Pyramid Probe
Online Cleaning Methods

APPLICATION NOTE

Overview

This application note applies to Pyramid Probes® with a plastic plunger assembly (Fig. 1). To learn about cleaning a P800-S type Pyramid Probe with a steel plunger (Fig. 2), see the application note titled *Pyramid Probe Card: P800-S Online Cleaning Instructions*.

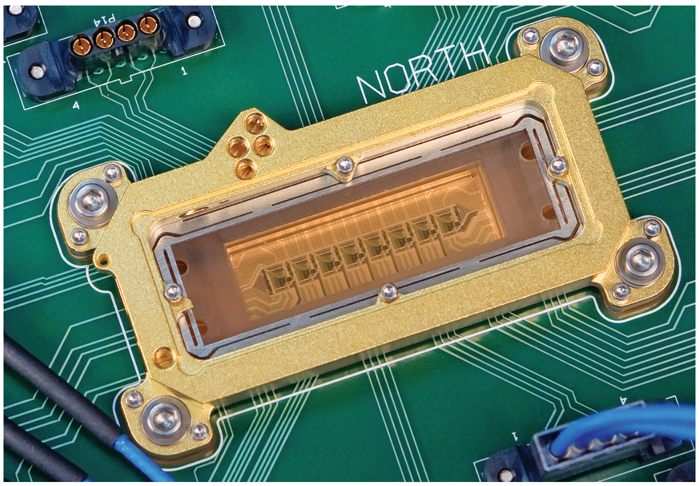

Figure 1. Pyramid Probe with a plastic plunger.

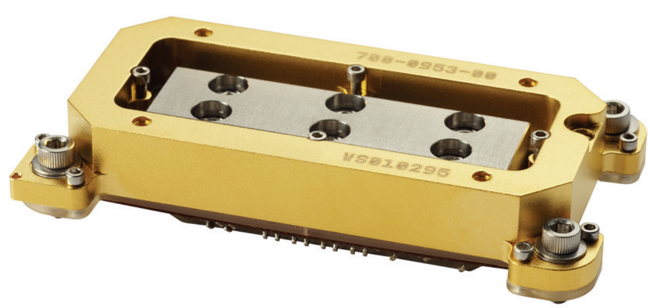

Figure 2. P800-S type Pyramid Probe with a steel plunger.

Pyramid Probes may collect contaminants that make cleaning necessary. The cleaning frequency and intensity required to keep a Pyramid Probe operating at its peak efficiency are primarily related to the probing environment. As a result, the exact formula for cleaning Pyramid Probes must be determined individually for each application. This application note starts with some general comments about cleaning Pyramid Probes and the contaminants that may be found in probing environments. It then describes Cascade Microtech's recommendations for online cleaning methods and describes a procedure for determining the optimum value of online cleaning parameters. Finally, this application note concludes with a discussion of recommended offline cleaning methods.

General Precautions for Cleaning Pyramid Probe Cards

CAUTION

When cleaning Pyramid Probes, never move the cleaning substrate in the XY-plane when the substrate and the probe tips are in contact.

When using a prober or cleaning station, never clean Pyramid Probes by moving the cleaning chuck back-and-forth in the XY-plane when it is in contact with the probe tips. Instead, clean the probe tips by touching them down on the cleaning substrate using a Z-axis motion only. Many probers and probe card analyzers default to a scrubbing X-Y motion. This action must be disabled.

When stepping Pyramid Probes down on a cleaning substrate, use an overtravel that does not exceed 250 µm. Overtravel between 35 µm and 75 µm has been found to work best in the factory for most cleaning applications. Higher overtravel is more likely to generate particles from the cleaning film, especially lapping films.

Step the cleaning chuck at least 2x the tip diameter in the X and Y directions between touchdowns to ensure the probe tips always contact fresh material and an even distribution of abrasive particles.

Cleaning Pyramid Probes by contacting a cleaning substrate takes multiple touchdowns to achieve good results. Usually, between 10 and 30 touchdowns are necessary. Experiment to find the cleaning count that works best in your environment. Ten touchdowns is a good number to start with.

Contaminants

Contaminants on Pyramid Probes can be divided into two general classes: Particulate contaminants and resistive buildup contaminants.

