

## Technical Bulletin

# Hiperloop High Performance TMIn Delivery



*The Hiperloop TMIn bubbler*

Nouryon High Purity Metalorganics (HPMO) has developed a High Performance Loop Bubbler, called the Hiperloop that consistently delivers stable Trimethyl indium (TMIn) flows from solid TMIn with greater than 90% source consumption. This performance has been demonstrated for flow rates of 300 sccm to 1000 sccm. As such, the Hiperloop offers better utilization of the TMIn source material and higher flow rates using a single bubbler design.

The Hiperloop is a patent pending proprietary design developed by engineers at Nouryon. The particular shape/design of the bubbler resulted from fluid dynamics simulations which optimized both source consumption and flow rates by accounting for heat and mass transfer characteristics. As such this bubbler avoids the significant decrease in TMIn concentration at source consumption levels of 50-70% and the limitation on flow rates (~500 sccm) at low pressures that are typically related to the formation of channels in conventional TMIn cylindrical bubblers.

Table 1 shows the performance of a 320 g TMI<sub>n</sub> Hiperloop bubbler at various flow rates and pressures (all below 225 Torr). The critical consumption listed in this table corresponds to the consumption level at which the Epison measured TMI<sub>n</sub> concentration drops by 1% from its mean value. From this data it is clear that efficient TMI<sub>n</sub> source utilization is achieved. In fact the critical consumption level is 95% at 600 sccm and only drops to 92% at 1000 sccm. Moreover, there was no evidence of TMI<sub>n</sub> fluidization for flow rates of 1000 sccm; i.e. there was no detection of TMI<sub>n</sub> particles exiting the bubbler.

*Table 1. Critical consumption values for the 320 g TMI<sub>n</sub> Hiperloop bubbler at various hydrogen flow rates and pressures*

H <sub>2</sub> flow (sccm)	Pressure (Torr)	Temperature (°C)	Critical consumption (%)
300	225	17	95
600	192	17	95
750	195	17	92
1000	200	17	92

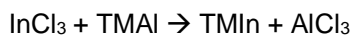
The stability of TMI<sub>n</sub> concentration versus TMI<sub>n</sub> consumption from the Hiperloop is shown in Figure 1 for three H<sub>2</sub> low rates while maintaining a pressure of 180 Torr at the outlet of the Epison and a thermostat temperature of 17°C. At a flow rate 600 sccm the mean Epison concentration is 0.474% with a standard deviation of 0.0014% whereas for 1000 sccm the mean value is 0.452% and stability improves to 0.0009%. This graph along with the statistical data presented in Table 2 shows that excellent TMI<sub>n</sub> concentration stability and high saturation can be achieved without compromising flow rates or source consumption.

Please note that there is an increase in the pressure drop across the Epison as the flow rate is increased. As a result, the pressures measured directly downstream of the Hiperloop are actually higher than 180 Torr and increase linearly with flow. These measured values are shown in Figure 1 and are the reason that the TMI<sub>n</sub> concentrations decrease with increasing flow even though 100% saturation is maintained.

Based on this performance data, the Hiperloop eliminates the industry wide limitations of solid TMI<sub>n</sub> delivery, which are typically poor source stability, poor gas saturation, and poor source consumption at high flow rates. These problems generally result from the formation of channels within the solid TMI<sub>n</sub> source material where the TMI<sub>n</sub> has been preferentially depleted.

As more TMI<sub>n</sub> is consumed and the channels widen, a reduction in interaction between the solid TMI<sub>n</sub> source material and the H<sub>2</sub> carrier gas results in a rapid decrease in TMI<sub>n</sub> delivery, even though only 50-70% of the TMI<sub>n</sub> source material has been consumed. Since the Hiperloop bubbler design eliminates channeling effects, high bubbler performance over a wide range of operational parameters can be realized with a single Hiperloop bubbler.

The Hiperloop is available with 320 grams of solid TMIn and has a footprint of 165 mm x 89 mm (6.5" x 3.5") with a fill height of 165 mm (6.5"). The Hiperloop can typically be accommodated in a standard bath within the gas cabinet and does not require any extra connections or fittings. Please ensure that the water bath liquid level is filled past the fill height (just below the fill port level) to ensure uniform delivery of TMIn. The Hiperloop is loaded with Nouryon HPMO solid TMIn which is the preferred precursor for growing Indium containing III-V semiconductor layers. Nouryon manufactures all of its TMIn source material using an exchange reaction.



Consistent high purity is achieved by utilizing TMAI, manufactured by Nouryon, and  $\text{InCl}_3$ , that is 99.999% pure, as the only reactants. Nouryon HPMO offers solid TMIn in Select Semiconductor Grade (SSG).

Figure 1 shows the TMIn concentration versus source consumption as measured by Epison for the 320 g Hiperloop operated at a pressure of 180 Torr measured downstream of the Epison, a temperature of 17°C, and  $\text{H}_2$  flow rates of 600, 750 and 1000 sccm. The pressures in the figure indicate the pressure measured at the outlet of the Hiperloop.

Figure 1. TMIn concentration versus source consumption

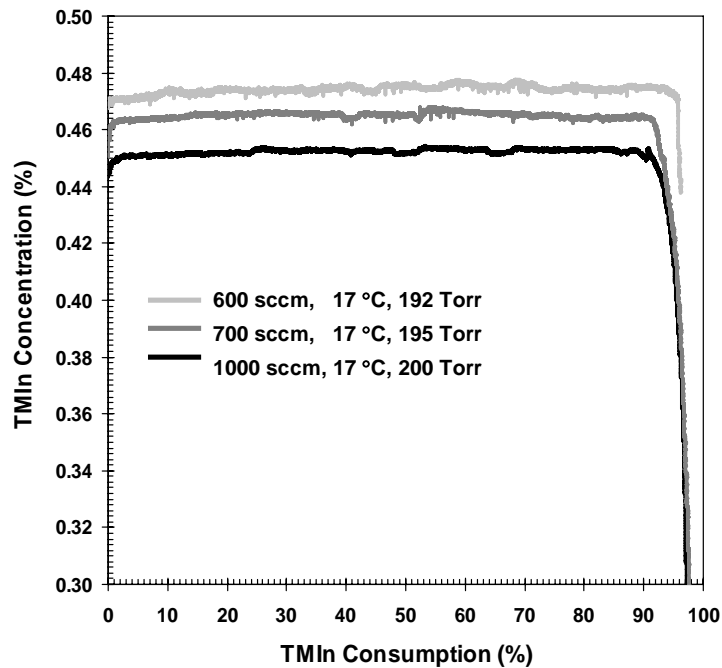


Table 2. The stability statistics for the data are shown in Figure 1. These statistics were measured from 1% consumption to the critical consumption values.

H <sub>2</sub> flow (sccm)	Pressure (Torr)	Mean conc. (°C)	Std. Dev. (%)	Std. Dev. Mean
600	192	0.474	0.0014	0.003
750	195	0.465	0.0015	0.003
1000	200	0.452	0.0009	0.002

**Note**

For smaller bath dimensions, a smaller footprint loop bubbler (the 'Hiperquad') is also available which operates over the same operational range and maintains the same high level of performance.



Volume: 485 ml  
 Fill weight: 350 g TMIn  
 Fill height: 6.7" (170 mm)  
 Fitting height: ~12.5" (~317.5 mm)  
 Max. width : 3.5" (88.9 mm)  
 Max. depth: 3.4" (86.4 mm)

*Hiperquad*

**Hiperloop**<sup>TMIn</sup>  
 High Performance TMIn Delivery



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