Technical Bulletin

Hiperloop
High Performance TMIn Delivery

The Hiperloop TMIn bubbler

AkzoNobel High Purity Metalorganics (AkzoNobel 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 AkzoNobel HPMO. 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 TMIn 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 TMIn concentration drops by 1% from its mean value. From this data it is clear that efficient TMIn 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 TMIn fluidization for flow rates of 1000 sccm; i.e. there was no detection of TMIn particles exiting the bubbler.

Table 1. Critical consumption values for the 320 g TMIn Hiperloop bubbler at various hydrogen flow rates and pressures

H_2 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 TMIn concentration versus TMIn consumption from the Hiperloop is shown in Figure 1 for three H_2 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 TMIn 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 TMIn 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 TMIn 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 TMIn source material where the TMIn has been preferentially depleted.

As more TMIn is consumed and the channels widen, a reduction in interaction between the solid TMIn source material and the H_2 carrier gas results in a rapid decrease in TMIn delivery, even though only 50-70% of the TMIn 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 AkzoNobel HPMO solid TMIn which is the preferred precursor for growing Indium containing III-V semiconductor layers. AkzoNobel HPMO manufactures all of its TMIn source material using an exchange reaction.

$InCl_3$ + TMAl à TMIn + $AlCl_3$

Consistent high purity is achieved by utilizing TMAl, manufactured by Akzo Nobel, and $InCl_3$, that is 99.999% pure, as the only reactants. AkzoNobel 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 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

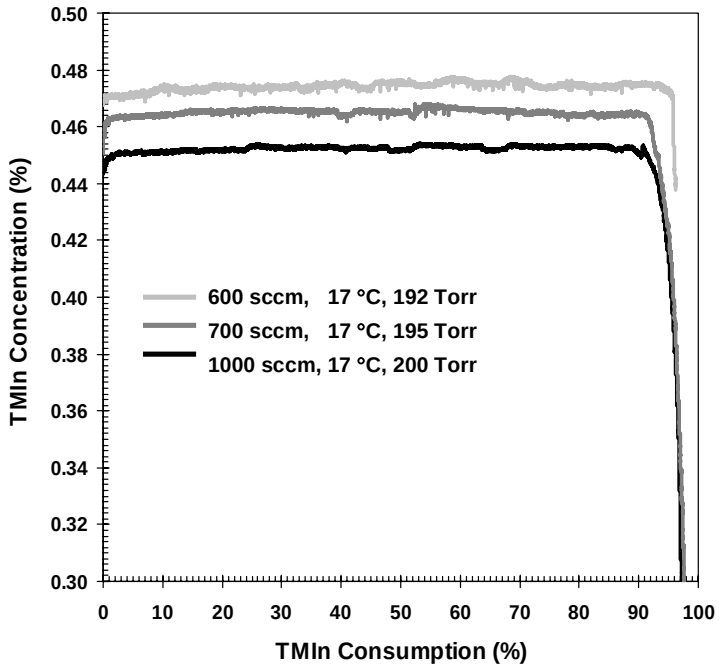

Table 2. *The stability statistics for the data are shown in Figure 1. These statistics were measured from 1% consumption to the critical consumption values.*

H_2 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™ TMIn
High Performance TMIn Delivery

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