status will change to green.
   - During the run, process data including chamber pressure, top and bottom temperatures, can be plotted by clicking **Data Viewer.**

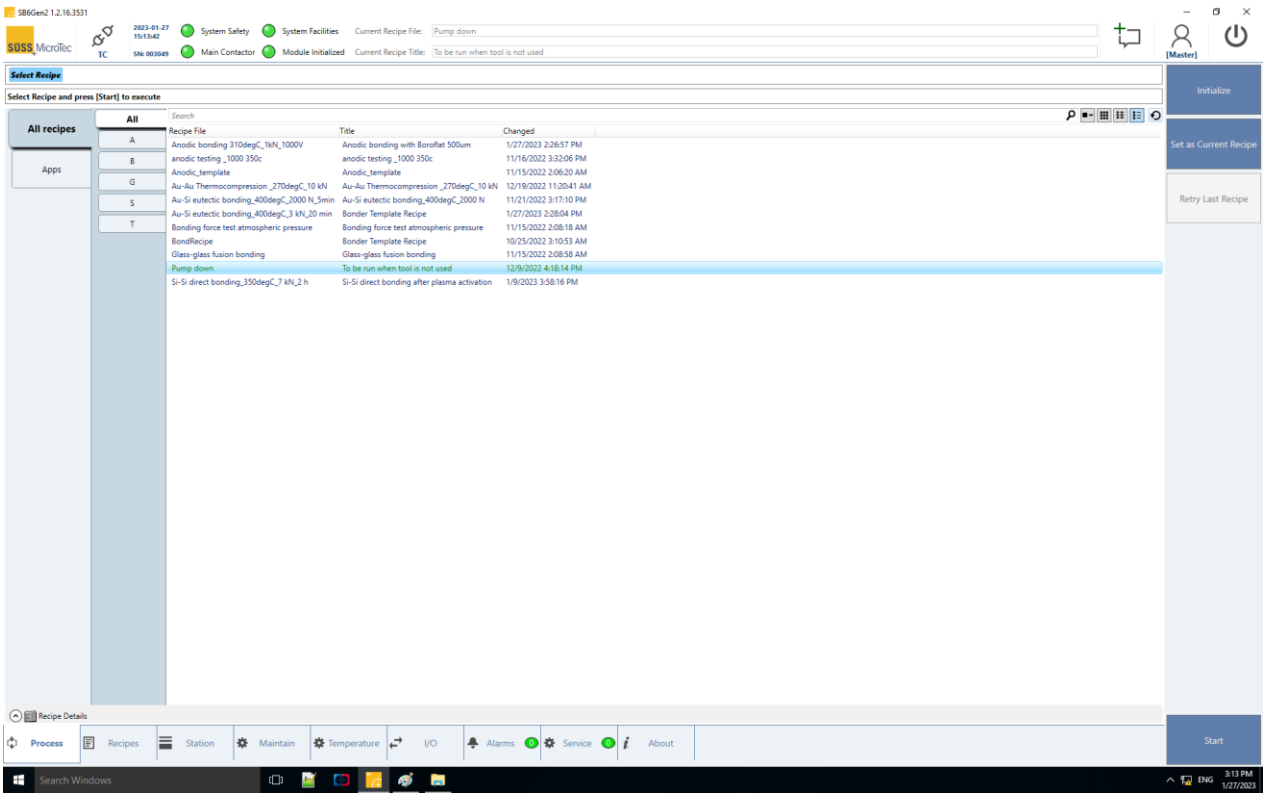


Figure 18: Process page with the list of recipes and Set as current and Start buttons

