Integrated Process Solutions

WWW.MKSINST.COM

Vapor Sublimation Trap

FOR SEMICONDUCTOR PROCESSES

Features and Benefits

Improved Wafer Yields

In processes used at several major semiconductor fabs we have seen 2-3% improvement in overall yields. There are three reasons for this:

- The high flow conductance of the trap leads to a lower base pressure in the furnace. With a lower base pressure, less residual gas remains in the furnace. This prevents redeposition of the gas on the wafer, causing hazing.
- The lower base pressure leads to a lower vapor pressure for the gas. This reduces particles backflowing to the furnace.
- The large transition zone in the trap reduces clogging. A change in pressure occurs when the trap is about 70-80% full. This will indicate the need to clean the trap, preventing clogging in the middle of a wafer process run.

Increased Uptime

In nitride process systems it is common to see a five time increase in intervals between cleaning. The trap has a patented thermal transition zone, which allows for optimized cooling of the gas so that the solidifiable vapor does not all collect in the port area of the trap. The MKS 6" Vapor Sublimation Trap was designed to be cleaned in a nitride process with a gas flow rate of 150 sccm, every 250-280 runs. The 8" high-capacity trap with the same gas flow, will last 750-850 hours. Actual run hours may be different depending on gas ratios. Figure 2 shows an estimate of the cumulative deposition time before cleaning.

Protects Pump

Solids are very damaging to vacuum pumps. Even if the by-product enters the pump as a vapor, compressing it will convert the vapor to a solid. The trap has a patented two stage design (see Figure 1). Close to 95% of the gas is collected in the first stage. The second stage contains perforated cones that collect the remaining 5% to achieve over 99% collection efficiency and maintain high flow conductance of the trap. This prevents the ammonium chloride from clogging or damaging the pump, and reduces the amount of dilute gas required for purging the pump.

Low Cost of Ownership

The use of the 6" trap by two major semiconductor fabs allowed them to increase their maintenance cycle from 26 runs to over 120 runs. This resulted in 5-8 extra runs per week or an increased uptime of 16 hours per week. If the profit generated per machine is $1,000 to $5,000 per hour, a savings of $16,000 to $80,000 per week is realized. A trap costs around $2,000, so the payback for this investment is less than one day.

Ease of Maintenance

For cleaning NH_4Cl, fully immerse the trap in a circulating water bath for about one hour. When the trap is clean, dry it in an oven. This removes all the water, which could contaminate the system when the trap is reinstalled.

Water leaks, during trap removal for cleaning, are essentially eliminated with the self-sealing, quick-release coupling option. These couplings for the cooling water inlet and outlet ports ease installation and removal by eliminating the need to shut off the water source.

Other Features

- The bonnet seal uses bolts or ISO claw clamps versus a V type clamp. V-clamps can easily deform, causing leaks in the bonnet seal. This then causes increased maintenance and reduced uptime.
- The materials in the trap are 304 stainless steel and the water-cooling coils are 316 stainless steel.
- The traps are smaller and more compact in size than others offered on the market, so that it can fit in systems easier.
- Traps are available in angle and inline configurations. Other configurations can be provided, please contact the MKS engineers for further assistance.
- A variety of bonnet seals can be provided for corrosion resistance: Viton® and silicone.

Description

Current semiconductor chemical processes demand less maintenance, more uptime, and product yield enhancement through efficient reduction of process solid buildup. One solution that is effective for reducing these contaminants in pump lines is the combined use of heated lines and a Vapor Sublimation Trap. In fact, according to one independent user, uptime of their reactor increased by 16 hours per week. The Vapor Sublimation Trap assures less downtime and higher product yield with an efficiency rating higher than 99 percent and a capacity unmatched by any other vapor trap.

The Vapor Sublimation Trap draws in effluent vapors and solidifies them before they have a chance to backstream to the reaction chamber, contaminating and hazing your wafers. It also prevents gases from entering and damaging your vacuum pump.

