ZERO DEFECTS

Entegris Newsletter

June 2013

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Entegris Acquires Jetalon Solutions, Inc.

Entegris acquired in April the assets of privately held Jetalon Solutions, Inc., a California-based supplier of fluid metrology products.

Jetalon Solutions' metrology and sensor products use refractive index technology to achieve greater precision in real-time chemical blending, which is increasingly critical in applications where minute variations of process fluid concentration levels can adversely impact manufacturing yields.

In semiconductor manufacturing, Jetalon products monitor and control liquid concentrations in all wet processing areas including:

- wafer surface preparation and cleaning,
- photolithography,
- CMP, post-CMP cleaning,
- and copper electroplating.

In the biopharmaceutical market, these solutions are used in both upstream and downstream processing in applications such as real-time in-line concentration monitoring of media and buffer preparations. This is an area of increasing interest for biopharmaceutical applications given the growing trend from batch manufacturing to real-time or continuous manufacturing processes.

Bertrand Loy, president and chief executive officer, said: "*We are excited about the acquisition of Jetalon Solutions and the potential it has for Entegris. Jetalon's unique technology expands our fluid sensing and control offering and adds to our existing capabilities for creating innovative and differentiated solutions to improve our customers' process control capability and manufacturing yields not only in semiconductor applications, but in life sciences and other industries as well.*"

>> To read more, click here

Entegris at SEMICON West 2013

Entegris returns to SEMICON® West this year with a focus on defect reduction and yield improvement. In partnership with SEMI®, we will sponsor the first annual **Yield Breakfast Forum: Defect Reduction in the Sub-20 nm Era**. A moderated panel will discuss defect trends, detection and reduction; root cause analysis and yield management challenges. Learn more

We will continue to conduct customer meetings and showcase our newest products and technologies at the W San Francisco, featuring our leading-edge solutions for 450 mm, EUV and sub-20 nm semiconductor processes. Solutions for PV solar will also be displayed.

Please contact your sales rep to attend the Yield Breakfast or schedule a meeting. We look forward to seeing you there!

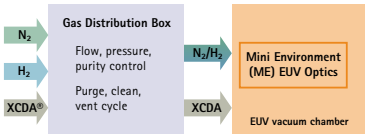
Entegris
creating a material advantage

Process Stability

Sub-Atmospheric Gas Purification for EUVL Vacuum Environment Control

By Abneesh Srivastava, Stenio Pereira, Thomas Gaffney - Entegris, Inc.

High-purity gas supply for optics purging and cleaning under vacuum is required at the output of the mini-environment gas distribution box in EUV scanners. Gaseous Hydrogen (H_2) is used for cleaning while Nitrogen (N_2) is used for evacuating H_2 from the exposure chamber.

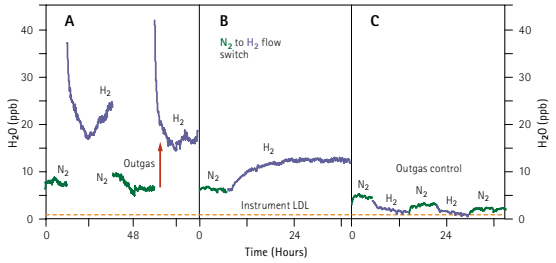


Block diagram of gas distribution box, EUV mini-environment and vacuum chamber

In this work, we explore the moisture removal performance of dual gas (N_2 and H_2) purifiers under sub-atmospheric pressure conditions with an aim to limiting moisture release to an EUV chamber from a gas distribution box. A key aspect of our test is to characterize the effect of gas supply switching, adopted in the ME, on moisture outgassing from a gas purifier.

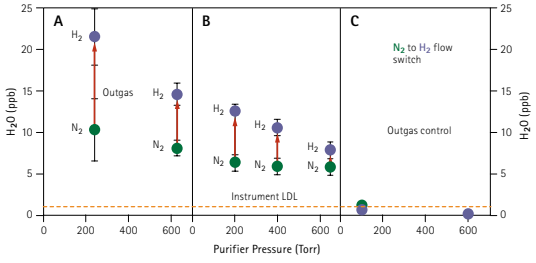
Results N_2–H_2 Gas Flow Switch

Purifier C (HX media) maintains near-constant H_2O levels on the gas switch, mitigating any H_2 induced moisture outgassing, if any. In all cases except C, the switch to H_2 gas flow causes moisture release in the process stream.



Comparison of moisture outgassing under sub-atmospheric conditions for three purifier technologies, A, B and C (HX media).

