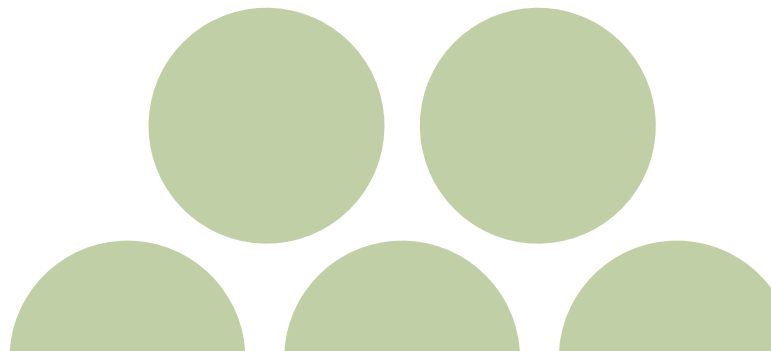




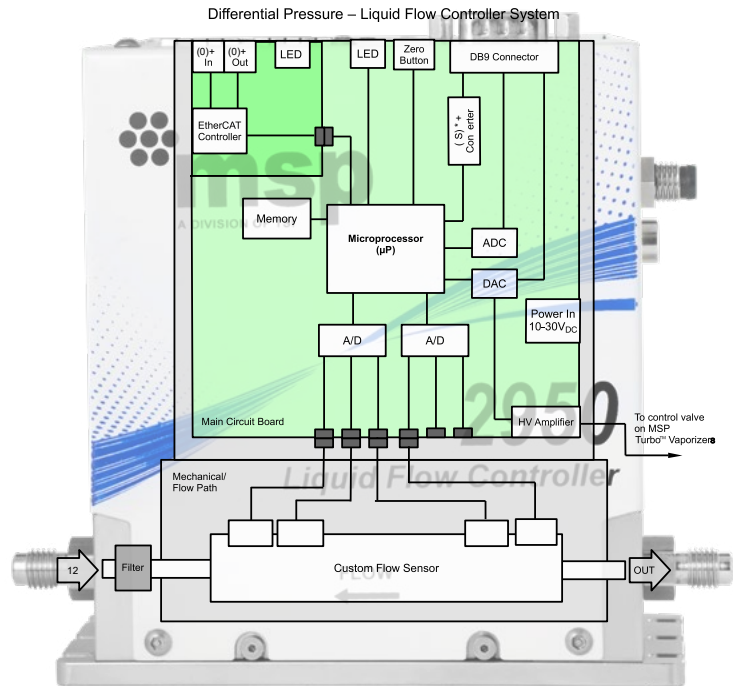
Liquid Flow Control for Advanced CVD Processes

