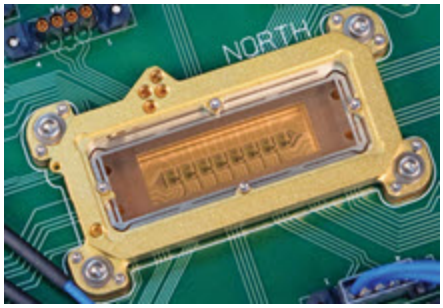
Pyramid Probe Card: Online Cleaning

Particulate contamination can build up on the probe face and tips during probing, resulting in damage and poor performance. This guide describes the materials and methods recommended for online cleaning of Pyramid Probes configured with plastic plungers.

Pyramid Probe with plastic plunger



P800-S Pyramid Probe with steel plunger

NOTE

For information on cleaning P800-S Pyramid Probes with steel plungers, see the Pyramid Probe Card: P800-S Online Cleaning Quick reference Guide.

This guide includes information on the following topics:

Contaminants

Pyramid Probe contaminants can be divided into two general classes:

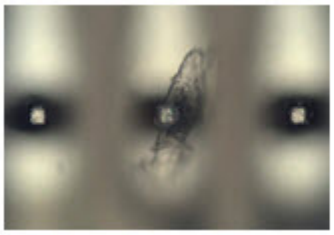
- Particulate Contaminants
- Resistive Buildup Contaminants (Organics, Oxides)

Pyramid Probe Card: Online Cleaning

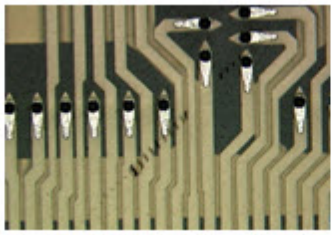
Particulate Contaminants

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. Large, hard particles can crush probe tips and are a leading cause of premature, catastrophic probe card failure.

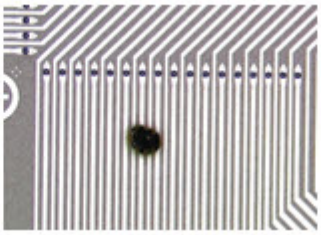
Examples: particulate contamination and its effects



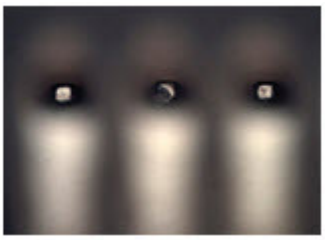
Particle on tip, likely open



Repeating particle indent, near miss



Deep particle indent, three open traces



Particle hit, probe tip damaged

Once particles have been transferred to the membrane, they are best removed by using the offline cleaning brush supplied with your core. See the *Pyramid Probe Cores Offline Cleaning With Brush Quick Reference Guide* for details.

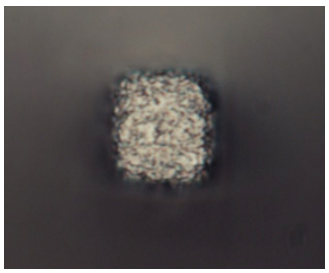
The best solution for particulate contamination, however, is removal of the particles at their source. A few simple precautions can protect Pyramid Probes from particulate damage. To avoid accidental damage to the probe core:

- Probe in a clean room environment
- Wash wafers immediately before probing (particularly after laser scribe operations)
- 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 probe wafers that have been stored in an unclean environment
- Do not touch the membrane, even with gloved hands
- Perform regular preventative maintenance to clean the wafer area of the prober

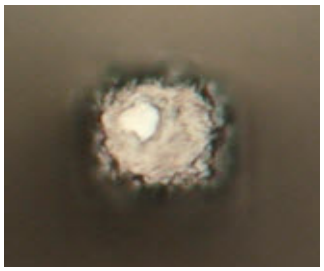
Resistive Buildup Contaminants (Organics, Oxides)

Resistive buildup contaminants such as organics and oxides can accumulate on the probe tips during probing. To maintain high yield, these contaminants must be removed by abrasive cleaning. For best results, preventive measures should be taken to remove this contamination. Resistive buildup contaminants do not usually damage probe tips directly, but can result in increased contact resistance. To compensate, users may choose to increase overtravel, which can stress probe tips and cause premature probe failure.

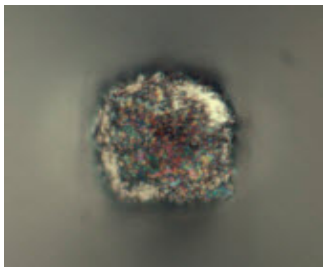
Pyramid Probe tips do not typically experience as much resistive contaminant buildup as other probe technologies, as the patented MicroScrub action of Pyramid Probes penetrates the metal oxides and cleans the probe tips with each contact. When contaminant buildup does occur, it typically appears as a discoloration on the probe tip.



