



# (Ultra) low flow Coriolis competence



Source: ABB



**Bronkhorst®**

# Bronkhorst®

Bronkhorst® specializes in low flow Mass Flow Meters and Controllers for liquids and gases. Our Coriolis principle based instruments are designed to accurately measure and control flow ranges from 0.1 g/h up to 600 kg/h.

They are suitable for numerous applications within semiconductor, laboratory and chemical environments. Combined with a (gear) pump or (shut-off) valve, compact liquid mass flow dosing systems can be offered as an alternative to gravimetric or volumetric filling and dosing methods. All instruments can be supplied with face seal fittings (VCR).



Bronkhorst® is a supplier to many of the world's biggest and most respected companies. Our Coriolis Mass Flow Meters and Controllers can be used in various applications:

- Dosing and controlling supercritical fluids (e.g. Supercritical CO<sub>2</sub> cleaning)
- Deposition of protective layers on wafers before (laser-) dicing
- Spray coating in flat-panel displays (FPD)
- Metal Organic Chemical Vapor Deposition (MOCVD)
- Atomic Layer Deposition (ALD).



## Customer first

Bronkhorst® provides not only instruments, but also total flow solutions. Our global perspective with local focus ensures that our international distributor network is able to provide on-site support and discuss the best solution to any given application. This ethos also includes product adjustments to ensure that the finer details of your application will always be met with a bespoke solution if necessary.



## Round the clock support

Bronkhorst® is a worldwide organization with its Head Office located in Ruurlo, The Netherlands. The Customer Service Department offers 'seven days a week' support to customers in every corner of the world. Our specialist teams are available to you to fulfill the needs of pre- and aftersales support, on-site inspection & calibration and start-up assistance



# The innovating Semiconductor market

Due to faster and smaller semiconductor devices and higher levels of integration, a higher precision in the production process is required. To increase the wafer production process, new materials are being used.

## Wafer Cleaning

**Cleaning with supercritical CO<sub>2</sub> will be the 'next generation' cleaning method as supercritical CO<sub>2</sub> has the following advantages:**

- Zero surface tension (no wafer damage)
- A tunable density
- Environmentally friendly (non toxic)
- A recyclable process.

With regard to wafer cleaning, the Coriolis instruments of Bronkhorst® offer the following benefits:

**A high accuracy (0.2% reading) and a great repeatability**

The (mini) CORI-FLOW™ sensors have an accuracy of 0.2% reading and a perfect repeatability, creating a constant endresult and highly stable flow control.

**A quick response on start, stop and setpoint changes**

The quick start/stop control in a (mini) CORI-FLOW™ saves expensive machine run-time as no long start-up time is needed. Within seconds the flow is stable and accurate.

**No calibration needed**

A (mini) CORI-FLOW™ sensor does not need to be (re-)calibrated during a process or liquid change.

This results in saving machine run-time and service time which is needed during maintenance.



## Layer Deposition

**Performing (thin)film layer deposition is possible by several ways.**

**The two most common ways are Spray Coating and Chemical Vapor Deposition.**

### Spray Coating

Spray coating, the alternative for Spin Coating, is much more effective in applying a thin, uniform coated layer.

Other advantages of Spray Coating are:

- An improved throughput time by high-speed coating
- Better yield ratios as a result of a superior coating uniformity on (non round) surfaces
- No (re)calibration needed during the process.

Examples of well known processes that can be significantly improved using a Bronkhorst® (mini) CORI-FLOW™:

### Laser dicing

Applying a very precise protection layer onto the surface with a (mini) CORI-FLOW™ protects the surface against debris (particles) and simplifies the cleaning of the wafer. This results in a higher quality, higher yield and less field returns.

### FPD- and solar cell coating

Thanks to precise dosing and quick start/stop time, a (mini) CORI-FLOW™ sensor will bring a nearly 100% efficiency in the use of coating materials during the production processes.