MSP Turbo™ Liquid Flow Controller

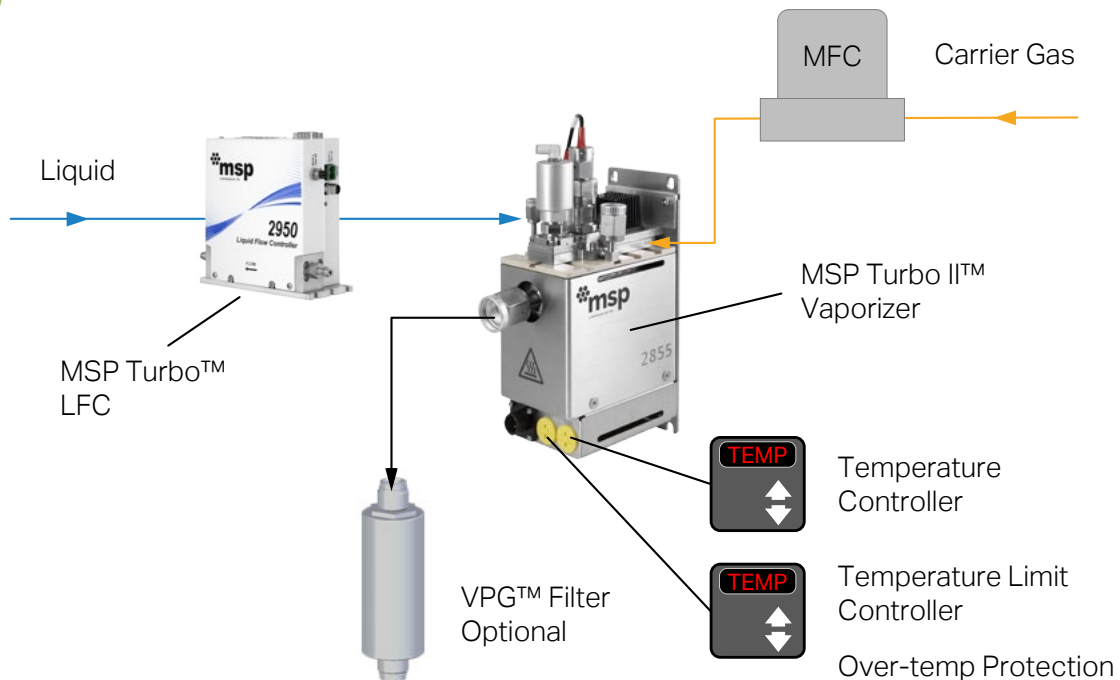


Liquid Flow Controller 2950

Built upon field-proven technology and designed specifically for leading edge microelectronic applications; this highly accurate, high-speed Liquid Flow Controller (LFC) pairs with MSP, a Division of TSI®, Turbo II™ Vaporizers to provide unmatched liquid source vapor delivery performance, versatility, and longevity. The 2950 contains a custom engineered high-precision, high-speed flow sensor and meticulously designed flow control electronics to provide the world-class performance necessary for advanced semiconductor processing.



Typical MSP Turbo II™ Vaporizer System Configuration



When High Performance is the Only Option

2950 LFC + Turbo II™ Vaporizer

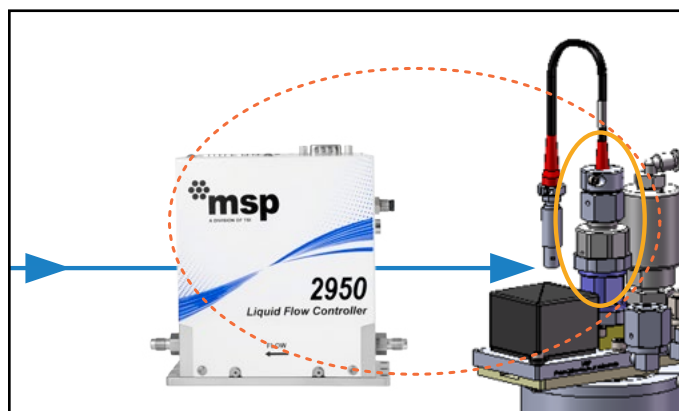
The 2950 was engineered to pair with MSP Turbo II™ Vaporizers to provide a reliable, high-performance liquid vapor delivery solution. Widely used in 300mm fabs across the globe, MSP's innovative, patent-protected line of direct-liquid injection (DLI) vaporizers re-defines liquid source vaporization for mid- and high-performance applications.

The unique, field-proven MSP Turbo II™ Vaporizers provide:

- Less maintenance and clogging versus other commercial solutions; saving our customers time and money.
- Higher liquid flow rates/deposition rates – the highly efficient heat transfer results in the ability to run higher liquid flow rates which can lead to higher deposition rates.
- Wider process window – the unique design allows you to vaporize difficult precursors which may have a low vapor pressure or be sensitive to thermal decomposition. Additionally, MSP Turbo II Vaporizers have a wide dynamic flow range – meaning they are able to vaporize extremely low and high liquid flow rates.
- Extremely stable vapor concentration – DLI technology combined with ultra-efficient vaporization results in very stable concentration output, which is particularly important for plasma processes.

Precision Flow Control

The 2950 LFC contains a flow sensor and liquid control electronics to control the Piezo valve on MSP's Turbo II Vaporizers. For vaporizers without an on-board liquid control Piezo valve, a 2950-V series Turbo™ LFC can be used.



