



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

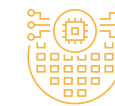
Proven process technology with high-quality results and ROI

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 and 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.



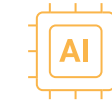
Our Markets



Advanced Packaging



Photonics



Artificial Intelligence



MEMS and Sensors



RF and Power Devices

ClassOne at a Glance

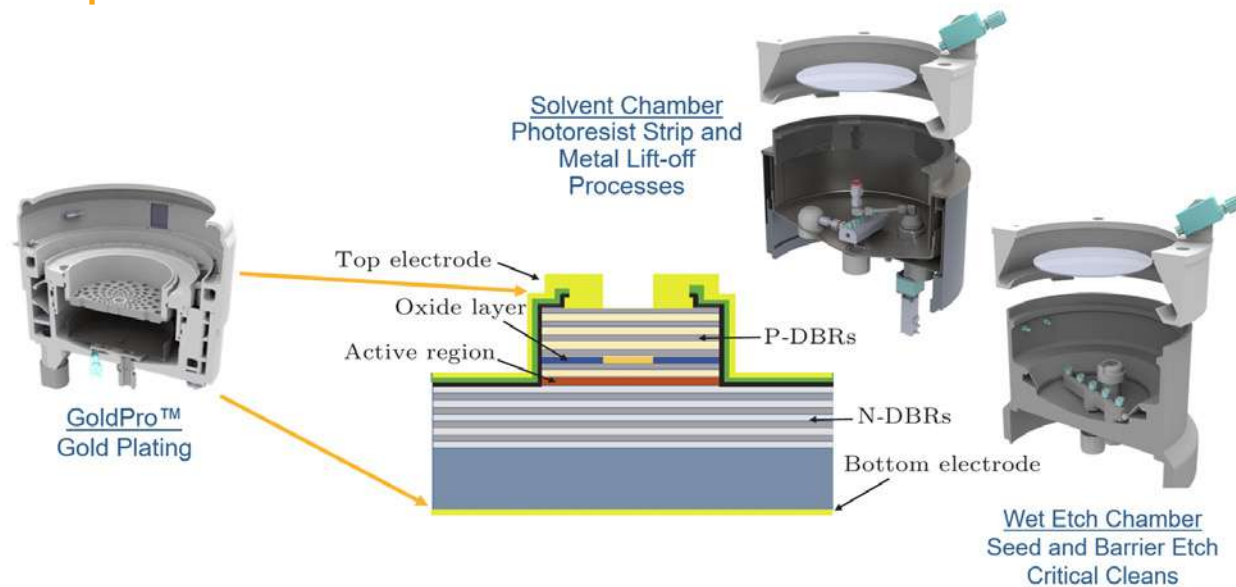
- Advanced single-wafer electroplating platform, established as tool of record in multiple industry segments
- >750 chambers installed worldwide
- Headquarters in Kalispell, Montana
- Global footprint with offices and customer support regionally based
- Founded in 2013

Device-Level Applications

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

- Gold Plating
- Gold Via Liner
- Photoresist Strip
- Backside Etch and Cleans
- Bevel Etch
- Metal Lift-Off (MLO)

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

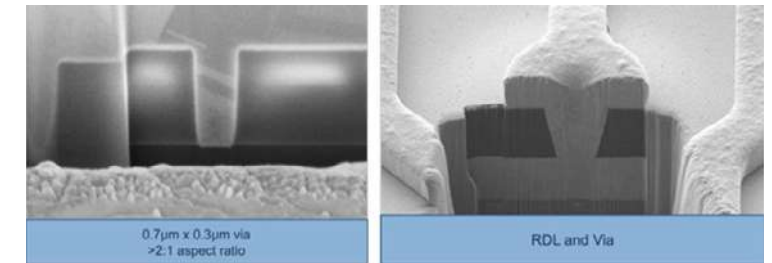
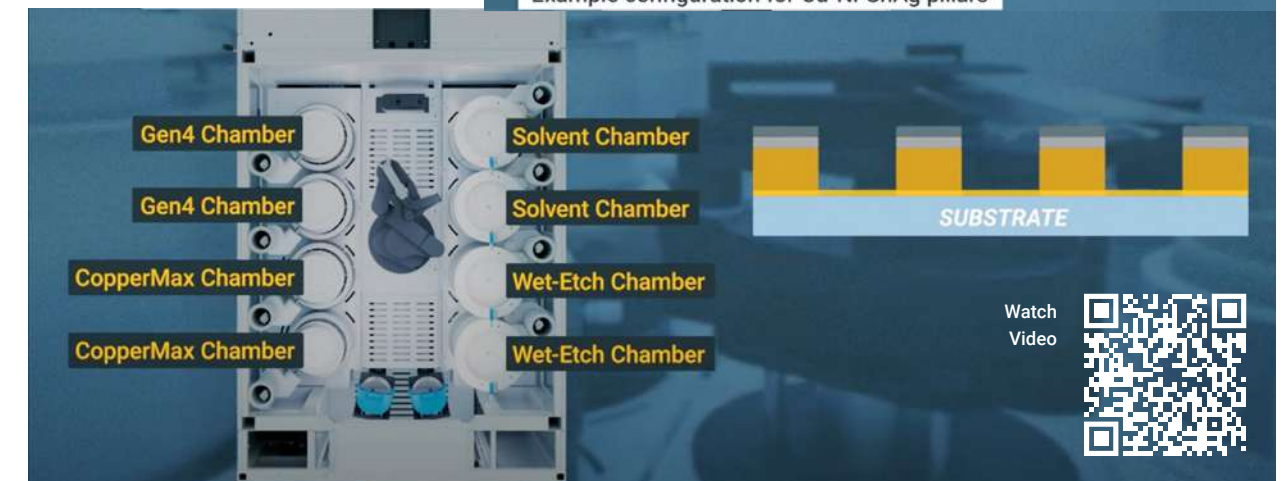


