ZERO DEFECTS

Entegris Newsletter

January 2014

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Entegris Partners with SEMATECH®

Entegris Inc. and SEMATECH announced they have partnered to move forward the development of advanced nanoscale particle removal processes and cleaning technologies for next-generation wafers and devices.

This collaboration will address some of the profound changes taking place in the semiconductor industry that are impacting fundamental aspects of process and equipment design — such as integration of new materials and process technology for sub-20 nm node manufacturing, next-generation lithography requirements and the progression to 450 mm wafers. One key issue relates to the preparation of critical surfaces through the entire semiconductor manufacturing process. Entegris will work with experts from SEMATECH's Nanodefect Center to develop new technologies and solutions to reduce nano-scale particle contamination during wafer processing.

"We are pleased to partner with SEMATECH to provide early solutions for wafer surface cleaning," said Bertrand Loy, president and CEO of Entegris. "Our goal is to leverage our contamination control expertise to develop filtration and particle detection methods for the most advanced cleaning processes."

"SEMATECH's Nanodefect Center aims to build industry participation in detecting, modeling, characterizing, and providing solutions for defect issues as geometries shrink below the 10 nm node," said Michael Lercel, senior director of Nanodefectivity and Metrology. "Our partnership with Entegris brings additional expertise to SEMATECH, and in turn will raise the level of our research efforts and further strengthen SEMATECH's commitment in identifying the challenges of future technology nodes."

Built on more than a decade of technical expertise in surface cleaning, particle removal and cleaning technology development, SEMATECH's Nanodefect Center provides a world-leading suite of metrology and analysis capabilities, investigating the generation, propagation, removal and impact of defects generated by equipment, equipment components and materials used in advanced semiconductor processes such as lithography, etch, CMP, deposition and cleaning.
www.sematech.org

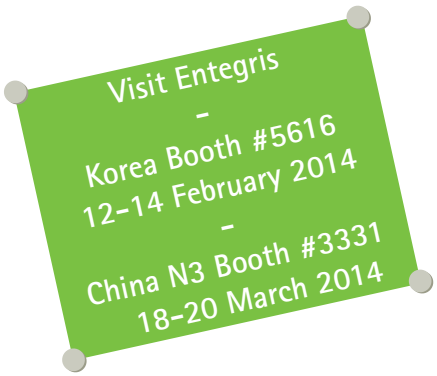
Entegris on the Asian Stage

Entegris was invited to joint-promote our latest products and technology at **Infineon Innovation Week** in Kulim, Malaysia on 4 September 2013.

Entegris gained online brand exposure at the **ANFF Annual Research Showcase** 2013 in Australia on 13 November 2013.

Entegris investment in Taiwan was featured by Taiwan Ministry of Economic Affairs **Regional Headquarters in Taiwan Series** Volume III on 19 November 2013.

Entegris @ SEMICON® Korea and China



Entegris
creating a material advantage

Innovation

Is There a Need to Change the Existing Standards for 3D Wafers?

By Anne Jourdain and Alain Phommahaxay - IMEC | Mike Zabka and Luc Van Autryve - Entegris

This poster presented at Semicon Taiwan 2013 is highlighting the joint collaboration with Entegris and IMEC to elaborate a preliminary list of recommendations for 3D and thin wafer handling and shipping.

Motivation and Objectives

- 3D wafers (e.g. edge trimmed, bonded or thin) are not SEMI standards and can cause problems during internal transport in standard FOUPs or FOSBs
- Shipping thin wafers from a foundry to an OSAT in a safe way remains very challenging
- Manual handling of the film frame is a key contributor to thin wafer damage after debond

