Simon Fraser University 8888 University Drive, Burnaby, B.C. V5A 1S6
E info@4dlabs.ca T 778.782.8158 F 778.782.3765 www.4dlabs.ca

AML-AWB aligner wafer bonder

Standard Operating Procedure

Revision: 1.0: Feb.13/2019

Overview

This document will provide a detailed operation procedure of the AML-AWB aligner wafer bonder. Formal Training is required for all users prior to using the system.

Revision History

#	Revised by:	Date	Modification
4	Mohamad Rezaei	02/13/19	Updated format, modified contact info, and added more procedure details
5			
6			
7			

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Simon Fraser University 8888 University Drive, Burnaby, B.C. V5A 1S6
E info@4dlabs.ca T 778.782.8158 F 778.782.3765 www.4dlabs.ca

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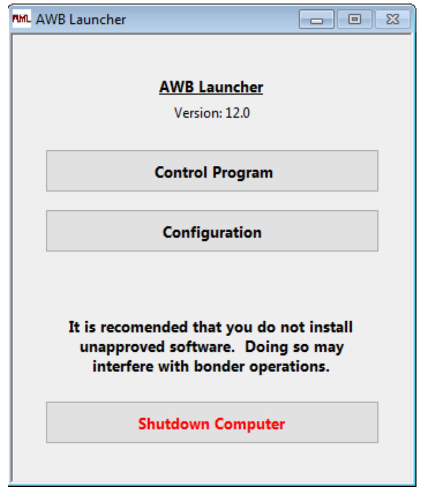
General Information

The AML-AWB aligner wafer bonder platform can perform in-situ aligned bonding of two flat substrates using the following bonding methods: anodic, glass frit, adhesive, thermo-compression, eutectic, solder and direct (low T "RAD" activated), provided the required options are chosen.

Operation Procedure

1. Start the system

- Start the "*AWB Launcher*" by double clicking.
- Under normal circumstances both the **Control Program** and **Configuration** are available from this screen:



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- Selecting either the Control Program or the Configuration Program will open the appropriate program.

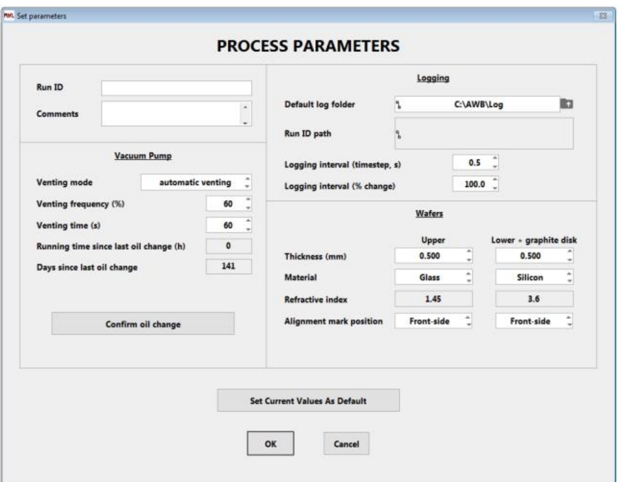
NOTE: **Configuration** program is used to define the machine options and must be used only by tool owner.

- Select **Control Program**
- After the hardware initialization, the mode selection screen is displayed.
- Three options available are as follows:
    - Manual mode (this requires the engineers' password)
    - Anodic Automatic mode
    - Other Automatic mode

1.2. Manual Mode

Manual mode gives the user the opportunity to change the process parameters during the run.

- Select the manual mode you will see the **PROCESS PARAMETERS** window



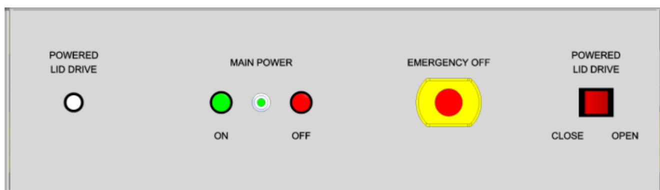
- In the **PROCESS PARAMETERS** window enter below parameters
    - Run ID: Enter the name of the Run ID in this box.
    - Comments (Optional): Comments about the run can be recoded in this box.
    - Thickness: Enter the thickness of both wafers in mm

    NOTE: For the lower wafer, include the thickness of the graphite paper (if present).
    - Material: Select a wafer material from the drop-down list.