Vapor Sublimation Trap accomplishes collection of solidifiable vapor in two stages. The first stage, at the entrance of the trap, has a high capacity to trap more than 95 percent of all condensable gases. Figure 1 is a cross section of the Vapor Sublimation Trap. It shows the high volume reserved for first stage trapping. This avoids rapid clogging frequently encountered with other traps. In just half the volume, the trap has the capacity to capture more than five times the vapor than the nearest competitor.

The second stage is a polishing scrubber designed for greater efficiency. This stage maximizes heat transfer between the gas and the cooling surface, while maintaining high flow conductance. The combination of cooling water coils and perforated stainless steel cones solidifies the residual vapors that have passed through the first stage.

Heated lines and valves upstream of the Vapor Sublimation Trap maximize the benefits and efficiency of the trap and should be used to ensure reduced particulate contamination. With the combination of the two contamination reduction methods, the total number of process runs significantly increases before any cleaning is necessary. Figure 2 shows how many hours of deposition time can be attained based on gas flow rates of typical silicon nitride LPCVD systems.

Applications

Semiconductor CVD processes produce gaseous by-products that can readily be pumped out of the reaction chamber. However, they usually solidify in a vacuum pipe line since the line temperature is lower than the reaction chamber. A clogged line means longer down time and lower product yield, especially with the trend of larger wafers and smaller feature size.

One of the most common processes is LPCVD silicon nitride. Since sublimation is temperature driven, use heat to maintain the by-products in the vapor phase and use cooling to intentionally sublimate the vapors in the trap.

LPCVD Nitride

LPCVD silicon nitride process deposits solid silicon nitride on the wafer and creates an ammonium chloride (NH_4Cl) by-product. Ammonium chloride will solidify in the vacuum pump line if the line is not heated. To keep NH_4Cl in its vapor stage, the system temperature must be from 130°C to 150°C at 150 mTorr. This allows the system to transport it away from the furnace. Higher pressures will require a higher temperature (see the vapor pressure curve in Figure 3).

In a typical silicon nitride CVD process the NH_3/DCS ratio is around 3 to 1. A higher NH_3/DCS ratio leads to longer cumulative deposition time. There are several reasons for installing heated lines and a Vapor Sublimation Trap in a silicon nitride CVD process.

1. Collecting NH_4Cl in the trap for ease of maintenance;
2. Large trapping capacity leads to longer preventative maintenance cycles for increased uptime;
3. High trapping efficiency provides better protection of the pump, control valve and downstream instrumentation;
4. Lower NH_4Cl vapor pressure in the trap (due to lower temperature) results in higher process yield.

MKS heater jackets uniformly heat the pump line, elevating the vapor temperature to 130° to 150°C. This allows the by-products to reach the Vapor Sublimation Trap. The trap can be placed in a variety of locations but is usually found before the dry pump as shown in Figure 4 (A) and (B).

Other Semiconductor Processes

The Vapor Sublimation Trap can be used in other semiconductor processes where by-product vapors can be physically solidified and cleaned by dissolving them in a solution (like water). For example, ammonium hexaflurosilicate $(NH_4)_2SiF_6$ has been observed in a silicon nitride PECVD process due to the cross chemical reaction between the by-products formed in the deposition process and the etching process.

