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MultiPrep™ Procedure

Parallel De-layering of an Integrated Circuit (IC)

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Overview

The MultiPrep™ is an excellent tool for parallel polishing, and the most common parallel technique is IC de-layering. Other applications include PCB de-layering and thinning of substrates, compound semiconductor wafers, optical devices, geological specimens and other materials.

Parallel de-layering of IC's is a useful technique for construction, failure or defect analysis, reverse engineering, bitmapping and others. The MultiPrep™ allows precise, semiautomatic polishing, eliminating the tedious function of finger polishing or holding polishing tools by hand. Mechanical polishing on the MultiPrep™ provides controlled material removal.

Mechanical polishing offers certain advantages over other etching methods. However, it is quite common to use chemical and plasma etching techniques in

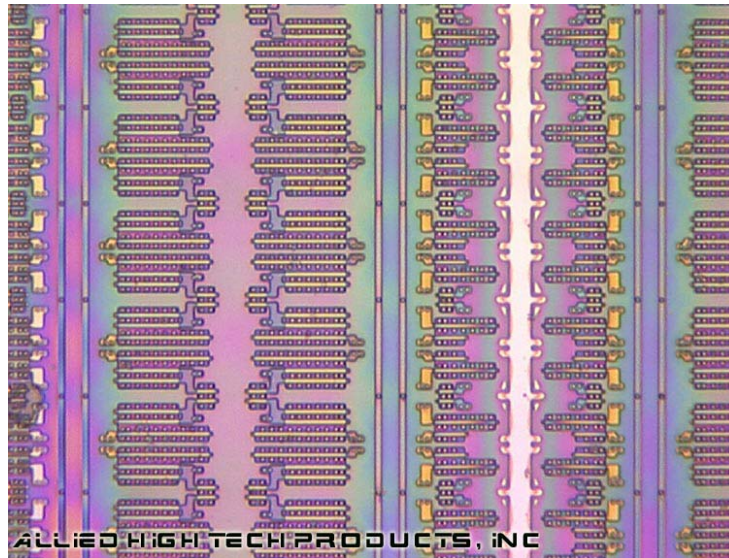
conjunction with polishing for precise removal of the entire layer due to uneven circuit topography. This procedure works well when polishing aluminum, copper, tungsten, ILD (inner layer dielectrics), silicon dioxide and other protective layers.

In this procedure, a standard aluminum based IC will be mounted to a calibrated lapping fixture and polished to expose underlying circuit layers.

It is strongly recommended that the MultiPrep™ System manual be studied to ensure familiarity with the terms used to describe certain functions and components in this procedure.

Consumable selection, machine settings and techniques used in this procedure were developed using the

MultiPrep™ System in Allied's applications laboratory.



Equipment Used:

15-2000 MultiPrep™ System
15-1020 Parallel Polishing Fixture
300-10000 Fluid Dispensing System (optional)

Zeiss AxioImager Compound Microscope

Note: Part numbers for microscopes depend on desired configuration.

Consumables Used:

50-150-500 Imperial Polishing Cloth
85-150-500 Final P Polishing Cloth
180-20000 0.05µm Non-Crystallizing Colloidal Silica Suspension
210-30000 Cotton-Tipped Applicators (Swabs)
69-Tape Double-Sided Tape
71-10040 Hot Mounting Wax
148-10000 Micro Organic Soap
200-20000 Aero-Duster Canned Air

Other:

Acetone
Isopropyl Alcohol
Glass Beakers, 100mL
Tweezers

Procedure

1. Calibrate the MultiPrep™ System following the procedures outlined in the manual.
2. Be sure and remove any polyimide or thick protective oxides prior to polishing. It is not possible to remove polyimide and not recommended to remove thick passivation layers by polishing.
3. Thoroughly clean the parallel polishing fixture using Acetone, then IPA, to remove any residue, dirt, grease, oil or fingerprints that may hamper adhesion of the tape or wax that will be used to secure the sample to the fixture. **Note:** Because slight variations in parallel surfaces from one fixture to another may create flatness errors, the same fixture used for calibration *must* be used for parallel de-layering. Then secure the sample to the fixture with either double-sided adhesive tape or wax using the applicable method described below:

Attaching the Sample to the Polishing Fixture

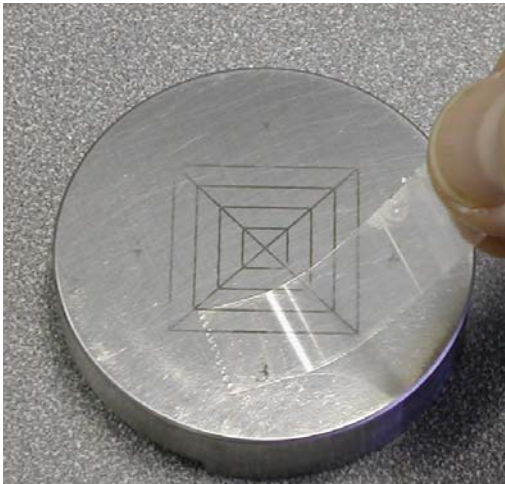


Photo 1

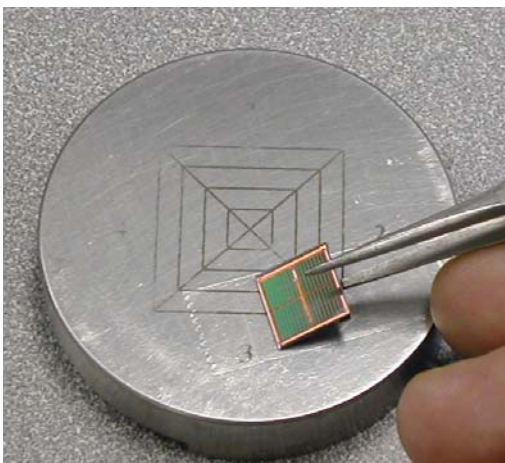


Photo 2

Tape method:

- A. Remove a piece of double-sided tape from the roll. It may be necessary to remove a piece around the entire circumference to ensure nothing that might be stuck to the tape gets between the sample and the fixture. Do not touch the tape near the area where the die will make contact. A roll dispenser makes it easier to remove the tape.
- B. Place the tape onto the fixture off center (see *Photo 1*) and roll it onto the surface using the natural contour of the tape. If done properly, there will be no bubbles between the tape and the fixture, allowing the die to lay flat/parallel with the fixture surface. **Note:** Make sure the backside of the die is clean and flat. Foreign particles will not allow the die to rest parallel with the fixture surface and polish flat (see troubleshooting) or provide the best adhesion characteristics.
- C. Place one edge onto the tape, allowing it to "hinge" onto it (see *Photo 2*).
- D. Using a cotton swab, gently and firmly apply pressure to the entire surface of the die to ensure good adhesion to the tape (see *Photo 3*).

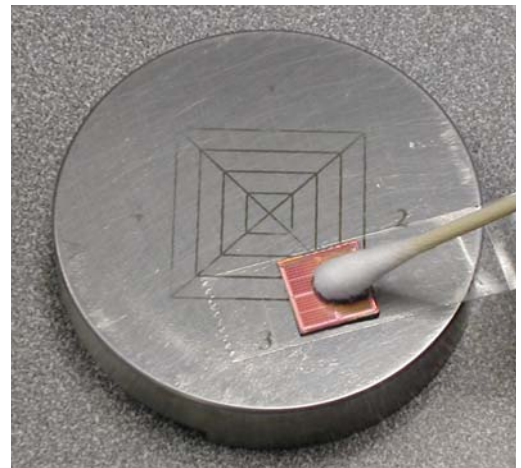


Photo 3

Wax method:

- A. Place the fixture onto the hot plate and heat to 175° C.
- B. Place a small piece of wax on the fixture, off center (see *Photo 4*).
- C. When the wax is melted, saturate a cotton swab with Acetone.
- D. With the saturated swab, spread and thin the wax on the fixture surface in an area slightly larger than the die to be mounted (see *Photo 5*). **Note:** The wax should appear hazy on the fixture surface.
- E. Place one edge of the sample in the wax and allow the rest of the die to hinge onto the fixture surface (see *Photo 6*).
- F. Using a cotton swab, gently and firmly apply pressure to the entire surface of the die.
- G. Remove the fixture from the hot plate and allow it to cool to room temperature.