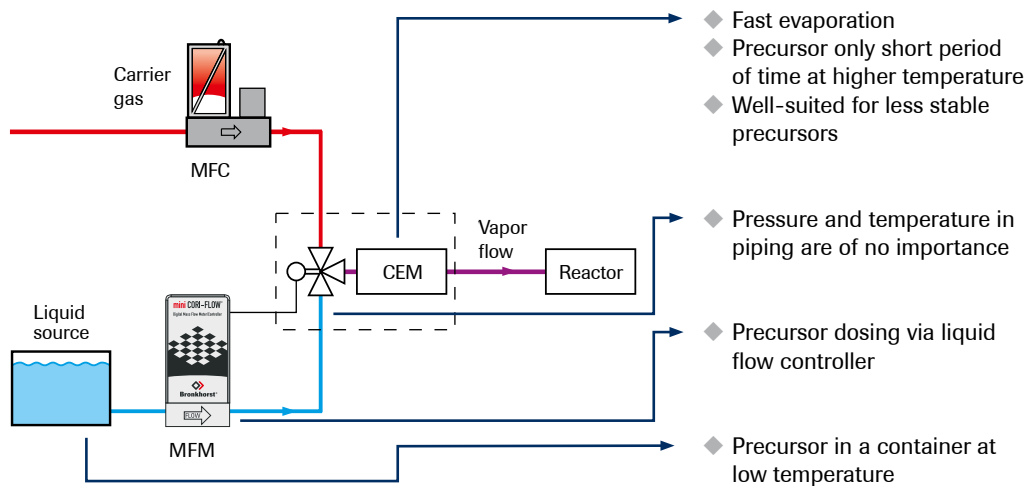


Source: Argonne National Laboratory



# Chemical Vapor Deposition (CVD)

CEM: Controlled Evaporation Mixing



There are several types of CVD processes in which a (mini) CORI-FLOW™ sensor is able to improve and simplify the process significantly. Bronkhorst® instruments introduce the following benefits:

- High accurate vapor flow control and excellent reproducibility
- Excellent batch-upscaling
- Fluid independent; no recalibration needed during the process.

To create a mixture of gases and liquids in a CVD process, bubblers are most commonly used. A Bronkhorst® CEM system can replace the bubbler system eliminating the bubbler's disadvantages. The advantages of a CEM system in comparison with a regular bubbler are given in the overview below:



	Bubbler	Bronkhorst® CEM system
Temperature	Optimum Temperature needed	Temperature independent
Energy consumption (heating)	High; liquid in container is heated	Low; heating at last stage before reactor
Pressure	Optimum Pressure needed	Pressure independent
Accuracy	Low	Accurate: Liquid: 0.2% reading Gas: 0.5% reading
Response time		
On start/stop	Slow	Quick
On change	Slow	Quick
(Long term) stability	Poor	Very stable
Waste	Decomposition by overheating	No waste
Working temperature	High	Low
Fluid handling	One gas/liquid	Various gasses/liquids/mixtures
Reproducibility	Low	High

## Metalorganic Chemical Vapor Deposition

Several metalorganic source fluids are used in the MOCVD process which can be mixed and controlled by a CEM system.

## Atomic Layer Deposition

ALD is a process which offers thin film growth as fine as atomic/molecular scale per monolayer. In this process Bronkhorst® instruments can make the difference. (mini) CORI-FLOW™ instruments for dosing precursors offering:

- Excellent Reproducibility: < (0.1% +Zero Stability) variation over 24 hr
- Quick dosing due to very fast response time: < 0.5 seconds
- Liquid and gas independent: No (re-)calibration during operation or after fluid change.

# How to reduce production costs by using a (mini) CORI-FLOW™ controller

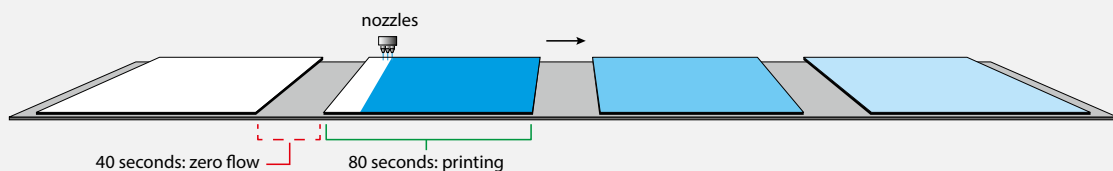
Using conventional mass flow instruments requires regular recalibration of the instruments to ensure constant accuracy, especially when changing the fluids. If we look at Coriolis instruments, we see that recalibration is not necessary. This can save a lot of costs. Figures below show an overview of cost savings possible for flat panel display production:

## Calculations based on the use of mini CORI-FLOW™ instruments

Calculation of the total savings possible by using a Bronkhorst Coriolis instrument (e.g. an ML120) based on:

### 1. Reduction of expensive fluid waste Save 5 gram of OLED material per 55" OLED display panel

The (mini) CORI-FLOW™ controllers can reduce the waste of materials by decreasing the flow to zero during stops, when no layers are printed. The Coriolis sensors do not need any stabilization time (in contrast to competitor instruments) and the flow reaches the setpoint very fast again after the stop. An example of material savings per panel possible by reducing the fluid waste is in the illustration and tables below.



