Direct Injection of Ultra Pure Water Vapor into Vacuum

Eliminates need to degas source water or use a bubbler; includes purification membrane

Water vapor has been shown to have significant effect on thin film layers in ALD, wafer bonding, carbon nanotubes, MOCVD, molecular surface cleaning, and sputtering processes. The ability to deliver water vapor free from atmospheric contaminants is critical to film integrity.

Water is frequently used as a source of atomic oxygen. The use of water as a precursor has economic and safety benefits compared to other oxide sources. However the controlled delivery of pure water vapor is challenging. Direct flow control of the water into vacuum is difficult due to the expansion of 1 gram of water to 1,000,000 cc of gas at room temperature and 1 mbar pressure. Water vapor typically condenses unless it is added to a carrier gas stream or directly injected into vacuum.

How It Works

The Vaporizer is designed to control the delivery of water vapor into vacuum processes. The vaporizer uses a non-porous membrane that selectively allows water molecules to pass through it, but rejects other gas species.

The non-porous ionic perfluoropolymer membrane excludes particles, micro-droplets, volatile gases, and other opposite charged species from being transferred and ensures that only water vapor is added. The membrane is highly selective, also preventing most process gases from crossing over into the water source.

The membrane is supported by stainless steel internal support. The exterior of the membrane is encased in a PFA/PTFE shell to allow deionized (DI) water to be contained and/or circulated over the membrane. This eliminates the need to disconnect the vaporizer for water addition. The membrane rejects dissolved gases in the DI water, eliminating the need to degas water to remove gases such as oxygen, nitrogen, and CO_2.

The flow rate of water vapor across the membrane is a function of the surface area of the membrane and the water temperature. The mass flow rate is controlled by varying the water temperature. With ampoules, water delivery is controlled through a load lock that allows only discrete delivery. Bubblers require a carrier gas. The Vaporizer can provide continuous delivery of 100% water vapor into vacuum without a carrier gas.

With bubblers and ampoules, the water supply is directly exposed to vacuum. The DI water must be degassed before use, to remove residual oxygen and nitrogen in the water. Degassing can take up to 48 hours to reach baseline acceptable levels, preventing tool use. Refill requires breaking the vacuum system integrity. In contrast, the Vaporizer uses an external water source so water filling, recirculation and draining can be accomplished without breaking the vacuum of the tool. This eliminates service related to change out, degassing, and vacuum leak checking needed with other delivery techniques.

Microdroplet Control

Microdroplets lead to entrainment of ion contamination and particulates. Furthermore cold spots occur where microdroplets land leading to non-uniformity and warpage. Microdroplet entrainment can also increase variability in the delivered water. In order for oxide films to work properly, the film thickness and uniformity are critical. The membrane process solves many of the challenges for direct delivery of water vapor by completely changing the way water molecules are converted from liquid to gas phase.

Bubblers and ampoules have problems with contamination and bacterial growth, as well as variability with temperature, pressure and fill level. The bubbler cannot be directly exposed to the vacuum environment. When exposed to vacuum violent boiling can occur, water droplets are carried into the process chamber and therefore the actual volume of water delivered is not controlled or repeatable.

Where bubblers and vaporizers depend on water molecules overcoming the surface tension and water molecule binding energies, the RASIRC products are based on a hydrophilic membrane that uses the ion charge of the membrane to separate each water droplet into its molecular components. The energy required to enter the membrane is equal to the heat of vaporization. Transfer across the membrane is restricted to single and small channel transfer rates. Once molecules cross the wall of the membrane, they are energized and ready to enter the gas phase based solely on the vapor pressure curve that relates to the temperature of the water. Using the membrane as the phase separator prevents water droplets from permeating the membrane and ensures very smooth and consistent flow.

Key Benefits

- Separates liquid water from vacuum system
- Eliminates need to degas water prior to use
- Eliminates service around ampoule and bubbler change out
- Improves up time
- Purifies water vapor
- Controls delivery rate of water molecules by external temperature control
- Delivers 100% pure water vapor with no carrier gas
- Delivers continuously without downstream valves to generate fixed control volumes
- Eliminates microdroplets
- Minimizes condensation

Applications

- Wafer bonding
- Carbon Nanotubes
- Atomic Layer Deposition
- Molecular surface cleaning
- PPM level water generation