Ultra-high Efficiency, Extremely Low Pressure Drop

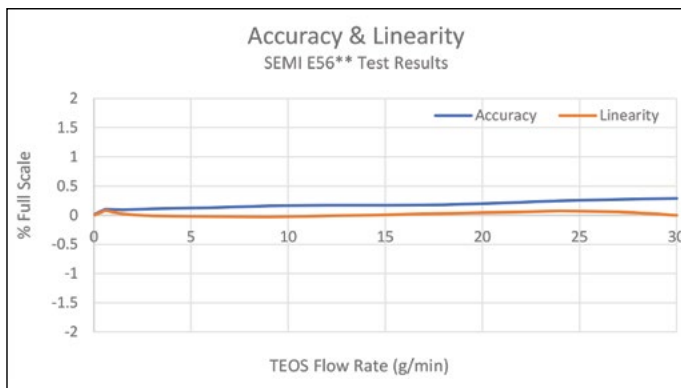
Ensure your vapor stream is free of any particles by using MSP's 316SS vapor/gas filter. Designed specifically for downstream of a vaporizer, these patent-protected filters feature ultra-high filtration efficiency (down to 2nm) and extremely low pressure drops, while also providing enough thermal mass to act as a small 2nd stage heat exchanger.



When There is No Room for Error

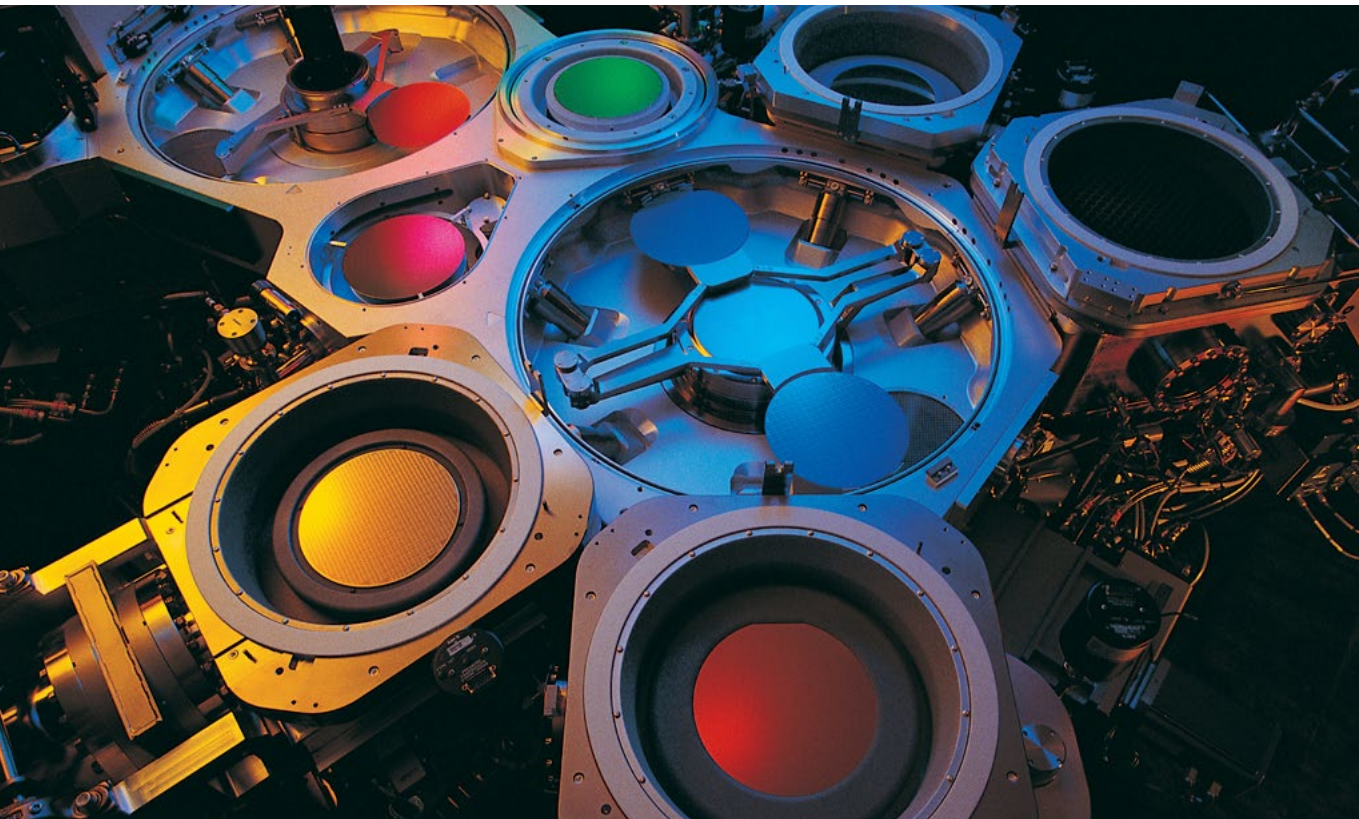
Exceptional Accuracy & Linearity

In advanced microelectronic applications, there is very little room for error. The 2950 Liquid Flow Controller provides world-class accuracy and linearity*; supplying the high performance you need to support your high-precision semiconductor process.



