



ClassOne
TECHNOLOGY

Experts in Advanced Electroplating and Wet Processing

At ClassOne, our mission is to deliver the world's highest performing and most elegantly designed electroplating and wet processing systems for the manufacture of advanced microelectronics.



Byron Exarcos, CEO

Proven process technology with high-quality results and ROI

Category-leading device manufacturers around the world, use our Solstice platforms to fabricate devices on a broad array of substrate sizes and materials – from silicon, GaN, GaAs, SiC, InP, to glass, sapphire, and more.

Our Solstice® single-wafer platform is highly configurable, including both fully and semi-automated systems for electroplating and wet processing applications—with the industry's most competitive ROI.



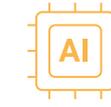
Our Markets



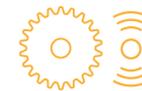
Advanced Packaging



Photonics



Artificial Intelligence



MEMS and Sensors



RF and Power Devices

ClassOne at a Glance

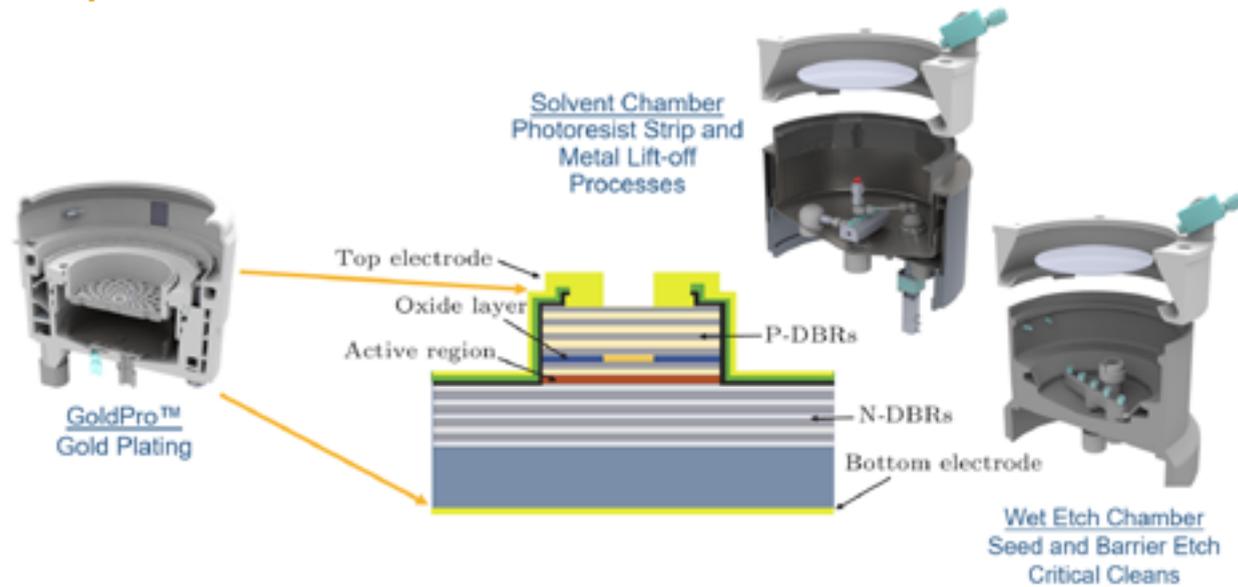
- Founded in 2013
- Headquarters in Kalispell, Montana
- >500 chambers installed worldwide
- 55% plating / 45% surface prep install base
- Leading supplier of advanced plating and wet process equipment to the semiconductor industry

Front-End Applications

Solstice is used in front-end applications across compound semiconductor and silicon devices. In front-end applications, Solstice provides both electroplating deposition and surface preparation. Solstice is used by customers in VCSEL, power device, RF, microLED, and other analog devices for fine feature metal interconnects, critical cleans and etches, and solvent applications.

- Damascene fill
- TSV fill
- Polymer removal
- Photoresist strip
- Backside etch and cleans
- Bevel etch

Example Photonic Device



Packaging Applications

Solstice's ability to provide multiple metallization and surface prep processes allows customers to advance heterogenous integration and dense interconnects. For WLP, 3D stacking and 2.5D packages, Solstice gives fabs the performance they need.

- Copper Pillar
- Solder Bump
- Redistribution Layer (RDL)
- Gold Bond Pad
- TSV Fill (Through Silicon/Substrate Vias)
- TGV (Through Glass Vias)
- Hybrid Bonding
- Interposer Metallization
- Metal Lifftoff Metal Isolation