Example:

	Actual HD display*	
	Competitor MFC	mini CORI-FLOW™ MFC
Waste time <sup>1</sup>	40 sec	2 sec
Fluid flow e.g. <sup>2</sup>	80 mg/min = 1.33 mg/s	80 mg/min = 1.33 mg/s
Produced panels	1	1
MFC's (nozzles) <sup>3</sup>	100 pcs.	100 pcs.
Wasted liquid / panel	80 mg/min: 5.32 g	80 mg/min: 0.266 g
<b>Savings / panel</b>	<b>&gt; 5 grams per panel</b>	

<sup>1</sup> Waste time (Total production time - EML print time = 120s - 80s) = 40s

<sup>2</sup> Calculated from layer thickness print time and panel area<sup>1)</sup>

<sup>3</sup> Estimated from available data 1 MFC per nozzle

\* Changing the parameters (e.g. fluid flow) will give different results

As the capacity of the OLED production equipment is 10,000 55" panels per month per machine, a reduction of 5 grams per panel adds up to a total saving of 240 kg of OLED EML liquid per machine per year

Savings / panel	5 g/panel
Panels / year / machine	Approx. 120,000
<b>Savings / year / machine</b>	<b>Up to 240 kg</b>

### 2. No (re) calibration needed Savings because regular calibration is not needed:

Using conventional thermal mass flow instruments requires regular recalibration of the instruments to ensure constant accuracy, especially when changing the fluids. If we look at Coriolis instruments, we see that recalibration is not necessary, as they work like inline weighing scales, independent of fluid properties. An overview of cost savings possible by reducing machine down-time for calibration is shown below.

	Competitor MFC	mini CORI-FLOW™ MFC
Machine down-time*	4 hrs/month	0 hrs/month
<b>Savings</b>	<b>48 hours machine down time / per year</b>	

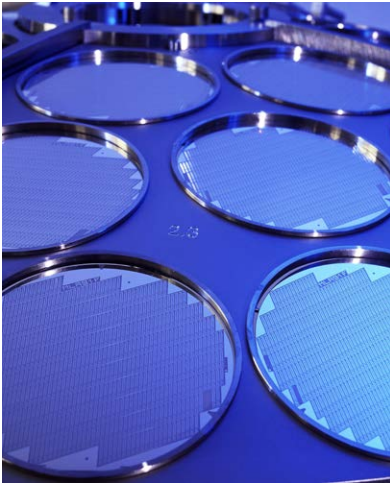
\*Assumption: Machine down-time based on

- (Re)Calibration of competitor MFC for:
  - MFC Calibration.
  - Recalibration after fluid change.
- Machine switched-off for calibration.
- 100 MFC per machine.



# The benefits of (mini) CORI-FLOW™

Bronkhorst® Coriolis Mass Flow Meters and Controllers are known for their high accuracy, repeatability and employability for multiple fluids. They behave like scales for flowing mass. Besides this they provide a fast response and a capability to measure and optionally control very low flow rates. Looking specifically at the semiconductor market, the benefits below are important.



## Repeatability

During processes like wafer cleaning and layer deposition, the repeatability of the process has an important role. The solutions of Bronkhorst® make sure the repeatability is constant and the quality will be guaranteed. Features of Bronkhorst® solutions are:

- The (mini) CORI-FLOW™ sensor maintains a stable mass flow which is independent from pressure and temperature changes in the process
- Excellent accuracy to ensure an optimal process quality
- Perfect repeatability to ensure that the process conditions are kept within strict limits.

## One sensor, all fluids

Changing instrument combinations to perform various different process steps of applications requires a sensor that is compatible with numerous different fluids. This feature is crucial to the success of (mini) CORI-FLOW™ as without any changes to the sensor the user is indeed able to use the same instrument for multiple different process steps of applications. This will ensure:

- Convenience to work with several fluids without changing the instrument
- During the operation, no (re)calibration is needed. The sensor will be calibrated in our factory and will be ready for use.



## Convenience of change

With a (mini) CORI-FLOW™ it is possible to use the same sensor for multiple processes. Simply configure the software settings and start working. (mini) CORI-FLOW™ gives the following benefits:

- Pumps, valves and sensors can easily be combined by the user
- Different tests require different setups. A (mini) CORI-FLOW™ is able to be applied to a whole host of different processes.

# Bronkhorst® FlowWare, free software tools

For the convenience of their customers, Bronkhorst developed various software tools, to support the operation of their digital mass flow meters and controllers.

These software tools are suitable for operation by personal computer and available free of charge.

## > FlowDDE

Interface between digital instruments and Windows software.

## > FlowView

FlowView is an application to easily operate Bronkhorst® digital instruments and readout units (E-8000 series).

## > FlowPlot

Software tool for monitoring and optimizing digital instruments.