***Linearity** – A metric for accuracy across the full range. An LFC that has good (low variability) linearity is able to remain within defined limits over its entire specified flow range. Linearity is defined in Semi E56 as the difference between actual flow rate and the ideal linear value (a line between zero and full scale actual flow). Based on this, linearity is zero at both ends of the flow range (0 and F.S.).

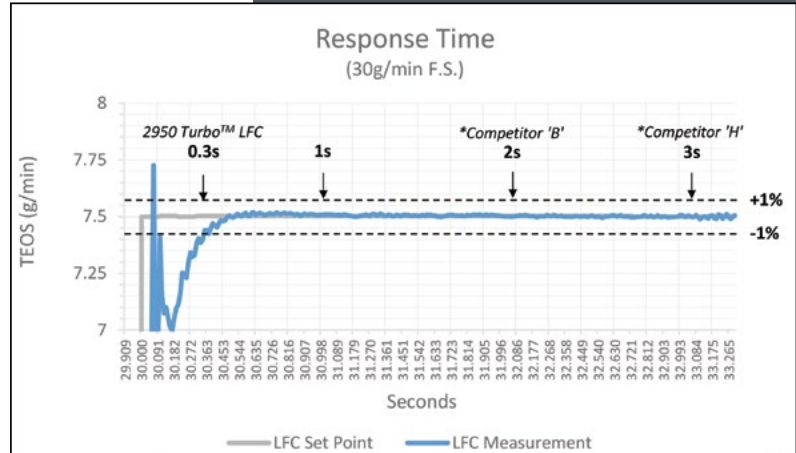
****SEMI E56** – A Test Method for Determining Accuracy, Linearity, Repeatability, Short-Term Reproducibility, Hysteresis, and Deadband of Thermal Mass Flow Controllers (read more about SEMI E56 on semi.org).



When You Need to be Fast Because Every Second is Money Spent

Ultra-fast Response Time

Designed for speed, the 2950 Liquid Flow Controller can get to $\pm 1\%$ of set point within 300ms. This industry-leading response time can save time and money by increasing throughput and reducing waste. Shortened stabilization times result in shorter processes and less time diverting process flows. Fast response also makes the 2950 an excellent choice for short pulse processes like ALD or short pulse CVD.

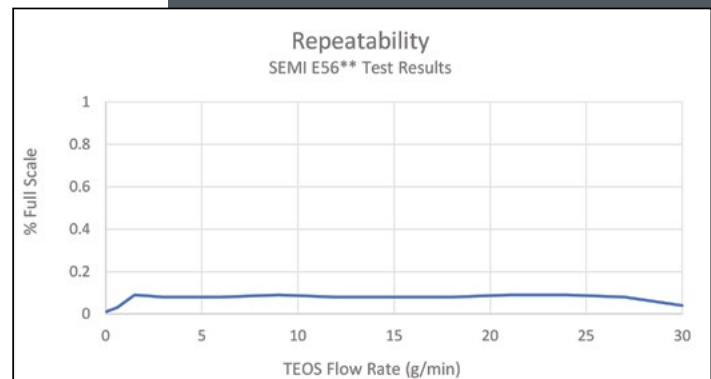


*Specification from publically available manufacturer specification sheet

When Repeatable Means in Control

Superior Repeatability

Measurement repeatability leads to predictable results and is necessary to identify problems and improve processes. The 2950 LFC's exceptional repeatability helps users to reduce chamber-to-chamber or tool-to-tool variation, enabling better yield and higher throughput. Processes can be more tightly controlled – allowing manufacturing engineers to know sooner if the process is moving out of control.



When Flexibility Can Enable Innovation

PID Tuning Made Easy

Our new 2950 liquid flow controller does not require PID* tuning for every process change, and when it is required, PID adjustments are easier to make.

The speed of the 2950 flow sensor enables good response time performance using less aggressive PID settings; this means that the 'out of the box' PID values can be used for a wide range of set points and process conditions without needing to be changed - while still getting to set point within ~2 seconds. This makes the flow controller extremely easy to use if your application doesn't require ultra-fast response.