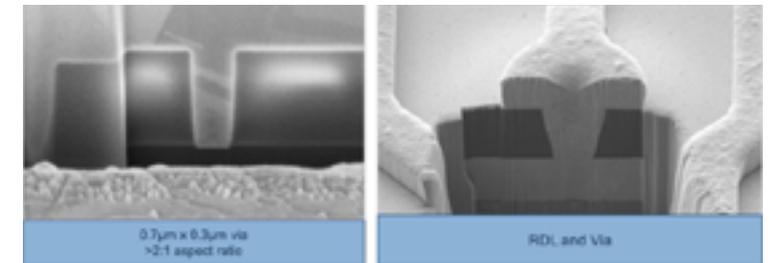
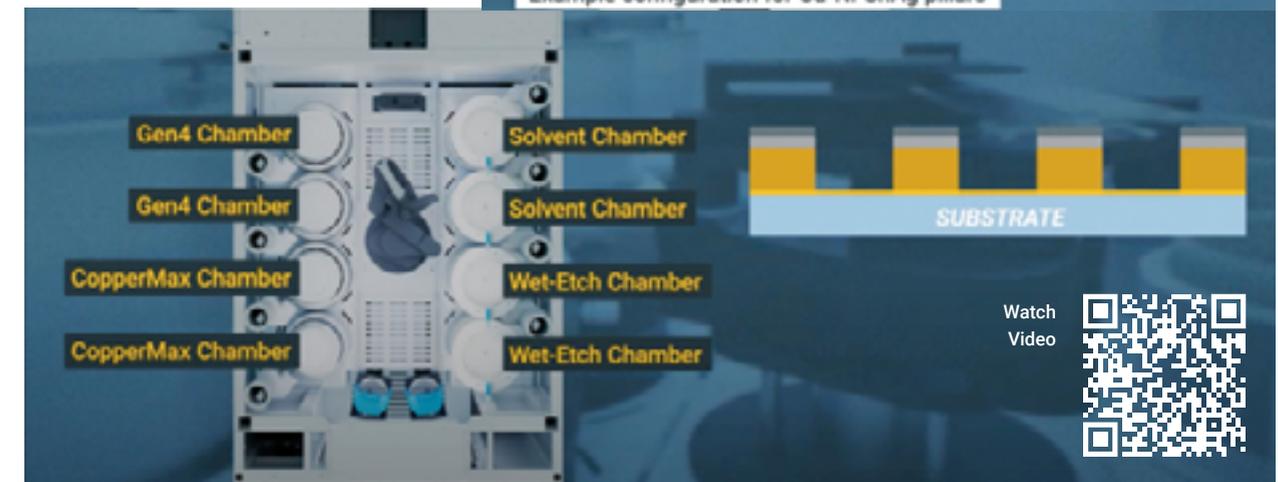


Figure 2: These focused ion beam scanning electron microscope (FIB SEM) images show cross-sectional views of vias and RDL features used in advanced packaging.

Solstice for Advanced Packaging

Example configuration for Cu-Ni-SnAg pillars



Watch Video



SOLSTICE

Max Series

- Modular platform, extendible in the field
- 200mm and 300mm wafer capable
- From 2 to 16 chambers

S-Series

- Monolithic frame
- 3-inch to 200mm wafer capable
- From 2 to 8 chambers
- Smallest footprint

Both platforms are compatible with the full suite of ClassOne advanced plating and wet processing chambers, and are available in configurations tailored for both R&D and high-volume production.



SINGLE WAFER 300MM SOLUTIONS

Solstice Max Series



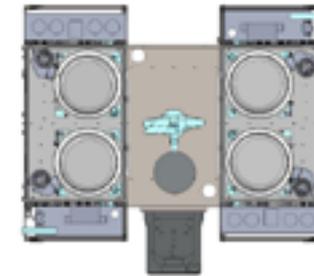
M2

M4 (Expandable to M8, M12 and M16)

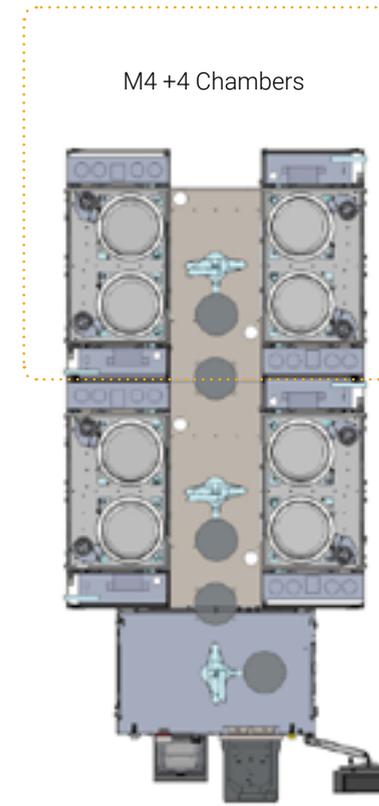
- Modular platform, extendible in the field
- 200mm and 300mm wafer capable
- From 2 to 16 chambers
- Configurable with single load port or EFEM (Equipment Front End Module)
- Flexibility with all Solstice chamber types from electroplating to surface prep including solvent processing

The Max Series platform enables the Solstice to meet customer needs today and in the future with no compromise.

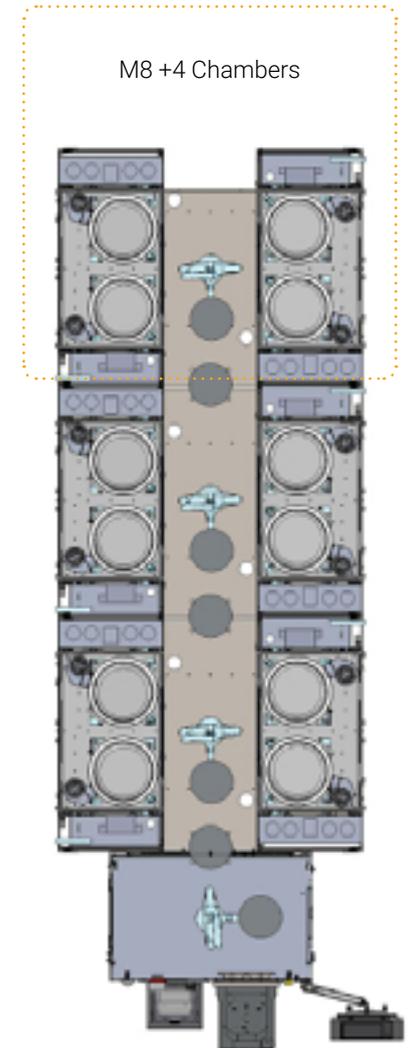
An important advantage is its field extendibility - an M4 system can be installed in a fab and then upgraded to an M8, M12, or M16 when budget and product volume allow for a larger tool. This provides fabs with extraordinary flexibility in how they plan for fab expansion and future wafer volume ramps.