Particulate contaminants

Particulate contamination can build up on the probe face and tips during probing. In some cases, particulate contamination may go unnoticed by the user. In other cases, it can cause persistent open channels. Furthermore, large, hard particles are a leading cause of premature, catastrophic probe-card failure, usually brought on by damaging one or more probe tips.

Figures 3 through 6 present examples of particulate contamination and its effects:

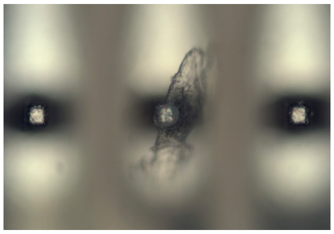

Figure 3. Particle on tip, likely open.

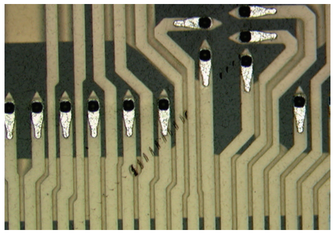

Figure 4. Repeating particle indent, near miss.

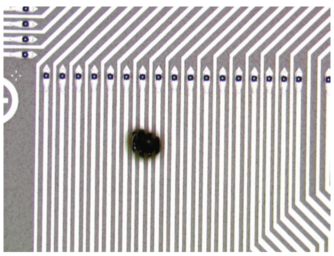

Figure 5. Deep particle indent, three open traces.

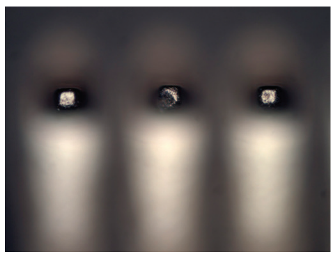

Figure 6. Particle hit, probe tip damaged.

Once they have been transferred to the membrane, particles are best removed by offline brush cleaning using the cleaning brush provided by Cascade Microtech. Refer to Cascade Microtech's application note, *Pyramid Probe Core Off-line Cleaning With a Brush.*

However, the best solution for particulate contamination is to remove the particles at their source. Many simple actions can protect Pyramid Probe cards from particulate damage.

- DO probe in a cleanroom environment
- DO wash wafers immediately before probe (especially after laser-scribe operations)
- DO use extreme caution when probing correlation wafers
- DO regular preventative maintenance to clean the wafer area of the prober
- DO NOT load or unload probe cards with the wafer on the chuck
- DO NOT share brushes between Pyramid Probes and other probe card technologies
- DO NOT probe wafers that have been stored in a dirty or questionable environment
- DO NOT touch the membrane, even with gloved hands

Resistive buildup contaminants (organics, oxides)

Resistive buildup contaminants accumulate on the probe tips during probing. To maintain high yield, these contaminants must be removed by abrasive cleaning. For best results, this contamination should be removed preventively. Resistive buildup contaminants do not usually damage probe tips directly. However, in response to the increasing contact resistance caused by this buildup, users may choose to increase overtravel — which stresses the probe tips and can cause premature probe failure.

Pyramid Probe tips do not typically experience as much resistive contaminant buildup as other probe technologies. The patented MicroScrub® action of Pyramid Probes penetrates the metal oxides and cleans the probe tips with each contact (Fig. 7).

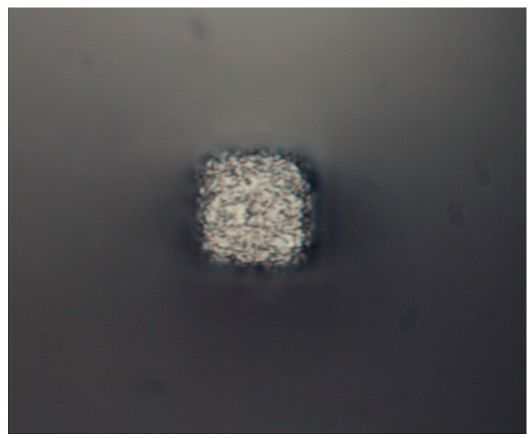

Figure 7. Clean probe tip.

Yet, when a buildup does occur, it typically appears as a discoloration on the probe tip (Fig. 8 and Fig. 9).

