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Photo available at <http://www.rasirc.com/news/downloads/photos/rainmaker.jpg>

Datasheet available at <http://www.rasirc.com/library/RainMakerX.pdf>

**RASIRC's RainMaker Humidifier Allows Sterile Transfer of Water Vapor
into Process Gases**

*Unique non-porous membrane technology excludes micro-droplets, metals, and dissolved
gases from water vapor or steam during transfer*

San Diego, Calif. – April 3, 2007 – RASIRC™, the steam purification company, introduces the RainMaker™ Humidifier, a device that controls the transfer and purification of pure water vapor directly into a carrier gas stream. With the RainMaker, controlled and purified vapor can be delivered into most carrier gases including inert, corrosive, and flammable gas such as hydrogen at a wide range of flow rates.

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 specifically 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.

The RainMaker fully saturates the carrier gas based on the temperature of the gas, providing for accurate delivery of water vapor. With the addition of a back pressure regulation device, accurate delivery of low vapor pressure gases can be delivered into sub-atmospheric processes. The temperature range is from the freezing point to the boiling point for the liquid with a maximum operating temperature of 115 degrees Celsius.

The RainMaker Humidifier is highly selective. It prevents most carrier gases from crossing over into the source, resulting in the safe use of gases that should be constrained from mixing with liquid water. It also limits the pressure the source container will see during normal operation, since the pressure of the carrier gas does not significantly affect the source container. This allows for vessels made from quartz to be used where more robust materials would be required for some other methods. In addition, when working with flammable chemicals such as hydrogen or isopropyl alcohol, metallic containment is often required depending on the local codes. With the use of the RainMaker, metallic impurities that may have been picked up from the metal source container are prevented from contacting the carrier gas, so safety and purity are both improved.

Purification tests run on the RainMaker Humidifier showed a significant reduction on metallic contamination. When tested for 67 different metals, the number of metallic contaminant species was reduced from 31 to 18 specific contaminants with the RainMaker. The total quantity of metallic impurities was reduced from 19.8 ppb in the source de-ionized (DI) water to 4.9 ppb.

Bubblers are low cost, but have inaccuracies due to the temperature of the gas and liquid, the 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 limited gas flow rates. If the flow rate exceeds limited velocities, explosive bubbles blast the source liquid out of the vessel and into the downstream piping, forcing the use of phase separators which lead to increased particulate, condensation, and flow instability.

Membrane contactors can be used to allow gas transfer between a liquid and gas, but are not specific to which gases can permeate so have no purification capability. They are made with hollow fiber membranes which are porous, allowing simultaneous transfer of the gas into the liquid and the liquid into the gas, so the carrier gas can permeate the liquid source. This can be problematic if the carrier gas is pyrophoric or toxic. The porous membranes cannot prevent the penetration of micro-droplets across the hollow fiber into the carrier gas. Micro-droplets are known for carrying particulate and ionic impurities that cannot be carried by pure vapor alone.

In addition the porous nature requires operating pressures to be carefully managed. This generally requires the gas pressure to be lower than the water source pressure and can lead to severe process limits in design of humidification systems. Most hollow fibers are hydrophobic and must be modified to work with hydrophilic molecules. Some hollow fibers can be chemically modified, but it is a surface treatment that is only partially effective.

Applications for the RainMaker Humidifier include rapid thermal processing (RTP), atomic layer deposition (ALD), plasma stripping, immersion lithography, diffusion, wafer cleaning, and to control humidity in cleanrooms. Water vapor is also needed to grow oxides. RTP needs high flow rates of water vapor for short periods of time. ALD needs very small amounts of water vapor for High K film formation where the purity of water vapor is critical for good film formation. Plasma stripping is more effective with water vapor to help lift the film off the wafer surface. Lithography needs high flow rates of humid clean air. The humidity in semiconductor and medical cleanrooms requires very tight control of air purity and process stability

“The RainMaker Humidifier is the only humidifier capable of selectively allowing water vapor to pass into the carrier gas stream. Now the water vapor used for humidification will be significantly cleaner than the source DI water,” said RASIRC founder and president Jeffrey Spiegelman. “We can exclude oxygen or nitrogen from the water vapor. This is a real advantage for certain contamination sensitive processes.”

The RainMaker’s unique ultrapure design is made of either all fluoropolymer or fluoropolymer and 316L stainless depending on the application. Fittings are based on customer requirements, which can include face seal, compression, flare, or tube stub. These fittings are commonly known as VCR[®], Swagelok[®], or Flaretek[®]. The RainMaker can be supplied with heaters and temperature control. Price is based on flow rate. Prices start at under \$1000. Lead time is 3 weeks on standard configurations.

About RASIRC

RASIRC develops products that purify and deliver ultra pure liquids and gases, with a primary focus on water vapor. While steam is used extensively in the semiconductor industry, RASIRC

technology is the first to purify live steam to generate ultra high purity (UHP) steam. Starting with de-ionized water and using specialized membranes to reduce total metals to less than 10 parts per trillion while achieving very high flow rates, this technology reduces cost, improves yield, and dramatically improves safety. The UHP steam generated by RASIRC products is of critical importance for many applications in the semiconductor, pharmaceutical, medical, biological, fuel cell, and power industries. RASIRC is a winner of the 2006 *Gases & Technology* Gassy Award, the *Solid State Technology* SEMICON West Attendee's Choice Award, and was selected by SEMI for its Technology Innovation Showcase. For more information, contact Jeffrey Spiegelman at +1 858-259-1220, e-mail info@rasirc.com, or visit the website at www.rasirc.com.

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