Thin Wafers Shipping on Film Frame

Aug 2012 **Oct 2012** **Apr 2013**

Phase 1 → Phase 2a → Phase 2b → Phase 3

1. Preliminary evalua-tion of the protection ability of E400 Film Frame Shipper (FFS)	2. Impact of three important parameters on crack formation	3. Comparison E400 FFS vs 450 mm Multiple Application Carrier (MAC)
- Use of 50 µm thin wafers on metal frames - Use of secondary packaging for shipment	- Wafer thickness (40, 50, 60 µm) - Film frame (plastic/ metal) - Diced vs full wafer Phase 2a: 50 µm wafers ONLY Phase 2b: Follow up with 40 and 60 µm thin wafers	- Focus on metal frames ONLY - E-testing of TSV wafers - E400 FFS vs MAC

- ISTA® 2A shipping simulation tests conducted on E400 FFS with 50 µm thin wafers on metal and plastic frames
- Each shipper included three test frames with 50 µm thick wafers and 10 dummy frames
- Visual inspection performed before/after simulation test: random vibration and free fall drop

No damage, crack, cross slot or visible particles observed on both shippers and test wafers.

Diced vs full wafer did not make any difference

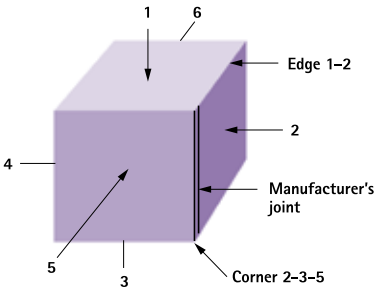
E400 FFS with secondary packaging

Vibration tester

Free fall drop tester

ISTA 2A Random Vibration Test Sequence

Step	Action	Testing Orientation	Vibration Duration
1	Put the packaged product on the vibration table so that face 3 rests on the platform.	Face 3 on table surface	30 minutes
2	Start the vibration system to produce the random vibration spectrum indicated in "Before You Begin Vibration Testing."		
3	Stop the vibration system after the completion of 30 minutes. Invert the packaged product so that face 1 (top) rests on the platform.		
4	Begin the vibration duration for this orientation.	Face 1 on table surface	10 minutes
5	Stop the vibration system after the completion of 10 minutes. Place the packaged product so that either face 2 or 4 rests on the platform.		
6	Begin the vibration duration for this orientation.	Face 2 or 4 on table surface	10 minutes
7	Stop the vibration system after the completion of 10 minutes. Place the packaged product so that either face 5 or 6 rests on the platform.		
8	Begin the vibration duration for this orientation.	Face 5 or 6 on table surface	10 minutes
9	Stop the vibration testing at the end of 10 minutes.		
10	Vibration testing is now complete. Go to TEST BLOCK 5 (Shock).		



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Is There a Need to Change the Existing Standards for 3D Wafers?

By Anne Jourdain and Alain Phommahaxay - IMEC | Mike Zabka and Luc Van Autryve - Entegris

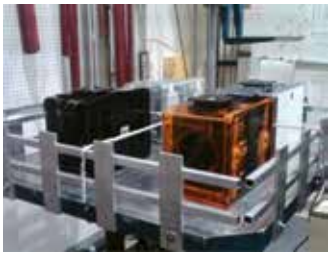
FOUP Transport of Thin Bonded Wafers

- **Goal:** understand whether an increased wafer retention force can improve the performance of the A300 FOUP
- Previous bonded wafer vibration tests showed the Spectra™ to be the best in handling 3D wafers in terms of marks/debris generation
- Vibration study performed on an A300 FOUP with modified door: Two PC strips attached to the inner door under the wafer retainer to increase the wafer retention force

The increased wafer retention force prevented the bonded wafers from rotation and did not leave marks on the wafers

"Debris" was found on the side column backstop of 2 slots: temporary glue transferred from bonded wafers to the FOUP