Figure 2: These focused ion beam scanning electron microscope (FIB-SEM) images show cross-sectional views of vias and RDL features used in advanced packaging.

Solstice for Advanced Packaging

Example configuration for Cu-Ni-SnAg pillars



Solstice

SOLSTICE™

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

SOLSTICE MAX

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

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.



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 3-inch 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:

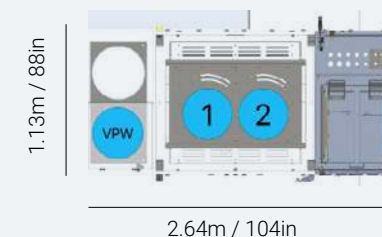
- Up to 3 chambers: 2 ECD, or 2 ECD plus 1 vacuum prewet chamber
- Economical entry to single-wafer processing
- Easy scale-up path to automated production
- Improved process quality and consistency
- Smallest Solstice system footprint
- LT3 available with vacuum pre-wet (VPW) for wetting high-aspect-ratio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

The Solstice® LT is a full-featured, easy-to-use system for electroplating and surface preparation application that 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) and spray 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 system uses 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 expands.

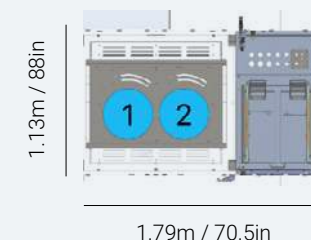
The Solstice LT system chambers may be configured with a mix of different plating and surface prep chambers, including GoldPro, CopperMax, Wet Etch, Solvent/MLO, Bevel Etch, Gen4 ECD, and Vacuum Pre-Wet.

DIMENSIONS:

LT3



LT



Solstice[®] S4



Solstice[®] S4

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

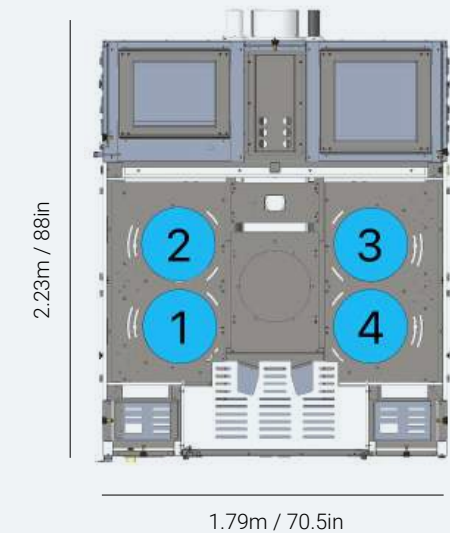
KEY BENEFITS:

- 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 four-chamber tools 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 specialty 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, Gen4 ECD, and Vacuum Pre-Wet.

