

Purified Water Vapor Added to Carrier Gas Stream

RASIRC's RainMaker Humidifier Meets Semiconductor Lithography Requirements

The **RainMaker** Humidifier is the first closed loop humidifier to purify the water before it enters the gas stream. The nonporous membrane limits transfer of dissolved gases, particles, hydrocarbons, and ionic contaminants into the gas being humidified. Figure 1 shows the results of metal transfer testing. Testing for 67 different metals with sensitivity levels to less 1 ppt , 20 ppb of total metals were found in the water supply . The humidified gas stream was also tested and shown to have less than 5 ppb, a reduction of 75% for metals. Similar results have been seen for dissolved gases.

The **RainMaker** Humidifier consists of a non-porous membrane that excludes particles, micro-droplets, volatile gases, and other opposite charged species from being transferred to the carrier gas and ensures only water vapor is added. The membrane is designed specifi-

cally to select only the source gas molecules. Other contaminants in the liquid source cannot permeate across the membrane or enter the carrier gas stream, resulting in a saturated product that is consistent and pure. Because the **RainMaker** works on 100% saturation of the carrier gas, the system can be cycled on and off without significant effect on accuracy.



Advantages over Existing Technologies

	RASIRC RainMaker	Hollow Fiber Contactor
Materials of Construction	non-porous hollow fiber membrane	porous micro-hollow fiber
	hydrophilic membrane	hydrophobic membrane
	perfluoropolymer or 316L stainless steel	only with perfluoropolymer
Particle Filtration	Yes	Yes
Water Vapor Purification	Yes	No
Transfer Rate	High	Low
Prevent Gas Back Streaming into Water	Yes	No
Pressure Independent for Water/Carrier Gas	Yes	No - requires higher water pressure
Humidify Without Heat	Yes	No
Water Droplet Permeation	Cannot	Can wet out - Catastrophic Failure
Maximum Operating Temperature	80° C	40° C
Cost per Liter Humidified	Low	High
Size per Liter Humidified	Small	Large
Pressure Drop per Liter Humidified	Low pressure drop / large diameter fiber	High pressure drop / small diameter
Membrane Seal	Proprietary mechanical seal high integrity	Proprietary welded seal - low yield
Capable of 120 slm	Yes	No
Capable of 400 slm	Yes	No
Lead Time	3 to 4 weeks	3-16 weeks
Vacuum compatible	Yes	No
Steam sterilizable	Yes	No

Obsoletes Existing Technologies

Until now, the controlled humidification of ultrapure gas has been difficult. Choices have been limited to direct liquid injection (DLI), bubblers, or membrane contactors. Each technique has significant limitations.

Direct Liquid Injection

DLI is costly and problematic with different flow rates. At low flow rates control has limited accuracy and at high flow rates it is susceptible to bubbles in the liquid which generate erratic values. DLI needs a metallic vaporizer or an additional metal hot plate to convert the liquid to gas, can vaporize only limited quantities due to thermal transfer rates. Most critically, it cannot provide any purification of the liquid being vaporized, since everything in the liquid is vaporized into the process.

Bubblers

Bubblers are low cost, but have inaccuracies due to the temperature of the gas, liquid, operating pressure, liquid level, and thermal droop. They leave behind some contamination during vaporization and cannot prevent entrainment of dissolved gas, volatile molecular contaminants, and micro-droplets which can carry particulate and ionic molecular contaminants. Bubblers have very



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