

# NANOCHEM®

## NANOCHEM® In2Go™ Purifier Medium NANOCHEM® Inert Gas and Ammonia Purifiers

*The Next Generation Purifier for Inert Gases and Ammonia All the Benefits of OMX™ and OMA™ Media with Stability to Air Intrusions*

NANOCHEM® In2Go™ is an inorganic medium that provides high capacities and efficiencies and also offers resistance to air intrusions. NANOCHEM® In2Go™ not only removes H<sub>2</sub>O, O<sub>2</sub>, CO<sub>2</sub> and CO but also removes hydrogen sulfide and dopant impurities, such as silane, germane, and siloxanes in ammonia and inert gases. Byproducts upon accidental exposure to air are limited to easily removable compounds, such as carbon dioxide, moisture, trace methane and trace ammonia, which do not condense in process lines and can be purged from the system. NANOCHEM® In2Go™ is available in a wide range of purifier sizes from compact point-of-use to bulk purifiers capable of handling up to 1000 slpm.

### Features and Benefits

- Purification of inert and flammable gases and ammonia used in ultra-high purity applications
- Ideal for SiGe Epi, GaN and SiN processes
- **Highest Lifetimes**
- **Best Impurity Removal Efficiencies**
- **Fiber Optic Endpoint Detection available**
- Removes oxygenated species (O<sub>2</sub>, H<sub>2</sub>O, CO, CO<sub>2</sub>, NO<sub>x</sub>, CO<sub>x</sub>, etc) and trace dopants, such as silane, germane, and siloxanes
- Improves and ensures gas purity for process consistency
- Demonstrated improvements in process yield and device quality
- **No hydrocarbon breakdown with air intrusions**
- Does not require heating and cooling
- No external power source required, except for fiber optic sensor
- 0.003 µm particle filter with 99.9999999% retention

### Specifications

- < 0.1 ppb O<sub>2</sub>, H<sub>2</sub>O, CO<sub>2</sub>, CO in inert gases, measured by API-MS
- < 5 ppb O<sub>2</sub> in ammonia, measured by GC-PID, LDL
- < 45 ppb H<sub>2</sub>O in ammonia, measured by FTIR, LDL

### ANALYTICAL PERFORMANCE

#### Typical Performance

Impurities are typically removed to the detection limits of state-of-the-art analytical techniques

Impurity/ Matrix	Efficiency (ppb)	Challenge (ppm)	Analytical Method
H <sub>2</sub> O in Ar	< 0.3 (LDL)	35	API-MS
H <sub>2</sub> O in NH <sub>3</sub>	< 75 (LDL)	3.5	FTIR
CO <sub>2</sub> in He	< 11 (LDL)	500	GC-DID
CO <sub>2</sub> in NH <sub>3</sub>	< 11 (LDL)	25	GC-DID
O <sub>2</sub> in NH <sub>3</sub>	< 0.5 (LDL)	328	GC-PID
GeH <sub>4</sub> in N <sub>2</sub>	< 0.1 (LDL)	2.5	API-MS
SiH <sub>4</sub> in N <sub>2</sub>	< 0.1 (LDL)	2.5	API-MS
Siloxanes in N <sub>2</sub>	< 0.1 (LDL)	(trace)	API-MS
GeH <sub>4</sub> in NH <sub>3</sub>	< 1 (LDL)	0.5	GC-AED
SiH <sub>4</sub> in NH <sub>3</sub>	< 3 (LDL)	0.5	GC-AED
TEOS (siloxane) in NH <sub>3</sub>	< 40 (LDL)	640	GC-DID