M4



M8



M12

M8 +4 Chambers

M4 +4 Chambers

Solstice[®] M2



Solstice M2

Manually loaded tool for process development, and low volume R&D applications

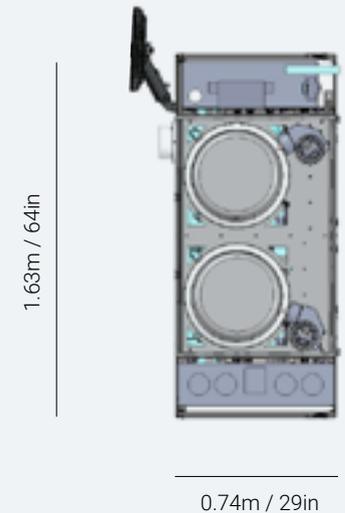
KEY BENEFITS:

- M2 can be extended with 4 or 6 chambers
- Each M2 can be configured with 2 chemically compatible processes
- All Solstice chamber types can be configured within the M2

The M2 platform provides low volume and R&D customers the ability to manually run up to 300mm wafer sizes in a compact system. Because the chambers are identical to the high-volume automated system, scaling to production is straightforward and easy.

The Solstice M2 tool is a semiautomated manual loaded tool. An operator will use the integrated wafer vacuum wand to load and unload wafers into the rotors. The chamber automation, fluidics, chamber design, and recipe is identical to the fully automated tools. The chambers within the M2 can be any pair of chemically compatible chambers. M2's can be sequenced together allowing for 4 or 6 chamber systems. The Max Series platform makes use of a modular frame with integrated adjacent electrical pods that allows for easy repair and maintenance. Additionally, an easily accessed fluidics bay contains all the wetted components like tanks, pumps, filters, heaters, valves in a maintainable layout.

DIMENSIONS:



Solstice[®] M4



Solstice M4

Fully automated single wafer ≤ 300mm processing in a compact footprint

KEY BENEFITS:

- M4 provides automated ECD and SP processing
- M4 allows for all Solstice chamber solutions to be configured
- Fully extendable to M8/M12/M16 in the future
- M4 can be configured with a 5th position for support chambers

The Solstice M4 system makes use of a single 4 chamber frame. It can be configured with a full EFEM for multiple cassette or FOUP load ports or a single load port. Configured with the single load port, the M4 system provides an unprecedented, compact tool for fully automated processing. This M4 can be used for a full bumping process (prewet/SRD, copper, nickel, tin silver) or other plating and surface prep processes. A fifth chamber can be added for increased capability, and it can be removed or repositioned when the tool is extended to an M8/M12/M16.

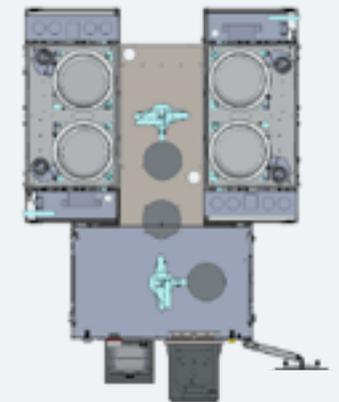
The M4's frame uses integrated adjacent electrical pods that allow for easy repair and maintenance. A single radial robot with dual end effectors allows for efficient wafer automation between FOUP or cassette and chambers. Additionally, an easily accessed fluidics bay below each pair of chambers contains all the wetted components like tanks, pumps, filters, heaters, and valves in a maintainable layout. Facilities can be adapted for "out-the-side" or "out-the-bottom" fabs.

DIMENSIONS:



2.21m / 87in

M4 configured with Single Load Port and 5th Support Chamber Position



M4 configured with EFEM

Solstice[®] M8/M12/M16

M8 = M4 + 4 Chambers M12 = M8 + 4 M16 = M12 + 4



Solstice M8/M12/M16

Solstice Max Series platform scales from compact and low-volume to efficient high-volume production

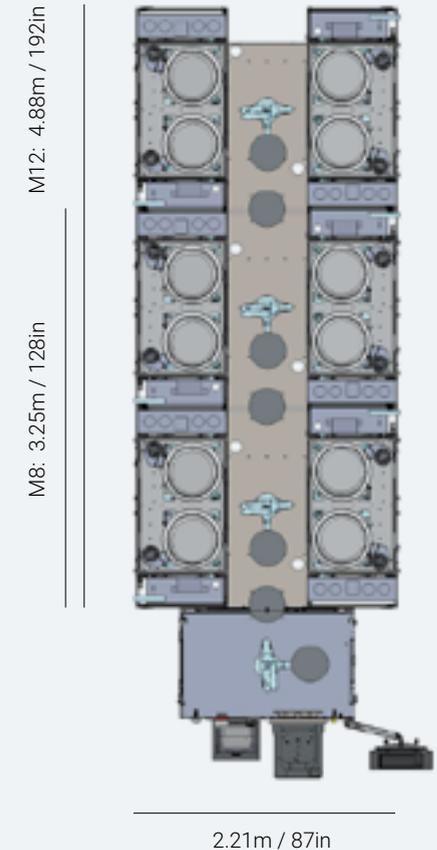
KEY BENEFITS:

- M8 provides automated ECD and SP processing
- M8 allows for all Solstice chamber solutions to be configured
- Fully extendable to M12/M16 in the future
- Advanced control system for MES and ancillary equipment integration

The M8/M12/M16 represents the complete extensibility of the Max Series platform. These high volume tools make use of multiple quad frames sequenced together. Each quad frame uses its independent robot to service chambers and shuttle wafers between adjacent quads or EFEM. Pass through stations that span the quads are accessible from both adjacent quads. This platform allows for high volume processes with many identical chambers running in parallel.