DIMENSIONS:



Solstice[®] S8



Solstice[®] S8

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

KEY BENEFITS:

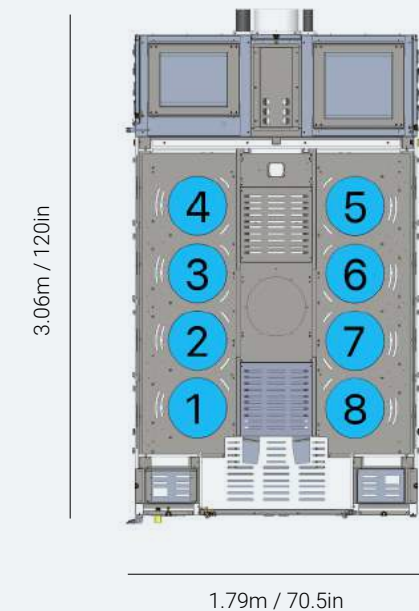
- High plating rates, excellent throughput
- Exceptional quality plating and surface prep
- Special processing chambers can substantially reduce plating costs
- Superior process control and excellent uniformity

The Solstice[®] S8 is the most powerful, easy-to-use and cost-efficient route to single-wafer volume production for electroplating and many other 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 and 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, Gen4 ECD and Vacuum Pre-Wet.

DIMENSIONS:



SINGLE-WAFER 300MM SOLUTIONS

Solstice Max Series



M2

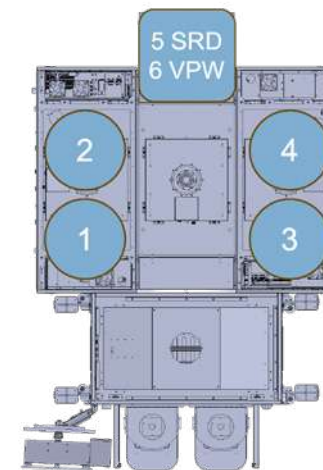


M4 (Expandable to M8, M12 and M16)

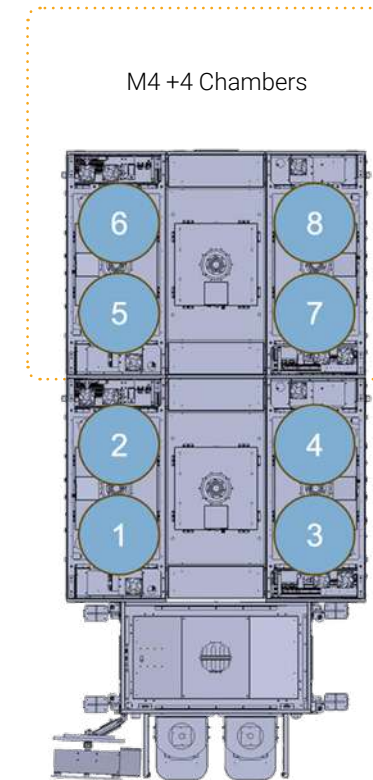
- 200mm and 300mm wafer capable
- From 2 to 16 chambers
- Configurable with single load port, dual load port, or EFEM (equipment front-end module)
- Flexibility with all Solstice chamber types from electroplating to surface prep, including solvent processing
- Modular platform, extendable in the field

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

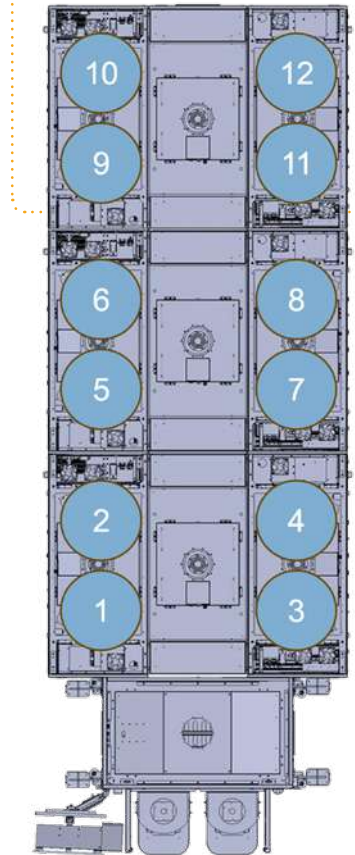
An important advantage is its field extendability: An M4 system can be installed in a fab and then upgraded to an M8, M12 or M16 when budget and product volume allow for a larger tool. This provides fabs with extraordinary flexibility in how they plan for fab expansion and future wafer-volume ramps.