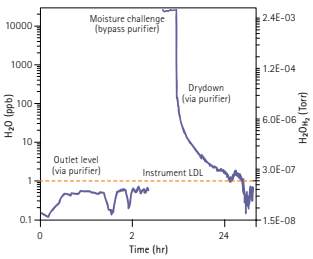
Purifier C maintains below <1 ppb levels at the lowest pressure probed under H_2 flow. At the higher pressure, average outgassing excursions and stabilization under H_2 flow are marginally reduced. Flow switch from N_2 to H_2 result in <50% of levels observed in N_2 for both purifiers A and B.



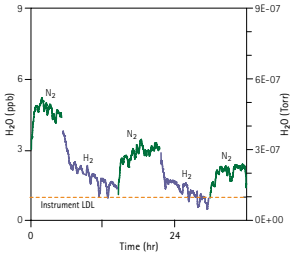
Pressure dependence of outgassing levels for three representative purifiers under N_2 to H_2 gas flow switch. Purifier C outlet moisture levels are maintained below instrument LDL (1 ppb) in the 100–600 Torr range.

Dynamic Range of Moisture Removal

Performance of purifier C was put to further test in H_2 gas by subjecting it to a high moisture level at the inlet. The purifier outlet was measured below instrument LDL. The moisture challenge of 25 ppm is removed to below 1 ppb at a pressure of 150 Torr. Subsequently, the inlet challenge was measured and the dry down response was characterized. Levels of <1 ppb were established within 8 hours.



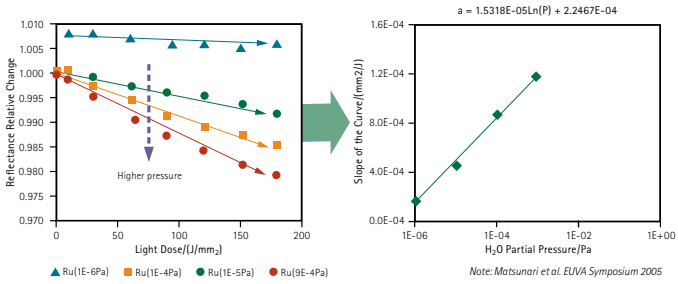
Measurement of HX purifier outlet moisture under dry (<50 ppb) inlet moisture during N_2-H_2 flow switch.



Measurement of HX purifier outlet moisture under 25 ppm moisture inlet challenge in H_2 gas.

Optics Reflectance and H_2O Contamination

It has been demonstrated that the presence of moisture under EUV vacuum conditions can cause permanent reflectance loss. Wedowski et al. observed a 12% loss in EUV exposure of Mo/Si optics in the presence of relatively low moisture levels (1E-6 Torr). Matsunari et al. also observed reflectance loss attributable to the presence of moisture (7.5E-6 Torr). Based on reflectance and XPS correlation data, it is posited that EUV assisted oxidation caused by moisture, promotes a loss of optics reflectance.



Reflectance loss dependence data of Matsunari et al. on H_2O pressure for Ru-capped Ru/Si optics under EUV exposure.

HX purifiers are shown to limit moisture to <1E-07 Torr in 100 Torr H_2 gas. Therefore the amount of moisture introduced into the ME would be reduced and subsequent reflectance loss could be mitigated.

Conclusion

Above comparisons of moisture removal data across three representative H_2 purifier technologies demonstrate distinct advantages of HX under sub-atmospheric conditions. A probe of material properties were conducted (data not shown) to develop <1 ppb moisture removal for EUVL application.

Overall Equipment Efficiency

PrimeLock® Fittings Evaluated as Superior by TSMC®

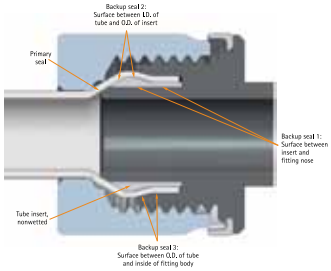
By TSMC and summarized by Rick Lindblom - Entegris, Inc.

TSMC recently published a paper in Solid State Technology® that compares four different flare style fluoropolymer fitting designs - among which the Entegris' new PrimeLock fitting - that are used in ultra high-purity chemical applications.