Photo 4

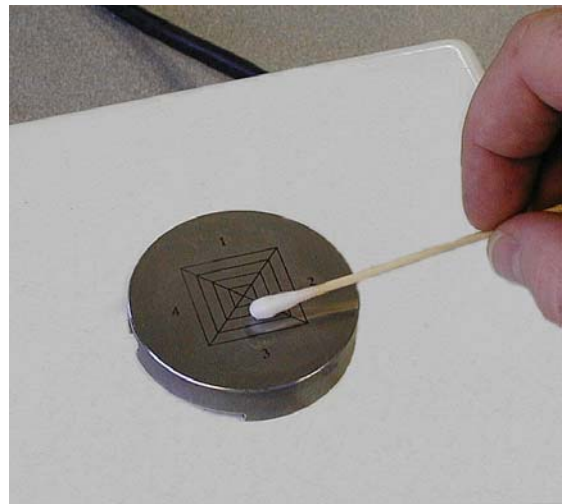


Photo 5

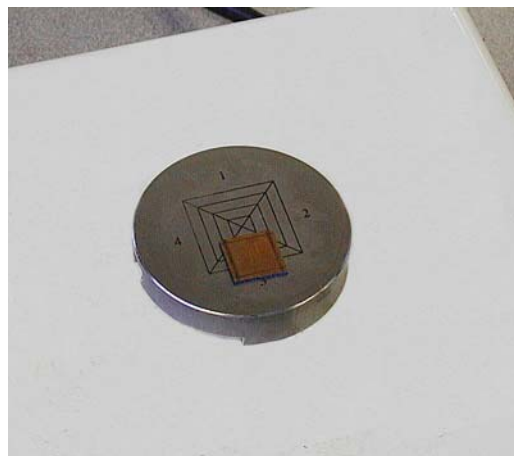


Photo 6

Adhering the Cloth to the Platen

Before the cloth is adhered to the platen, the bottom surface of the polishing fixture must be positioned relative to the platen based on sample thickness and polishing cloth being used. Below is an explanation of this procedure.

Height Adjustment Method for Parallel Delayering IC's, **Copper** and/or **Aluminum** Metallization

Because a polishing cloth is used for parallel delayering, it is difficult to know when contact between the sample and the cloth is made when positioning the sample onto the platen/abrasive surface. If lowered into the cloth too much, the edges of the die are rounded and the flatness is affected. If it does not make sufficient contact, it can take days to remove a single layer.

The front dial indicator is useful only when the spindle lifts from the arm that supports it. Unfortunately, this only occurs when the cloth is fully compressed. A quantitative method is used to position the sample so it makes enough contact with the cloth to remove material at a reasonable rate and maintain planarity across the entire die with little or no rounding at the edges.

Different cloths are used for either copper or aluminum metal circuitry. As a result, the mechanical position of the fixture must change to compensate for the difference in the cloth thickness.

Two cloths have been identified to provide excellent results for both types of metallization:

Aluminum (Al): Imperial Polishing Cloth, #50-150-500

Copper (Cu): Final P Polishing Cloth, #85-150-500

The following data was collected from tests based on a die thickness of 500 μm (microns). As die thickness changes, so must the distance/value used in positioning the sample.

Imperial (Al) cloth thickness: 0.840 mm

Final P (Cu) cloth thickness: 0.710 mm

The difference in the thickness between these two cloths is represented in the numbers listed in Table 1 (130 microns, 0.130 mm).

