Pyramid Probe Card: P800-S Online Cleaning

Quick Reference Guide

Objective

Particulate contamination can build up on the probe face and tips during probing. In some cases, particulate contamination may go unnoticed by the user, while in others it can cause persistent open channels. Large, hard particles can crush probe tips and are a leading cause of premature, catastrophic probe card failure. This application note describes the recommended online cleaning methods for Pyramid Probes with a steel plunger stack, for example the P800-S (*see* Figure 1), when probing solder balls.

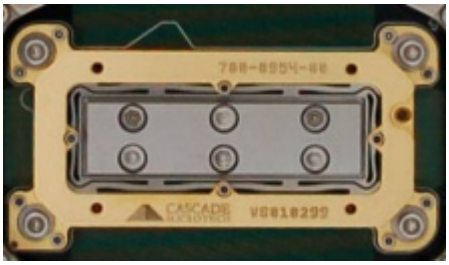


Figure 1. P800-S mounted on a PCB.

This application note starts with some general information regarding contaminants that may be found in probing environments. It then describes Cascade Microtech's recommendations for online cleaning methods and a proposed cleaning recipe. Finally, a procedure for determining the optimum value of online cleaning parameters is described.

NOTE

For details on cleaning Pyramid Probes with a plastic plungers, see the application note titled "Online Cleaning Methods for Pyramid Probe Cards".

Contaminants

Contaminants on Pyramid Probes can be divided into two general classes:

- Particulate contaminants
- 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, while in others it can cause persistent open channels. Though unlikely in solder ball probing applications, large, hard particles can crush probe tips and are a leading cause of premature, catastrophic probe card failure.

Once particles have been transferred to the membrane, they are best removed by using the offline cleaning brush supplied with your core. This procedure is described in the application note titled *Pyramid Probe Cores Off-line Cleaning With Brush*.

The best solution for particulate contamination, however, is removal of the particles at their source. A few simple precautions can protect Pyramid Probes from particulate damage. To avoid accidental damage to the probe core:

- Probe in a cleanroom environment.
- Use extreme caution when probing correlation wafers.
- 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 touch the membrane, even with gloved hands.
- Do regular preventative maintenance to clean the wafer area of the prober.

Resistive-Buildup Contaminants From Solder

Resistive buildup contaminants such as organics and oxides can accumulate on the probe tips during probing (*see* Figure 2, Figure 3). 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.

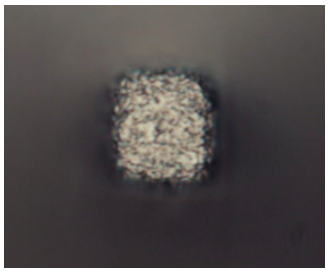


Figure 2. Clean probe tip.

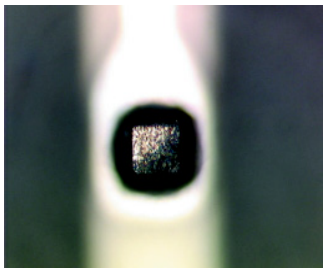


Figure 3. Solder buildup.

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. 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.

Online Cleaning Materials

CAUTION

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

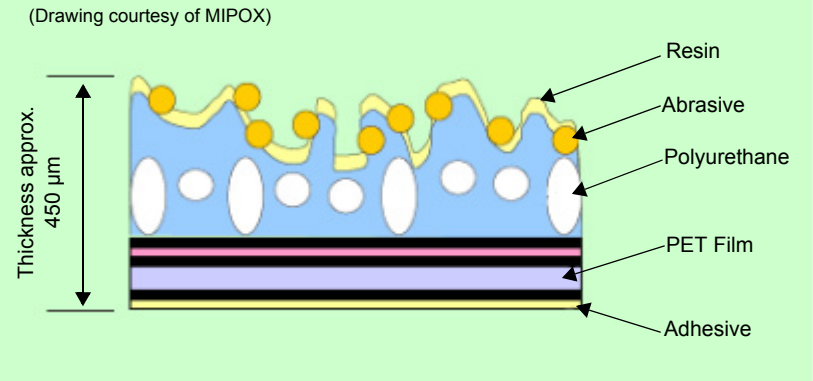
The most effective method for controlling contact resistance (Rc) and cleaning resistive buildup from Pyramid Probe tips is online cleaning by touching down on an abrasive. Abrasive cleaning media can be divided into four categories:

- Abrasive coated foams
- Abrasive loaded elastomers
- Lapping films
- Soft-backed lapping films

The only recommended media for cleaning the P800-S is an abrasive coated foam.