If your application does demand ultra-fast response, our user software makes it easy to adjust the PID to maximize speed for your application. You can adjust the PID settings in the software, watch the flow curve, and calculate the time to $\pm 1\%$ of set point. The 2950 LFC's fast feedback simplifies optimizing your values.

Change Liquids WITHOUT Factory Calibration

For best accuracy, factory calibration with your chosen liquid is still the best option. However, if you want the flexibility of using a variety of liquids without waiting for factory calibration, you have two options:

1. You can perform a field calibration using your liquid and the user software.
2. You can input the viscosity and density of the liquid you are using to make a mathematical adjustment to the flow controller response. This quick field adjustment, while not as precisely accurate ($\pm 1-10\%$ accuracy depending on accuracy of liquid viscosity), gives you a quick repeatable measurement enabling you to speed up your development process and reduce the number of LFC's you need to invest in.

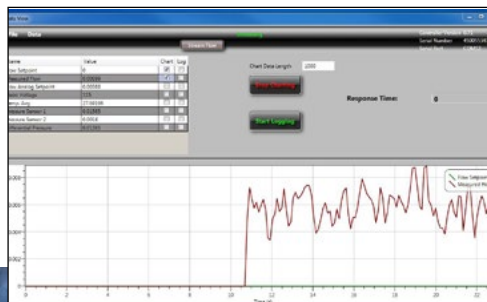
Wide Flow Range Options

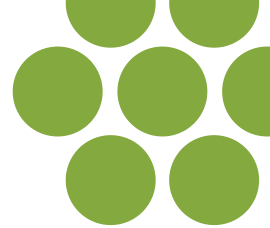
With full scale units available from 200 mg to 30 g/min; the MSP Turbo™ LFC can provide the liquid flow control performance you need across a wide range of applications.

More Protection from Environmental Variability

The design of the flow sensor in the 2950 is less affected by environmental temperature changes. Additionally, the sophisticated control algorithm of the 2950 compensates for environmental temperature and pressure changes – providing high quality flow control in a variety of process environments.

**PID- Proportional, Integral, Derivative. PID control is a type of real-time sensor feedback control loop used widely in Mass Flow Controllers and other applications that require continuously modulated control. PID are three constants that can be inputted into the control algorithm to adjust the control response for different application requirements and set-points.*





Liquid Flow Controller 2950

Specifications

Model 2950	LFC w/o Valve
Model 2950-V	LFC w/Valve
Turndown Ratio ^[2]	30:1
Max Viscosity (cp) ^[3]	10
Accuracy % F.S. ^[4]	±1.0
Repeatability % F.S. ^[4]	±0.4
Linearity % F.S. ^[4]	±0.6
Response time(s) ^[5]	≤0.3 to ±1% S.P.; 2950 ≤0.5 to ±1% S.P.; 2950-V
Environmental Temperature (°C)	15-45; 0-80% RH
Liquid Temperature (°C) ^[6]	15-35, 100% F.S. 35-40, <80% F.S.
Temperature Sensitivity (% F.S.) ^[7]	±0.05°C
Max Pressure Drop (kPa/psig) ^[8]	90/13
Max Operating Pressure (kPa/psig) ^[2]	360/52
Leak Integrity (Pa m ³ /s, He)	≤ 1 × 10 ⁻¹⁰
Power	+10-30VDC;
Typical	1.0W (w/o EtherCAT) 1.5W (w/ EtherCAT)
Max.	15W
Wetted Materials	316SS, Nickel, FFKM, BNI-5
Fittings (Inlet & Exit)	
Inlet	1/8" VCR male
Exit	1/8" VCR male
Interface	
EtherCAT ^[6]	2xRJ45
RS485	9-pin D connector (male)
Analog	9-pin D connector (male)
Software communication via RS485	
3 Output Control Signals	
1 Fixed	1-130V (for Piezo Control)
2 Configurable Options	0-5V, 0-10V, 4-20mA 1-5V, 2-10V, 0-20mA
1 Analog Input	
Configurable Options	0-5V, 0-10V