Modified A300 door to match Spectra door closure force

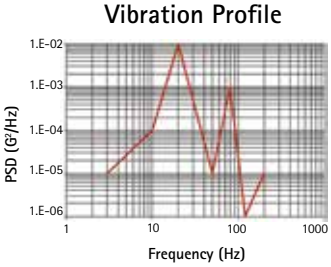


Modified A300 door to match Spectra door closure force

Modified A300 door to match Spectra door closure force

Test	Baseline A300 Door	Modified A300 Door
1	8.1	11.6
2	8.4	11.2
3	8.1	11.9

Vibration Profile



Recommendations and Follow-up

E400 Film Frame Shipper

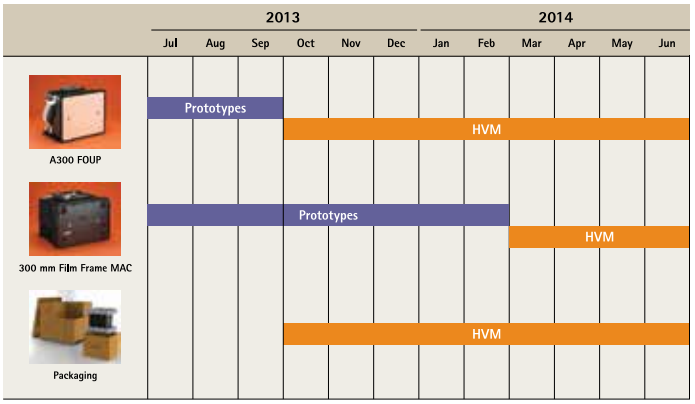
The current E400 FFS in conjunction with Entegris engineered packaging is a viable solution for thin wafer on frame shipping but requires manual loading and handling

300 mm Film Frame Multiple Application Carrier (MAC)

Based on our 450 mm carrier, Entegris is developing a fully automated 300 mm film frame process and shipping solution for thin wafer handling

3D MAC Secondary Shipping System

ISTA 3E compliant packaging system. Use to safely ship 3D 300 mm tape frame wafers in 3D MAC.



Development and Characterization of a New CVD Diamond CMP Pad Conditioner

By Rakesh K. Singh, Manager, WW CMP Applications and New Business Development, Andrew Galpin, Product Manager and Christopher Vroman, Director, CMP Products - Entegris

Characteristics of a revolutionary new design - SiC with high integrity and consistency, non-contaminating CVD Diamond "Planargem®" CMP pad conditioner (Figure 1) are discussed in this article with performance data. Planargem design:

Figure 1. Planargem Pad Conditioner

- provides maximum abrasive flexibility, effectiveness and efficiency
- extends pad and conditioner lifetime
- eliminates diamond fall-out issues
- results in highly tunable pad conditioning, with a full range of pad cut-rates and surface roughness for polymeric and poromeric pads

Experimental data will be presented for metal extractables for new conditioning disks, pad cut-rate (PCR) and pad surface roughness (Ra).

In this note we report results of comparative evaluations of different conventional diamond pad conditioning disks and the newly developed Planargem disk in terms of the PCR and Ra stability in order to quantify their ability to provide consistent pad conditioning performance throughout pad and disk lifetime.

Our objective was to assess the Planargem disks pad conditioning stability over time with the thermoplastic and thermosetting polyurethane polymeric pads and a softer poromeric pad.

CMP Pad Conditioning for Advanced Technology Nodes

Typical conventional diamond disks have limitations of diamond quality and consistency, diamonds breaking/chipping during usage, and size, shape and height variability, resulting in a wide PCR range and rapid performance variability over useful lifetime. CMP pad conditioners for the next-gen applications (Figure 2a) must have attributes of "tunability in design" and "stability in performance."

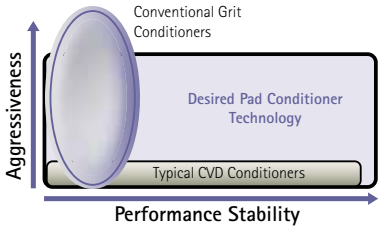


Figure 2a. Next-generation "Desired Pad Conditioner Technology" performance attributes

These new designs should have much tighter control of the materials and dimensions to create consistent and significantly cleaner final products. Increasingly stringent abrasive feature size, shape, protrusion, aggressiveness, and distribution control in such disks should result in a shorter pad break-in time, stable pad surface morphology, and extended pad and disk lifetime. Planargem design was developed to effectively meet these requirements.