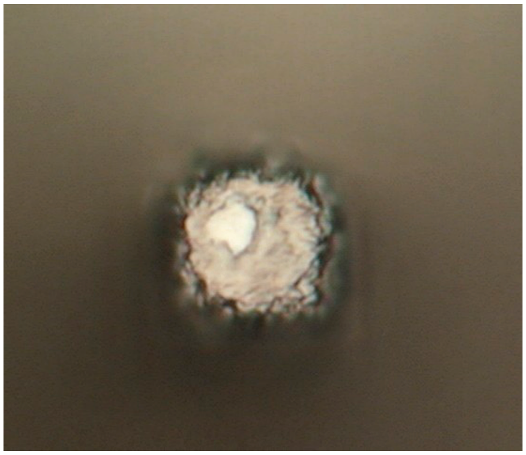

Figure 8. Aluminum buildup.

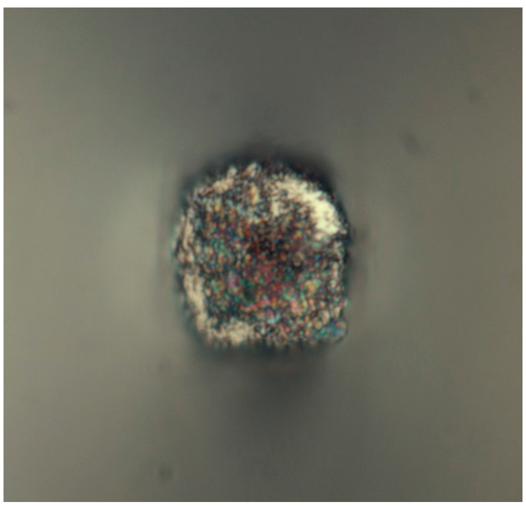

Figure 9. Copper buildup.

Special considerations for solder probing

Probe tips for solder-ball probing are much more susceptible to accumulation of resistive buildup contaminants. Under normal probing, the soft solder material sticks to the probe tip surface. This buildup typically appears as a dark-colored mass that covers the entire tip surface and occurs with all types of solder alloys (Fig. 10). Often, the mass will include areas that are green, blue, brown, or black. Yield will suffer if this buildup is not removed preemptively with aggressive online cleaning.

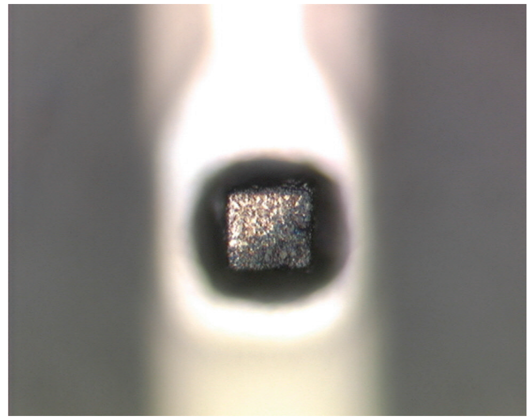

Figure 10. Solder buildup.

Recommended Online Cleaning Methods and Materials

Abrasive cleaning media

Online cleaning by touching down on an abrasive is the most effective way to control contact resistance (Rc) and to clean resistive buildup off Pyramid Probe tips. Abrasive cleaning media can be divided into four categories:

1. Lapping films
2. Abrasive loaded elastomers
3. Coated foams
4. Soft-backed lapping films

Cascade Microtech recommends lapping films, abrasive loaded elastomers and coated foams as the cleaning media. Soft-backed lapping films should not be used.

CAUTION

Excessive use of abrasive substrates may cause premature failure of Pyramid Probes.

1. Lapping films

This is the traditional type of cleaning film for cantilever probe cards. These films are typically 75-125 µm thick. The backing is usually made of polyester. They are relatively hard, with an abrasive on the surface. The abrasive is held in place with some kind of resin binder.

In studies at Cascade Microtech, no correlation has been found between overtravel on lapping films and tip wear. In fact, there is a drawback to high cleaning overtravel, because there is a strong correlation between overtravel and particle generation. It is recommended that you use the minimum overtravel required to get good results.

All lapping films have been observed to generate particles during the cleaning process. The source of particles is the binder used to attach the pieces of abrasive to the backing.