- Refractive index: This is read-only, unless the wafer material is Other
- Alignment mark position (If you have alignment marks): Can be either Front-side or Back-side

- Select OK
- You will see the Control program in Manual mode

- Loosen the chamber bolts enough, lift the washers and slide them out of their slots.
- Open the chamber lid by holding down the white button and open switch on the AML front switch panel.



2. Anodic Bonding

Anodic bonding is a technique for joining silicon to glass, also known as Field Assisted bonding. The bond is irreversible, very strong and has good hermetic properties. The technique does not cause any flow of the glass and requires no additional interlayer.

- Make sure Molybdenum/Tungsten + Graphite as upper platen is selected the configuration program
- Make sure you are using a bonder set up with graphite face plate.

NOTE: To set up graphite face plate contact the tool owner

- Release the wafer clamp by hitting **Open Clamp [F12]**
- Load the wafers
    - Load glass on the upper platen (Min glass thickness that can be securely held in upper platen is 250µm.)
    - Load Si on the lower platen.

NOTE: Ensure the flats of both wafers are aligned to the platen scribe marks.

- Close the wafer clamp
- Close the lead by holding down the white button and close switch on the AML front switch panel.
- Tighten the chamber bolts enough using the Allen key
- Ensure the turbo pump is OFF (0 Hz)
- Open the isolation valve by hitting **Open Isolation**
- Start pumping down the chamber by hitting **Start Pump** and Pump down to pressure <5e-4
- If in situ alignment needed, make sure the marks on both wafers are well visible before starting heat-ing
- Check HV – set the voltage and current to low value (100V, 1mA) and activate HV to check if works OK and no short circuit error appears
- When voltage applied ensure chamber pressure <10-4mBar (unless specific bonding pressure specified by customer)

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- Start heating – standard temperature is 300ºC - 370ºC range. Monitor the chamber pressure. If it goes up to 5e-3mbar, stop heating and wait until it is below 5e-3mbar.
- Perform alignment (if needed) and contact wafers when at required temperature
- Apply ~500N force to the platens (may vary depending on the wafers).
- When facing plate is used, contact wafers with 1kN force and dwell for 5min. This is because the TC is inserted into the Moly/W platen and we need to ensure the heat is transferred to the graphite facing plate and it is at the same temperature as the platen underneath.
- Turn HV on – typically 800V, max current as below

Wafer ø	I_{limit}	Charge transfer	I_{final}
3″	2mA	1155.2mC	0.2mA
4″	4mA	2000mC	0.4mA
5″	6mA	3125mC	0.6mA
6″	8mA	4500mC	0.8mA
8″	16mA	8000mC	1.0mA

Bonding time ≈ 10 minutes (estimated)

Total charge for standard 4″ wafers is approximately 2000mC. Note that this scales with bond area. NOTE: The completion of the bonding process is determined by monitoring the charge transfer and the current. After an initial displacement current that can be so large as to cause a drop in the applied voltage, the current will then gradually reduce with time before reaching a residual value as per the above table. If the current has not fallen to this level within 15 minutes then bonding time should be extended – unless the charge transfer value has already been reached.

- Typical I-V vs. time trace for 4 inch standard anodic bond is shown below

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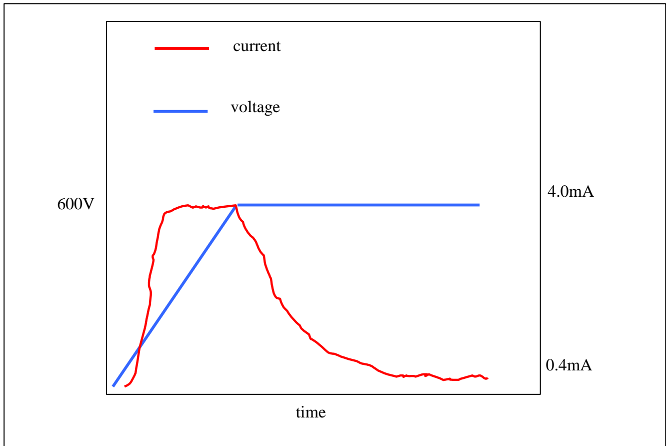

- When bonding is finished, switch the HV off
- Turn the heaters off
- Release the upper wafer (if upper wafer clamp used)
- Cool the bonded wafer at ~12mm separation under nitrogen flow
- Stop cooling and remove the wafers when T<200°C

3. RAD Activated Direct Bonding

- To perform direct bonding it is necessary to fit the "spring pin assembly actuator" to the upper platen.