- Free software program for monitoring and service purposes on Bronkhorst® digital instruments and readout units
- Good insight into the dynamic behaviour of meters and controllers and thus the process
- Allows adjustment of the controller, alarm and counter settings
- FlowPlot has benefitted a great many users when first establishing a new experiment or process. The graphical representation of so many measured parameters simultaneously, e.g. flow, temperature, density, etc is a useful visual tool at the point of set-up.

- Density (100% = 2000 kg/m<sup>3</sup> - 0% = 0 kg/m<sup>3</sup>)
- Temperature (percentage = °C)
- Setpoint (wanted value; 100% = FS = capacity)
- Measure (actual flow; 100% = FS = capacity)
- Controller output value



### Typical functions

#### • Re-ranging mini CORI-FLOW™ instruments

Coriolis instruments are very linear, therefore the instruments can be rescaled at any desired value within the specifications of the instrument.

#### • Optimizing (PID) controller settings

The products of Bronkhorst® have an integrated PID controller. Therefore it is possible to control valves and pumps directly. With FlowPlot it is possible to optimize these setting to your personal preferences. In addition it is also possible to save your personal preferences. This can be very useful if you would like to use one MFC for several processes.

#### • Printing a hardcopy of graphs

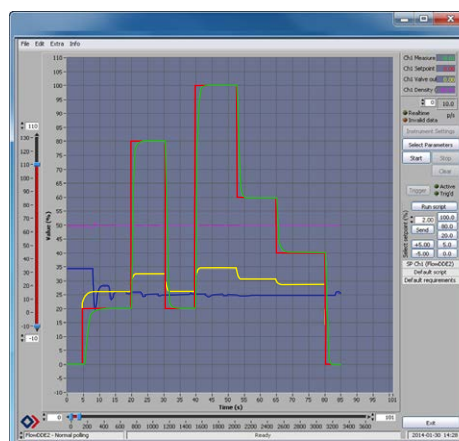
Share your results with colleagues and/or customers.

#### • Data logging to comma separated files

All parameters can be logged, therefore you will have an excellent traceability of your process. This is very useful when it comes to quality assurance.

#### • Batch counter settings

The Bronkhorst® Coriolis instruments are equipped with the CORI-FILL™ technology. With the integrated counter function it is possible to perform highly accurate batch dosages. The counter function also ensures that the actuator will react as soon as the batch has been reached. Normally several components would be needed to achieve this. By using CORI-FILL™ you will have this functionality in one component, in one assembly and from one supplier, without the need of complex programming of additional hardware.



This screen shows the selected parameter value sizes as a function of the time to get an impression of the dynamic flow (and other parameter) behavior.

# Bronkhorst® Fluidics Handling Solutions for the Semicon Market



## Coriolis Mass Flow Meters and Controllers

Precise and compact Mass Flow Controllers (MFCs) for gases and liquids, based on the Coriolis measuring principle, designed to cover the needs of the low flow market. The MFCs offer “multirange” functionality: factory calibrated ranges can be rescaled by the user, maintaining the original accuracy specs. Standard digital communication over RS232, optional fieldbus communication: PROFIBUS DP, DeviceNet™, Modbus-RTU, FLOW-BUS. On ML120 series also PROFINET and EtherCAT®.



## Thermal Mass Flow Meters and Controllers

Metal sealed Mass Flow Controllers (MFCs) for gases, for use in high purity applications. The MFCs offer “multi fluid / multi range” functionality: factory calibrations can be modified by the user with the aid of free configuration software. Standard digital communication over RS232, optional fieldbus communication: PROFIBUS DP, DeviceNet™, Modbus-RTU, FLOW-BUS, PROFINET and EtherCAT®.



## Digital Pressure Meters and Controllers

Digital Pressure Meters and Controllers for gases and liquids, for use in high purity applications. Metal Seal Pressure Meters and Controllers of Bronkhorst® are characterised by their unique, patented metal-to-metal seal construction with excellent resealing capability. Standard digital communication over RS232, optional fieldbus communication: PROFIBUS DP, DeviceNet™, Modbus-RTU, FLOW-BUS, PROFINET and EtherCAT®.



## Vapour Delivery Solutions

A Bronkhorst vapor generation system consists of a (thermal or Coriolis) liquid flow controller, an MFC for carrier gas and a temperature controlled mixing and evaporation device. As an option, these components can be integrated in a pre-tested, safe and ready to use Vapor Delivery Module (VDM). This module can generate (saturated) vapor flows within the range of 100 ml./min up to 10 l./min and features integrated power supply with display (1.8”TFT) and control functions. As an option, the unit offers local or remote trace heating temperature control. The VDM-Series can be applied for atmospheric or vacuum processes and is capable of evaporating mixtures and even solids, dissolved in solvents.

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