**LDL** Lower Detection Limit of Analytical Test Method

**API-MS** Atmospheric Pressure Ionization Mass Spectrometry

**FTIR** Fourier Transform Infrared Spectrometry

**GC-AED** Gas Chromatography with Atomic Emission Detector

**GC-DID** Gas Chromatography with Discharge Ionization Detector

**GC-PID** Gas Chromatography with Photo Ionization Detector

**GF-AAS** Graphite Furnace Atomic Adsorption Spectrometry

**ICP-MS** Inductively Coupled Plasma with Mass Spectrometry

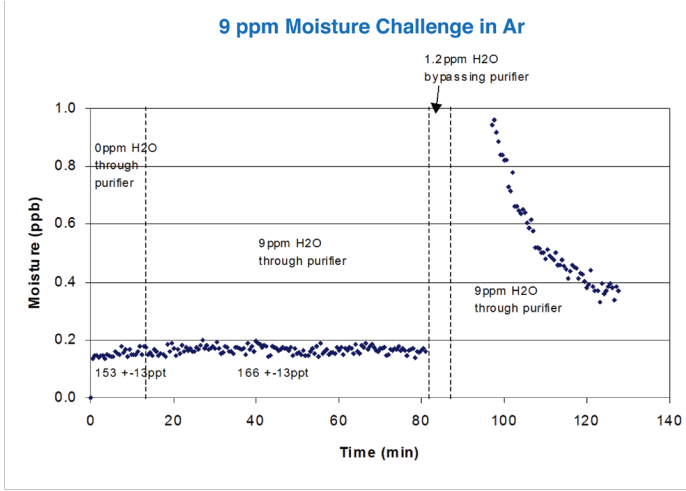
*NOTE: Detection limits of such instruments can vary from day to day.*

### Metal Emissions

Metal emissions of most elements from In2Go™ purifier in ammonia service are below the limits of detection (sub-ppb levels) by ICP-MS and GF-AAS. Only traces (< 1 ppb – 2 ppb) of Al, Ca, B, K, and Fe were detected. Such elements are usually contaminants in gas sampling systems.

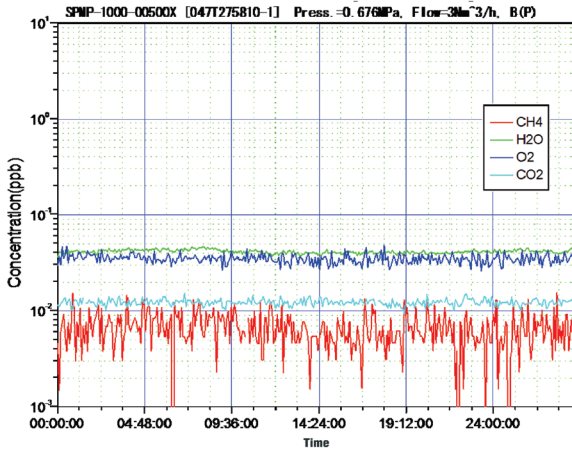
## Capacity & Efficiency in Argon

NANOCEM® In2Go™ offers high capacities and efficiencies. The figure below shows that an inlet moisture content of 9 ppm in argon is reduced to < 0.2 ppb.



The figure below shows that oxygen, moisture, and carbon dioxide in electronic-grade nitrogen are reduced to < 0.1 ppb by NANOCEM® In2Go™ medium.

## Removal of Impurities in Electronic-Grade N<sub>2</sub>



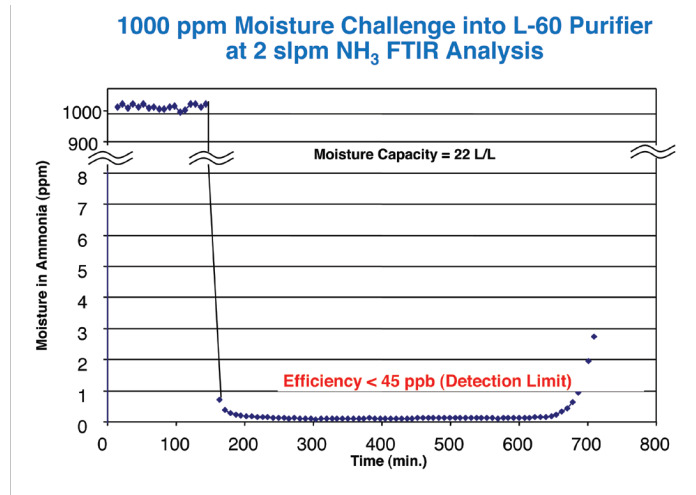
Impurities	Inlet	Outlet	Detection Limit
O <sub>2</sub>	16 ppb	<0.09	<0.09
C <sub>2</sub> O	2 ppb	<0.07	<0.07
H <sub>2</sub> O	6 ppb	<0.1	<0.1