The results of a cleaning study performed at Cascade Microtech were presented at the at the 18th Annual IEEE Semiconductor Wafer Test Workshop in June 2008 in a paper by Eric Hill and Josh Smith, *Probe Card Cleaning Media Survey*. The presentation can be viewed at: http://www.swtest.org/swtw_library/2008proc/PDF/S07_01_Hill_SWTW2008.pdf.

Table 1. Recommended, acceptable and unacceptable online cleaning materials and methods.

Recommended	Abrasive Coated Foams	The most common source for abrasive coated foams is MIPOX International. Abrasive-coated foams consist of a layer of abrasive particles in a resin binder. Instead of being bonded to a polyester film carrier like a lapping film, the particles are coated onto a soft, open-celled foam. These films are typically 450-500 µm thick. Abrasive-coated foams are the only recommended cleaning media for P800-S type Pyramid Probes.  Figure 4. Abrasive coated foam architecture. MIPOX International Corporation offers probe card cleaning sheets with foam backing materials in a variety of abrasives and grit sizes. Contact MIPOX directly for application-specific recommendations and product support (http://www.mipox.co.jp/en/contact/index.html). MIPOX International's WA6000-SWE is used in the factory for cleaning P800-S Pyramid Probes. Sheets of 9 x 11 inch MIPOW WA6000-SWE are available directly from MIPOX (p/n WA6000-SWE FWX w/PSA).
Acceptable	Abrasive Loaded Elastomers	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. The most common source of this type of cleaning film is International Test Solutions (ITS). Abrasive-loaded elastomers are expected to be safe for use.

Unacceptable	Lapping Films	The traditional method used for cleaning cantilever probe cards. Lapping film contains abrasive particles that have been bonded to the backing film with a relatively hard resin binder. These films are typically 75-125 µm thick. The preferred method for cleaning Pyramid Probes with a *plastic* plunger uses Allied High Tech Products' 3 µm Diamond Lapping Film, after removing some of the binder. However, lapping film should NOT be used with the P800-S type Pyramid Probes, as too much overtravel (force) is required to make contact with all the probe tips.
	Soft-Backed Lapping Films	Using soft backed lapping films applies uneven pressure on the probe tips causing uneven wear, reducing coplanarity, especially at the edges or corners of an array of tips, and increasing the overtravel requirement over time. In addition, too much overtravel is required to make contact with all the probe tips. This type of cleaning material should not be used to clean Pyramid Probes. Examples of soft-backed lapping films include: • MIPOX PF3 types, for example, GC6000-PF3 and GC8000-PF3, SI10000-PF3 • 3M Type CL (cushion layer) • Stacked layers of cleaning films to create the equivalent of a soft-backed lapping film
	Other	A number of probe cleaning methods common within the industry can cause irreversible damage to Pyramid Probe cards. These methods must not be used with Pyramid Probe cards under any circumstances: • Tungsten Carbide, Silicon Carbide, Alumina or other Ceramic Plates - even if they are similar to the Allied 3 µm diamond lapping film in grit size, probing on these surfaces will quickly grind away Pyramid Probe tips. • Non-qualified chemicals - many chemicals are incompatible with the materials used in Pyramid Probe cores. Refer to the Cascade Microtech application note, *Pyramid Probe Core Off-line Cleaning With Brush* for a list of qualified chemicals. • Lapping Films with the abrasive contained in ceramic beads - the large ceramic beads can damage the probe tips. The beads are also brittle and can shatter, causing 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 include: — Allied High Tech Products, Type B lapping films — 3M Type B lapping films

Online Cleaning Parameters

General Precautions

When using a prober or cleaning station, never clean Pyramid Probe cards 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 contacting the cleaning substrate using only a Z-axis motion. Many probers and probe card analyzers default to a scrubbing X-Y motion, which must be disabled.

CAUTION

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

When stepping Pyramid Probe cards down on a cleaning substrate, do not exceed 250 µm in overtravel. Overtravel between 35 and 75 µm is optimal for most cleaning applications. Higher overtravel is more likely to generate particles from the cleaning film.

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 Probe cards by contacting a cleaning substrate takes multiple touchdowns to achieve good results. A ratio of 2.5 probing cycles to the number of cleaning cycles is expected. Experiment to find the cleaning count that works best in your environment. Eighty cleaning contacts for 200 touchdowns is a good number to start.

Online Cleaning Frequency – Yield vs. Wear

Each time a probe card is cleaned abrasively, a small amount of probe tip material may be removed 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. 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.

Figure 5. Probing-to-cleaning touchdown ratio.

Overtravel

If all the 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.