Clean probe tip



Aluminum buildup

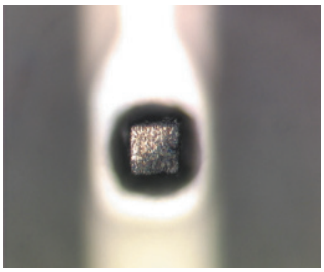


Copper buildup

Pyramid Probe Card: Online Cleaning

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. 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.



Solder buildup

Online Cleaning Methods

- Recommended Cleaning Materials
- Unacceptable Cleaning Materials
- Uncharacterized Cleaning Materials

Recommended 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, described in Table 1.

Table 1. Abrasive cleaning media.

Media	Description
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. Abrasive coated foams have demonstrated good results. However, a tendency to round probe tips has resulted in increased pressure on the pad, potentially requiring a requalification if used on pad-over-active-area (POAA) or low-K dielectric devices. Abrasive coated foams should be acceptable for all other applications. MIPOX International's WA6000-SWE is the recommended cleaning material for P800-S type Pyramid Probes.
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.

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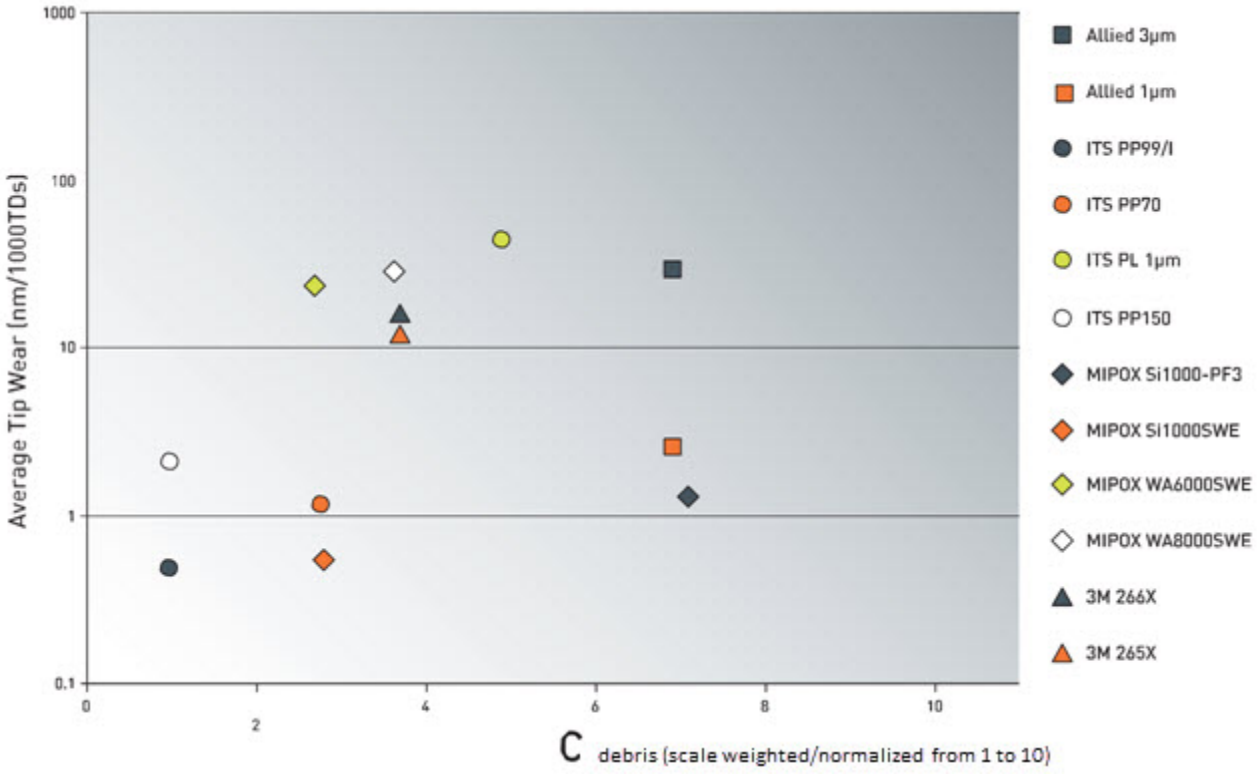
Media	Description
Lapping films	Lapping films are the traditional method used for cleaning cantilever probe cards. Lapping film contains abrasive particles that have been bonded to a polyester backing film with a relatively hard resin binder. These films are typically 75-125 µm thick. No correlation has been found between overtravel on lapping films and tip wear on Pyramid Probes. In fact, there is a strong correlation between high cleaning overtravel and particle generation. The minimum overtravel for good results is recommended. All lapping films have been observed to generate particles (from the binder attaching the abrasive particles to the backing) during the cleaning process. **NOTE** *The only acceptable soft backed, lapping film is MIPOX Si10000-PF3, as the abrasive (SiO2) is softer than the Pyramid Probe tips, making damage unlikely.*
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 is safe for use and does not change the planarity or probe tip position. Recommended overtravel is 30 to 75 µm.