M4



M8



M12

M8 +4 Chambers

Solstice[®] M2



Solstice M2

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

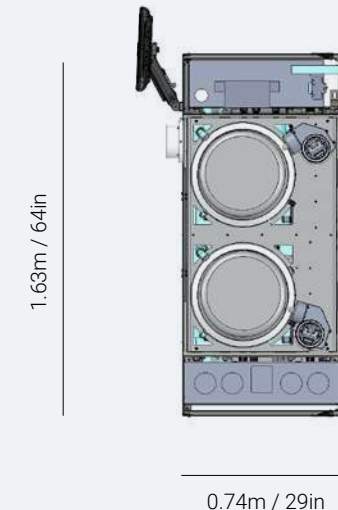
KEY BENEFITS:

- M2 can be configured with two process chambers or one process chamber and one stacked SRD/Vacuum Pre-Wet
- The M2 chambers are identical to those used in the M4 & M8 automated tools for rapid process transfer
- 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 semi-automated 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 are identical to the fully automated tools. The chambers within the M2 can be any pair of chemically compatible chambers. The Max Series platform makes use of a modular frame with integrated adjacent electrical pods, allowing for easy repair and maintenance. Additionally, an easily accessed fluidics bay contains all the wetted components like tanks, pumps, filters, heaters and valves in a maintainable layout.

DIMENSIONS:



Solstice[®] M4



Solstice M4

Fully automated single-wafer $\leq 300\text{mm}$ processing in a compact footprint

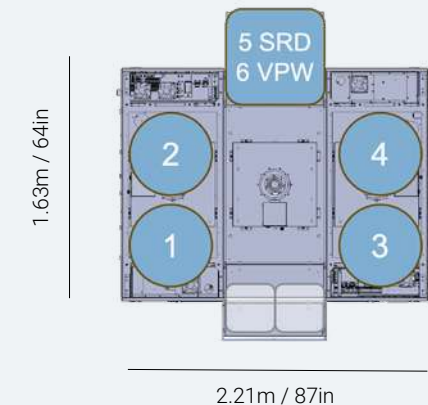
KEY BENEFITS:

- 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 & 6th position for SRD & vacuum pre-wet chambers, allowing up to four different metals in a compact footprint

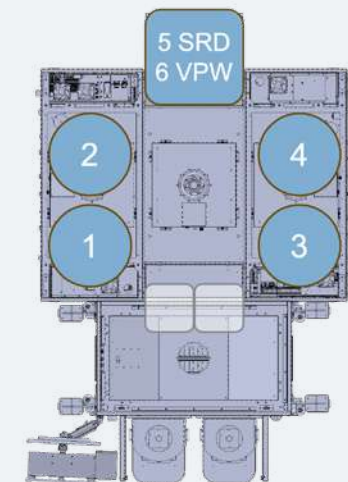
The Solstice M4 system makes use of a single four-chamber frame. It can be configured with a full EFEM for multiple cassette or FOUP load ports or a single load port. Configured with the single load port, the M4 system provides an unprecedented, compact tool for fully automated processing. The M4 can be used for a full bumping process (prewet/SRD, copper, nickel, tin silver) or other plating and surface prep processes.

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:



M4 configured with Dual
Cassette Load Port



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

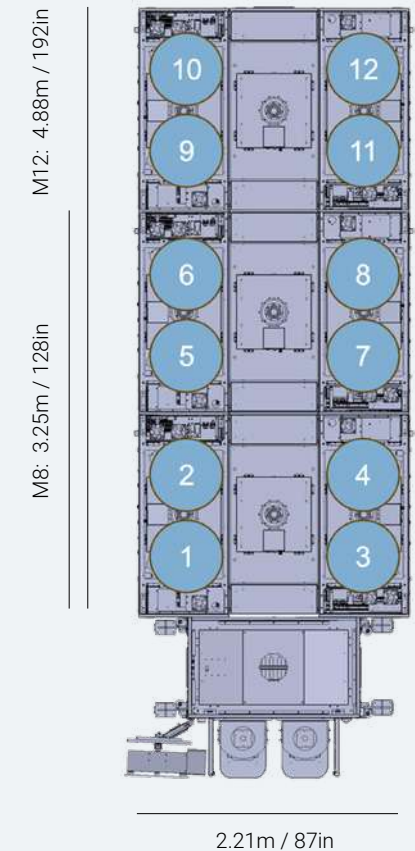
KEY BENEFITS:

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

DIMENSIONS:



Solstice Chamber Options

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

Electroplating Chambers

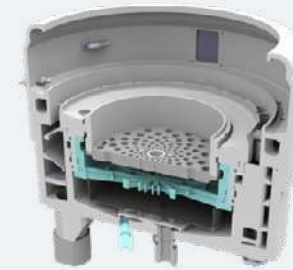
GoldPro



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

The 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.

CopperMax



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

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

Gen4 ECD

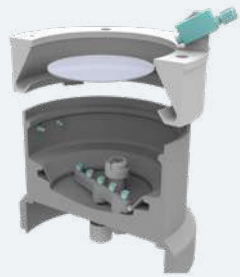


Excellent cross-wafer uniformity and repeatability, robust in situ rinse and fast transfer times, ensures excellent intra-layer adhesion.

