Celadon Probe Cards and Products

A Guide to Contact Resistance, Frequently Asked Questions, and Best Practices

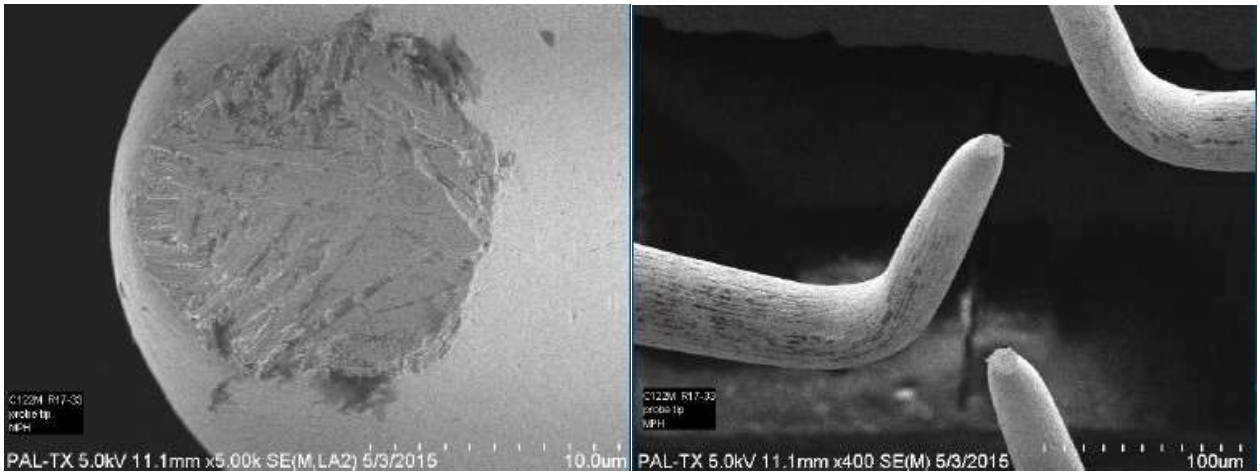

Figure 1: SEM images of a probe tip

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1 INTRODUCTION: WHAT IS CONTACT RESISTANCE, AND WHY DOES IT MATTER

This guide provides information on Contact Resistance [Cres] as measured in ohms [Ω] from probe tip to bond pad on semiconductor wafers. Cres is an electrical quantity that measures how the contact area between the probe and the pad impedes the electrical flow.

Why is this important?

Maintaining low Cres is crucial for preserving the electrical integrity and quality of collected data. Improper management of Cres can lead to data offsets and an increased risk of probe tip damage, wear, and melting. Testing for an extended period requires stable Cres measurements to provide accurate data.

In addition, managing Cres is essential for extending the lifespan of probe tips on a probe card. In high-current applications, an increase in Cres due to embedded particles or oxidation can cause localized Joule heating as power is directed through a smaller area. If Cres becomes excessively high, it can result in damage or complete melting of the probe tip, leading to significant repair costs for the card. Maintaining the probe performance and preventing damage can be accomplished using an appropriate cleaning protocol.

2 FREQUENTLY ASKED QUESTIONS

- **What cleaning process should I use for my probe cards?**
  - The exact cleaning process and recipe can differ considerably among customers due to the significant variations in tests, conditions, and wafer materials. While Celadon Systems provides basic basleine recommendations, the specific cleaning protocol should be tailored by each customer based on the test requirements, electrical tests conducted, lab environment, and wafer material.

- **What is the cleaning material replacement frequency?**
  - Probe card cleaning materials are used to remove and capture debris from the probe process. Over time, debris will accumulate on the working surface, reducing cleaning effectiveness. Each process generates different amounts of debris and has unique requirements for maintaining contact resistance. When the cleaning sheet becomes saturated with debris, it loses its ability to recover contact resistance and should be replaced. Regular visual inspection is recommended, and cleaning materials should be replaced once Cres recovery becomes inconsistent.

- **Will aggressive cleaning to manage Cres decrease probe lifetime?**
  - Aggressive cleaning of a probe tip will remove some amount of probe material with each cleaning cycle along with the contaminants. Although this process will recover the Cres, it will also dramatically affect the longevity of the probes. Over time, an aggressive cleaning process reduces the probe tip length and will also make the scrub marks larger. As a result, the overall lifetime of the probe card will be dramatically reduced. Celadon has developed a balanced cleaning process that manages Cres with regular elastomer online cleaning combined with a periodic abrasive cleaning using a WC substrate. The online elastomer cleaning maintains the tip shape during long-term testing and the WC is effective for periodically addressing “stubborn” debris to refresh the contact surface. By utilizing this combination of materials for regular cleaning, extremely long probe life in Celadon probe cards can be attained.