Table 2. Cleaning film wear rate (per every 1000 touchdowns).

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

Pyramid Probe Card: Online Cleaning

Tested cleaning films: tip wear and debris generation



Abrasive cleaning media are available from these suppliers. Contact the supplier directly for application specific recommendations and product support.

- International Test Solutions (ITS) (www.inttest.net) – offers a broad range of probe card cleaning products
- MIPOX International Corporation (www.mipox.co.jp/en/contact/index.html) – offers probe card cleaning sheets with foam backing materials, in a variety of abrasives and grit sizes.

> **NOTE**
>
> *Sheets of MIPOX WA6000-SWE (9 x 11-inch) are available directly from MIPOX (p/n WA6000-SWE FWX w/PSA).*

- 3M (www.3m.com/electronics) – offers lapping films in a variety of abrasive materials, grit sizes, and resin hardness

Unacceptable Cleaning Materials

The cleaning methods described Table 3 and Table 4 can cause irreversible damage to Pyramid Probe cards. These methods must not be used with Pyramid Probe cards under any circumstances.

Table 3. Unacceptable online cleaning materials.

Media	Description
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. See the *Pyramid Probe Core Offline Cleaning With Brush Quick Reference Guide* for a list of qualified chemicals.
Soft backed lapping films	In general, soft backed lapping films should be avoided. 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
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

Table 4. Unacceptable cleaning materials and damage likely to occur.

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 Cleaning Materials

The common industry cleaning methods discussed in Table 5 can pose potential issues when used with Pyramid Probes. However, these methods may be acceptable in certain applications. Contact FormFactor for application support before implementing any of these methods.

Table 5. Uncharacterized cleaning materials.

Media	Description
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. FormFactor 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. Brush cleaning settings in some prober/probe configurations can drive the probe into the side of the cleaning chuck, causing irreparable probe damage. Before using prober brushes to clean Pyramid Probe cards, contact a FormFactor representative to determine appropriate prober configurations and settings.

System Configuration

Prober Software Settings

CAUTION

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

Although the basic functionality is the same for all probers, the terminology to set probe cleaning parameters varies between manufacturers. Familiarize yourself with the terminology, parameter names, and capabilities of your specific prober before setting up a Pyramid Probe.

CAUTION

Take note of these prober-specific cautions to avoid damaging your probe.

Prober	*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" refers to total distance traveled during a cleaning instruction, rather than the incremental step size from one cleaning touchdown to the next. 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.*

NOTE

Consult your prober documentation and make sure the settings are correct before executing any procedure described in this document.

Table 6. Prober specific settings.

Prober	Settings
Electroglas (EG)	• 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)	• Contact Count for Needle Polish • Same Position Contact Count • Polisher Upper Limit • Execution Interval
Accretech (TSK)	• Wafer Interval • Die Interval • Cleaning Contact Interval • Number of Touchdowns per Cleaning • Shift Between Touchdowns

Auxiliary Chuck

Probers with an auxiliary cleaning chuck offer 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 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 provides 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 loaded into the prober in place of a product wafer. To avoid unnecessary setups, the cleaning interval here is typically the wafers tested between cleanings, which may not be enough cleaning to maintain yield.

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 XY 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.

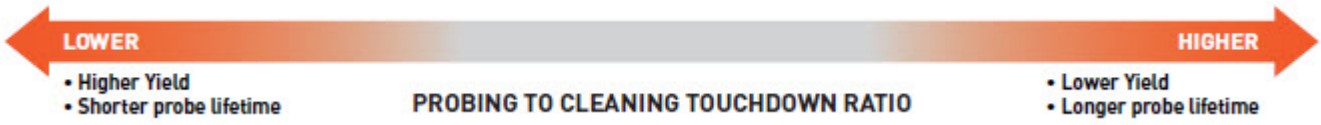
When stepping Pyramid Probe cards down on a cleaning substrate, do not exceed 250 µm in overtravel. Overtravel between 35 and 75 µm is optimal for most cleaning applications. Higher overtravel is more likely to generate particles from the cleaning film.