NOTE: To adjust the DB pin please contact the tool owner

- Ensure the RAD ring is attached and electrically connected to the lid feed through
- If the RAD ring has not been used for a day or more then it will need to be conditioned

3.1. Conditioning the RAD system

1. During the initial pump down leave the water vacuum valve open [Evacuate AVI] until the turbo pump reaches 1000 Hz, or system pressure drops below 5 mbar. This will remove the bulk of the adsorbed gasses.
2. Pump chamber to below 1E-2 mbar
3. Activate pressure control, set to 1 mbar
4. Wait for pump speed and chamber pressure to stabilize
5. Set platens to maximum separation (~28mm)

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6. When pressure is stable Set voltage to 500V (such that the system is limited by current)
7. Set current to 100mA for AWB04 systems
8. Run RAD system for 20 mins (unless specifically instructed otherwise by job process schedule). Use on screen timer.
9. Switch off RAD power supply.
10. Switch off pressure control
11. Re-open the AVI evacuate valve and close it after ~20 seconds
12. At 5e-4 mbar chamber pressure close the isolation valve and stop the pump
13. Open the AVI vapor inlet valve and keep it open for 5 minutes
14. Record the chamber pressure after 5 minutes
15. Vent the system
16. Open the isolation valve and start the pump.
17. When the system pressure is <100 mbar open the AVI valve.
18. When the system pressure is <5 mbar close the AVI valve.
19. At 5e-4 mbar chamber pressure close the isolation valve and stop the pump
20. Open water injection valve and keep open for 5 min.
21. Record the pressure at 5 minutes
22. Repeat step 15-21 until the recorded pressure at 5 minutes is within 10 mbar
23. NOTE: If it is necessary to repeat more than two times (so four measurements in total) then there is the high possibility of a leak in the water injection system. Fix this leak before continuing and then restart the water conditioning process.
24. Vent and open chamber

3.2. Direct Bonding

- Ensure that the water has been conditioned
- Load wafers
- Activate the DB spring pin (see section 1.2.3.)
- Close lid, open isolation valve and start pumping

- At <100 mbar open water AVI valve
- At <5 mbar close AVI valve
- If alignment is required, perform a coarse alignment while pumping chamber
- Set platens to maximum separation (~28mm).
- Continue pumping until pressure reaches <1E-2 mbar
- Activate pressure control, set to 1 mbar. Pressure should be stable between 9.5E-1 and 1.05 mbar.
- Switch on RAD power supply when pressure has stabilized:
- Set voltage to 500V (such that the system is limited by current)
- Set current to 100mA for

NOTE: There is no maximum RAD time as it does not harm the wafers.

- Run RAD system for recommended activation times given below:

	4″	6″	8″
O_2	5 min	10 min	15 min
N_2	10 min	15 min	20 min

- Switch off RAD power supply.
- Use the vapour injection system to inject water at the end of the activation step.
  - Switch off pressure control
  - Open AVI valve for 20 second
  - Continue pumping until the chamber pressure drop to <1E-2 mbar.
  - As soon as the pressure has dropped below this level close the isolation valve and switch off the pump.
  - Open the vapour injection valve and leave until the chamber pressure has reached 10 mbar. Once the chamber pressure has reached 10 mbar close the water valve.
  - It is not possible to bond at less than the final water injection pressure; however the chamber can be vented with Nitrogen or the process gas for higher pressure bonds. This should not affect the final bond strength.

- Once the RAD process is complete the chamber and platens can be set to the required bonding conditions.
- Engage the DB actuator.
- Standard direct bond conditions are as follows:
    - Bonding time: 5 mins
    - Bonding Force given in the table below:

Wafer Size	100 mm	150 mm	200 mm
Bonding Force	1 kN	2.25 kN	4 kN

- Perform in-situ anneal if required.
- Release the wafers (if upper wafer clamp used), separate the platens and purge chamber
- Remove wafers for post bond anneal / further processing.

Reference and Files

AML - Applied Microengineering Ltd Manual and training notes.

Contact Information

Questions or comments in regard to this document should be directed to 4D LABS at Simon Fraser University, Burnaby, BC, Canada.