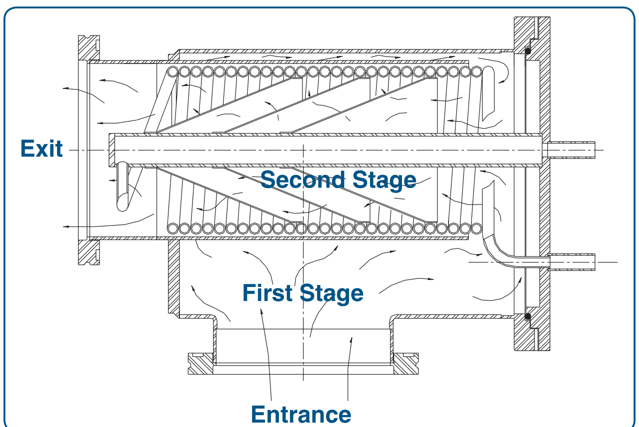


Figure 1 —

Patented Vapor Sublimation Trap Design

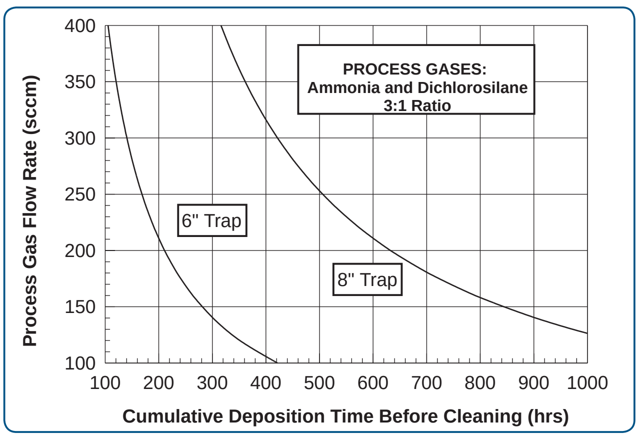


Figure 2 —

Cumulative deposition time before cleaning Vapor Sublimation Trap (actual results may differ based on gas ratios used)

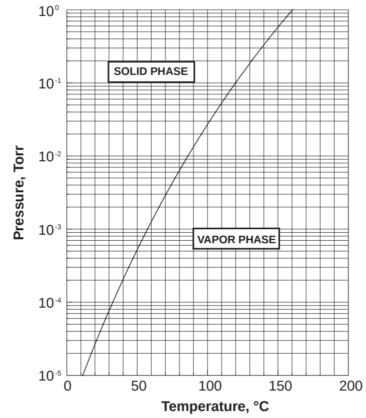


Figure 3 —

Vapor pressure curve for NH_4CL

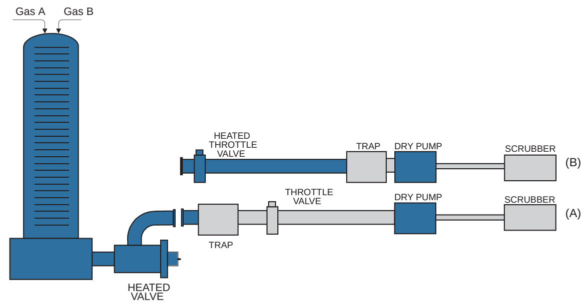


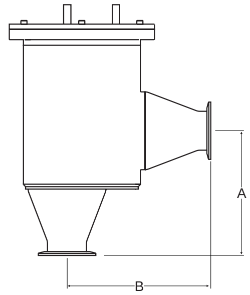
Figure 4 —

Installation guideline for heated line and trap in CVD and etch systems

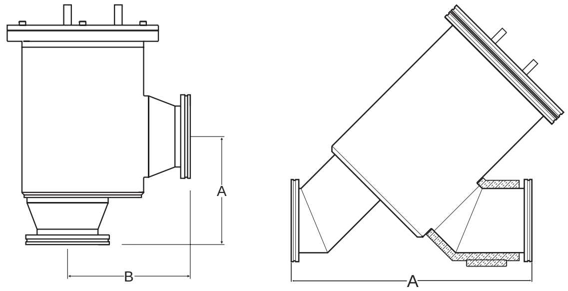
Dimensions

	NW50		NW80		NW100	
	6" Body	8" Body	6" Body	8" Body	6" Body	8" Body
Angle A B	7.03 (179) 7.77 (197)	6.72 (171) 9.51 (242)	5.32 (135) 7.86 (200)	5.00 (127) 9.61 (244)	5.00 (127) 5.00 (127)	4.25 (108) 6.75 (171)
Inline A	—	—	15.00 (381)	15.00 (381)	15.00 (381)	15.00 (381)

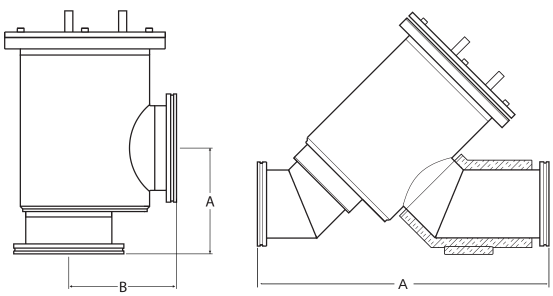
NW50 Trap Dimensions in. (mm)