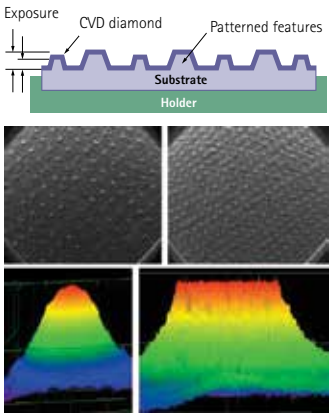


Figure 2b. A novel, highly-tunable CVD diamond "Planargem" CMP pad conditioner

Planargem design (Figure 2b), based on an innovative texturing approach provides full design flexibility (for all pad materials and types) due to the replacement of diamonds with well controlled topography (features) created in substrate material, and fine-tuning of the CVD diamond coating properties, to achieve the desired level of performance consistency and lifetime in most demanding applications.

Experimental Results of Pad Conditioner Evaluations

Case study 1

In this study, metal extractables were measured in pH3 HCl and Aluminum CMP slurry for a conventional diamond disk and Planargem segments and disks. The ICP-MS metals analysis data for different disks are presented in Table 1. In general, the results show lower extractable levels in Planargem related extractions.

TABLE 1: ICP-MS METALS ANALYSIS DATA FOR DIFFERENT CMP PAD CONDITIONERS

Extraction 24-Hour Soak (µg/device)	Brazed Conditioner Submerged pH3 HCl	Planargem Segments Surface Extracted pH3 HCl	Planargem Conditioner Submerged pH3 HCl	Planargem Conditioner Submerged Aluminum Slurry
Na	0.162	0.169	0.199	0.470
Mg	0.078	0.041	0.129	0.315
Al	0.705	0.028	0.454	0.289
K	0.120	0.148	0.178	0.098
Ca	2.198	1.573	3.669	3.486
Ti	0.014	0.003	0.103	0.002
Cr	3.079	0.002	0.086	0.940
Mn	3.051	0.001	0.507	1.431
Fe	21.965	0.064	3.422	10.954
Ni	432.716	0.002	1.610	0.570
Co	0.103	0.000	0.030	0.053
Cu	0.007	0.441	0.748	2.244
Zn	20.171	0.028	0.711	1.842
Ag	0.000	0.000	0.030	0.047
Ba	0.021	0.002	0.032	0.015
Pb	0.116	0.000	0.030	0.011
Total	**484.407**	**2.502**	**11.937**	**22.767**

continued overleaf

Development and Characterization of a New CVD Diamond CMP Pad Conditioner (continued)

By Rakesh K. Singh, Manager, WW CMP Applications and New Business Development, Andrew Galpin, Product Manager and Christopher Vroman, Director, CMP Products - Entegris

Case study 2

In this comparative evaluation, three Planargem disks and two conventional diamond conditioning disks were tested with IC1000™ pad, DI water, and 7 lbs downforce on a Buehler® polisher.

Figure 3 shows the stability of PCR for Planargem designs and the flexibility of this approach in designing the required aggressiveness disks.

In contrast, the two conventional disks show significant drop in PCR during the 10-hour tests.

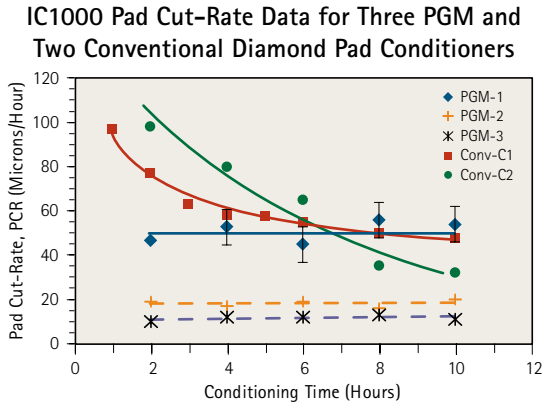


Figure 3. PCR data for three types of Planargem disks and two types of conventional diamond disks

Case study 3

In this study, a Planargem disk was tested on APD-800 300 mm polisher with a new polymeric Pad-A. Figure 4 shows the stability of PCR and Ra data for the 50-hour conditioning test.

