PM5 Precision Lapping & Polishing Machine

Fig. 1

1. Emergency STOP button
2. Mains isolator switch
3. Process Data screen
4. Process keys
5. Lift-off lapping/polishing plate
6. Autofeed ON/OFF
7. Plate speed control keys
8. STOP key
9. Power ON/OFF membrane key
10. START key
11. Timer SET key
12. Timer ZERO key
13. Preset time display
14. Time elapsed display
15. Removable drip tray
16. Slurry chute
17. Drip detect unit (optional)
18. Abrasive autofeed cylinder
19. Intra-red detector for use with PSM1's (optional)
20. Roller arm pillar
21. Roller arm assembly
22. Slurry scraper assembly
**Definitions**

Lapping is the wearing away of material by abrasion from a free flowing slurry or fixed abrasive pad. It produces a matte surface.

Polishing is the removal of surface damage usually created by lapping to produce a higher quality surface. It produces a reflective surface.

**Preparation**

Substrate Thickness Measurement

- Turn Electronic thickness measurement gauge, CG10 on.
- Clean base and stylus with a wipe and IPA.
- Set unit of measurement to millimeters.
- Zero the system. The base should be at zero millimeters.
- Place substrate on base and measure several places.
- Measure base again to be sure system is still zeroed.
- Average the measurements taken.

Lapping Jig

- Use the indicator on the jig to monitor substrate thickness while lapping. On the outer dial: one revolution is 200µm, the numbered tick marks are 10µm apart, and the small tick marks are 2µm apart. The inner dial is in millimeters.
- The lapping rate is dependent on the downward pressure and the size of the substrate. The more pressure, the faster the lapping rate (Pressure = force / area).
- The downward force can be increased or decreased by adjusting the load adjustment screw.
  - Up adjustment : Reduces the downward force.
  - Down adjustment : Increases the downward force.
- The down force reading can be obtained thru the sample-loading gauge.
- If you are lapping a sample to a thickness below 200µm, you may have to reduce the pressure to prevent your substrate from cracking.
- The dial indicator should be zeroed when you first put your substrate on the lapping plate.

Substrate Bonding

- Clean a glass carries using a wipe and acetone.
- Inspect both surfaces of the glass carrier for indentation, scratches, etc. The substrate is mounted on the worst looking side and perfect side is goes against the face of the vacuum chuck on the lapping jig.
- Set hotplate temperature to 90°C, place the glass carrier on the hotplate, apply some wax on the center of the glass carrier, and let it melt.
- Only use as much wax as needed, wax should not be running off the side of the glass carrier.
- Only place one substrate per carrier if a precise final thickness is needed.
- Press down on the substrate with the Teflon tweeze and move the substrate around to give a uniform thickness to the wax under the substrate.
- Transfer & load the glass carrier together with the substrate onto the bonding jig.
- Heat up the bonding jig to temperature of 90°C and bonding time is about 20min to ½ hr
- Removed the bonding jig to the cooling block for cooling down the temperature. Do not used liquids to force cool the glass carrier as the thermal shock might crack the carrier.
- After the glass carrier is at room temperature, carefully remove excess wax with a penknife. Scrape parallel to the substrate edge so you won’t accidentally pop the substrate off the carrier. Leave some wax around the substrate to protect the edge.
- Blow off wax particles with a N2 gun and clean off wax residue from the glass carrier.
- Turn the carrier over and look for air bubbles under the substrate. If air bubbles are too many or cover too much area, place carrier on hotplate to repeat mounting procedure.
- Measure the mounted substrate thickness on the Electronic thickness measurement gauge.
- Find the wax thickness by subtracting the initial substrate thickness from the mounted thickness.
Example:
  Bare substrate thickness is X mm
  Mounted substrate thickness is Y mm
  Wax thickness = X – Y
- Calculate the “Lap To” thickness of the mounted substrate
  • Determine the final substrate thickness, e.g. 400µm.
  • Determine the wax thickness, e.g. 40µm.
  • Estimate material to be removed by polishing later on (if needed), e.g. 20µm.
  • “Lap To” thickness of mounted substrate is:
    400µm + 40µm + 20µm = 460µm
  • Amount of material to lap away is:
    Thickness of mounted substrate - “Lap To” thickness of mounted substrate.