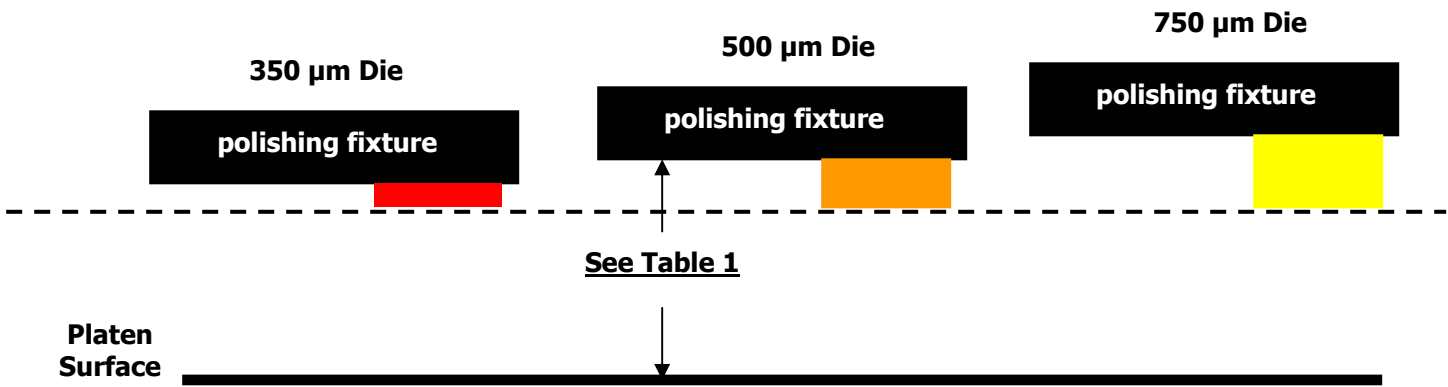


Diagram 1

As the die thickness changes, so must the distance between the bottom of the polishing fixture and platen.

	<u>Imperial</u>	<u>Final P</u>
Die Thickness (μm)	Distance to Platen (mm)	
350	1.074	0.944
500	1.224	1.094
750	1.474	1.344

Table 1

Procedure

With the sample load set to full, lower the spindle using the cam/spindle riser and zero the front dial indicator.

Any hard object can be used as a spacer to set the position. Another polishing fixture (item # 15-1020) is optimum because it is precision lapped and parallel. The thickness of the spacer must be known and is easily measured using a set of calipers. For this example, the thickness of the polishing fixture is approximately 12.65 mm.

Subtract the value (determined from Table 1) the fixture must be positioned (according to the cloth being used) from the thickness of the spacer or use the following equation is used to determine proper vertical position of the sample relative to the platen:

Distance from Platen to bottom of polishing fixture = $((T_S - T_C) - T_D) + 0.116$ mm

T_S = Spacer thickness

T_C = Cloth Thickness

T_D = Die Thickness

For example:

Thickness of Die (T_D): 500 microns (0.500 mm)

Thickness of Spacer, mm (T_S): 12.65 (if using a lapping fixture, whatever the measured thickness)

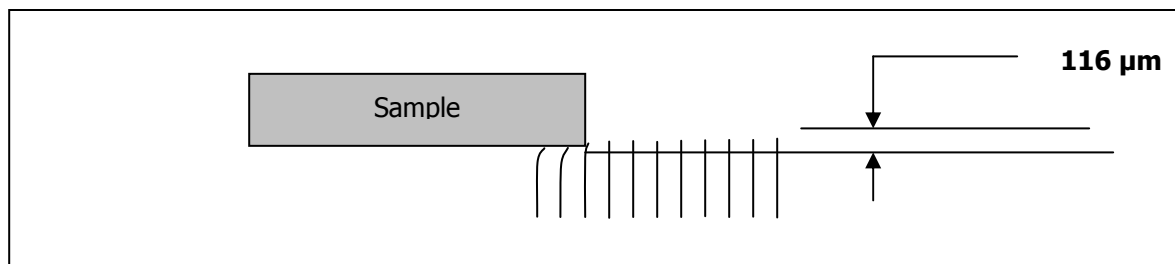
Thickness of Cloth (T_C): depending on which is selected

If using **Imperial Cloth:**

12.65mm (spacer thickness) – 1.224mm (from table 1) = 11.426 is the dial indicator setting