Method: API-MASS

## Capacity and Efficiency in Ammonia

### 1. Removal of Moisture

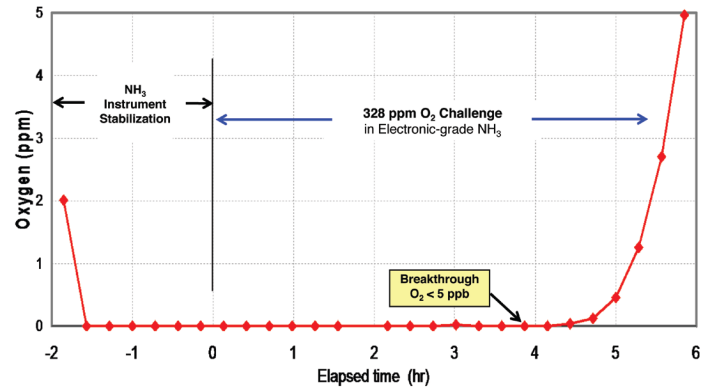
In2Go™ offers the highest lifetime and the best efficiency, similar to NHX™-Plus for the removal of moisture in ammonia.



### 2. Removal of Oxygen

In2Go™ also offers high lifetimes and high efficiencies for the removal of oxygen in ammonia.

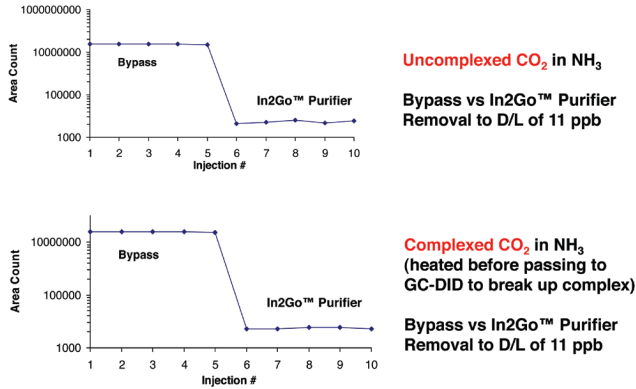
## Oxygen Capacity Test in NH<sub>3</sub>



### 3. Removal of Free and Complexed CO<sub>2</sub>

In2Go™ offers the best efficiency for the removal of NH<sub>3</sub> - CO<sub>2</sub> complexes. CO<sub>2</sub> is often present in the form of complexes, such as Carbamates (NH<sub>4</sub>CO<sub>2</sub>NH<sub>2</sub>).

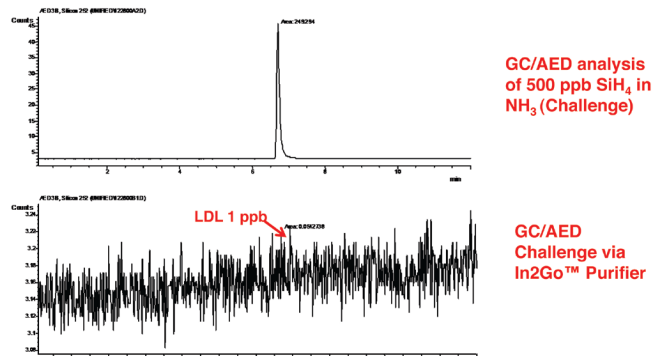
Removes Both Free and Complexed CO<sub>2</sub>



### 4. Dopant Removal – Removal of Silane (SiH<sub>4</sub>) in NH<sub>3</sub>

In2Go™ purifier was exposed to a challenge of 500 ppb silane in ammonia. The silane was completely removed – below the detection limits of ~ 1 ppb, measured by GC-AED. The lower figure (with an expanded scale for the baseline) indicates that the level of residual silane in the purified ammonia can't be distinguished from the baseline noise.