PrimeLock fittings

The paper compared and evaluated traditional flare style fittings along with both wetted and non-wetted insert style fittings in the following tests:

- Maximum tube pull-out tensile force
- Chemical entrapment
- Assembly time study
- Particle evaluation



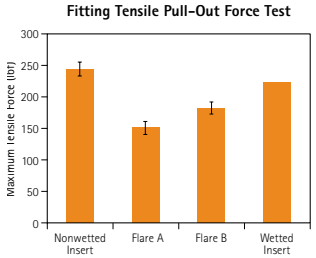
PrimeLock cross-section 3 backup seals

This article highlights excerpts of the TSMC article* focusing on PrimeLock performances. More details on the test methodology can be found in the original document: link

Maximum Tube Pull-Out Tensile Force

Fitting connections might be unintentionally exposed to tensile forces that attempt to pull the tubing out of the fitting.

▸ The nonwetted insert style fitting, PrimeLock, demonstrated the **highest pull-out force performance** of all the fittings tested. It was 34% stronger than the nearest flare style fitting and 9% stronger than the wetted insert style fitting.

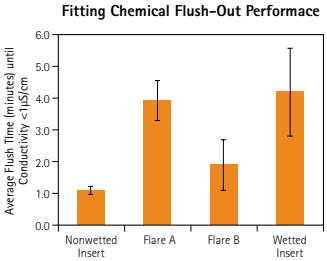


Fitting tensile pull-out force test results

Chemical Entrapment Test

Minimizing chemical entrapment areas is an important consideration when evaluating fitting cleanliness performance as it can lead to contamination issues.

▸ Primelock, the nonwetted insert style fitting demonstrated the **shortest flush time** to reach a stabilized fluid conductivity of less than 1 µS/cm. It was approximately 74% less than that of the wetted insert style. This fitting type cleaned up four times faster than the wetted insert style fitting in sulfuric acid.



Chemical entrapment test results

Assembly Time Study

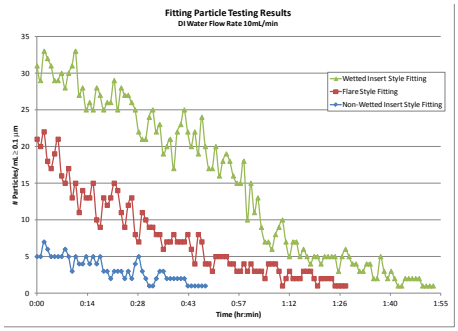
Fitting assembly time is another consideration when designing a fluid handling system. Fittings that are easy to assemble can save time on the manufacturing floor during repairs or new assemblies.

▸ The nonwetted insert style fitting and the wetted insert style fitting both took the **least amount of time to assemble**. Insert fitting technology substantially reduces assembly time as it eliminates the heating and cooling steps required to produce the tube flare.

Action Performed	Nonwetted Insert Style	Flare Style A	Flare Style B	Wetted Insert Style
Heating time with air gun	N/A	0:30	0:30	N/A
Hold tubing on mandrel	N/A	0:20	0:20	N/A
Cooling time on mandrel	N/A	3:00	3:00	N/A
Push insert into tubing	0:30	N/A	N/A	0:30
Nut torque time	0:30	0:30	0:30	0:30
Total Assembly Time	**1:00**	**4:20**	**4:20**	**1:00**

Particle Evaluation

Fittings can generate particles (contaminants) within a system after they are assembled.



Particle evaluation chart showing trends for fitting types

▸ Both the flare style and wetted insert style fittings took longer to reach the baseline particle count level than the nonwetted insert style fitting.

Conclusion

The paper concludes that non-wetted insert style fittings are superior. The fitting chosen by TSMC for its superior performance is Entegris' new PrimeLock fitting.

PrimeLock fitting is starting to gain traction with key customers and an endorsement by TSMC will help this trend continue. In addition, we recently landed PrimeLock wins at 2 major integrated device manufacturers in the US.

*Acknowledgements to TSMC who authorized Entegris to publish this article based on their study.

Innovation

Enabling The Move To 450 mm

By Paola Gonzalez Ph.D., Engineer Application Development | CEA-LETI Assignee - Entegris Europe

450 mm age has come, manufacturers are experiencing incredible pressure to increase productivity in the fab and stay cost competitive. As a result, companies are making the move to invest in technology that increases yields by minimizing product defects caused by contamination.

Entegris 450 mm Wafer Handling Solutions

Entegris has released three new handling and shipping products for the safe, reliable transport and processing of 450 mm wafers. These products are the result of the Company's ongoing investment to support the semiconductor industry's transition from the current 300 mm wafer sizes to 450 mm wafer production.

The new products, which are part of a comprehensive solution that includes an innovative packaging system, include:

- 450 mm Multiple Application Carrier (MAC),
- 450 mm Front Opening Unified Pod (FOUP)
- 450 mm Single Wafer Shipper (SWS).