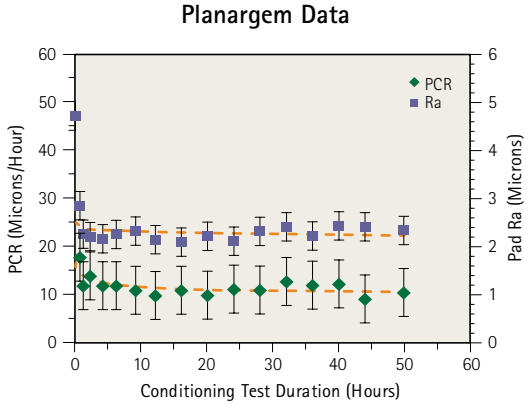


Figure 4. PCR and Ra variation during Planargem conditioning of Pad-A (50 hours)

Case study 4

In this evaluation, a Planargem disk was tested on APD-800 polisher with a poromeric Pad-B. Figure 5 demonstrates the stability of PCR and Ra data over the 18-hour test. This confirmed the suitability of Planargem design for the new Pad-B break-in and extended period conditioning. Laser confocal microscope results of pad surface imaging and surface height pdfs for this study (not included here; presented at ICPT 2013*) showed the significant effect of pad conditioning and opening of the pore structure.

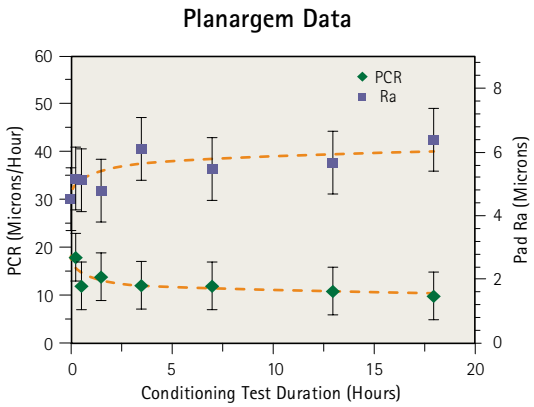


Figure 5. PCR and Ra variation during Planargem conditioning of Pad-B (18 hours)

Conclusion

Design and performance characteristics of a novel, highly tunable CVD diamond "Planargem" CMP pad conditioner are presented.

This innovative design, based on an unique texturing approach and replacement of diamonds with well controlled size and shape abrasive topography (created in the substrate material and CVD diamond coated) provides full design flexibility, much higher level of cleanliness, performance stability, and extended lifetime in next-gen applications.

This study shows the advancements and opportunities for the lab scale evaluation of CMP pads and conditioners. Further evaluations are continuing to understand the interactions of pad and conditioner materials, designs attributes, and process parameters in various applications.

*Results of this study were presented at the International Conference on Planarization/CMP Technology (ICPT 2013) and published in the Symposium Proceedings, pp. 72-79, October 30-November 1, 2013 Taiwan.

Cost Reduction

Advanced Technology in High-flow Gas Purification

By Entegris

The GateKeeper® Gas Purification System, DX series, is the latest continuous service high-flow gas purification system from Entegris. The system brings advanced technology to high-flow gas purification providing semiconductor manufacturers with an innovative, efficient and cost-effective solution to purify purge gases used in dry and immersion-based lithograph tools. The Entegris DX series represents the culmination of 15 years of experience in gas purification and delivery technologies. It delivers purified CO_2 gas to today's scanner platforms including immersion lithography tools.

The new "DX" media represents the latest advancement in purification technology from Entegris, providing for outlet purity in parts-per-trillion (ppt) levels. The system applies ambient temperature purification, so heating is not required for purification. This means resource conservation and lower energy costs.

