

**A novel state-of-the-art INTEGA High Tech Product available now:**

# **Adjustable Precision Gas Mixing System with high dynamical range - Cascade Gas Fine-Tuning and Mixing System (MINI-MIX - CGFMS)**

## **Demands**

In principle gases can be mixed in any relation of volume. Theoretically this is a pretty simple action but in reality (i.e. chemistry, pharmacy and especially in semiconductor technology) this is a very hard task. Mixtures in the range of 100 % to  $10^{-3}$  can be established pretty easily, ppm ( $10^{-6}$ ) and ppb ( $10^{-9}$ ) concentration levels are really challenging and this is even more complicated or nearly impossible for the ppt ( $10^{-12}$ ) region.

For many High-Tech Applications it is necessary to reach very high **precision**, unrestricted **repeatability** and excellent **reproducibility** entering this range of concentrations when dealing with very special gas mixtures. For some different methods of production (i.e. Diffusion, Doping for CVD- and Epitaxy-processes, Synthesis of special chemicals by means of Micro-Reaction-Technology, ...) it is absolutely necessary to manage this range of concentration of mixed gases very precisely and carefully. So, it is really time to design and build Gas-Mixing-Systems that are capable to create gas mixtures of desire and make these systems commercially available for the customer's applications.

## **ppm-Level as Limit for conventional customary gas mixtures with good quality**

The well known and conventionally used technique of volumetric dosing for fabrication of gas mixtures by adding a calculated small quantity of one gas to a second calculated quantity of another gas, hits practical limits already in the range of ppm. The amount of gas, which is adsorbed to the walls of the large gas mixing containers is not negligible any more and causes significant errors.

The consequent step to avoid these errors, is to apply the very precise and well adapted method of dynamic mixing of gases using so-called "Microstructure-Mixers" as best approach. This devices can mix different gases, delivered by means of very steady, precise and reproducible electronic Mass Flow Controllers (MFC). Within an extremely small volume and short inter-diffusion distances in the range of  $10\ \mu\text{m}$  up to  $100\ \mu\text{m}$  the distribution is very intensively and therefore an absolutely uniform mixture is produced with excellent reproducibility and stability.

The flow ranges of the MFCs can only cover adequate flow rates and flow ratios and will limit this dynamic mixing technique to a dilution ratio of about  $1/1000$  ( $10^{-3}$ ) for each Microstructure-Mixer unit. Expanding this to even lower levels underneath  $10^{-3}$  will result in increasingly non-linear error rates and causes strong instability effects.



## **Gas Mixtures in the sub-ppm range reaching ppt-levels**

To overcome the limits of  $10^{-3}$ , the concept of dynamic mixing is used in a consecutive cascade arrangement. A small fraction of the mixed gas out of mixing stage 1 is used to be further diluted in mixing stage 2, and so on and so forth. This can result in generation of concentration levels of ppm ( $10^{-6}$ ), ppb ( $10^{-9}$ ) or even ppt ( $10^{-12}$ ) using more than one mixing stages in series. This MINI-MIX Cascade Gas Fine-Tuning and Mixing System can offer a very wide dynamic range of as large as 12 orders of magnitude or even more. A system like this can cover all commercially used concentration levels of gas mixtures and consequently all imaginable gas mixtures are available on-site, on-demand and with adjustable output concentration without handling a countless number of individual gas cylinders with all their variations in quality and concentration and inconveniences of storage.

Of course this system hits its limits as well. This limits will appear below the ppt level, because due to this extremely low concentration levels, increasing effects of gas adsorption at the walls and surfaces of the MFCs, gas tubes, valves, etc. will occur. This leads to inhomogeneities and the time for reaching the state of equilibrium will increase dramatically, finally the system collapses in sudden fluctuations and strange oscillations of concentration at the lower bottom of its applicable working range.

### **Range of Application**

- > 100% to  $10^{-4}$  = volumetric Mixing
  - >  $10^{-2}$  bis  $1/10^{12}$  = dynamic Mixing
- MINI-MIX Cascade Gas Fine-Tuning  
and Mixing System**

