A need exists in thin film processes to deliver solid precursors to CVD reactors in a precisely controlled manner. Currently, the only commercially available method to deliver solids is using solvent/solute chemistries with liquid delivery methods (i.e. liquid flow meters or direct liquid injection). A limitation of liquid delivery methods is that some solid precursors have solubility limits which restrict the maximum precursor mass flow that can be delivered to the process chamber.

MKS has developed the Type 1153 to deliver controlled amounts of vapor from a solid source or low vapor pressure liquid source precursor to the process chamber at rates consistent with high throughput requirements.

**Features & Benefits**

- Delivers low vapor pressure liquids and solids without the need for a carrier gas system, for precise, repeatable vapor source delivery
- High operating temperature up to 200°C
- On-board CPU allows for control of flow over a wide range
- Control of flow via analog (0-5 VDC) or RS-232 offers flexibility and diagnostic capabilities
- All metal internal CF-style seal design eliminates contamination due to permeation of elastomeric seals
- Maximum flow (process dependant): 10 slm with 760 Torr inlet to a 10 Torr process allows for high throughput
The MKS Type 1153 Low Vapor Pressure Source Mass-Flo Controller is a pressure-based measurement and control system designed to meter and control vapor from low vapor pressure liquid and solid sources directly, without the need for a carrier gas. The flow of vapor is controlled via pressure-based techniques using two Baratron® pressure transducers, a flow orifice, and a high temperature solenoid valve. Tight temperature control is possible using a thermally optimized heater block design.

Materials

The Type 1153 is used for CVD thin film applications in the semiconductor, industrial coating, and flat panel display industries to deliver low vapor pressure precursors. For example, the Type 1153 is being used for the delivery of solid titanium precursors for the deposition of barriers. The delivery of polymer compounds is also being evaluated for the deposition of low k dielectrics. In addition, the delivery of tetramethyl heptandionate (TMHD) compounds for the deposition of high k dielectrics and ferroelectrics is being investigated.

System Integration

In application, the Type 1153 is placed downstream of the heated source ampule (Figure 2). Delivery lines from the source ampule to the process chamber should be as short as possible and heated. A positive temperature gradient should be maintained on components and the plumbing from the source ampule to the process chamber to prevent condensation. The Type 1153 may be placed in a heated source oven with ambient temperatures up to 45°C. MKS has developed a computer model to aid in the configuration of a Type 1153 Low Vapor Source Flow Controller to best suit a particular material, flow rate, and system pressure. Given the necessary information, a computer-generated plot of flow versus voltage is easily obtained.

System Components

Pressure measurements in the Type 1153 are made by reliable MKS Baratron® capacitance manometers. Components are assembled to the flow element body using CF seals. The environment around the mechanical assembly of control valve, flow element, and sensor is controlled up to 200°C using safe 24 VAC cartridge heaters and an aluminum heater block design. Contained on-board is a CPU (Central Processor Unit) which processes input signals and controls temperature and flow output signals. Using a digital control loop, the valve driver output is sent to a high temperature solenoid control valve upstream of the flow element to deliver the desired amount of gas flow to the process chamber.

Figure 2 — System Integration

A typical system set up using the Type 1153 is shown.
**Mass Flow Measurement Theory**

The gas mass flow equation used in the Type 1153 is:

$$q = C A P_1 \sqrt{\frac{1}{M T}} \times f \left[ k, \frac{P_2}{P_1} \right]$$

- $P_1$ = Upstream pressure
- $M$ = Molecular weight of vapor
- $T$ = Temperature
- $C$ = Discharge coefficient
- $k$ = Ratio of specific heats
- $A$ = Area of orifice opening

Figure 3 shows how flow through an orifice is calculated. Absolute pressure measurements upstream and downstream of the orifice are required.

Mass flow is a function of the downstream to upstream pressure ratio and the upstream pressure. The CPU accurately calculates flow rates for all downstream to upstream pressure ratios.

**Custom Applications & Accessories**

MKS Instruments, Inc. has developed computer design programs to calculate the delivery of vapor source materials used in various applications. These programs are designed for the 1153 as well as the Type 1150 Series and Type 1640. They are a combination of vacuum system design routines used to determine pressure drops in upstream and downstream tubing, and solutions to the generalized flow equation. This allows the determination of the best pressure sensor ranges, control valve size, and flow element dimensions to meet particular customer requirements.

A specially-designed power supply, electronic controller and cables are available to provide the required power supply voltages, input command signals and output signals for the Type 1153.

Please contact the MKS Applications Engineering Group with information regarding your application, and allow them to determine a Type 1153 system configuration for you.
Specifications & Ordering Information

Full Scale Range

Full Scale range is dependent on process conditions; Consult Applications Engineering at 800-227-8766 (e.g., if delivering N₂ at an inlet pressure of 8 Torr and a process pressure of 2 Torr, F.S. ranges of 10 sccm to 250 sccm are available).

10% - 100% of F.S.

Accuracy

± 3% of F.S.

Repeatability

± 0.2% of F.S.

Measurement Resolution

± 0.1% of F.S.

Operating Temperature Range

30° to 200°C (Ambient temperature 15°C to 45°C)

Settling Time

2 seconds to within ± 2% of set point

Input Power Required

Heaters

24 VAC at 8 Amps

Analog control

± 15 VDC ± 5% at 1 Amp

Flow Set Point Signal

0-5 VDC from < 20K W source

Temperature Set Point Signal

0-5 VDC from < 20K W source

Flow Output Signal

0-5 VDC from > 10K W load

Temperature Output Signal

0-5 VDC from > 10K W load

Connector Type

DC Power

9-pin Type "D", RFI/EMI shielded, male

I/O

15-pin Type "D", RFI/EMI shielded, female

Heaters

15-pin Type "D", RFI/EMI shielded, male

RS-232

9-pin, digital, female

Maximum Line Pressure

35 psia (higher for 5000 Torr range sensors and up)

 Leak Integrity

To atmosphere < 1 x 10⁻⁹ scc/sec He

Through closed valve < 3% of F.S. at process conditions

Process Wetted Materials

316 L S.S., Inconel®, and nickel

Swagelok® 8 VCR® male

Fittings

Software

RS-232 Operational Functions

Flow

Temperature

Valve OPEN/CLOSE/CONTROL

Gas Calibration Factors (ratio of specific heats, molecular weight, calibration constants)

Attitude Sensitivity

Do not mount unit upside-down

Ordering Code Example: 1153A2000

Code Configuration

Type 1153 Mass Flow Controller 1153 1153

Product Revision Number

Revision A 1153

File numbers to be provided by MKS Applications Engineering Group 2000

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