2. Abrasive loaded elastomers

The most common source of this type of cleaning film is International Test Solutions (ITS). Abrasive-loaded elastomer media consist of a relatively thick layer of elastomer (such as silicone, polyurethane, or rubber) with abrasive particles mixed evenly throughout the polymer. This gel-like film is generally mounted to a polyester backing film or a cleaning wafer. In comparison, lapping film has abrasive particles that have been bonded to the backing film with a relatively hard resin, instead of particles mixed evenly throughout an elastomer. Abrasive-loaded elastomers are safe for use.

3. Abrasive coated foams

The most common source of this type of cleaning media is MIPOX International. Like lapping films, abrasive-coated foams consist of a layer of abrasive particles in a resin binder. But instead of being bonded to a polyester film carrier, the particles are coated onto a soft, open-celled foam. Abrasive-coated foams have been shown to have good results, except that they rounded the probe tips. The change from a flat to a round probe tip will increase pressure on the pad and may require a requalification if used on pad-over-active-area (POAA) or low-K dielectric devices. These coated foam materials should be acceptable for all other applications. MIPOX International's WA6000-SWE is the recommended cleaning material for P800-S type Pyramid Probes.

4. Soft backed, lapping films, SiO abrasive

In general, soft-backed lapping films should be avoided. Only one soft-backed, lapping film was found to be acceptable, MIPOX Si10000-PF3. The abrasive (SiO_2) is softer than Pyramid Probe tips, so it cannot change or damage the tip.

Elastomeric substrates ("Tacky Mats")

Elastomeric substrates clean by removing particles from the probe tips by adhesion. These materials can adhere to the membrane itself. The ITS Probe Clean® has been evaluated and is safe for use. It does not change the planarity or probe tip position. Recommended overtravel continues to be 30 µm to 75 µm.

Comparison of abrasive cleaning media

Table 1 shows cleaning films that have been evaluated and do not cause damage to Pyramid Probes. The entries are sorted by wear rate. This is the amount of material removed from a Pyramid Probe tip every 1,000 cleaning touches during a controlled experiment. If you use one of these materials and are considering a change, you can see if the new material will clean (wear) the probe tip more or less than the existing one.

Table 1. Evaluating Cleaning Films

Manufacturer	Product	Type	Wear Rate (nm/1k TDs)
MIPOX	Si10000-SWE	Abrasive Coated Foam	0.5
ITS	Probe Polish 99/I (PP-9903SC/I-M)	Abrasive Loaded Elastomer	0.6
MIPOX	Si10000-PF3	Soft-backed Lapping Film	1.3
ITS	Probe Polish 70 (PP-7003SCM)	Abrasive Loaded Elastomer	1.5
ITS	Probe Polish 150 (PP-150SCM)	Abrasive Loaded Elastomer	2.6
Allied High Tech Products	Diamond Lapping Film, 1 µm (50-30145)	Lapping Film	2.6
3M	Imperial Lapping Film, 1 µm (265X)	Lapping Film	11.7
3M	Imperial Lapping Film, 3 µm (266X)	Lapping Film	15.5
MIPOX	WA6000-SWE	Abrasive Coated Foam	23.6
MIPOX	WA8000-SWE	Abrasive Coated Foam	28.8
Allied High Tech Products	Diamond Lapping Film, 3 µm (50-30140)	Lapping Film	29.9
ITS	Probe Lap, 1 µm (ITS-PL-A1H)	Lapping Film	54.6

Figure 11 shows the cleaning films that have been evaluated. Using this chart, you can compare the aggressiveness and debris generation of two different films. The scale for debris is weighted and normalized to a scale from 1 to 10.