If using **Final P:**

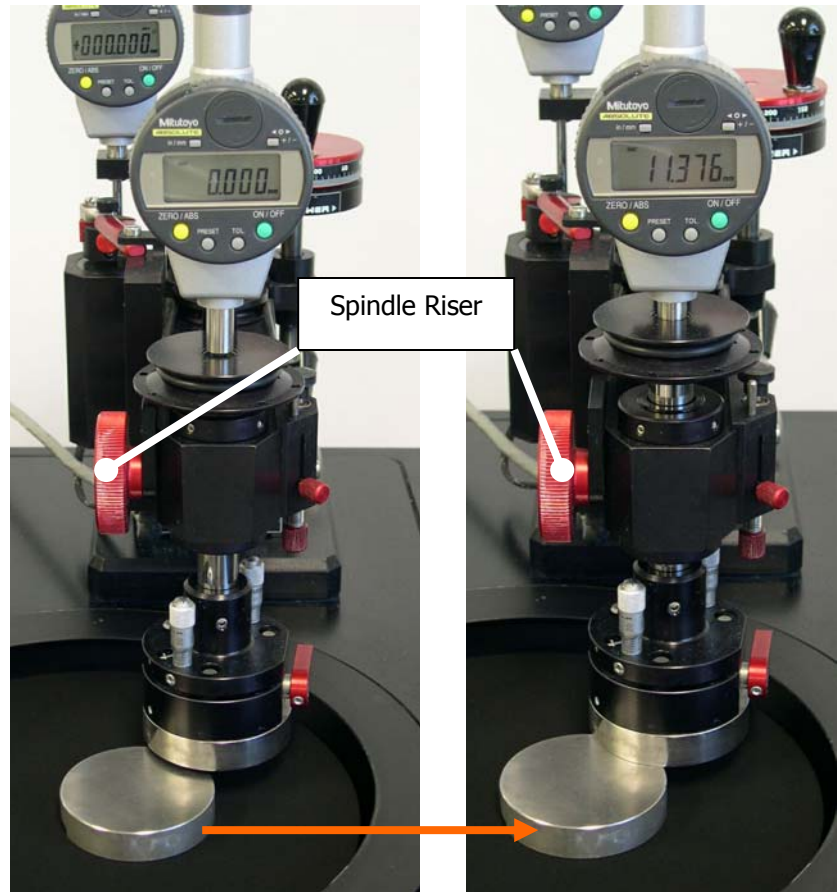
12.65mm (spacer thickness) – 1.094mm (from table 1) = 11.556 is the dial indicator setting



Position the spacer on the platen beneath the polishing fixture being used for delayering (see photo). With the vertical adjustment knob, lower the arm/spindle until the polishing fixture (not the sample) makes contact with the spacer and the dial indicates the predetermined value (from zero).

Once this has been done, lift ONLY the spindle using the spindle riser (see photo). By using the spindle riser, the vertical position of the sample relative to the platen is left un-changed.

Proceed to applying the cloth to the platen and step 4.



Attaching the Cloth to the Platen

4. Adhere the polishing cloth to the platen as shown in *Photo 7*. **Note:** When placing a new cloth onto a platen, it is important to avoid trapping air bubbles. To prevent this, place the edge of the cloth near the edge of the platen and sweep your fingers across the cloth back-and-forth, advancing them to the other side until the entire cloth is applied.
5. Attach the fixture to the MultiPrep™.
6. Following the instruction manual, adjust the sweep range so that the edge of the fixture extends from near center to 0.25 inch (6.5mm) from the outer edge of the cloth. This will ensure even wear of the cloth and exposure to the sample.

System settings:

Platen Speed:	225 RPM
Platen Direction:	CCW
Rotation Speed:	Full (speed 8)
Oscillation Speed:	Speed 3

