Brooks® / MSP Models 2800 & 2820 Turbo-Vaporizer™ Systems
Precision Vapor Delivery for Thin Film Processes

Introduction
The Brooks/MSP Model 2820 Turbo-Vaporizer™ System is a fine droplet, Direct Liquid Injection (DLI) vaporizer used for generating high purity vapor from liquid precursors required for thin film deposition. It is applicable for high-purity vapor generation for semiconductor films, chemical research, catalyst production, production of fiber optics, optical coatings, industrial coatings, and fuel cells.
Highlights of Vaporizer System Components

Precise Liquid Mass Flow Measurement

Stable and repeatable liquid flow measurement and control are key to consistent film formation. Precursor chemicals used for thin film deposition have thermophysical properties that are usually not very well determined.

The Model 2820 uses a QUANTIM® mass flow controller from Brooks Instrument for liquid precursor flow control. A Coriolis sensor is at the heart of the device, which measures liquid mass flow directly, with an accuracy that is independent of fluid properties. This is in contrast to other liquid flow sensor technologies, which do not measure mass directly, but infer mass flow based on the measurement of another related fluid property. Errors in flow control can lead to measurable variations in film deposition rate and quality.

A fast-responding, low-flow control valve is integrated into the design of the QUANTIM® flow controller. Precursor mass flow setpoint is transmitted to the QUANTIM controller using either a voltage or current input signal. Measured precursor flow is transmitted as a voltage or current signal and can be used by the tool controller to monitor delivery rate.

Brooks calibrates every QUANTIM controller to mass standards traceable to the National Institute of Standards and Technology (NIST). This NIST-traceable calibration ensures mass-flow measurement accuracy resulting in consistent vapor delivery.

Coriolis technology can also accurately measure the density of a fluid in the sensor. This density measurement can be used to confirm that the proper liquid precursor canister has been connected to the vaporization system. This can protect expensive process equipment from contamination due to an operational mistake. Density can also be used to determine when one liquid has been purged from the plumbing using a second fluid of different density. Density measurement is transmitted as a current or voltage output signal.

Consistent Carrier Gas Flow Control

A Brooks thermal gas mass flow controller is used to control the flow of carrier gas to the atomizer.

The vaporizer will work with a wide variety of carrier gases, which can include hydrogen, nitrogen, helium and argon. Carrier gas should be ultra high purity and have very low water content.
**Fine Droplet Atomization**

Fine droplet atomization is a key technology to generating pure vapor with the Model 2820 Turbo-Vaporizer™. It creates very small liquid droplets and greatly increases the surface area available for gas phase heat transfer to the droplet. Heat is transferred indirectly from the heated metal surface through an intervening gas layer to the droplets for vaporization. The small droplets themselves remain relatively cool due to evaporative cooling. Small droplet size minimizes droplet impact on hot metal surfaces, thereby avoiding thermal decomposition and by-product formation that may otherwise occur.

Vapor generation using conventional coarse droplet sprayers or direct contact flash vaporizers results in precursor liquid-to-metal contact, which can cause thermal breakdown of the precursor resulting in fouling, plugging and particle formation. Precursor thermal decomposition and the resulting by-product formation in a conventional vaporizer is the leading cause of unreliable operation. The outcome is impure vapor, degraded film quality, low product yield, the need for frequent hardware replacement and tool downtime, all of which result in increased operating costs.

**Multiple Liquid Atomization and Vaporization**

Many films require the simultaneous vaporization of multiple precursor liquids. The Model 2820 Turbo-Vaporizer has the ability to simultaneously atomize up to 3 liquids using a common carrier gas. These fine droplets are vaporized in the isothermal heat exchanger. Additional QUANTIM liquid mass flow controllers are supplied when the multiple liquid option is specified.
Multi-Stage Isothermal Turbo-Vaporization

The Model 2820 Turbo-Vaporizer uses a multi-stage isothermal heat exchanger. The first stage incorporates a heated turbo-mixer, where the majority of the precursor droplets are vaporized. A second-stage heat exchanger, an integrated hot-gas filter, and a final super-heater insure complete liquid vaporization at the lowest possible temperature.

Integrated Hot-Gas Filtration

The Model 2820 Turbo-Vaporizer generates a pure precursor vapor that is substantially free of decomposition products and particulate contaminants. The integrated filter is effective in removing particles and is also an effective guard against any precursor handling mistakes that might contaminate the process.

Heat is transferred from the hot metal surface to the liquid droplets.