The tips on a Pyramid Probe range from 20-55 µm tall. The foam on abrasive coated foams is soft, enabling the probe tips to push into it relatively easily. Therefore, increasing overtravel values far beyond the tip length does not increase the cleaning action because the tips are buried and the probe face is simply compressing the foam.

It is best to set the overtravel high enough to ensure that all tips contact the 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.

Cleaning Recipe, Initial Settings

Experiments were performed in the factory on solder covered wafers to establish a cleaning recipe to use as a starting point for customers probing solder balls with P800-S Pyramid Probes. Contact resistance was monitored while the number of cleaning touches was varied. Cleaning cycles were made after every 200 contact resistance measurements. A ratio of probing contacts to cleaning contacts was calculated for each recipe. The tested ratios were 1:1, 2.5:1, 5:1, and 10:1. The results showed that the highest ratio of probing to cleaning that maintained less than 0.5 ohms increase in contact resistance was 2.5:1; or 80 cleaning cycles for every 200 measurements. A cleaning recipe can be created using the process described in this document, or by starting with these values and refining them based on yield.

Die between cleaning cycles	200
Cleaning TD per cycle	80
Cleaning overtravel:	50 µm
Cleaning material	MIPOX WA6000-SWE

Procedure: Determining Cleaning Parameters

NOTE

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

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

1. Ensure 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. 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 are optimal. Typical probe-tip dimensions are:
   - 18 µm nominal for fine-pitch solder balls
   - 25 µm nominal for wide-pitch solder balls
4. Verify the prober cleaning settings.
   - Cleaning Type set to Z-only
   - The XY increment between cleaning touchdowns is at least 2 times the tip diameter
5. Choose initial cleaning overtravel in the range of 35 to 75 µm. 50 µm is the recommended.

CAUTION

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

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. *See* Contaminants on page 1 for information on contamination type, 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.

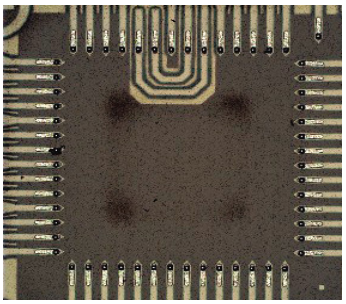


Figure 6. Lapping film abrasion on membrane.

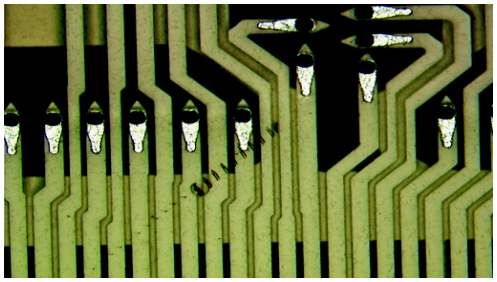


Figure 7. Repeating particle indent, near miss.

Troubleshooting

Troubleshooting your cleaning process depends on the device yield, and the type and amount of contamination found. Refer to Table 2 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, refer to Table 2 to increase the cleaning efficiency.
- If the yield is stable and acceptable, consider reducing the cleaning touchdowns per cycle or increasing the interval between cleanings to verify the settings and optimize the process. See Table 2 below for guidance.

Table 2. Troubleshooting.

Issue	Possible Actions
Contamination on tips: • Metal • Organic • Oxide • Or yield does not recover after cleaning	• Run cleaning cycle 1 or 2 times (100-200 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
Particles around the tips	• Brush clean • Reduce cleaning overtravel • Clean cleaning media • Change to a different type of cleaning media
Abrasion on membrane (*see* Figure 6)	• Reduce cleaning overtravel • Check probe tip height • Check cleaning medium height and planarity

Issue	Possible Actions
Repeating indents on probe face (*see* Figure 7)	• Clean cleaning media • Change cleaning media
None	• Return to service • Increase cleaning interval • Reduce touchdowns per cleaning

Recommended Offline Cleaning Methods and Materials

Brush Cleaning

Refer to the Cascade Microtech Application Note, *Pyramid Probe Core Off-line Cleaning With a Brush* for a complete brush-cleaning procedure.

Abrasive Cleaning

CAUTION

Offline 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.

In most cases resistive tips can be cleaned up with only 150-200 touchdowns on the cleaning film. However, sometimes more aggressive cleaning is required. In these instances, up to 1000 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.

Service

To remove the most severe contamination, return the probe card to Cascade Microtech for cleaning. Before shipping a part to Cascade Microtech, obtain a Return Material Authorization number (RMA #). Contact Cascade Microtech customer service at (800) 550-3279 or (503) 601-1000.

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