The DX series effectively and efficiently removes contaminants such as volatile bases, refractory compounds, condensable organics and moisture from CO_2 gas.

Features and Benefits

- Power failure will not damage the purification system
- Completely automatic operation saves time, increases reliability
- Purifies to ppt (parts-per trillion) levels
- Low pressure drop means no changes to inlet pressure are required
- Self-regenerating purifiers provide the lowest cost of ownership
- Ambient temperature purification means lower energy costs and resource conservation
- CE and SEMI certified
- Start-up service is provided, making it easy to integrate the unit
- Ethernet connection allows for remote monitoring capability
- Designed for easy field maintenance and upgrades
- Available worldwide through Entegris' global infrastructure

Competitive Comparison

Contaminant	Purity requirement (pptv)	Entegris DX performance (pptv)	Closest competitor (pptv)
TOC (non-condensable)	1000	5 (as butane*)	1000 (as toluene**)
TOC (condensable)	150	5 (as toluene**)	150 (as decane***)

* Butane (C_4H_{10}, b.p. -1.0 °C)
** Toluene (C_7H_8, b.p. 110.6 °C)
*** Decane ($C_{10}H_{22}$, b.p 174 °C)
**** Condensable Organic defined as liquid at room temperature and ambient pressure

Note: Toluene is a condensable organic, not a non-condensable! Competitor is incorrectly using toluene as their surrogate for their non-condensable specification.

Contaminant Hydrocarbon	Molecular Weight (g/mol)	Condensable Classification ****
C1 – Methane	16.05	Non-Condensable Organic
C2 – Ethane	30.08	
C3 – Propane	44.11	
C4 - Butane	58.14	
C5 - Pentane	72.17	Condensable Organic
C6 – Hexane	92.15	
C7 - Heptane (Toluene)	100.21	
C8 - Octane	114.23	
C9 - Nonane	128.26	
C10 – Decane	142.32	

Yield Improvement

On-site Services: Enhance Predictability, Maximize Productivity, Reduce Costs

By Richard Ploner, Director Global Service - Entegris

In today's ever more sophisticated manufacturing environment, having superior protection for your products during processing means higher yields. Outsourcing that capability allows for the reduction in overhead costs, this translates into real productivity gains.

Depending on the products a chip manufacturer is producing, cleaning, handling and testing process carriers is an important component of the process, as the smallest particle or contamination can create significant costs and yield loss.

Who better to manage wafer or disk handling products than the people who make them? Outsource to a dedicated Entegris team and focus on your core competencies.

Process Carriers and FOUPs Cleaning

Two of the main service activities for FOUPs or process carriers is cleaning and maintenance. Our on-site specialists perform many steps including:

- FOUP/FOSB/Pod populations cleaning
- Clean etch, diffusion, quartz and Lithography parts cleaning
- Preventative maintenance on all kind of equipments such as cleaning equipment, dimensional check or analytical equipment

- Aesthetic, scratches, microcracks or conspicuous marks visual checks
- Dimensional inspection & measurements
- Door alignment checks
- Liquid Particle Counts (LPC)
- Tracking of FOUP's including scanning and data maintenance with dedicated software.

Other services are available, including: Training, analytical service support and end-of-life management.

On-site Service Benefits

Reduce your cost of ownership through outsourcing to a professional third party. In response to an industry-wide request for support solutions on site services are offered to:

- Maximize productivity with better maintenance planning
- Reduce costs through longer life
- Improve quality through controls at the right points

With an Entegris on-site team,

- Improve and optimize the cleaning processes
- Control particle and contamination levels
- Define the most efficient maintenance processes and cycles

Or, decide on Entegris to simply follow prearranged procedures with a fully trained and dedicated team.