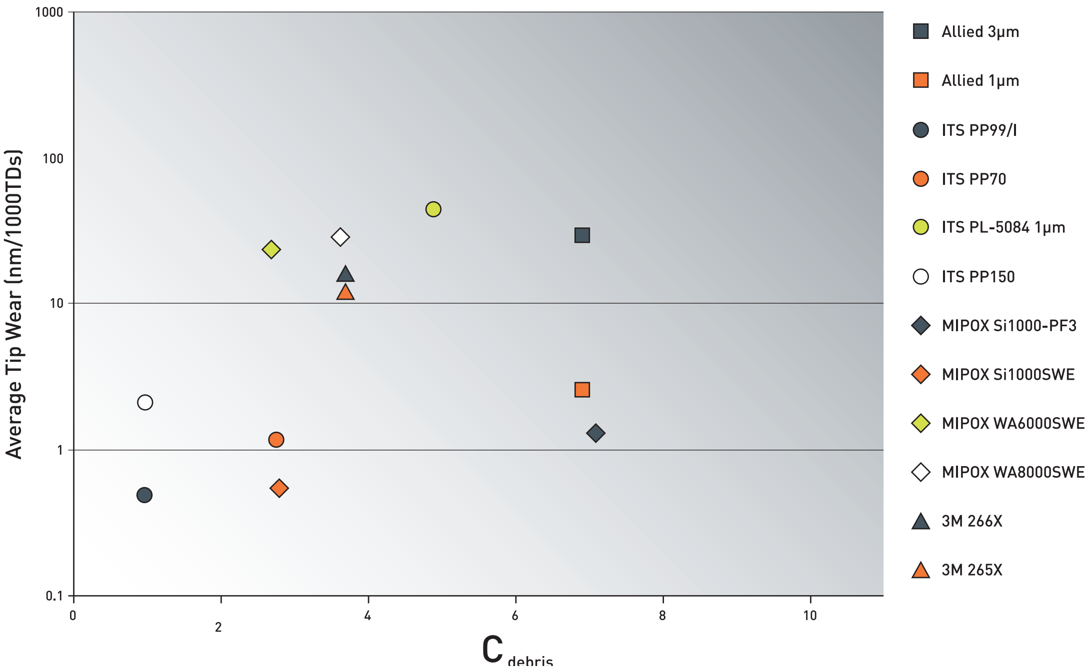

Figure 11. Comparison of tip wear and debris generation.

A study of cleaning materials was performed at Cascade Microtech. The results were presented at the 18th Annual IEEE Semiconductor Wafer Test Workshop in June 2008, in the paper by Eric Hill and Josh Smith, *Probe Card Cleaning Media Survey.* (www.swtest.org/swtw_library/2008proc/PDF/S07_01_Hill_SWTW2008.pdf).

Methods to avoid

A number of probe cleaning methods common within the industry will damage Pyramid Probe cards. These methods must not be used with Pyramid Probe cards under any circumstances. Irreversible damage to your Pyramid Probe may result.

- **Tungsten carbide, silicon carbide, alumina or other ceramic plates:** Even if they are similar to the Allied 3µm diamond lapping film in grit size, probing on these surfaces will quickly grind away Pyramid Probe tips.

- **Non-qualified chemicals:** Many chemicals are not compatible with the materials used in Pyramid Probe cores. Refer to Cascade Microtech's application note, Pyramid Probe Core Off-line Cleaning With a Brush, for a list of qualified chemicals.

- **Soft-backed lapping films:** Using soft backed lapping films applies uneven pressure on the probe tips. This causes uneven wear on the probe tips and reduces the coplanarity of the probe tips; especially at the edges or corners of an array of tips. The overtravel requirement would increase with time. This type of cleaning material should not be used to clean Pyramid Probes.

  Examples of soft-backed lapping films:

  - MIPOX PF3 types, for example, GC6000-PF3 and GC8000-PF3
  - 3M Type CL (cushion layer)
  - Stacked layers of cleaning films to create the equivalent of a soft-backed lapping film

- **Lapping films with the abrasive contained in ceramic beads**: The ceramic beads are large and damage the probe tips. They are also brittle and can shatter, causing a lot of contamination on the face of the probe. This type of cleaning material should not be used to clean Pyramid Probes.

  Examples of lapping films with ceramic beads containing abrasive:

  - Allied High Tech Products, Type B lapping films
  - 3M Type B lapping films

Table 2 shows cleaning films that have been evaluated and have been determined to likely to damage a Pyramid Probe.

Table 2. Cleaning films likely to damage a Pyramid Probe.