Entegris 450 mm MAC

Entegris 450 mm FOUP

Entegris 450 mm SWS

450 mm and AMC Challenges

With the transition from 300 mm wafers to 450 mm wafers and decreasing technology nodes,
AMC (airborne molecular contaminants) control and cross contamination issues emerging from the interaction between:

- the clean-room environments,
- the process tool minienvironment and
- the container-wafer system

makes crucial to have the appropriate methodologies in order to understand the physics and chemistry behind the contamination mechanism.

300 mm FOUPs are used in IC manufacturing for transport and storage and to isolate wafers from AMC contamination. However, contamination issues can still exist inside this closed environment because FOUP's are made with polymeric materials that not only outgas their own AMCs but can also absorb moisture and other volatile compounds introduced into their atmosphere from the clean room air or after the connection to equipment or following the release of molecular contaminants from wafers stored inside.

The subsequent outgassing of contaminants trapped in FOUPs constitutes a significant issue with respect to wafer environmental control.

450 mm and Wafer Handling Challenges

The move towards 450 mm creates new wafer handling challenges, Entegris in collaboration with CEA-Leti in Grenoble France have clear evidence of **the molecular cross-contamination scheme for volatile acids**, for different microenvironment platforms designed to protect critical materials from molecular contaminants for 300 mm IC manufacturing. It shows that the accumulation process (i.e. absorption) followed by the release process (i.e. reverse diffusion and outgassing) are long-term phenomena that can last for days and into weeks.

The results obtained, mainly based on study of FOUPs materials and platform contamination and their impact on FOUPs-wafer cross contamination phenomena in AlCu and Cu full sheet wafers and the intrinsic properties controlling the contamination process as Diffusion and Solubility parameters **allows to elucidate the ideal polymers for the 450 mm new platforms** and foresee additional contamination control solutions such as purge, cleaning and the use of purification/gettering media.

The results already obtained in the collaboration with CEA-Leti have given place to an oral participation at international *Sematech Surface Preparation and cleaning conference* [1], followed by the submission to a peer reviewed paper at *Microelectronic Engineering Journal* [2], in addition two papers in technical magazines as *Future Fab International* and *Entegris Zero Defects Newsletter* [3,4]

1) Sematech Surface Preparation and Cleaning Conference, March 19-21, 2012; Austin, TX

2) Paola Gonzalez Aguirre, Hervé Fontaine, Carlos Beitia, Jim Ohlsen, Jorgen Lundgren, Poshin Lee, Microelectronic Engineering, Microelectronic Engineering, 105 (2013), 113-188.

3) Paola Gonzalez Aguirre, Hervé Fontaine, Carlos Beitia, Jim Ohlsen, Jorgen Lundgren, Future Fab International, issue 42, July 2012.

4) Paola Gonzalez Aguirre, Hervé Fontaine, Carlos Beitia, Jim Ohlsen, Jorgen Lundgren, Poshin Lee, Zero Defects Vol. 11 Issue 1, 2012, Europe Newsletter

Yield Improvement

Strategy for Yield Improvement with Sub-10 nm Photochemical Filtration

By Jennifer Braggin - Entegris, Inc. | Colin Brodsky, Mike Linnane, Paul W. Klymko - IBM

Several tools are available to photolithography engineers to improve yield

- Equipment enhancements
- Software upgrades
- Materials improvements

This paper discusses strategies utilized to improve yield on 32 nm BEOL (back end of line) lithography processes with sub-10 nm photochemical filtration.

- Use of 5 nm UPE (ultra high molecular weight poly-ethylene) in OPL (optical planarizing layers) showed a 69% improvement in overall median yield for an OPL material used in the first metallization layer, and a 26% improvement for a second OPL material used in subsequent metallization processes
- Prewetting of a 5 nm point-of-use filter before track installation
- Experiment

Equipment

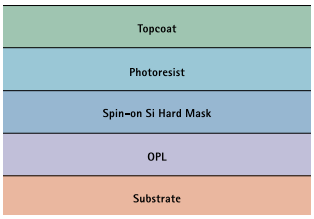
Tokyo Electron Limited Clean Track™ Lithius® i+ coupled to an ASML® 1900i scanner

Rapid Yield Learning Vehicle

- PDF Solutions®
- Characterization Vehicles®Defect of interest: Single line opens