Gas heat provides the energy to vaporize the liquid droplets.
Model 2820 Turbo-Vaporizer System

Equipment Description

The Model 2820 Turbo-Vaporizer System is a direct liquid injection (DLI) vaporizer that uses fine droplet technology to vaporize liquid precursor chemicals. It is the ideal solution for thin film deposition by either chemical vapor deposition (CVD) or atomic layer deposition (ALD) processes.

The Model 2820 features fine droplet atomization, precision liquid and gas mass flow control and low temperature vaporization. An efficient multi-stage turbo-vaporizer with integral hot gas filtration generates vapor for delivery to the process while maintaining the integrity of the precursor molecule.

The Model 2820 Turbo-Vaporizer base configuration is for vaporizing one liquid stream. As an option, one or two additional liquid streams can be added to the system so that a single vapor or a mixture of vapors can be generated for multi-component films such as Borosilicate Glass (BSG), Phosphosilicate Glass (PSG), or Borophosphosilicate Glass (BPSG).

Fine droplet vaporization is an essential technology in the Turbo-Vaporizer design. It virtually eliminates particulate formation when compared to conventional flash vaporizers, where precursor thermal decomposition results in particulate formation, leading to degraded film quality, contamination, loss of product yield, and unreliable vaporizer operation.

Configuration and Flow Rates Options

The base configuration Model 2820 will vaporize a single liquid stream. Two and three liquid stream versions are available as options for generating complex vapor mixtures for multi-component film deposition.

The Model 2820 can be operated at gas flow rates as low as 50 sccm to as high as 10 slm using N₂, Ar, He, H₂ as a carrier gases. Liquid feed rates can range from about 3 g/hr to 600 g/hr, i.e. 50 mg/min to 10 g/min. Higher flow rate configurations are available by special request. Please contact the factory for details.

The Model 2820 is standard equipped with Brooks Instrument liquid and gas mass flow controllers. The multi-stage vaporizer uses VCR fittings for liquid and gas inlet and gas/vapor mixture outlet. The package is completed with an electric heater sized for the maximum liquid vaporization rate. Temperature control and over-temperature shutdown thermocouple sensors are also provided. The vaporizer is packaged to provide operator protection from high temperature surfaces. The internal electrical heater requires a separate temperature controller. Setpoints for the liquid and gas flow controllers will originate from the process controller.

An optional Vaporizer Control Module is available, which allows stand-alone operation of the vaporizer in a research environment, or where process controllers do not have the necessary control capability for the vaporizer. It can also be used in those applications where the vaporizer will be replacing a bubbler and the process controller software is not set up for Direct Liquid Injection operation. This unit has integrated temperature controllers for the vaporizer along with over-temperature shutdown protection. Power and control signals are generated for the liquid and mass flow controllers.
A Vaporizer Control & Interface Module is also available to provide interface to a PC or a laptop computer for vaporizer control and data display via the computer.

MODEL 2820 TURBO-VAPORIZER
GENERAL CLASSES OF APPLICATIONS:

- Insulating, electrical films
- Precision water-vapor generation for semiconductor, fuel cell, instrument calibration, and industrial applications
- Liquid precursors for fiber optic production
- Vaporization for bench top and pilot plant chemistry research
- Catalyst research and fabrication

Available Vaporizer Configuration
Brooks MSP Model 2820-1 Turbo-Vaporizer System
Single Liquid Vaporizer

Product Description:
Turbo-Vaporizer with fine droplet atomizer, multi-stage isothermal vaporizer, and integral hot gas filter complete with Brooks mass flow controllers for liquid (QUANTIM) and gas (thermal), electric heater, temperature sensors.
Specifications

The Model 2820 Turbo-Vaporizer System is capable of operating over a very wide range of liquid and gas flow rates and can be supplied with the appropriate flow controllers to meet user requirements. Liquid vaporization rates and gas flow rates outside the indicate ranges can be supplied on special order. Contact factory for details.