Manufacturer	Product	Type	Note
Allied High Tech Products	Type B Diamond Lapping Film, 1 µm (50-30145B)	Lapping Film	Damaged Tips
Allied High Tech Products	Type B Diamond Lapping Film, 3 µm (50-30140B)	Lapping Film	Damaged Tips
Allied High Tech Products	Type B Diamond Lapping Film, 6 µm (50-30135B)	Lapping Film	Damaged Tips
Allied High Tech Products	Diamond Lapping Film, 6 µm (50-30135)	Lapping Film	Extreme Debris
3M	Imperial Lapping Film, Cushion Layer, 3 µm (T-CL)	Soft-backed Lapping Film	Uneven Wear
MIPOX	GC6000-PF3	Soft-backed Lapping Film	Uneven Wear
MIPOX	GC8000-PF3	Soft-backed Lapping Film	Uneven Wear

Uncharacterized online cleaning methods

Some common industry cleaning methods can pose issues when used with Pyramid Probes, however, these methods may be acceptable in certain applications. Contact Cascade Microtech for application support before implementing any of these methods.

- Other lapping films: Lapping films are available from a number of manufacturers. Grit material, relative grit density, backing film hardness, bond resin hardness, and other variables affect the suitability of each film for cleaning Pyramid Probe cards.Cascade Microtech makes no specific recommendations regarding the suitability of these films.

- Prober-mounted brushes: These brushes may contaminate or scratch the probe face surface or cause other damage. Also, in some prober/probe configurations brush cleaning settings will cause the Pyramid Probe to be driven into the side of the cleaning chuck. This will irreparably damage the probe. Before using prober brushes to clean Pyramid Probe cards, contact Cascade Microtech for support determining appropriate prober configurations and settings.

Abrasive cleaning media suppliers

- International Test Solutions (ITS) offers a broad range of probe card cleaning products. Contact ITS directly for applicationspecific recommendations and product support. www.inttest.net

- MIPOX International Corporation offers probe card cleaning sheets with foam backing materials with a variety of abrasives and grit sizes. Contact MIPOX directly for application-specific recommendations and product support. www.mipox.co.jp/en/contact/index.html

  9 x 11 inch sheets of MIPOW WA6000-SWE are available directly from MIPOX (p/n WA6000-SWE FWX w/PSA).

- 3M offers lapping films in a variety of abrasive materials, grit sizes, and resin hardness. Contact 3M's Electronics Markets Materials Division for application-specific recommendations and product support. www.3m.com/electronics

Recommended Prober Settings

CAUTION

Probers can destroy Pyramid Probes! Consult your Cascade Microtech representative if you have any doubt of the correct prober software settings to use with Pyramid Probes.

It is important that you are familiar or become familiar with the terminology, parameter names, and capabilities of your particular prober before setting up a Pyramid Probe. Although the basic functionality is the same for all probers, the terminology to set probe cleaning parameters varies from manufacturer to manufacturer. Division for application-specific recommendations and product support. www.3m.com/electronics

Software settings
Electroglas (EG) prober parameters: Clean Type (set to "Z Only" for Pyramid Probe cards), Clean Every Nth Touchdown, Stroke Length, Number of Strokes, Location of Clean.

Tokyo Electron (TEL) prober parameters: Contact Count for Needle Polish, Same Position Contact Count, Polisher Upper Limit, Execution Interval.

Accretech (TSK) prober parameters: Wafer Interval, Die Interval, Cleaning Contact Interval, Number of Touchdowns per Cleaning, Shift Between Touchdowns.

Consult your prober documentation and make sure the settings are correct before executing any procedure described in this document. Additionally, experience has highlighted several prober-caused issues that have destroyed Pyramid Probe cores. When using any of the probers listed below, pay special attention to the specific caution.

EG2001: Use only "Z-Drive" or "Axis" mode for cleaning Pyramid Probes. "Probe Polish" mode is a circular motion that will quickly grind the probe tips away.

EG4090: The CPCS capacitive overtravel zeroing feature is not compatible with Pyramid Probes. There are known cases of crashed probe cards from the CPCS feature incorrectly detecting the probe tip height.

Accretech (TSK) UF200/UF3000/APM90: The Accretech variable "SHIFT BETWEEN TOUCHDOWNS" does not refer to the incremental step size from one cleaning touchdown to the next. Instead, it refers to total distance traveled during a cleaning instruction. The incremental step size is this value divided by the number of cleaning touchdowns per cycle. "SHIFT BETWEEN TOUCHDOWNS" must be large enough to make the incremental step size larger than the probe tip diameter.