The M8/M12/M16 platform can be integrated with customized EFEMs that meet fab needs. Up to 4 Load ports, wafer scribe OCR (optical character recognition), alignment, and other features can be configured to an EFEM that enables fabs to meet customer expectations. Importantly, an M4 that initially uses a single load port can be upgraded to use an EFEM in the field. The Max Series platform enables the Solstice to meet customer needs today and in the future with no compromise.

DIMENSIONS:



SINGLE-WAFER 200MM SOLUTIONS

Solstice S-Series



Our flexible Solstice® single-wafer platform offers a broad portfolio of electroplating and surface preparation applications in a single, compact system. Engineered for reliability and uptime, Solstice delivers advanced performance with maximum throughput and wafer uniformity.

- Use for plating, cleaning and etching
- From 2 to 8 process chambers
- For 3in to 200mm substrates
- Quick and simple diameter change
- Faster plating rates, higher throughput
- Intuitive operation, higher reliability
- Superior control, greater uniformity
- Thin or bonded, transparent or opaque substrates
- Powerful Solaris 2.0 software
- Smallest footprint in the industry for single wafer plating and wet process tools.

Solstice® LT



Solstice® LT

Semi-automated single-wafer process development with up to three chambers

KEY BENEFITS:

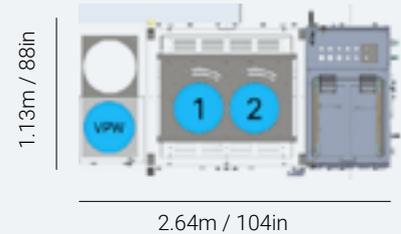
- Up to 3 chambers: 2 ECD, or 2 ECD plus 1 vacuum prewet chamber
- Economical entry to single-wafer processing
- Easy scale-up path to automated production
- Improved process quality and consistency
- Smallest Solstice system footprint
- LT3 available with vacuum pre-wet (VPW) for wetting high aspect ratio features

The Solstice® LT is a full-featured, easy-to-use system for electroplating and surface preparation application, can process a broad range of wafer sizes down to 75mm. In addition to electroplating, the system can perform high-pressure metal lift-off (MLO) spray and acid applications such as UBM etch, and more. The LT accommodates up to three chambers for manual-load, semi-automated process development, R&D, or low-volume production. The systems use the same software and controls, and the same selection of chambers as the Solstice S4 and S8 configurations, providing an easy scale-up to automated production as capacity need expand.

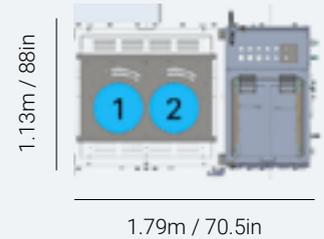
The Solstice LT system chambers may be configured with a mix of different plating and surface prep chambers, including: GoldPro, CopperMax, Wet Etch, Solvent/MLO, Bevel Etch, and Gen4 Chamber.

DIMENSIONS:

LT3



LT



Solstice® S4



Solstice® S4

Advanced, single-wafer, high-throughput ECD and surface preparation, with up to four chambers

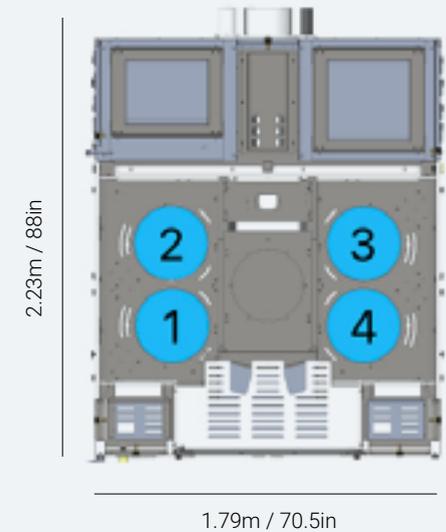
KEY BENEFITS:

- Smaller footprint and lower cost than Solstice S8
- High plating rates, excellent throughput
- Exceptional quality plating and surface prep
- Special processing chambers can substantially reduce plating costs
- Superior process control and excellent uniformity

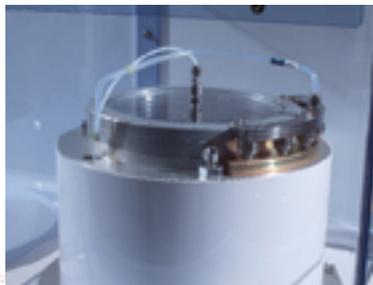
The Solstice® S4 automated electroplating systems are high-speed, fully -automated, 4-chamber tool designed for electroplating as well as surface preparation wet processing. The S4 provides all the essential features and capabilities of the S8, but with fewer chambers, a smaller footprint, and a lower price. The S4 can be ideal for users with simpler processing needs or who require an economical entry point into mid-level automated single-wafer electroplating production with enhanced process control.

The Solstice S4's four chambers may be configured with a mix of different plating and surface prep chambers: GoldPro, CopperMax, Wet Etch, Solvent/MLO, Bevel Etch, and Gen4 Chamber.