- Ultimate uniformity and process control across a wide range of metals, solders and alloys
- Adjustable electric field control
- In situ rinse
- Fully programmable power supply with pulse option

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.

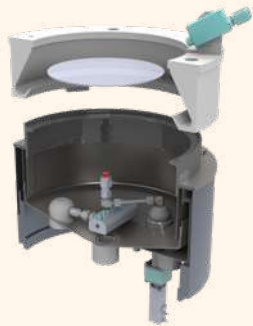
Vacuum Prewet



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

Surface Preparation

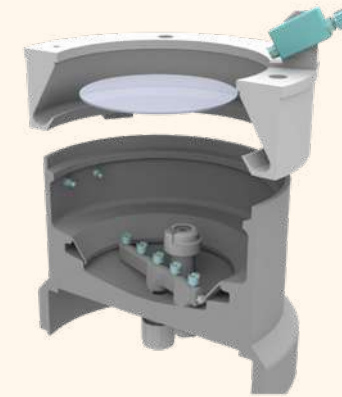
Solvent & MLO with FaceUp SRD



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 3,000 psi)
- Front- and backside side rinse
- Face Up SRD for segregated dry – no wet transfers
- Inline heaters for up to 80°C, +/- 1°C
- Inline filtration and solids drain screen

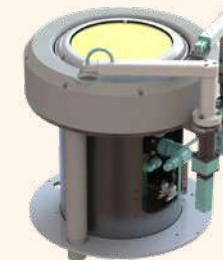
Wet Etch



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

- Optical endpoint detection
- Flow rates up to 4 LPM
- Customizable spray bar
- Front- and backside rinse
- Face Up SRD for segregated dry
- Inline heaters for up to 60°C +/- 1°C
- Inline filtration