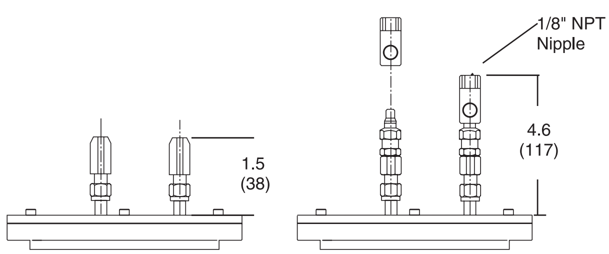
NW80 Trap Dimensions in. (mm)



NW100 Angle Dimensions in. (mm)



Water Fittings Dimensions in. (mm)



Specifications and Ordering Information

Specifications

Capacity	
6”	3.0 lbs (1.4 kg) NH_4C
8”	10.0 lbs (4.5 kg) NH_4Cl
Efficiency	> 99%
Flow Conductance (Viscous Flow Region)	p = pressure in mTorr
6”	C (l/sec) = 20.74p
8”	C (l/sec) = 45.63p
Pressure Drop Across Trap	Q = gas flow rate in sccm p = pressure in mTorr
6”	Δp (mTorr) = 812 Q/p^2
8”	Δp (mTorr) = 369 Q/p^2
Cooling Water Flow Rate	> 6 gal/hr (400 ml/min)
Cooling Water Temperature	< 86° F (30° C)
Typical Dry Weight	
6” (w/ MF Flanges)	16.5 lbs (7.5 kg)
8” (w/ MF Flanges)	28.0 lbs (12.7 kg)

Ordering Information

Vapor Sublimation Trap Ordering Information

Body Configuration WCTRAP	Port Size -XXX	Configuration -X	Flanging X	Body Size X	Seal Type -X	Water Fittings -XXX
Select 1	Select 1	Select 1	Select 1	Select 1	Select 1	Select 1
WCTRAP	**050** NW 50 **080** NW 80 **100** NW 100	**A** Angle NW 50 & 100 **H** Heatable Angle NW 80 Only **N** Inline NW 80 & 100	**K** KF NW 50 Only **M** MF **K** KF NW 80 & 100	**6** 6” Body **8** 8” Body	**V** Viton® **S** Silicone	**QRS** Straight **QRL** Elbow **None** 3/8” Tube

Add the price of the options to the price of the body. For example, WCTRAP-100-AM6-V-QRS. Heaters and a heater power cord are needed for the inline and NW 80 angle models and must be ordered separately.

Accessories and Spare Parts

Description	Part Number
Replacement Internals 6” Body 8” Body	 100004954 100009608
6” Bonnet Flange Seals Viton® Silicone	 100003597 100004790
8” Bonnet Flange Seals Viton® Silicone	 100762020 100009637
Self-Sealing, Quick Release Water Fittings Straight 90° Elbow	 100004980 100004981

Heaters

Description	Part Number
Angle NW 80 Heaters 6” or 8” body, 120V 6” or 8” body w/ LTA, 120V	 9640-0291 9640-0273
Inline NW 80 Heaters 6” body, 120V 6” body, 120V, w/ LTA 8” body, 120V 8” body, 120V, w/ LTA	 9635-1093 9635-1094 9635-1091 9635-1092
Inline NW 100 Heaters 6” body, 120V 6” body, 120V, w/ LTA 8” body, 120V 8” body, 120V, w/ LTA	 9640-1093 9640-1094 9640-1091 9640-1092
Heater Accessories Power cord, 6’, GFELCI LTA Monitor NW 80 Flange Insulator NW 100 Flange Insulator	 43PWRCORD04 100010832 4530-0016 4540-0016

mks

MKS Instruments, Inc.
Global Headquarters
2 Tech Drive, Suite 201
Andover, MA 01810
Tel: 978.645.5500
Tel: 800.227.8766 (in USA)
Web: www.mksinst.com

MKS Instruments, Inc.
Integrated Process Solutions
5330 Sterling Drive
Boulder, CO 80301
Tel: 303.449.9861
Tel: 800.345.1967 (in USA)

VaporSubTrap - 2/17