Hardware configuration
Sometimes the hardware that is available on a prober constrains the online cleaning interval. Probers with an auxiliary cleaning chuck give the users more online cleaning options. When an auxiliary chuck is available, the cleaning film can be applied either directly to the chuck or to a removable substrate that is held by the prober. Here the cleaning interval is the probe insertions between cleanings (or die tested with a single-DUT probe). An auxiliary chuck gives the user the flexibility to set the cleaning interval as frequently (or as infrequently) as necessary with little impact on the production flow.

If the prober has no auxiliary chuck, the cleaning medium must be applied to a wafer that is loaded into the prober in place of a product wafer. To avoid unnecessary set-ups, the cleaning interval here is typically the wafers tested between cleanings. Sometimes this may not be enough cleaning to maintain yield.

Online Cleaning Frequency vs. Trade-offs

Each time you abrasively clean a probe card, the abrasive may remove a small amount of probe tip material in addition to the contaminant. When developing a cleaning strategy for probe cards, a trade off is made between the lifetime of the probe card and the test yield. Yield suffers if the probing-to-cleaning ratio is set too high. Alternatively, probe card lifetime and test equipment utilization suffer if the probing-to-cleaning ratio is set too low (Fig. 12). When developing the cleaning strategy, the objective is to determine a probing-to-cleaning ratio low enough to minimize probe tip wear, but high enough to maximize yield.

Overtravel
If all tips are in contact, increasing cleaning overtravel on Pyramid Probe tips does not increase the foreign material removal rate. In fact, higher cleaning overtravel may accelerate the accumulation of particles from the cleaning substrate.

It is best to set the overtravel high enough to ensure that all tips contact the lapping film, but low enough to minimize particle generation from the film. Typical cleaning overtravel used in the Cascade Microtech factory environment is 35 to 75 µm.

Figure 12. Trade-off between yield and probe lifetime.

Determining online cleaning parameters
Use the following procedure to determine cleaning parameters (cleaning interval, touchdowns per clean, and cleaning overtravel).

Note: Cleaning parameters quoted below are guidelines only. Optimized cleaning parameters for the best yield and lifetime must be developed in your unique probing environment.

CAUTION

Difficulty autofocusing on the probe tips can cause actual and programmed overtravel to be different. This can lead to poor cleaning performance.

1. Make sure that the proper cleaning medium is installed on the cleaning chuck or wafer.

2. Verify that the prober is set for the correct height offset or will detect the height of the cleaning surface optically.

   - ITS Probe Lap varies in thickness from 104 to 120 µm thick.

   - MIPOX International's WA6000-SWE film thickness varies from 470 to 500 µm.

3. Before installing the card in the prober, examine the probe tips under a microscope. Magnification levels of 500 to 1000x and bright-field lighting work best.

Typical probe-tip dimensions are:

- 12 µm nominal for standard aluminum or copper pads
- 18 µm nominal for POAA or low-K dieletric
- 18 µm nominal for solder balls and Sn-capped copper pillars
- 25 µm nominal for gold pad applications
- The probe tips for oxidizing metals (aluminum, copper and solder) should look similar to those shown in Figure 13 and be free of debris

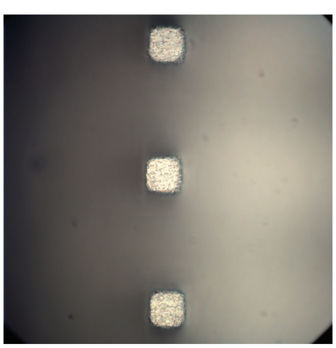

Figure 13. New probe tips for probing oxidizing metals.

4. Verify the prober cleaning settings.

   - Cleaning Type set to Z-only

   - XY increment between cleaning touchdowns at least 2 times the tip diameter

5. Choose initial cleaning overtravel, typically 35 to 75 µm.

6. Determine the cleaning interval

   a) Probe until a yield drop occurs

   b) Clean the probe tips very well with 150-200 cleaning cycles.

   c) Repeat steps a and b enough times until you can predict the number of die probed before a yield drop.

   d) Set the cleaning interval to be about 75 or 80% of the average number of touchdowns before yield drops.