- **Is In-Situ [In-Line] cleaning sufficient to maximize the life of my probe card?**
  - Celadon probe cards benefit from a balanced maintenance approach using a combination of in-situ and off-line cleaning strategies:
    1. In-Situ cleaning using prober auxiliary chucks with cleaning substrates or cleaning wafers
    2. Off-line cleaning with the Celadon toothbrush on-site
    3. Bi-annual Probe Maintenance [PM] at Celadon headquarters [details on PM service in section 3.

    When Properly maintained, Celadon probe cards can achieve over 10 million device or test structure touchdowns [ref:1].

- **Does my offline cleaning alcohol effect the product?**

- Celadon has determined that the type of alcohol can impact the electrical performance of probe cards and accessories. Isopropyl alcohol (IPA) may leave a residue that leads to leakage and performance issues. Therefore, Celadon advises using semiconductor-grade ethyl alcohol, specifically "Denatured Ethyl Alcohol - Anhydrous 99% - Technical Grade NA-1987."

- **Should I clean my motherboard PCB?**
  - Spot cleaning 4062, 4062-80, and 4080 series motherboards is acceptable. Use a clean room cloth with Ethyl alcohol to spot clean, wipe off with clean room cloth and DI water, bake for 2hours at 80C. **Do not fully submerge!**

3 Contact Resistance Management – Best Practices

Proper maintenance of probes and probe cards is essential for maintaining low contact resistance (Cres). High and unstable Cres does not increase with a single test but gradually rises as particles accumulate on the tip of the probe, affecting the electrical signal and impeding current flow. The magnitude and variance of Cres increase with repeated touchdowns.

3.1 For Offline Probe Maintenance:

The following data represents measurements taken from an incoming probe card exhibiting Cres issues in the field. Celadon conducted incoming Cres measurements on a blanket aluminum sputtered wafer.

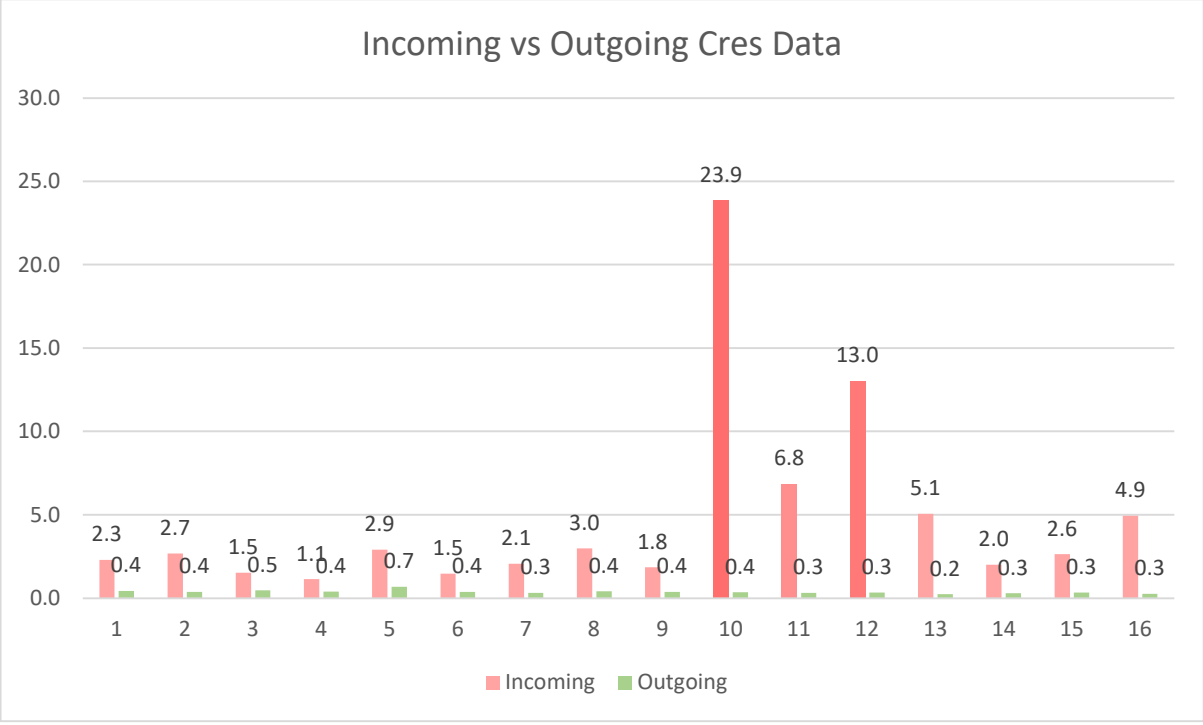

Figure 2: Real data of outgoing vs incoming data of Celadon services.