Filling the Abrasive Feed Cylinder

- Never intermix slurry solution (e.g. put 9µm slurry grit in the 3µm slurry cylinder. Cross contamination will result.
- Never shake the cylinder, as this motion will clog the valve.
- The 3µm and 9µm slurry solutions are a 15% mix of calcined alumina oxide powder in DI water. A full cylinder contains 1.5 liters of slurry; 150ml of this is calcined alumina oxide. A **FULL** cylinder is actually only filled halfway to the top (the line around the cylinder). Filling past the halfway mark will cause the slurry to flow out of the cylinder (when installed on the lapper) even when the lapper is off. It can also clog the valve.
- Inspect the cylinder for signs of damage.
- Carefully unscrew fill plug with flathead screwdriver.
Using a clean funnel, add proper size alumina powder, and then add the appropriate amount of DI water. Slurry level should not be above the halfway line on the cylinder.

- Clean the threads of the fill plug and fill plug hole. Screw the fill plug back into position. Do not over tighten. Slurry should not leak out.
- Clean the external surface of cylinder, valves, tools, and equipment.
- Slurry should last 4-6 hours between refills at 1-2 drops of slurry per second.
- Do not adjust the valve while the cylinder is rotating.

Cleaning of the PM5

- A clean lapper will prevent your work from being contaminated by a previous user’s work.
- Unload the lapping plate onto the water sink. Brush the plate with the running water and dry the plate with wipe and N2 gun.
- Use clean wipes and DI water to wipe down surrounding countertops and other surfaces.
- Ensure that the slurry drain hole on the lapper deck is not clogged.

Location of Lapping/Polishing Plate

- Remove the roller arm(s) [21] and slurry scraper [22] completely from the system.
- Holding the lapping/polishing plate by its edge, place the drive pins centrally in the annular groove of the driver plate. Manually rotate the plate in this groove until the drive pins are located in the holes and allow the plate to drop gently into place.

Slurry Scraper

- The slurry scraper is designed to remove abrasive and sample material from the lapping plate edge to prevent contamination and/or damage to the sample during processing.
- To set correctly, slacken the slurry scraper thumbscrew and swing in towards the plate so that the scraper is just touching the edge of the plate, i.e. no daylight should be visible between the plate edge and the slurry scraper.

SET- UP

1. Connect the machine and vacuum pump to a suitable electrical supply. Switch on the power supply.
2. Press the isolator switch [2], positioned on the bottom front right-hand corner of the base casting. It will illuminate, indicating that power is going to the machine. The emergency stop button [1] should be in the outermost position, not pressed in.
3. Press the “Power ON/OFF” membrane key [9]: a light in the corner of the button will illuminate and the fans will be heard to be operating. All displays will come on and read zero. At this point the PM5 Process Display Screen will power up, showing the machine serial number and the software version installed. After approximately three seconds, this will disappear, being replaced by the Initial Display Screen.

4. From the Process Data Screen, go for [Option] function and simply selecting the required Jig Type <PP6> and Machine Mode <Lap/Polishing>. After the selection, [Exit] back to the Main Screen.

**Lapping operation**

1. Initial checking of plate flatness monitor.
   a. Ensure that the bearing surfaces of the Plate Flatness Monitor and the Granite Master Flat Block are thoroughly clean. Attach the long monitor cable to the sockets on the monitor and the machine.
   b. Select [Setup] [Monitor] [Set-up] by pressing the touch panel key below this on the display.
   c. If the instrument is correctly calibrated, it should always be possible to obtain a monitor reading of between +/-10µm.
   d. Move the monitor gently around on the master flat block to obtain an approximate average.
   e. Pressing [Set] when the reading is between +/-10µm will zero the monitor.
   f. After the display back to the Lapping Set-up screen. Press [Exit] to return to the initial display screen, and disconnect the long monitor cable.

2. System Check
   a. Having returned to the initial display screen [Process] should now be selected.
   b. All jigs and fixtures must be removed from the roller arms before ‘System Checks” are run. This also applies when switching on the machine after the emergency stop button has been pressed.
   c. Selects [SysChecks], the machine will carry out a short series of internal system checks, and set the workstation and monitor support pillar to their mid positions, allowing the roller arms to be correctly positioned.