Bevel Etch

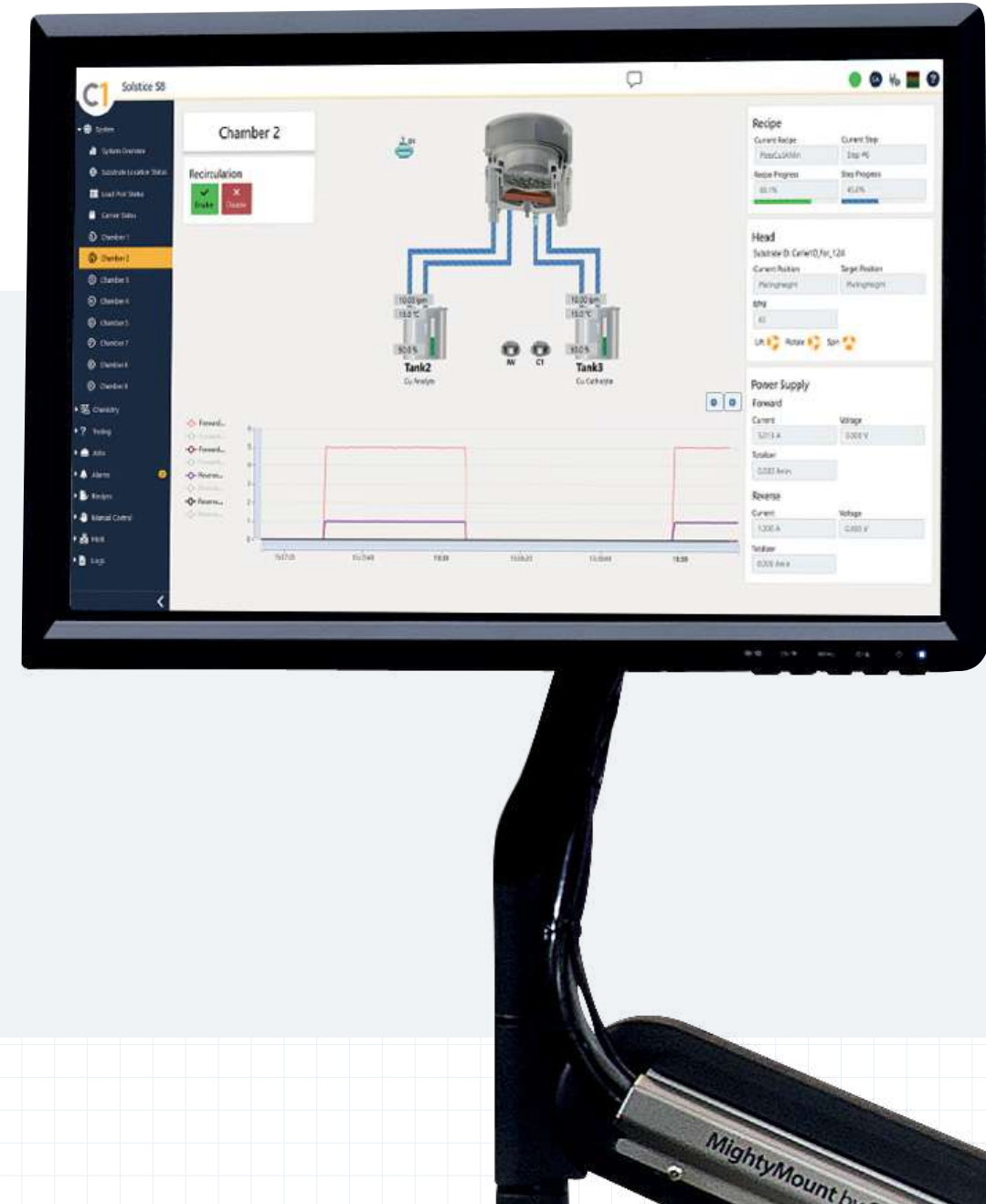


Uses precision clamping and swing arms to achieve accurate bevel cut widths of copper and other materials. Can also be used to etch and clean with backside chemistries.

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

Solaris 2.0 Controller

- Industrial-grade PC and PLC
- Raid storage array
- GEM SECS integration
- Rich and intuitive GUI
- Advanced data logging and reporting
- Automated wafer recovery
- Customizable user profiles
- Predictive, load-balancing wafer scheduler



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

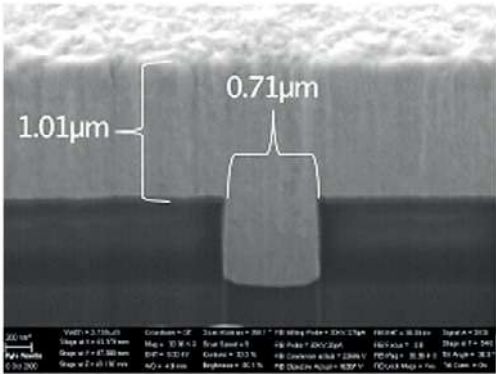
- Film Etch
- UBM Etch
- RCA Cleans
- TSV Cleans

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:

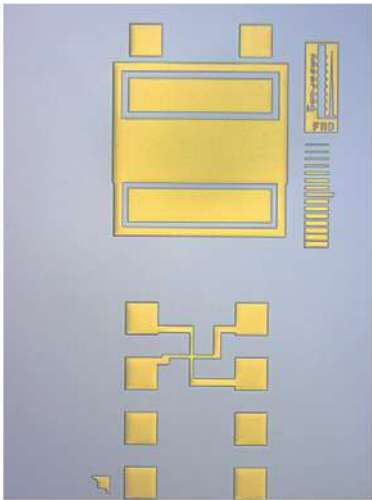
Plating Rate	Up to 0.5/minute (depend on chemistry and feature size)
Within-Wafer Uniformity	<2%
Within-Feature Uniformity	<2%
Wafer-to-Wafer Uniformity	<2%
Step Coverage	70%-93% (depend on aspect ratio)
Roughness	<2 kA

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:

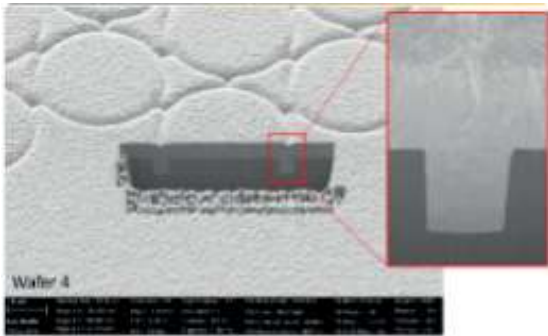
Within-Wafer Uniformity	<2%
Within-Feature Uniformity	<2%
Roughness	3A Ra

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:

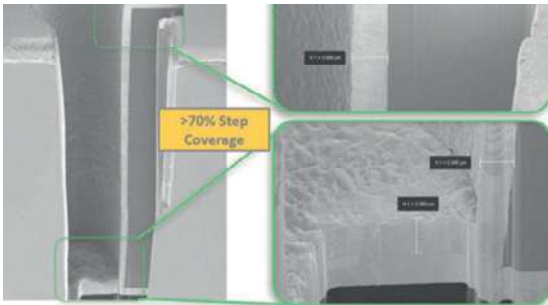
Plating Rate	Up to 1µm/minute (depend on chemistry)
Within-Wafer Uniformity	<2%
Within-Feature Uniformity	<2%
Roughness	<2 kA