DIMENSIONS:



Solstice® S8



Solstice® S8

Advanced single-wafer electroplating and surface preparation, with up to eight chambers

KEY BENEFITS:

- High plating rates, excellent throughput
- Exceptional quality plating and surface prep
- Special processing chambers can substantially reduce plating costs
- Superior process control and excellent uniformity

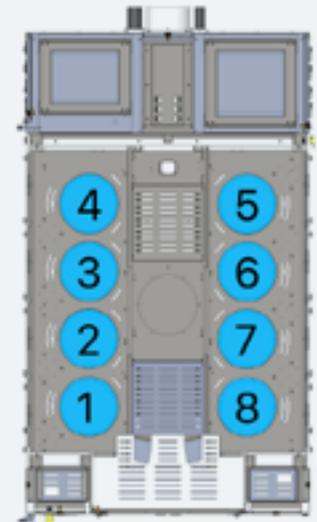
The Solstice® S8 is the most powerful, easy-to-use, and cost-efficient route to single-wafer volume production for many applications.

The S8 is engineered to deliver class-leading performance and exceptional operational flexibility. Its unique platform enables it to handle a spectrum of wet processes, from electroplating to high-pressure metal lift-off (MLO) to UBM etch and much more. The system is designed to accommodate many different substrate types, both transparent and opaque, from ultra thin to bonded. With its ability to deliver high-quality plating of a wide range of metals, the Solstice S8 can significantly reduce plating costs.

Solstice gives wet bench users an attractive, affordable, and easy upgrade path to the benefits of high-speed, cassette-to-cassette automated processing. The eight chambers of this system may be configured with a mix of different plating and surface prep chambers: GoldPro, CopperMax, Wet Etch, Solvent/MLO, Bevel Etch, and Gen4 Chamber.

DIMENSIONS:

3.06m / 120in



1.79m / 70.5in

Solstice Chamber Options

Solstice chambers are fully compatible with both the Max platform and S platform, providing versatile installation options.

Surface Preparation

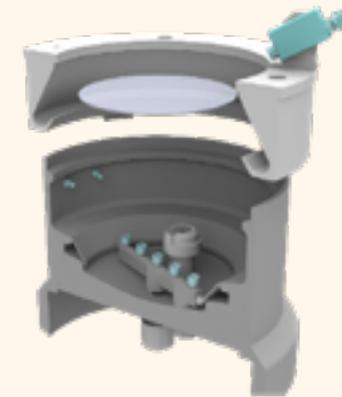
Solvent & MLO with FaceUp SRD



High-flow direct impingement spray and high-pressure swing arm delivery for maximum process flexibility, supporting all common solvent chemistries. Paired with FaceUp SRD for faster, cleaner spin-drying.

- Flood soak technology
- High pressure programmable scan arm (up to 3000PSI)
- Front and backside side rinse
- Face Up SRD for segregated dry – No wet transfers
- Inline heaters for up to 80degC +/-1deg
- Inline filtration and solids drain screen

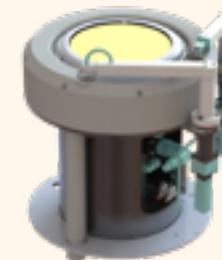
Wet Etch



High flow rates, highly uniform etching with low undercut for under-bump metallization (UBM) and other patterned etch applications.

- Optical Endpoint Detection
- Up to 4LPM flowrates
- Customizable spray bar
- Front and backside side rinse
- Face Up SRD for segregated dry
- Inline heaters for up to 60degC +/-1deg
- Inline filtration

Bevel Etch



Uses precision clamping and swing arms to achieve accurate bevel cut widths of Copper and other materials. Can also be used to etch and clean with backside chemistries.

- Backside cleans and etches
- Multiple programmable swing arms
- Optimized drain weir with no splashback
- Performs SRD functions

Electroplating Chambers

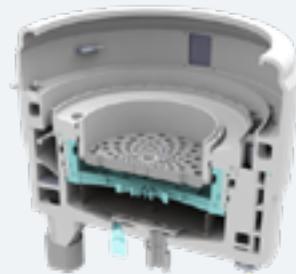
Gen4 ECD



Excellent cross-wafer uniformity and repeatability, robust in situ rinse and fast transfer times, ensures excellent intra-layer adhesion.

- Adjustable electric field control
- CFD designed
- In Situ rinse
- Fully programmable power supply with pulse option

CopperMax



High copper plating rates and quality, greatly reduced additive consumption to enable lower cost of ownership.

CopperMax reactor uses cationic exchange membrane to improve bath management and prolong the effectiveness of expensive organic bath additives.

GoldPro



Advanced design aimed at optimizing gold plating, delivers exceptional plating uniformity together with high wafer throughput.

GoldPro reactor improves upon fluid dynamics to improve the transport of gold cations at the wafer surface. This allows for faster and more uniform plating of gold across many features including fine features and via liners.

Electroplating Support

Prewet + SRD



Spin Rinse Dry with full spray coverage and complete rinsing. Paired with Face Up Dry gives fast and clean final dry of wafers.

Vacuum Prewet



Uses a vacuum to quickly wet out high aspect ratio features which won't wet with traditional soak or spray.

Solaris 2.0 Controller

- Beckhoff Industrial PC and PLC
- Raid Storage array
- GEM SECS integration
- Rich and intuitive GUI
- Advanced data logging and reporting
- Automated wafer recovery
- Customizable user profiles



Solstice Process Capability

For Ultimate Wafer Uniformity and Process Control

Configurable for multiple plating, solvent and wet-etch chambers all within the same frame, the Solstice platform is suitable for both R&D and high-volume manufacturing environments.