- [1] Nominal max flow determined using TEOS as reference liquid at 23±2°C. Flow rate range is a function of specified liquid.
- [2] Determined using TEOS as reference liquid at 23±2°C.
- [3] Higher viscosities will result in lower max flow ranges. Consult MSP for more information on use at higher viscosities.
- [4] Accuracy, repeatability, and linearity tested to SEMI E56-0317 using TEOS at 23±2°C.
- [5] Response time determined using TEOS as reference liquid at 23±2°C, when paired with MSP Turbo II™ "PE" Vaporizer, full scale flow, optimized PID, ≥45psi line pressure. Specification applies to all models except 2950-002, which has a response time 2-3 times slower due to the extremely low flow rate.
- [6] If the liquid temperature goes above 35°C, the full scale is reduced to 80% of nominal.
- [7] For every 1°C away from 23°C, accuracy can be degraded ±0.05%.
- [8] Pressure drop in device - not including downstream valves, 23 ± 2°C.
- [9] ETG.5003.2020 S (R) V1.2.0 compatible.

Nominal Max Flow (g/min) ^[1]

Model Number	TEOS Full Scale (g/min)	TEMAzr Full Scale (g/min)	H ₂ O Full Scale (g/min)
2950-002/V	0.2	N/A	0.14
2950-01/V	1	0.19	0.73
2950-05/V	5	0.95	3.6
2950-10/V	10	1.9	7.3
2950-20/V	20	3.8	14
2950-30/V	30	5.7	21

Other Liquids

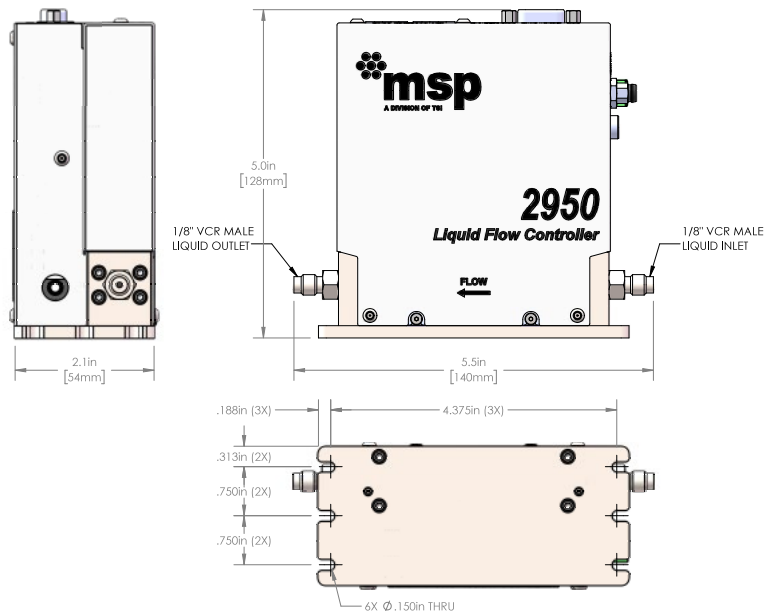
The full scale (F.S.) of the 2950 LFC is a function of liquid viscosity ($\mu_{\text{liquid(cP)}}$). To estimate the full scale (F.S.) of each model for your liquid, use the equation below:

If $\mu_{\text{liquid(cP)}} \geq 0.65$	If $\mu_{\text{liquid(cP)}} < 0.65$
$F.S._{\text{Other Liquid}} = F.S._{\text{TEOS}} * \frac{0.65 \text{ cP}}{\mu_{\text{liquid(cP)}}}$	$F.S._{\text{Other Liquid}} = F.S._{\text{TEOS}} * \frac{\mu_{\text{liquid(cP)}}}{0.65 \text{ cP}}$

Factory Calibration

TEOS used for factory calibration. For use with other liquids a factory calibration adjustment or field calibration with reference flow meter can be performed using 2950 Configuration Software. Factory calibration for other liquids may be possible. Visit tsi.com/contact to request more information.

Dimensions



Accessories

Specify	Description
VPG-A6 Filter	316SS in-line filter for downstream of vaporizer. Ultra-high efficiency (>99.9999999999% @ 2.5nm), ultra-low pressure drop (<1kPa @ 1 SLPM)

Vaporization Experts

Vaporization Experts

For over 30 years MSP has embraced and researched the science of vaporization, becoming the foremost experts in this specialized field. MSP offers the widest range of standard vaporizer solutions commercially available, and routinely partners with CVD equipment manufacturers to provide custom solutions perfectly tailored to their unique needs.