**MSP 2820 Atomization / Vaporization Module**

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
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<tbody>
<tr>
<td>Dimensions</td>
<td>14&quot; x 8&quot; x 8&quot; (356mm x 203mm x 203mm)</td>
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<tr>
<td>Weight</td>
<td>18 lb (8 kg)</td>
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<tr>
<td>Normal Fittings</td>
<td>Gas Inlet, ¼&quot; VCR; Liquid Inlet, 1/8&quot; VCR; Mixture Outlet, 1/4&quot; VCR</td>
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<tr>
<td>Wetted parts</td>
<td>SS 316 &amp; Ni</td>
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<tr>
<td>Leak integrity</td>
<td>&lt; 1 x 10⁻⁹ scc/sec He</td>
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<tr>
<td>Heater power</td>
<td>115/230VAC, 60/50Hz, 100W to 400W depending on liquid flow rate</td>
</tr>
<tr>
<td>Carrier gas</td>
<td>Helium, Nitrogen, Argon, H₂, etc.</td>
</tr>
<tr>
<td>Gas flow rate</td>
<td>Can be configured for flow rates from 50 sccm to 10,000 sccm</td>
</tr>
<tr>
<td>Liquid flow range</td>
<td>Can be configured for flow rates from 3 g/hr to 600 g/hr (TEOS equivalent)</td>
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<tr>
<td>Temperature range</td>
<td>40 to 280 °C</td>
</tr>
<tr>
<td>Inlet gas pressure</td>
<td>35 to 80 psig (240 to 540 kPa)</td>
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**Brooks QUANTIM Liquid Mass Flow Controller**

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<tr>
<th>Specifications</th>
<th>Details</th>
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<tbody>
<tr>
<td>Mass Sensor Technology</td>
<td>Coriolis</td>
</tr>
<tr>
<td>Flow Rates</td>
<td>Available from 5 g/hr to 600 grams/hr</td>
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<tr>
<td></td>
<td>17-7PH and Ni-Cr Braze</td>
</tr>
<tr>
<td>Density Sensor Technology</td>
<td>Coriolis</td>
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<tr>
<td>Density Measurement range</td>
<td>0.5 to 2.0 grams/cc</td>
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**Brooks 5850E Gas Mass Flow Controller**

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<th>Specifications</th>
<th>Details</th>
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<tbody>
<tr>
<td>Mass Sensor Technology</td>
<td>Thermal</td>
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<tr>
<td>Flow Rates</td>
<td>Available from 5 sccm to 10,000 sccm</td>
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<tr>
<td>Carrier Gas</td>
<td>Helium, Nitrogen, Argon</td>
</tr>
<tr>
<td>Process Wetted Components</td>
<td>Wetted Parts - Standard: Stainless Steel</td>
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<tr>
<td></td>
<td>Optional: Kalrez® or Buna-N</td>
</tr>
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BROOKS SERVICE AND SUPPORT

Brooks is committed to assuring all of our customers receive the ideal flow solution for their application, along with outstanding service and support to back it up. We operate first class repair facilities located around the world to provide rapid response and support. Each location utilizes primary standard calibration equipment to ensure accuracy and reliability for repairs and recalibration. The primary standard calibration equipment to calibrate our flow products is certified by our local Weights and Measures Authorities and traceable to the relevant International Standards.

Visit www.BrooksInstrument.com to locate the service location nearest to you.

START-UP SERVICE AND IN-SITU CALIBRATION

Brooks Instrument can provide start-up service prior to operation when required. For some process applications, where ISO-9001 Quality Certification is important, it is mandatory to verify and/or (re)calibrate the products periodically. In many cases this service can be provided under in-situ conditions, and the results will be traceable to the relevant international quality standards.

CUSTOMER SEMINARS AND TRAINING

Brooks Instrument can provide customer seminars and dedicated training to engineers, end users and maintenance persons. Please contact your nearest sales representative for more details.

HELP DESK

In case you need technical assistance:

- Americas ☎ 1-888-554-FLOW
- Europe ☎+(31) 318 549 290 Within Netherlands ☎ 0318 549 290
- Asia ☎ +011-81-3-5633-7100

Due to Brooks Instrument's commitment to continuous improvement of our products, all specifications are subject to change without notice.

TRADEMARKS

Brooks ......................................................... Brooks Instrument, LLC
Kalrez ......................................................... DuPont Dow Elastomers
MSP .......................................................................MSP Corporation
QUANTIM ................................................... Brooks Instrument, LLC

QUANTIM Patent Numbers as follows:
- US .....................D436876, 4843890, 4996871, 5231884, 5295084, 5555190, 5687100, 5929344, 6226195, 6476522, 6487507, 6505131, 6505135, 6512987, 6513392, 6526839, 6748813, 6769301
- Germany ........................................................................40004270.3
- UK .......................................................................................2092458
- China...................................................................................... 171140
Counterparts in other countries and other patents pending