3. Positioning of roller arms and monitor
   a. This is carried out with the aid of the Setting Tool supplied and the lapping jig to be used, after the machine has carried out its system checks. A message on the Process Data Display will prompt the user to use the Setting Tool.
   b. This procedure applies when initially setting up the machine for use or if the roller arms have been removed for any reason, such as cleaning or maintenance. If the arms have previously been set, there should be no need to re-position them.
   c. Firstly, place the Positioning Tool in the center recess of the lapping plate. Loosely position the roller arm for the Lapping jig on the right support pillar; do not full tighten the clamp screw until the arm has been positioned.
d. Place the Lapping Jig in its approximate position in the roller arm. Ensure that the rim of the Lapping Jig outer stop ring is positioned against the raised section of the Positioning Tool, as shown in the below diagram, and tighten the clamp screw.

![Diagram of Lapping Jig and Positioning Tool](image1.png)

Positing of Roller Arms

e. Repeat the above procedure for the other roller arm, but using the Plate Flatness Monitor placed against the Positioning Tool for precise location before tightening the clamp screw on the left arm.

f. Finally attach the short monitor cable between the Plate Flatness Monitor and the monitor cable socket.

g. Press [Proceed] when the procedure described above has been completed.

4. After the machine has completed its internal system checks, the Process Data Screen will offer the operator the option of beginning processing immediately – with a zero flatness target – or of setting a specific target value.
5. The target can be altered by pressing the touch panel keys below the Process Data Screen, either to make it convex, concave or to return it to a flat target. The position of the “-T-” demonstrates the value being set in relation to the zero value.

![Diagram showing target alteration](image)

**Tolerance for target value = +/- 2 microns**

**POLISHING**

1. If the operator has already been using the machine for lapping, i.e. the system checks have already been carried out, remove the lapping plate and fixtures, and clean the machine work deck, slurry chute and scraper thoroughly to avoid any contamination of the polishing process. Then select [Process] to reach the “Polishing Sweep Parameters” screen.

![Polishing Sweep Parameters](image)

**Polishing Sweep Parameters**

2. The appropriate polishing plate should be located on the machine’s driver plate and an Abrasive Auto-feed cylinder containing the polishing fluid placed on the machine.

3. After location of the polishing plate, the roller arm can then be positioned on the support pillar approximately central to the plate track.

4. By pressing the “Edit” key in the first screen, the operator will have the option of setting the parameters of the sweeping arm. Three screens are available when setting parameters for the sweep and appear in a cycle, so press the [Next] key to move on to the next screen in sequence. These are:
“Set Inner Sweep Limit” – to set the inner limit of the sweep movement.

“Set Outer Sweep Limit” – to set the outer limit of the sweep movement.

“Set Sweep Speed” – to set the rate at which the pillar moves.

5. The parameters for polishing may either be set prior to setting the plate in motion, or may be set while the plate is rotating. To adjust the inner, outer limits and sweep speed, press the [-] or [+] keys as appropriate. The band of blocks on the display screen shows the width of the sweep selected and the speed is represents as a percentage of the maximum sweep available.

Preparation of the polishing plate

Plate Flatness

1. Thoroughly clean the surface of the polishing plate by scrubbing with a nylon brush and water. After scrubbing, rinse thoroughly with clean (preferably deionized) water.
2. Clean the master flat block and the contact surfaces of the single dial gauge.
3. Place the single dial gauge on the master flat block and set to zero.
4. Moisten the surface of the polyurethane and carefully position the single dial gauge on the surface with the dial facing outwards.
5. Note the reading on the single dial gauge in this position. If the pointer is clockwise of the zero position the plate is convex; if the pointer is anti-clockwise of the zero position the plate is concave. Once this reading has been taken, track the gauge across the polyurethane pad, taking readings in at least three other positions.
6. If the plate is flat, i.e. within 1-2 microns as indicated on the dial gauge, there is no need to correct the curvature of the plate. However, the plate should be “surface conditioned” by running a conditioning ring with polishing media prior to the application of samples.