Global Footprint

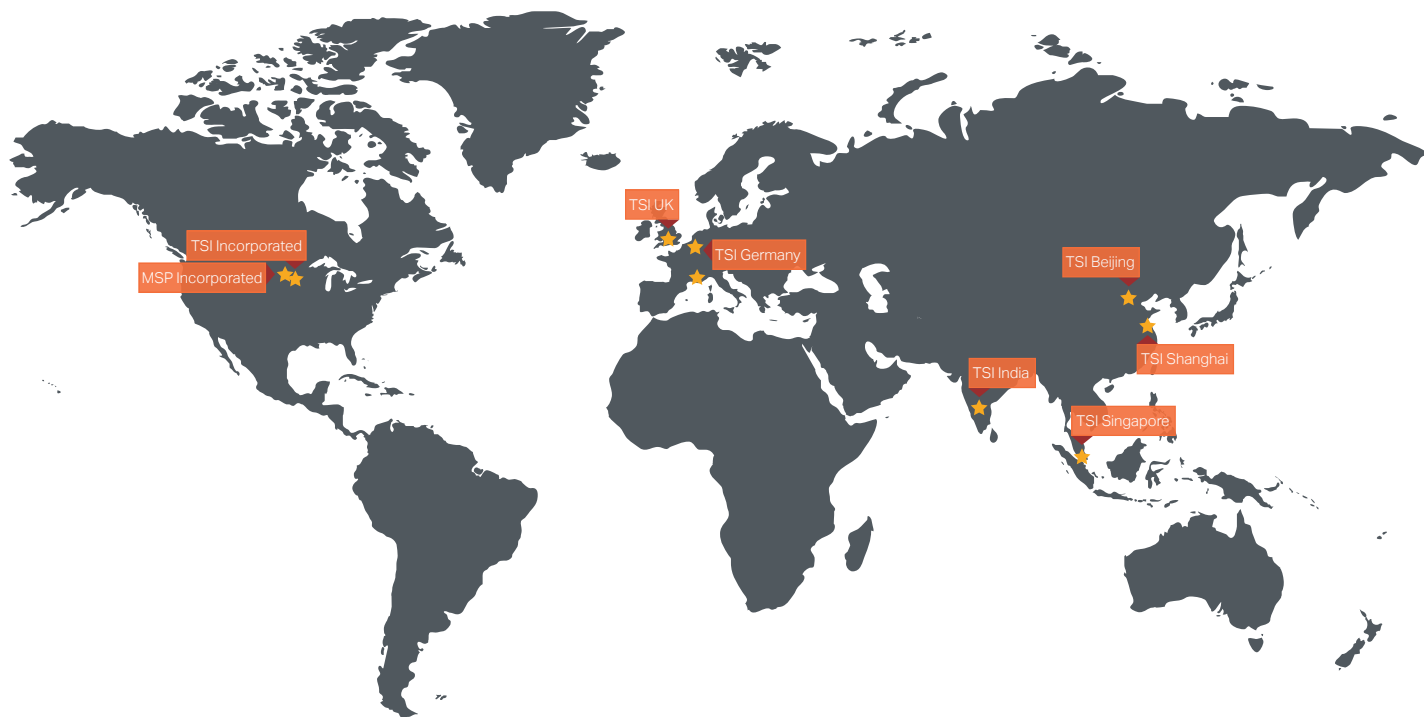
MSP is a Division of TSI® Inc. which has 11 offices worldwide including a dedicated facility in South Korea for sales, field service, inventory, and support of vaporizers in the semiconductor industry.

Field Proven

MSP vaporizers have enabled leading edge processes for decades, with vaporizers installed in almost every 300mm fab worldwide. This field-proven vaporization technology is successfully used for a wide array of processes including: TEOS, high-flow TEOS, high κ dielectrics (like TEMA/CpZr and TEMA/CpHf), OMCTS, TiCl₄, MTS, and many others.

Commitment to Innovation

Every year our MSP vaporization experts continue to innovate and drive vaporization technology to new heights to meet the demands of progressively challenging process requirements. With 40+ active design patents, MSP continues to lead the way in vapor delivery solutions.



Specifications subject to change without notice.

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MSP - Visit our website www.tsi.com/msp for more information.

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