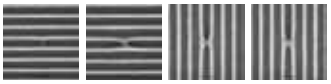
Materials

Trilayer Stack



Point-of-use Filtration

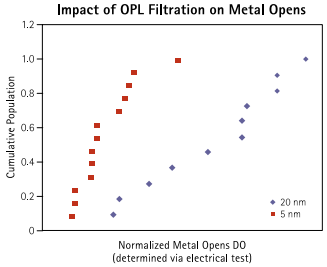
Asymmetric UPE (ultra high molecular weight polyethylene)



Results

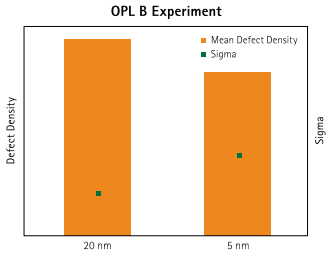
OPL Experiment 1: 20 nm vs 5 nm

- Three split lots demonstrated a median 69% reduction in electrical yield failures across two different manufacturing lots of OPL
- Likely these materials had small contaminants that were transferred into the substrate materials post-etch that would not have been caught by traditional inspection techniques



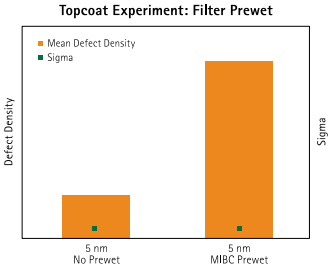
OPL Experiment 2: 20 nm vs. 5 nm

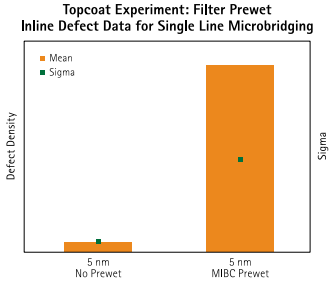
- OPL B showed a 26% reduction in median defect density across three development lots, including multiple thin wire levels



Topcoat Evaluation

- MIBC prewet did not have a positive effect on this material
- 5 nm greatly improved over 20 nm filtration
- Introducing a prewet solvent could potentially introduce additional defectivity into the process that isn't required electrical yield failures across two different manufacturing lots of OPL





Conclusions

- Point-of-use filtration in the lithography sector can have a statistically significant impact on electrical yield, especially for the smallest yield detracting defects.
- Filtration of all materials in a 32 nm trilayer stack, not just the photoresist, can be improved with sub-10 nm filtration.
- Pore sizes smaller than 5 nm have no negative impact on electrical yield.
- As IDMs drive 22 nm and beyond technologies, additional advanced filtration technologies will be required to improve yield in the lithography sector.
- A filtration roadmap thus becomes an essential part of the overall defectivity strategy for migration to more aggressive technology ground rules.
- These results can be further translated upstream to photochemical materials suppliers.

Product Highlight

Solaris® NMB Disposable Filters: The On-tool Filtration Solution for Advanced CMP Applications

Advanced CMP applications are moving toward lower solid concentration, very fine abrasive and very stringent defect level. Solaris NMB is specially designed to reduce critical large particle counts in many different appli-ca-tions, especially optimized for colloidal silica, ceria and very fine alumina slurries. Solaris NMB filters provide higher retention and longer lifetime performance.

- **Higher Retention, Lower Resistance and Superior Lifetime**

  Solaris NMB filters contain nanofibers and multi-layers CMB media for an improved flow path with high retention. Finer fiber can increase the media porosity and reduce the media resistance. The large gradients design increases particle-loading capacity and provides long-lasting filtration without compromising the filter retention performance.

- **Low Hold-up Volume Design**

  Solaris NMB filters have molded surfaces that are designed to be "well-swept" with minimal dead space. This minimizes the entrapment of "seed" particles, ensures good venting of any bubbles formed from hydrogen peroxide additives and eliminates potential slurry dry-out.

- **Less Handling, More Cleanliness and Safety**

  The convenient disposable design minimizes exposures to the slurry and reduces slurry waste. Solaris NMB is available with Entegris' patented Connectology® design for fast filter changeouts and increased cleanliness during the filter installation.

Features and Benefits

Nanofiber continuous melt-blown media	Superior agglomerate and gel removal efficiency
	Better particle-holding capacity, prolonging filter life over traditional media
Low pressure drop	No extra pressure cost when upgrading to the tighter pore filter
Low hold-up volume	Reduces waste and rapid setup
Self-venting filtration	Eliminates dead space and potential for slurry dry-out in the filtration media
Disposable Connectology design	Allows for quick installation, eliminates downtime and limits operator handling of hazard chemicals during the installation and processes

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