Plating

ELECTROPLATING METALS AND ALLOYS

- Copper
- Gold
- Nickel
- Tin Silver
- Indium

ELECTROPLATING FEATURES

- TSV
- Pillar
- RDL
- Damascene
- Via Liner

Surface Prep

SOLVENT

- Metal Lift-Off (MLO)
- Photoresist Strip (including dry film)
- Polymer Removal

WET-ETCH

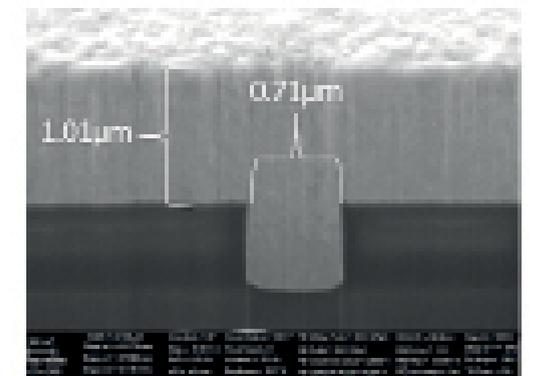
- Film Etch
- UBM Etch
- RCA Cleans
- TSV Cleans

Fine Feature Gold Fill

Using the Solstice® GoldPro™ Chamber

Benefits:

- High plating rate and high uniformity
- Extremely uniform field profile
- Maximized bath life
- Seal reach aligns to existing integration
- Continuously cleaner chemistry
- Precise, consistent flow rate control



Technical Data:

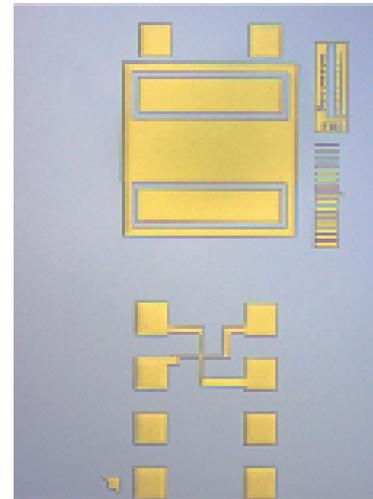
| | |
|----------------------------------|---|
| Plating Rate | Up to 0.5/minute (depend on chemistry and feature size) |
| Within-Wafer Uniformity | <2% |
| Within Feature Uniformity | <2% |
| Wafer-to-Wafer Uniformity | <2% |
| Step Coverage | 70-93% (depend on aspect ratio) |
| Roughness | <2kA |

Gold Deplating

Using the Solstice® Gen4 ECD Chamber

Benefits:

- Extremely uniform removal
- Optimal, responsive removal rate
- Extremely uniform field profile
- Contact reach aligns to existing integration
- Accurate, precise flow rate control



Technical Data:

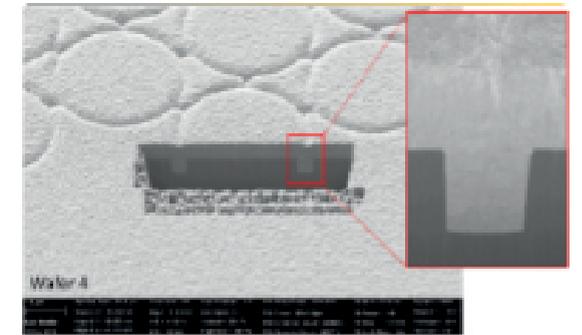
| | |
|----------------------------------|-------|
| Within-Wafer Uniformity | <2% |
| Within Feature Uniformity | <2% |
| Roughness | 3A Ra |

Through-Mask Gold Plating

Using the Solstice® GoldPro™ Chamber

Benefits:

- High plating rate and high uniformity
- Extremely uniform field profile
- Maximized bath life
- Seal reach aligns to existing integration
- Continuously cleaner chemistry
- Precise, consistent flow rate control



Technical Data:

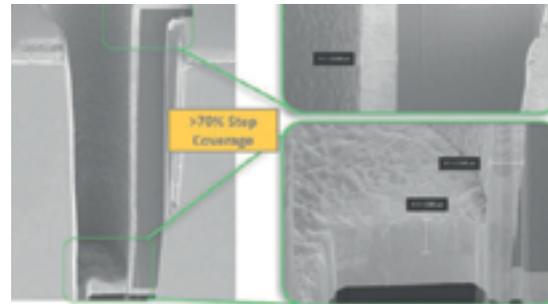
| | |
|----------------------------------|--|
| Plating Rate | Up to 1µm/minute (depend on chemistry) |
| Within-Wafer Uniformity | <2% |
| Within Feature Uniformity | <2% |
| Roughness | <2kA |

Gold TWV Plating

Using the Solstice® GoldPro™ Chamber

Benefits:

- High plating rate and high uniformity
- Extremely uniform field profile
- Maximized bath life
- Seal reach aligns to existing integration
- Continuously cleaner chemistry
- Precise, consistent flow rate control



Technical Data:

| | |
|--------------------------------|--|
| Plating Rate | Up to 1µm/minute (depend on chemistry) |
| Within-Wafer Uniformity | <2% |
| Step Coverage | 70-93% (depend on aspect ratio) |

Uniform Nickel Electroplating

Using the Solstice® Gen4 ECD Chamber

Benefits:

- Reduced film stress
- Fast transfer times
- Uniform plating performance
- High throughput



Technical Data:

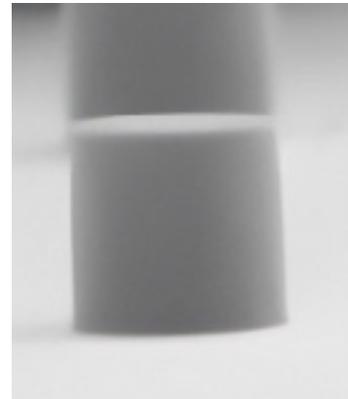
| | |
|----------------------------------|-----|
| Within-Wafer Uniformity | <3% |
| Wafer-to-Wafer Uniformity | <1% |

Copper Pillar Plating

Using the Solstice® CopperMax™ Chamber

Benefits:

- Additive costs reduced >95%
- Maximized bath life
- Extremely uniform field profile
- Seal reach aligns to existing integration
- Continuously cleaner chemistry
- Precise, consistent flow rate control



Technical Data:

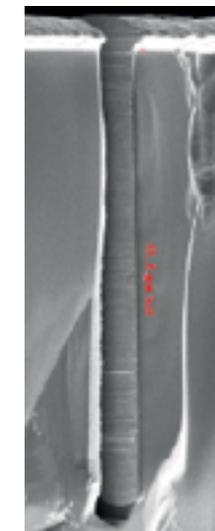
| | |
|----------------------------------|--|
| Plating Rate | >3 $\mu\text{m}/\text{minute}$, up to 6.5 $\mu\text{m}/\text{minute}$ |
| Within-Wafer Uniformity | <3% |
| Wafer-to-Wafer Uniformity | <1% |
| Coplanarity | <5% |

Copper TSV Fill Plating

Using the Solstice® CopperMax™ Chamber

Benefits:

- Additive costs reduced >95%
- Maximized bath life
- Extremely uniform field profile
- Seal reach aligns to existing integration
- Continuously cleaner chemistry
- Precise, consistent flow rate control



Technical Data:

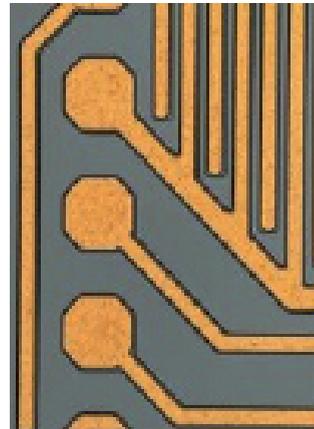
| | |
|----------------------------------|---|
| Aspect Ratio Capability | >10:1 |
| Overburden | <2 microns |
| Fill Rates | <1 hour for 10x100 μm , <20 minute for 5x50 μm (dependent on feature) |
| Within-Wafer Uniformity | <5% |
| Wafer-to-Wafer Uniformity | <1% |
| Fill Quality | Void-free and Seam-free |

Copper RDL Plating

Using the Solstice® CopperMax™ Chamber

Benefits:

- Uniform plated feature shape
- Lower chemistry costs
- Optimized cost of ownership



Technical Data:

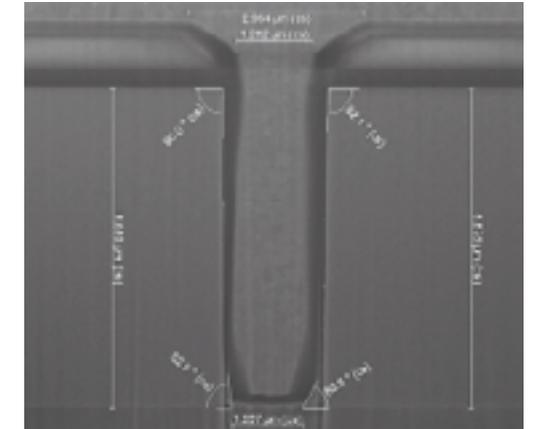
| | |
|----------------------------------|-----|
| Within-Wafer Uniformity | <3% |
| Wafer-to-Wafer Uniformity | <1% |

Copper Damascene Fill

Using the Solstice® CopperMax™ Chamber

Benefits:

- Additive costs reduced >95%
- Maximized bath life
- Extremely uniform field profile
- Seal reach aligns to existing integration
- Continuously cleaner chemistry
- Precise, consistent flow rate control



Technical Data:

| | |
|----------------------------------|---|
| Process Time | <3 minutes/wafer, <20 min for 5x50um (dependent on feature) |
| Within-Wafer Uniformity | <5% |
| Wafer-to-Wafer Uniformity | <1% |
| Fill Quality | Void-free |

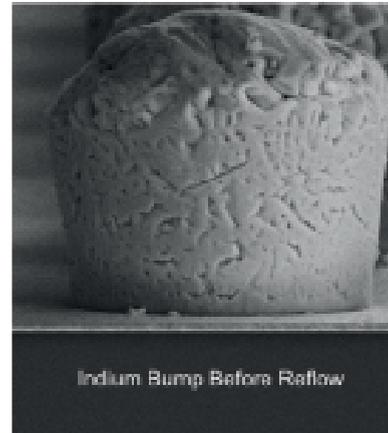
Indium Bump Plating

Using the Solstice® Gen4 ECD Chamber

Benefits:

Compared to traditional evaporation method:

- Low cost of ownership
- High aspect ratio bumps
- High throughput capable



Technical Data:

| | |
|----------------------------------|-----|
| Within-Wafer Uniformity | <5% |
| Within Feature Uniformity | <2% |
| Wafer-to-Wafer Uniformity | <3% |

Surface Preparation

For Ultimate Wafer Uniformity and Process Control

Through its innovative combination of face down processing and face up dry, Solstice delivers exceptional performance. Options can be configured for pH monitoring, temperature control, and precise mixing, dosing and spiking of baths. The wet etch chamber is also capable of optical end point detection to give fabs high confidence and efficiency in film removal.