RASIRC®
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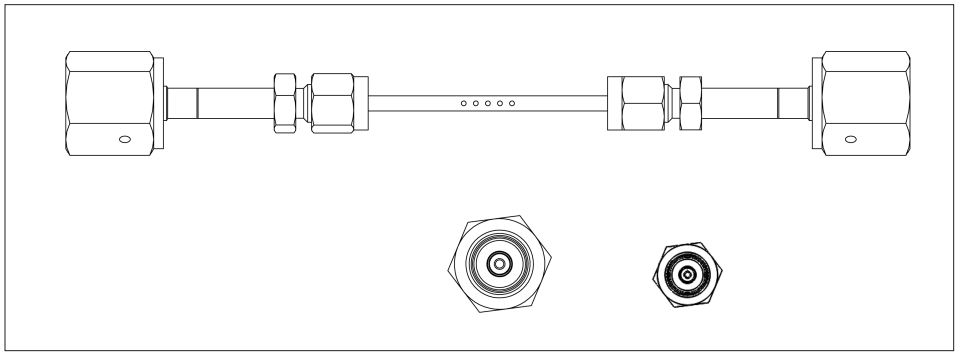
Size
- 6" to 12" depending on application

Fittings
- Gas -¼" Female VCR
- Water ¼" compression

Flow rate
- 0.01 to 10 sccm depending on hole configuration

Options
- Custom calibration



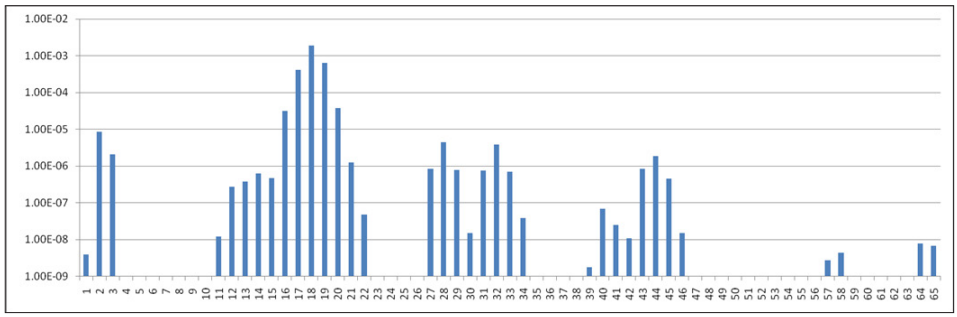


Figure 1: Full spectrum plot after running 12 hours.

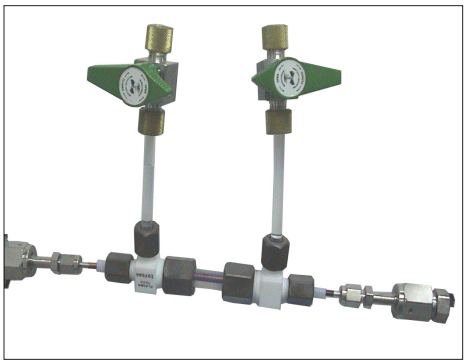


Figure 2: Vaporizer with chemical jacket.

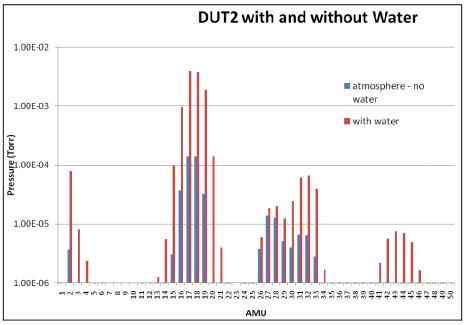


Figure 3: Relative change per species with membrane exposure to air and then immersed in water.

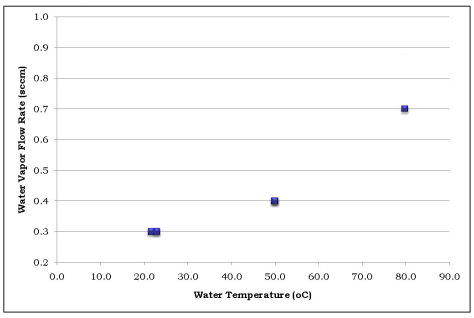


Figure 4: Flow increases with temperature.

Technical Paper

For more information on the vaporizer, download the technical paper "**Water Vapor Delivery for CIGSe and Other Thin Film Vacuum Processes**" from the RASIRC web site.

How to Order

To place an order for the **RASIRC Vaporizer**, specify the model number by selecting and combining the various options in the table below, prefaced with CVS.

Gas Type	#Holes	Hole Diameter (tenths of mm)	Fitting Type	Jacket
W (Water)	10	15	4RFF (¼" Female VCR fittings)	W (Water)
				CJ (Chemical)
				[blank] (No Jacket)

For example, for a calibrated vapor source with water as the gas type, 10 holes of diameter 15, 1/4" VCR female fittings and a water jacket the model number would be CVS-W-10-15-4RFF. Orders can be placed through authorized dealers or directly with the factory.

About RASIRC

RASIRC develops products that purify and deliver ultra pure liquids and gases. RASIRC steam generators, humidifiers and vaporizers are of critical importance for many applications in the semiconductor, microelectronics, solar, and related manufacturing.

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