Upon receipt of the card at Celadon, the card undergoes a series of cleaning processes involving an alcohol and hot water bath, followed by air drying, and then baking for 2-4 hours. This bath and bake procedure effectively manages leakage. Cres management is achieved by contacting the probe card on a Celadon Tungsten Carbide [CWC™] substrate. **For best results with the Tungsten Carbide cleaning substrate, it is crucial that the overdrive used matches that of the test environment.**

3.2 For In-Situ Probe Cleaning and Maintenance*:*

Celadon recommends Gel-Probe ReFine Cleaning Materials supplied by Gel-Pak. Gel-Pak® Gel-Probe REFINE™ polishing sheets consist of a proprietary Gel elastomer material that is uniformly blended with silicon-carbide abrasive particles and backed with a polyimide carrier film for easy installation. The elastomer materials is filled with various levels of abrasive particles to for controlled levels of polishing action.

The polishing Gel elastomer only exerts forces on the probes in the Z (vertical) direction and the force is less than that imparted during normal test conditions. No lateral force is applied to the probe tips.

There are different part numbers for various prober applications with standard cleaning unit or polish plate geometries. Some examples of the qualified Gel-Probe ReFine Part (ReFine-M3 and ReFine-H3) and associated XY dimensions for the prober plates are outlined in the table below.

Table 1: Gel-Probe sizes and offerings from Gel-Pak.

Probe Station	Gel-Probe part number	Size and Shape
TEL P8/P8E Accretech UF200	• GPF-R00050-M3 (~99%) • GPF-R00050-H3 (~150%)	50mm round cleaning sheet for cleaning stage.
Electroglas EG4085	• GPF-038038-M3 (~99%) • GPF-038038-H3 (~150%)	38mm x 38mm cleaning sheet for auxiliary plate.
Tokyo Electron P8XL-LC	• GPF-084100-M3-SV005 (~99%) • GPF-084100-H3-SV005 (~150%)	84mm x 100mm WAPP that includes a cut-out
Accretech UF200	• GPF-R00050-M3 (~99%) • GPF-R00050-H3 (~150%)	50mm round cleaning sheet for cleaning stage.
Cleaning Wafer, 200mm Cleaning Wafer, 300mm	• GPF-W2-M3 (~99%); GPF-W2-H3 (~150%) • GPF-W3-M3 (~99%); GPF-W3-H3 (~150%)	• 200mm (W2) Wafer • 300mm (W3) Wafer

NOTE – customized XY sheet sizes of the Gel-Probe materials are avaialbe from from Gel-Pak.

3.3 Basic Cleaning Recipe Guidance:

Cleaning recipe optimization is typically performed based on individual customer test requirements. When developing a cleaning strategy for Celadon probe cards, a balance must be found between the

probing-to-cleaning ratio in order to maximum probe card lifetime while maintaining best possible data quality.

If the probing-to-cleaning ratio is too high (i.e., not enough cleaning is performed), the data quality suffers. Conversely, if the probing-to-cleaning ratio is too low (i.e., too much cleaning is performed), both probe card lifespan can be dramatically reduced without data quality improvements. The objective is to find a probing-to-cleaning ratio that minimizes probe tip wear while maximizing performance.

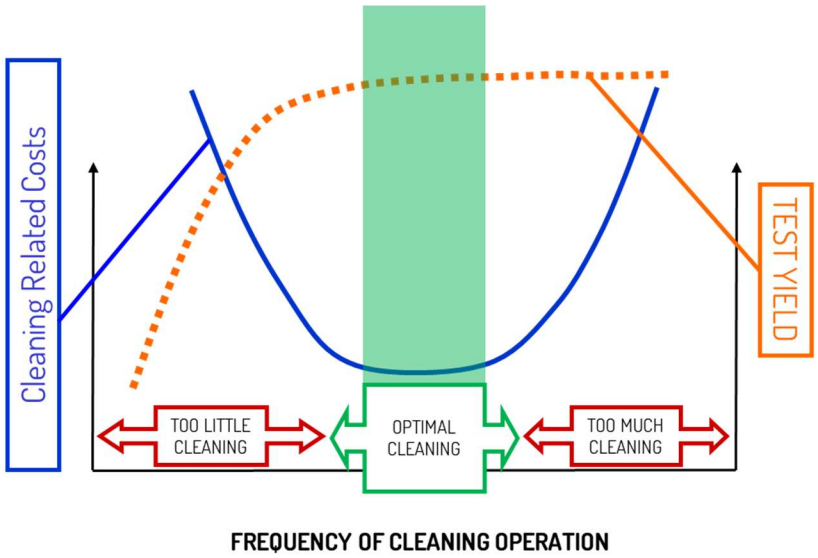

Figure 3: Visual of how the frequency of cleaning can impact customer testing.