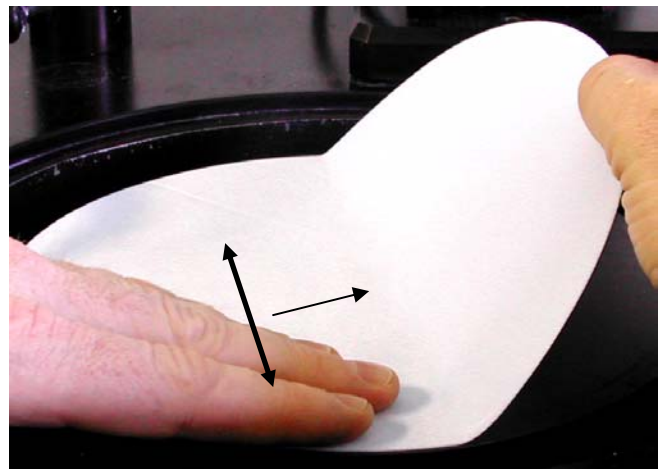


Photo 7

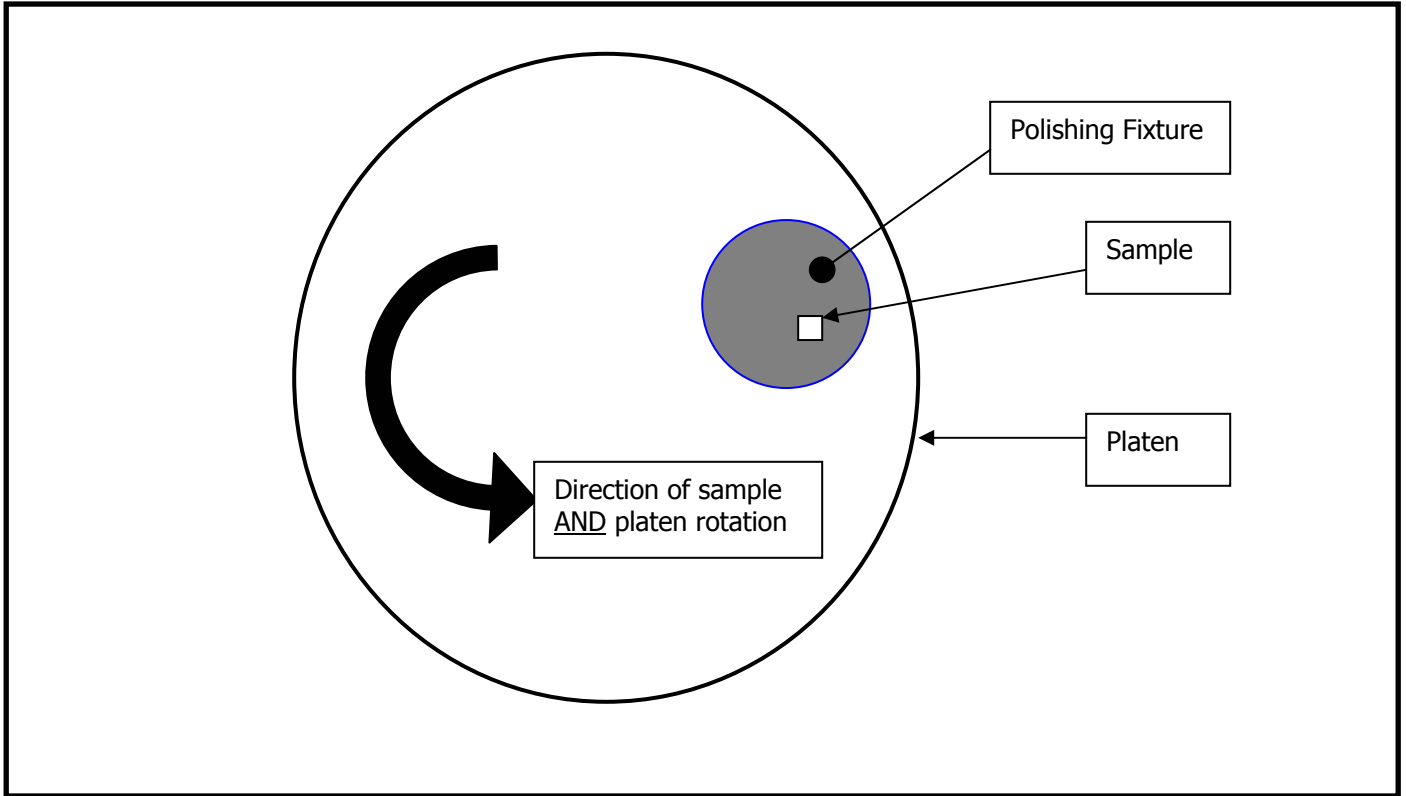


Figure 1

7. If the dispensing system is being used, position the stand as shown in *photo 8* and fill the buret with 0.05 μm colloidal silica.



Photo 8



Photo 9

Note: The stopcock can be adjusted to regulate the flow of colloidal silica onto the polishing cloth. Generally, one drop every two seconds is recommended, which produces a consistent, constant supply of abrasive. Increased flow will increase the polishing rate. The ideal drip rate may vary with sample size, cloth choice and abrasive type and should be determined through experimentation. During polishing, coolant should be activated so the stream touches the outer edge of the cloth (*Photo 9*). This will gently splash water in the bowl, cleaning the sides and keeping the colloidal silica from drying.