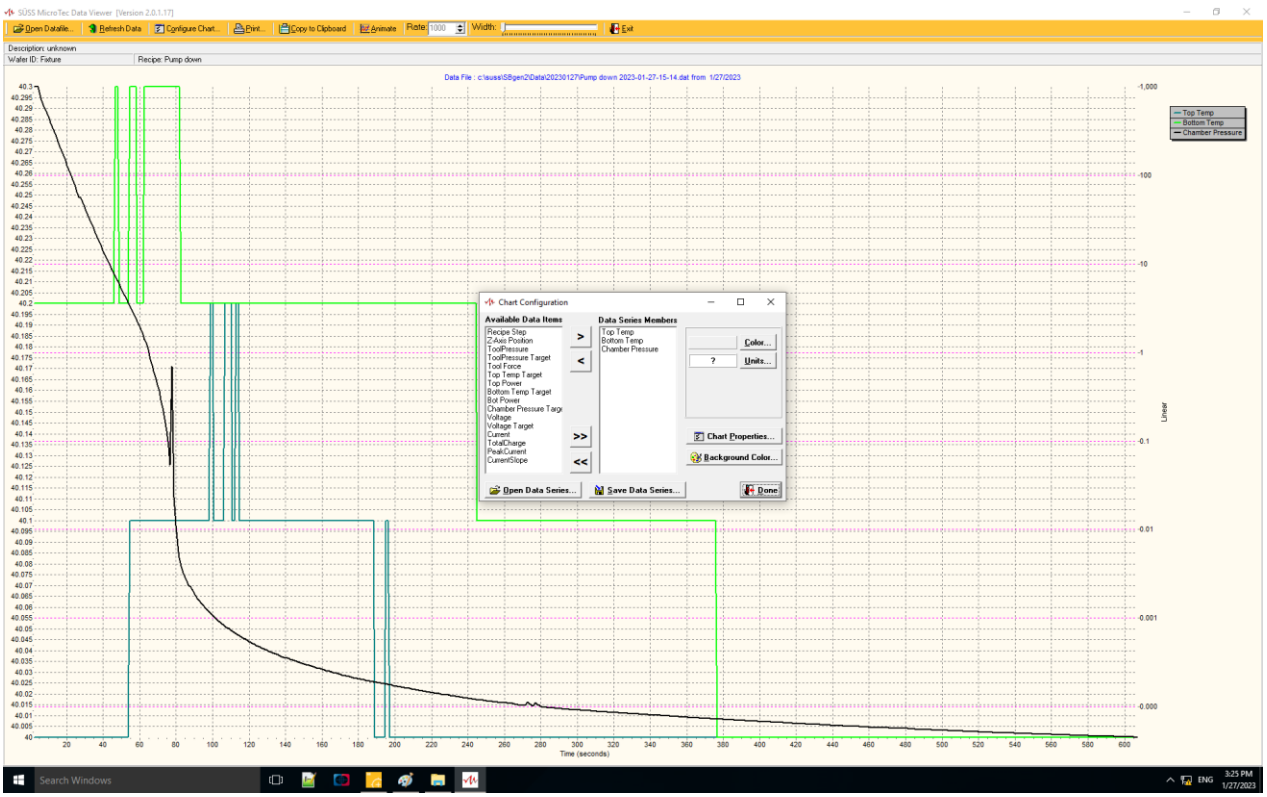


Figure 19: Data viewer with chart configuration

8.3. UNLOADING AND CLEANUP

When the bonding process is completed, the **Station** page will be displayed and the tool status will change to orange.

1. Unload the fixture:
   - Click **Prepare for unload** button. The chamber door will open shortly.
   - Push the loading slide into the chamber up to its limit stop. Hold the slide until it is locked by the pneumatic cylinder.
   - Press the **Unload takeover** button. Wait until the slide is released.
   - Bring the loading slide to its home position
   - Click **Unload complete** button.
2. Put on a pair of grey gloves.
3. If used, remove the quartz clamping plate.
4. Remove the bonded substrates with clean tweezers
5. Inspect the bonded substrates. Broken substrates and missing pieces must be reported to staff immediately.
6. Inspect the fixture, the clamps and the spacers. Any damage must be reported in Badger or to staff immediately.

At the end of the session, the fixture must be loaded in the chamber and kept under vacuum.

7. Place the fixture carefully on the loading slide.
8. In the **Station** page, load the fixture:
   - Click **Prepare for load** button. The chamber door will open shortly.
   - Push the loading slide into the chamber up to its limit stop. Hold the slide until it is locked by the pneumatic cylinder.
   - Press the **Load takeover** button. Wait until the slide is released.
   - Bring the loading slide to its home position.
   - Click **Load complete** button.
9. In the **Process** page, select and run “pump down” recipe:
   - Select “Pump down” recipe and click **Set as current recipe.**
   - Click **Start.**

9. TYPICAL PROBLEMS & SOLUTIONS

N/A

10.TECHNICAL DATA

N/A

APPENDIX

Bond Force to Tool Force Conversion

The “Tool Force” parameter in the control software, which generates the bond force, is a pressure value in millibar (mbar). This pressure value is applied inside a metallic bellows connected to the bonding head which in turn applies the bond force to the wafer stack. To specify the right tool force value, convert the bond force value needed (in Newtons) to tool force (in millibar) by multiplying the bond force value by 0.45. For example, a 2000 N bond force multiplied by 0.45 will give a tool force value of 900 mBar.