Face Down Processing:

- Direct impingement spray across full wafer
- Fast and uniform etching and stripping
- Cleaner MLO as material naturally falls away from wafer
- Safety with fully sealed and exhausted chambers

Face Up SRD (Spin Rinse Dry)

- Fast dry with HEPA filter air
- Segregated dry to improve cleanliness and throughput

UBM Etch and Patterned Metal Wet Etch

Using the Solstice® Wet Etch Chamber

Benefits:

- Low cost of ownership
- High flexibility
- Process effectiveness



Technical Data:

| | |
|----------------------------------|-----------------------|
| Undercut | No undercut |
| Within Feature Uniformity | High Uniformity (<3%) |
| Wafer-to-Wafer Uniformity | <3% |

Metal Lift-Off

Using the Solstice® Solvent/MLO Chamber

Post-MLO



Benefits:

- Flood soak technology
- Face down processing
- Dry to dry – no wet transfers
- High pressure option – up to 3000 PSI
- Face up SRD

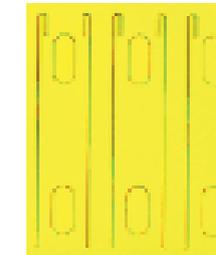
Technical Data:

| | |
|---------------------------------------|-----------------------------------|
| Readhesion or damaged features | No readhesion or damaged features |
| Feature size | <1 micron feature size capable |

Photoresist Strip

Using the Solstice® Solvent/MLO Chamber

Post-Strip



Benefits:

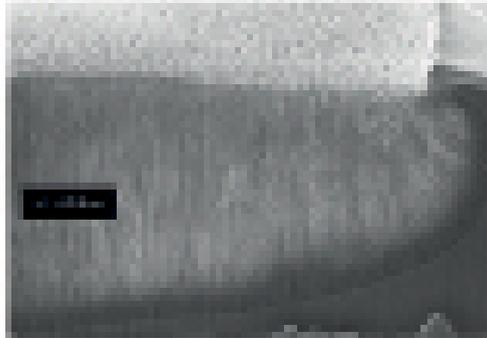
- Flood soak technology
- Face down processing
- Dry to dry – No wet transfers
- High pressure option – Up to 3000 PSI
- Face up SRD

Technical Data:

| | |
|---------------------------------------|-----------------------------------|
| Readhesion or damaged features | No readhesion or damaged features |
|---------------------------------------|-----------------------------------|

Anodization

Using Solstice® Gen4 ECD Chamber



Benefits:

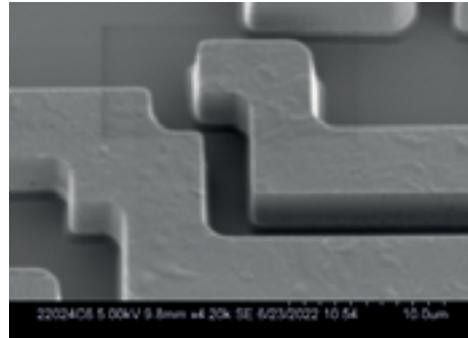
- Protected bevel and backside
- Highly uniform processing

Technical Data

- Customizable waveform
- Adjustable cathode shielding

Wet Cleans

Using Solstice® Wet Etch Chamber



Benefits:

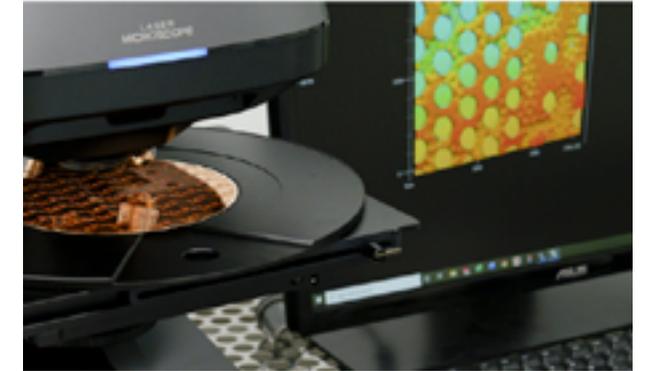
- Mixed chemistry control
- RCA cleans and solvent cleans
- Segregated dry (face up)
- Face down processing

Technical Data

- < 5 adders at 200nm inspection

Technology Development Center

ClassOne's Technology Development Center (TDC) provides our process and equipment experts with a cleanroom environment featuring advanced metrology and process equipment. The TDC affords us the capability to process customer wafers, execute process experiments, and test new products and enhancements to existing products. In addition, customers are always welcome to visit to observe our live technology demonstrations and rigorous technical training.



- Located in Kalispell, Montana USA
- 10,000 square feet with a Class 100 Cleanroom
- Core focus of Process Development, Hardware Development, Customer demos and Customer training
- Full suite of Solstice process chambers and metrology



Our Work

ClassOne Technology provides a full-range of world-class customer service and support to our worldwide customer base from pre-sale consultation all the way through system installation and applications/process development.

With an installed base in major fabs and R&D organizations throughout North America, Europe, China, Taiwan, Southeast Asia, Korea and Japan, we expanded our presence via our industry-leading distribution partner and customer service network.



ClassOne
TECHNOLOGY

Contact Us

ClassOne has a long-standing reputation for professional, in-depth, global customer support – before, during, and after the sale. Whenever and wherever we can help, we are there!

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