8. Activate platen rotation at 225 RPM counterclockwise.
9. Activate sample rotation at speed 8. **Note:** Although older TechPrep™ polishing machines did not feature a number display, speed selection can be performed. Consult the manual for instructions.
10. Activate sample oscillation and saturate the cloth with water.
11. Turn the water off and apply colloidal silica to the cloth.
12. If desired, program the timer to control the polishing cycle time.
13. When the desired time of polish has expired and the timer is not being used, stop the platen.
14. Raise the sample from the polishing cloth using the spindle riser. **Note:** By using the spindle riser instead of the vertical adjustment knob to raise the sample, the vertical position of the sample relative to the polishing cloth will remain intact so that when placing the fixture back onto the MultiPrep™ for continuation of the polishing cycle, adjustments to the vertical position of the sample will be unnecessary.
15. Remove the fixture from the MultiPrep™. **Note:** It may be necessary to activate sample rotation to position the cam-lock lever so the fixture can be conveniently removed from the front-side.
16. Rinse the sample with water for 5 to 10 seconds.
17. Using clean air (i.e. Aero-Duster), dry the sample in one direction ONLY. By aiming the airflow in a single direction, water spots and marks can be reduced or eliminated. Water spots will hinder observation of the features.
18. After observation, if it is necessary to remove additional material or polish for a longer time, continue polishing by repeating steps 8 through 10 and 12 through 17 until the sample is polished to the desired area of interest.
19. Once finished, rinse the cloth with water, remove the platen, dry the underside and store it for future use.
20. Wipe the base platen dry from any moisture or water.

FAQ's and other notes

How is sample pressure controlled?

Sample pressure is a factor of cloth compression. As the sample compresses the cloth, by lowering it with the vertical adjustment knob, more resistance is applied until the cloth completely supports the weight of the entire spindle assembly, with the sample between the lapping fixture and cloth. At this point, the fastest rate of removal can be achieved, however, extreme rounding at the die edges will occur.

How do I use the dial indicator to monitor progress?

The material removed is not measurable with the dial indicator. In addition, the cloth is too spongy to provide an accurate, precise measurement. Therefore, time is used to monitor removal based on experience. Polishing rates vary due to the following:

- A) Condition of the cloth (new vs. old)
- B) Concentration and type of abrasive (colloidal silica vs. diamond)
- C) Pressure
- D) Surface area of the sample

Why is my sample not polishing evenly/parallel?

There are several reasons:

- A) The sample may not be mounted properly to the polishing fixture
- B) Debris may be between the die and the polishing fixture
- C) The machine is not calibrated correctly
- D) Circuit topography may be uneven

How often should a cloth be changed? (How long will the cloth last?)

The surface area and amount of time polished on each sample varies. The rate of polish should be closely monitored and the cloth changed at the first sign of a decreasing rate. It is sometimes common to use two cloths for a single sample.

How do I reduce the rounding near the edges?

If the sample is extracted from a wafer, be sure to cut or cleave it at least 2mm larger on each side. This way any rounding that occurs will be located away from the circuitry on the sample. For samples extracted from packages, additional silicon wafer material may be placed along the edges of the sample so the cloth rounds the edges of the sacrificial silicon, not the actual sample.

NOTES

Parallel Polishing Fixture

The side on which the sample is mounted has a patterned grid with numbers. These markings exist for reference purposes and will not affect the flatness of the sample.

Rotation

Rotation is *key* when trying to evenly polish a sample. It allows the sample to be polished from all sides, eliminating smearing and maintaining flatness.

Sample position is another important factor to flatness. For instance, rotating the sample on axis (in the center of the lapping fixture) can create a "donut" effect because the outer edges, where the cloth compression takes place, polish at a faster rate than the center. To avoid this, mount the sample off-center (see Figure 1).

Direction and speed of sample rotation and platen rotation need to be adjusted so the cloth travels nearly the same rate and time across each edge of the sample. As the sample rotates (and oscillates) it moves its position on the platen. Since the linear travel rate of the cloth varies at different areas due to the difference in surface feet per minute (i.e. 2 inch radius vs. 3 inch radius), the cloth spends more time polishing one edge than the other. By "harmonizing" platen and sample rotation speeds, this effect is minimized (see system settings).

Platen speed

It is important that the cloth travel at a rate of speed so it does not decompress into the softer or less dense areas of the sample. By increasing the speed, the cloth does not have time to decompress into these areas. A platen speed of 205 to 225 RPM has been found to produce the best results for maintaining flatness. Platen speed should be determined prior to selecting sample rotation speed and will vary if using different cloths.

Equipment Photo Page



MultiPrep System



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