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 µm/minute, up to 6.5 µm/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:

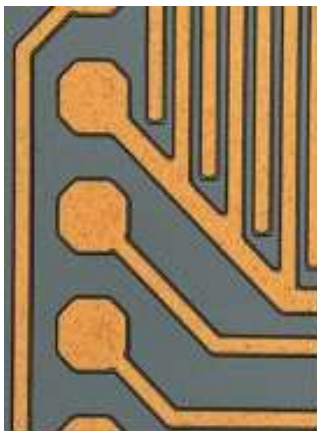
Aspect Ratio Capability	>10:1
Overburden	<2 microns
Fill Rates	<1 hour for 10x100µm, <20 minutes for 5x50µm (depending on feature)
Within-Wafer Uniformity	<5%
Wafer-to-Wafer Uniformity	<1%
Fill Quality	Void-free and seam-free

Copper RDL Plating

Using the Solstice® CopperMax™ Chamber

Benefits:

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



Technical Data:

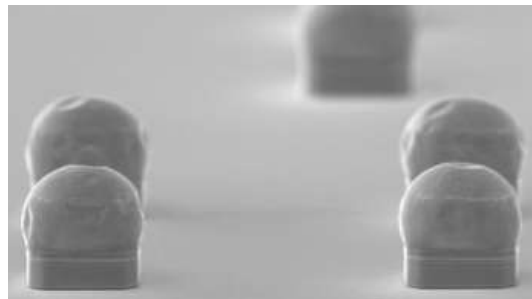
Within-Wafer Uniformity	<3%
Wafer-to-Wafer Uniformity	<1%

Multi Metal Pillar Fill

Using multiple Solstice® Chambers

Benefits:

- Multilayer metal bumps
- Example: Cu-Ni-SnAg and Cu-Ni-Au
- Automated intermetal wafer rinses
- Advanced scheduler for optimized tool throughput
- Vacuum Pre-Wet (VPW) for high-aspect-ratio wetting



Technical Data:

Within-Wafer Uniformity	<5%
Wafer-to-Wafer Uniformity	<1%
Fill Quality	Void-free

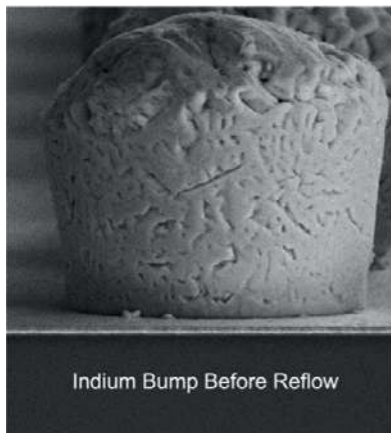
Indium Bump Plating

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

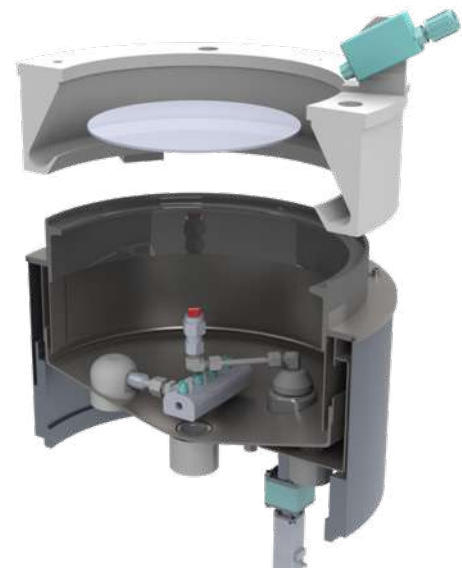
Through its innovative combination of face down processing and face up dry, Solstice delivers exceptional performance. Options can be configured for pH monitoring, temperature control, and precise mixing, dosing and spiking of baths. The wet etch chamber is also capable of optical endpoint detection 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-filtered air
- Segregated dry to improve cleanliness and throughput

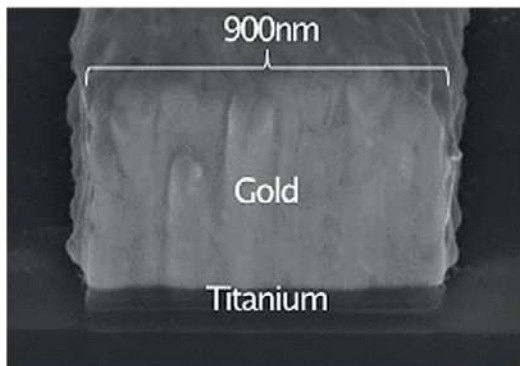


UBM Etch and Patterned Metal Wet Etch

Using the Solstice® Wet Etch Chamber

Benefits:

- Low cost of ownership
- High flexibility
- Process effectiveness



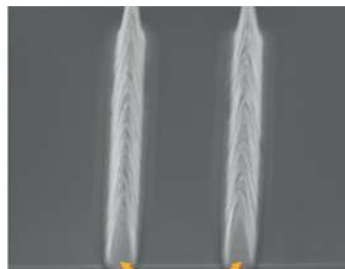
Technical Data:

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 3,000 psi
- Face up SRD

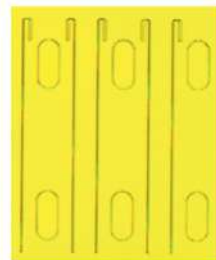
Technical Data:

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:

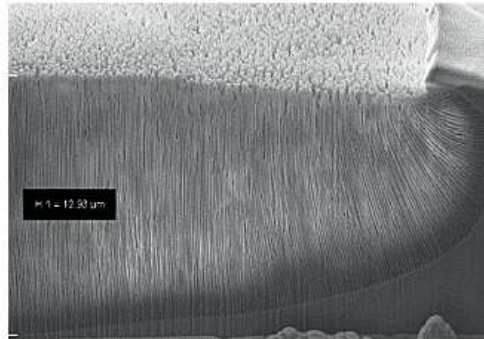
- Flood soak technology
- Face down processing
- Dry to dry – no wet transfers
- High-pressure option – Up to 3,000 psi
- Face up SRD

Technical Data:

Readhesion or Damaged Features	No readhesion or damaged features
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Anodization

Using Solstice® Gen4 ECD Chamber



Benefits:

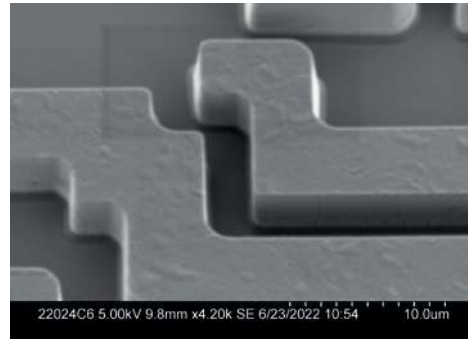
- Protected bevel and backside
- Highly uniform processing

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

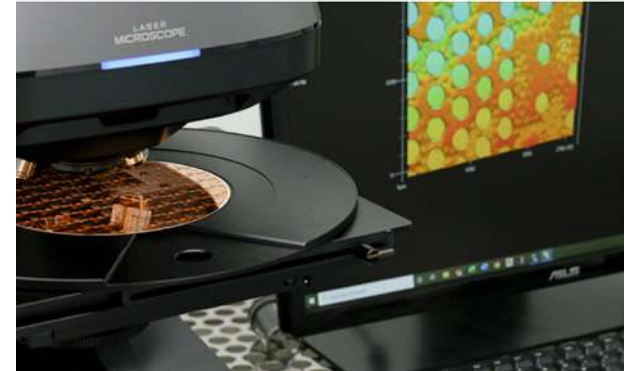
Technical Data

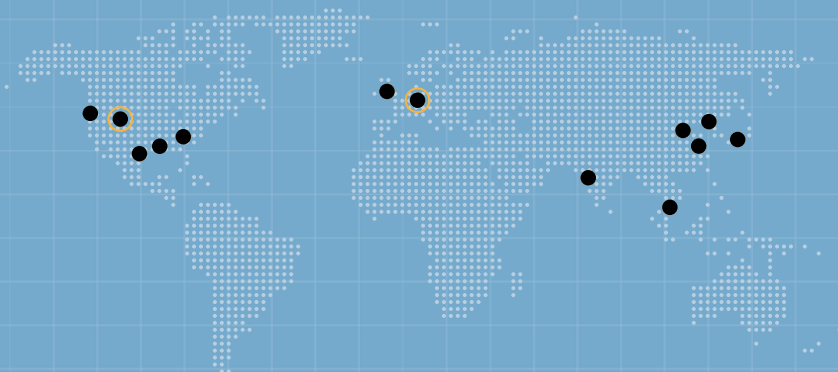
- < 5 adders at 200nm inspection

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 support and service to our customer base across the world.

Headquarters:

109 Cooperative Way,
Kalispell, Montana, 59901, United States

European Office:

ClassOne Technology GmbH,
Industriestr. 5, 83395 Freilassing, Germany

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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