7. Determine the number of touchdowns per cleaning cycle.

   a) Choose an initial value. Traditionally this has been a small number like 10 to 20. Recent experiments show that more cleaning touchdowns may increase the number of die between cleaning. Consider starting with 150 to 200 cleaning touchdowns, especially for solder ball probing.

   b) Probe several cleaning cycles to validate a stable process.

   c) Reduce the number of cleaning touchdowns by about 20%.

   d) Repeat steps b and c until the yield can not be maintained for the entire probing cycle.

   e) Increase the number of cleaning touchdowns to the previous, larger, number.

8. Remove the probe card and examine the probe tips under a microscope for signs of contamination buildup. Refer to the "Contaminants" section of this document to help you determine the type of contamination, if any, building up on the probe tips.

9. Determine the optimum overtravel using the same strategy. Start with a larger value and decrease until yield suffers.

Troubleshooting your cleaning process depends on the device yield and type and amount of contamination found. Refer to Table 3 for a summary of the actions to take based on the results:

After setting the initial parameters, allow the system to run for a period, perhaps 10 probing/cleaning cycles. When you have collected enough data to spot trends, review the device yield.

- If the yield decreases over time, varies cyclically with the cleaning interval, or is lower than expected, revisit Table 3 below to increase the cleaning efficiency.
- If the yield is stable and acceptable, consider reducing the cleaning touchdowns per cycle or interval between cleanings to verify the settings and optimize the process. Revisit Table 3 below for guidance.

Table 3. Issues and actions.

Issue	Possible Actions
Contamination on contact surface of the tips: • Metal • Organic • Oxide • Or yield does not recover after cleaning	Run cleaning cycle one or two times (150-200 touchdowns) Check probe tip height Check cleaning media height and planarity Check XY step between cleaning touchdowns Visually inspect probe marks on cleaning media Increase cleaning overtravel if contamination limited to some areas of probe Increase touchdowns per cleaning Decrease cleaning interval Monitor yield closely
Yield drops off between cleanings	Decrease cleaning interval Double Z touchdown on the DUT pads
Particles around the tips	Brush clean Reduce cleaning overtravel Clean cleaning media Change to a different type of cleaning media
Abrasion on membrane (Fig. 14)	Reduce cleaning overtravel Check probe tip height Check cleaning medium height and planarity
Repeating indents on probe face (Fig. 14)	Clean cleaning media Change cleaning media
None	Return to service Increase cleaning interval Reduce touchdowns per cleaning

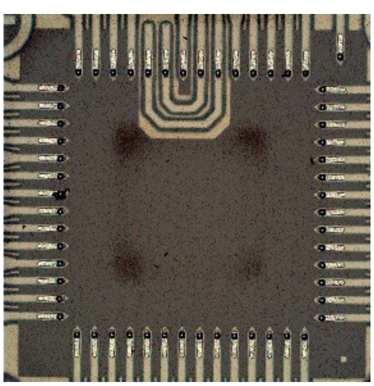

Figure 14. Lapping film abrasion on membranes.

Recommended Offline Cleaning Methods and Materials

Refer to the Cascade Microtech application note titled Pyramid Probe Core Off-line Cleaning With a Brush for a complete brush-cleaning procedure.

Abrasive Cleaning (Recovery Cleaning)

CAUTION

Abrasive cleaning can reduce the lifetime of your Pyramid Probe card. Use this procedure only after other possibilities have been exhausted.

Extreme resistive-buildup contamination can be removed by abrasively cleaning the probe tips. This cleaning process is identical to the online process described above, except that the number of touchdowns is higher.

A recovery clean can be performed with 150-200 touchdowns on an abrasive film. Sometimes more aggressive cleaning is required. In these instances, up to 1,000 touchdowns may be necessary to remove the contamination. Accumulation of contamination this tenacious usually indicates other problems in the probing environment. High current, residue on bond pads, insufficient online cleaning, and hot probing (making or breaking contact with power applied) can all contribute to abnormal accumulation of resistive films on Pyramid Probe tips.

Factory Service

To remove the most severe contamination, return the probe card to Cascade Microtech for cleaning. Contact your Cascade Microtech representative for an RMA number.

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