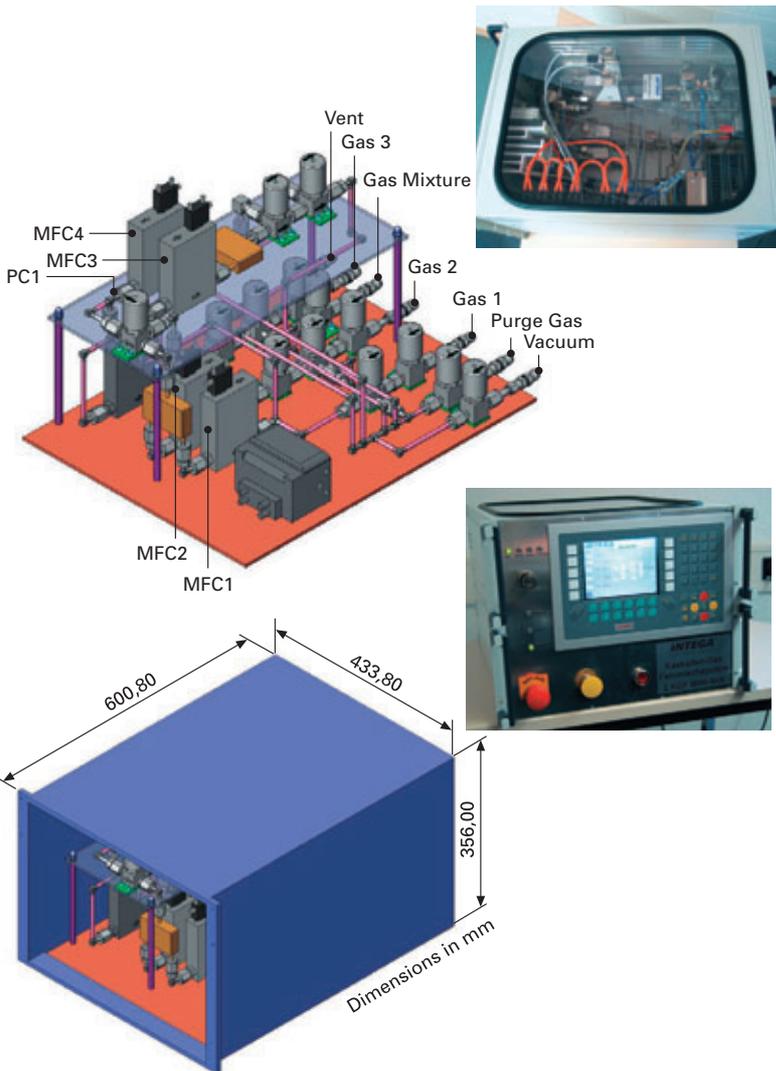


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## Cascade Gas-Fine-Tuning and Mixing System MINI-MIX for commercial use and unlimited applications

This gas mixing unit is part of the EU-funded project ASSYST (Advanced Laser Sensor Systems) which is intended to lead to affordable detection systems of trace gas impurity analysis in bulk and special gases of production processes. **INTEGA GmbH**, that was significantly involved in developing the gas mixing technique, can present the **MINI-MIX** gas mixing system of reasonable size and excellent functionality which is commercially available now. This is one of the first results that arose from the EU-project ASSYST.



### MINI-MIX Details

- Minimization by consequently using microstructure components (i.e. Micro Mixing Units)
- Reduction of space by compact assembly techniques into 19" rack mountable boxes. No large cabinets are needed any more! Large cabinets of former installations can now be equipped with 5 – 6 of this small 19" **MINI-MIX**-subunits.
- Strict reduction of dead ends and dead spaces in tubing and optimization of installation helps to avoid memory effects of gases and gives accurate concentrations according to set-point.
- Visualization and Control-System can be "on-board" or put apart in a central control rack.
- Easy connection to a Central Process Control System (CPCS) for Remote View and/or Remote Control and Data Acquisition
- Gas Monitoring can be included for explosive, toxic or other hazardous gases if necessary
- Integration of vacuum supply for system conditioning (pump/purge) is possible on demand
- Modular design with wide range of variation for customization
- Design, layout and fabrication according to customer request possible

### Mini-Mix CGFMS, brief description

#### Target Customers

- Semiconductor Industry
- Tool Supplier for Semiconductor Industry
- Automotive Industry
- Chemistry and Pharmacy
- Gas Suppliers
- Medicine and Suppliers of Medical Equipment

#### Field of Application

- On-line, on-demand production of accurate gas mixtures for:
  - Doping Gases in Semiconductor Industry
  - Test Gases for Motor Test Stands in Automotive Industry
  - Special Test and Purge Gases for manufactures of precise Optical Equipment dedicated for Semiconductor Industry
  - Reactive Gases for special Synthesis of Chemicals and Pharmaceuticals
  - Medical Gases for Anesthesia, Cancer Therapy and many other applications

### Shrink version to minimize space

In case of two step cascading (2 Microstructure-Mixer units in series) this equipment can be used to mix two different, selectable gases into a carrier gas of desire and cover a concentration range starting with pure undiluted gas down to a level of as low as about 100 ppb (100% -  $10^{-7}$ !!).

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### Benefits

- Generation of gas mixtures is possible on demand and online
- Reduction in cost and space for storage ( no more need for storage of many different cylinders with gas mixtures having all their disadvantages in aging and variation in concentration )
- Concentrations of gas mixtures can be selected within a wide dynamic range online
- Gas mixtures can be created on demand either in very small or even very large quantities

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