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.

Pyramid Probe Card: Online Cleaning

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. 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. 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.



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.

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 factory environment is 35 to 75 µm.

Procedure: Determining Cleaning Parameters

CAUTION

Difficulty autofocusing on the probe tips can cause a discrepancy between actual and programmed overtravel, leading to poor cleaning performance.

NOTE

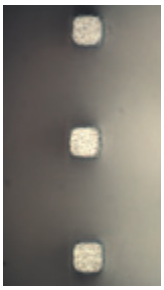
The cleaning parameters described here are guidelines only. Optimized cleaning parameters for the best yield and lifetime must be developed in your unique probing environment.

Follow these steps 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 that it 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. Examine the probe tips under a microscope. Magnification levels of 500 to 1000x and bright field lighting are optimal. Probe tips should be free of debris. Typical probe tip dimensions are:
   - 13 µm nominal for standard aluminum or copper pads
   - 11 um Sn-capped copper pillars (<100 µm diameter)
   - 18 µm nominal for POAA or low-K dielectric
   - 18 µm nominal for solder balls and Sn-capped copper pillars (>100 µm diameter)

– 25 µm nominal for gold pad applications

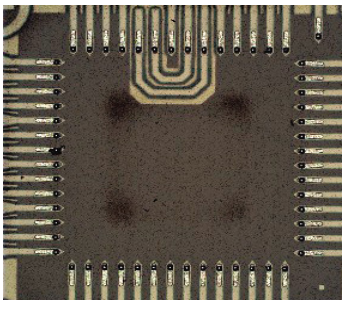
Example: probe tips for oxidizing metals
(aluminum, copper and solder)



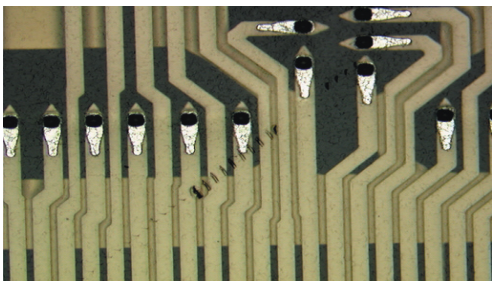
4. After probe card inspection, load the probe card onto the prober.
5. Verify the prober cleaning settings:
   – Cleaning type set to Z only
   – XY increment between cleaning touchdowns at least 2 times the tip diameter
6. Select the initial cleaning overtravel, typically 35 to 75 µm (50 µm is recommended).
7. Determine the cleaning interval:
   a. Probe until a yield drop occurs.
   b. Clean the probe tips well, with 200-500 cleaning cycles.
   c. Repeat step a and step b until you can predict the number of die probed before a yield drop.
   d. Set the cleaning interval to approximately 75% or 80% of the average number of touchdowns before yield drops.
8. Determine the number of touchdowns per cleaning cycle.
   a. Choose an initial value. This number is typically between 25 and 30.

> **NOTE**
>
> *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 approximately 20%.
   d. Repeat step b and step 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.
9. Remove the probe card and examine the probe tips under a microscope for signs of contamination. See Contaminants on page 1 for details on contamination types.



Lapping film abrasion on membrane



Repeating particle indent, near miss

Pyramid Probe Card: Online Cleaning

Troubleshooting

Troubleshooting your cleaning process depends on the device yield, and the type and amount of contamination found.

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 the table below 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.

Issue	Possible Actions
Contamination on tips: • Metal • Organic • Oxide • Or yield does not recover after cleaning	• Run cleaning cycle 1 or 2 times (200-500 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	• Offline brush clean • Reduce cleaning overtravel • Replace cleaning media • Change to a different type of cleaning media
Abrasion on membrane (see figure "Lapping film abrasion on membrane" on page 10)	• Reduce cleaning overtravel • Check probe tip height • Check cleaning medium height and planarity
Repeating indents on probe face (see figure "Repeating particle indent, near miss" on page 10)	• Replace cleaning media
None	• Return to service • Increase cleaning interval • Reduce touchdowns per cleaning

Offline Cleaning Methods

Brush Cleaning

For a complete brush cleaning procedure, refer to the *Pyramid Probe Core Offline Cleaning With a Brush Quick Reference Guide*.

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.

Pyramid Probe Card: Online Cleaning

In most cases resistive tips can be cleaned up with only 200-500 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 FormFactor for cleaning. Before shipping a part to FormFactor, obtain a Return Material Authorization number (RMA #). Contact FormFactor customer service at (800) 550-3279 or (503) 601-1000.

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