To begin defining the parameters for optimal cleaning, outlined below are some fundamental starting points for using elastomer cleaning in online cleaning recipe development. As indicated previously, the exact cleaning process and recipe can differ considerably between customers. Some production customers will execute cleaning cycles using ReFine cleaning materials as frequently as every 250-500 touchdowns/device contacts.

Table 2: Starting recommendations for cleaning when probing on Aluminum Pads

Cleaning Recipe Parameter	Starting Recommendation for Aluminum Pads Using the Gel-Probe ReFine (M3 and H3 Type) Cleaning Materials
Cleaning Frequency	• T < 25C: 50 to 250 die touchdowns • T = 25C: 50 to 500 die touchdowns • T > 25C: 50 to 250 die touchdowns *The number of cleaning touchdowns is adjusted based on the debris accumulation and electrical requirements*.
Cleaning Insertions per Cycle	• T < 25C: 25 to 50 clean insertions • T = 25C: 10 to 25 clean insertions • T > 25C: 25 to 50 clean insertions *Number of cleaning insertions per cycle is typically increased until the probe tip is clean and free of adherent debris*.
Cleaning Index	Index between insertions by approximately 1.25 to 2.25X the probe diameter in both the X and Y directions. *Cleaning surface should be regularly inspected during regular usage*.
Utilization	*The Gel-elastomer does not break down easily when repeatedly used in the same location; however, the probe type, and amount of debris generated will affect the total number of cleaning rotations before the cleaning performance is affected*.

For the Gel-Probe ReFine materials, touchdown Z-Up / Z-Down to 30 times in a step array, with at least 75 microns between steps. Stepping will prevent overuse of the polymer working surface that could result in picking up particulates onto the probes. Overdrive can be **over your normal test environment**, up to 100µm works well without damaging the probecard. To maintain consistent cleaning performance, the Gel-Probe ReFine cleaning sheets must be exchanged on a regular and consistent basis.

When Cres gets too high, only then do you use a CWC™ plate or wafer to remove embedded particles and oxidation.

The table below summarizes existing Cleaning Recipes from the field, along with the appropriate Gel-Probe part number replacements for legacy Probe Polish (PP) cleaning materials. Based on Celadon's qualifications with Gel-Probe materials, we are confident that the legacy Probe Polish (PP) cleaning materials can be replaced by equivalent Gel-Probe materials as a "drop-in" with minimal to no risk. Rigoirous internal testing has confirmed that the performance of Gel-Probe materials surpasses that of legacy Probe Polish (PP) materials.

Table 3: Existing cleaning material and Gel-Probe equivalent cross reference table.

User	Legacy Cleaning Materials	Gel-Probe Replacement Cleaning Materials	Cleaning Frequency (every Die TDS)	Cleaning TDs	Cleaning OT	Card Lifetime
1	PP70	ReFine L3	175	15	30um	>> 5M
2	PP150	ReFine H3	60	10	30um	unknown
3	Toothbrush					Not tracked
4	PP99	ReFine M3	350	30	100um	20M
5	CWC Substrate		Once per wafer	10	POT + 1um	Not tracked

For the "Celadon Toothbrush [PN: 27009]" cleaning method, please follow the link for off-line cleaning: https://www.youtube.com/watch?v=6lQT6TCs144

4 REFERENCES

1. *Production Parametric Test – Challenges and Surprising Outcomes Running in a High-Volume Manufacturing Environment*, presented at SWTest 2015 [produced in partnership with NXP]

2. *Gel-Probe Cleaning Technologies Maximize Yield and Reduce Cost of Test,* presented at Celadon CORE User Meeting 2025, by J. Broz and V. Tran of Gel-Pak.

5 CONTACT INFORMATION

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6 REVISION HISTORY

Revision	Changes	Date	Approval
1.0	Initial Release	6/27/17	GET
1.1	Updated to include UF200	7/25/17	GET
1.2	Recipes Added	10/6/17	GET
01.3	Misc Updates	11/6/17	GET
01.4	Added Lab Recipe	2/26/18	GET
01.5	Updated to CWC™	11/12/19	GET
01.6	Added notes on IPA	3/6/20	GET
01.7	Re-write with Delphon reccomendation	4/7/25	GET