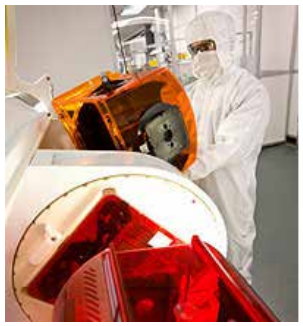
On-site Services Case Studies

FOUP Metrology

One of the top Semiconductor OEMs was concerned about particle levels and cross-contamination risks as FOUPs moved through its research and development fab. The Entegris on-site service team, supported by Entegris application team and Entegris' analytic labs, developed a Design of Experiment (DOE) to assess the risks to the OEM's FOUPs and processes.

After completing the testing, the Entegris on-site team presented a comprehensive report on the various contributors to contamination and particle levels from the process tools in the R&D fab. Based on that information, the on-site service team, working with the OEM, was able to implement a number of changes to the FOUP handling process as well as the cleaning process which significantly reduced the particle levels in the FOUPs and mitigated the risk of cross contamination in the fab.

FOUPs and FOUP Cleaning Equipment



One of the world's largest suppliers of semiconductor equipment wanted to study copper process effects on FOUP cleaning. They turned to Entegris for a partnership. Entegris' FOUPs were integrated in the fab and managed by Entegris on-site personnel. FOUP life and interoperability are also being studied.

The program takes advantage of Entegris' extensive laboratory testing facilities to help determine contamination issues. By partnering with Entegris, this manufacturer will ultimately benefit with an increased understanding of the interaction of advanced processes and FOUP cleaning.

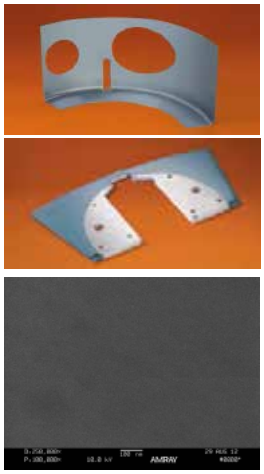
▸ Entegris' dedicated on-site service team has the experience and skills necessary to manage your wafer carrier cleaning and maintenance process. Contact Entegris to learn about a customized solution.

Product Highlight

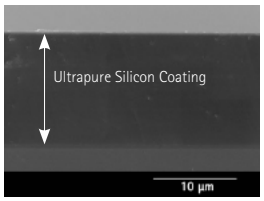
Ultrapure Silicon Coating (99.999%): Ultrapure Coating for Contamination Control

Entegris offers an ultra high purity silicon coating (99.999%) that is dense, micro-conformal, highly adherent and extremely smooth for a variety of applications. The silicon coatings are deposited by a proprietary Plasma Enhanced Chemical Vapor Deposition (PECVD) process which is versatile and allows for a high degree of flexibility in coating a variety of substrate materials. The coatings have low internal stress, therefore can be deposited in thicknesses ranging from <1 micron to 100+ microns depending on substrate material and finish.

Entegris silicon coatings are ideal in ion implant, wafer bonding and plasma nitriding applications. Other emerging applications show a need for silicon coatings substrates for optical mirrors, where precision polishing (sub-nanometer roughness) is desired.



SEM image - Coating Surface Morphology



SEM image - Coating Cross-section

Key Features

- Ultra high purity
- Low residual stress
- Dense, hard and micro-conformal
- Can be polished or single-point diamond turned to optical finish

Specifications

Substrate:	Compatibility	Metals, ceramics (AlN, Al_2O_3, quartz, PSZ, graphite, SiC, etc.) and polymers
	Size	Up to 91 cm (36")
	Geometry	Any shape, including complex geometries
Structure:	Amorphous; contains hydrogen	
Temperature:	Deposition	Below 150°C (302°F)
	Use	-50°C to 600°C (-58°F to 1112°F)
Coating thickness:	A few nm to over 150 µm	
Electrical resistivity:	5×10^8 Ω-cm, lower values possible	
Hardness:	600 HV	
Purity:	99.999%	
Wear resistance:	Good	
Corrosion resistance:	Excellent resistance to aqueous, alkaline and most acid environments	

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