Plate Conditioning

1. Plate conditioning is carried out on all polishing plates which are outside the flatness tolerance required and on all plates which are anew or freshly machined. A diamond conditioner and loading weight are used for this operation.
2. Check the accuracy of the conditioner using a single dial gauge and inspect the surface for damage. Ideally, the surface should be accurate to within 1-2 microns to achieve the best results with the plate. If the conditioner is damaged, or if it is not within the tolerance, it must be relapped before use. This is carried out on a grooved cast iron plate using 9 micron aluminium oxide abrasive and water.

3. With the plate fitted to the machine, apply a small quantity of water to the surface.
4. Set the speed control knob to zero. Position the conditioner on to the plate as close to the rollers on the half circle roller arm as possible and carefully place the loading weight on top of the conditioner.
5. Switch the machine on and set the speed control to rotate the plate slowly, thereby allowing the conditioner to move into the half circle roller are. When the conditioner is correctly positioned within the arm, stop the plate by turning the speed control to zero and adjust the reciprocation of the roller arm.
6. For concave plates, set the reciprocation such that the conditioner runs more toward the outside of the plate; for convex plates, set it such that it runs more towards the center of the plate. In both cases, however, ensure that the entire surface of the plate track is covered by the reciprocation in order to avoid a ridge being created at the edge or the center of the expanded polishing plate.
7. With the reciprocation set, set the plate rotating at 40 rpm for 10 to 15 minutes.
8. Set the speed control knob to zero, remove the conditioner and check the plate flatness using the single dial gauge.
9. Once a flat plate condition has been achieved, reset the reciprocation to provide a travel covering the entire track of the plate. Run the conditioner for a further 30 minutes to “surface condition” the plate.

Note: If the polyurethane becomes “glazed” or “shiny”, scrape the surface with the edge of a hacksaw blade, whilst the plate is running at between 60 and 70 rpm. This exposes a new surface, which needs to be reconditioned, using the diamond-smoothing block for 10 minutes, before normal usage can begin.

**Operation**

**CONTROL PANEL LAYOUT**

Membrane Control Panel

The machine membrane control panel is divided into 3 sections:

- **Main Drive** – controls for plate rotation and process time.
- **Abrasive Autofeed** – controls for cylinder rotation.
- **Process Data** – display screen, for operation of eccentric sweep and automatic plate shape control functions

**Use of Timer**

The timer control buttons are located on the Main Drive section of the membrane panel. The Timer system is operated in “set mode”. The following procedure should be used to set a processing time:
In the “set” mode, once the Preset Time has elapsed the plate will stop rotating. A red light in the corner of the “SET” key indicates the Timer is in the set mode. In this mode it is always necessary to set a processing time for the plate drive to operate.

To set a processing time press the “SET” key once; the red light in the corner of the button will glow, indicating the Timer is in “set” mode. The timer display will automatically default to ten minutes (0:10). Then press “+” and “-“ keys to set the required time, in hours and minutes, on the “Preset Time” display. (Maximum time available is 9 hour & 59 minutes i.e. 9:59). The “Time Elapsed” display will remain 0:00 until the plate is set in motion. The time elapsed will only count up while the plate is actually rotating.

The “Zero” key will return both “Preset Time” & “Time Elapsed” to 0:00.

**Plate Drive Operation**

When a time has been set, press the “START” key [10] – the light in the “STOP” key will go out & a light in the “START” key will come on.

The “Time Elapsed” display [14] will start to count and the plate speed can be increased or decreased by pressing the speed control keys [7]. The speed control keys will only operate if the “START” key has been activated.

**Abrasive Feed Operation**

The Auto-feed drive will only operate when the Main Drive is activated by pressing the “ON/OFF” key in the Abrasive Auto-feed section of the membrane panel [6]. A light in the corner of the key will come on to indicate that the system is energized. The flow rate is adjusted by turning the valve on the left of the cylinder. All aspects of operation of the actual abrasive auto-feed cylinder please refer to the preparation procedure of “Filling the Abrasive Feed Cylinder”.

**Use of Slurry Chute**

An adjustable slurry chute (Fig. 1) with drip wire is provided to feed the slurry onto the plate. The slurry chute is fixed in position by way of a clamp screw, allowing the slurry chute to be precisely positioned, ensuring it is located directly below the hole in the cylinder valve.