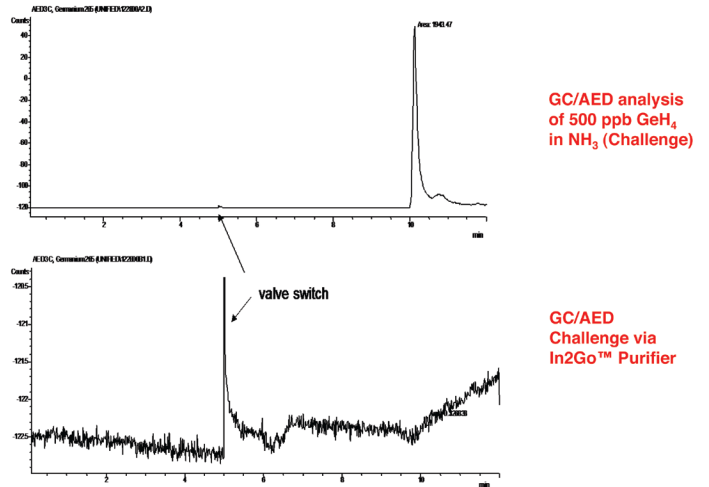
Removal of 500 ppb SiH<sub>4</sub> in NH<sub>3</sub> by In2Go™



### 5. Dopant Removal – Removal of germane (GeH<sub>4</sub>) in NH<sub>3</sub>

In2Go™ purifier was exposed to a challenge of 500 ppb germane in ammonia. The germane was completely removed below the detection limits of ~ 1 ppb as measured by GC-AED. The lower figure with an expanded scale for the baseline indicates that the level of residual germane in the purified ammonia can't be distinguished from the baseline noise.

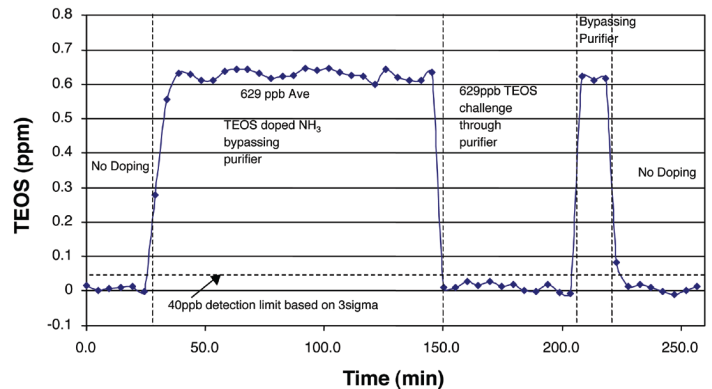
Removal of 500 ppb GeH<sub>4</sub> in NH<sub>3</sub> by In2Go™



### 6. Dopant Removal – Removal of Siloxanes in NH<sub>3</sub>

In2Go™ purifier was exposed to a challenge of 629 ppb of a siloxane (TEOS). The siloxane was completely removed to below the detection limits -- ~ 40 ppb.

Removal of 629 ppb Siloxane (TEOS) from Ammonia



## DEVICE PERFORMANCE

GaN films were grown on a sapphire substrate using a commercially available Aixtron MOCVD 200 RF Tool as shown. Ammonia was purified using either the organo-metal NANOCEM® OMA™ medium or the new Inorganic NANOCEM® In2Go™ medium. The figure to the right shows a noticeable improvement in the Performance Factor with the new In2Go™ medium. SIMS analysis indicated that when ammonia was purified by In2Go™ medium, the concentration of oxygen and silicon contaminants in the grown film was typically reduced by one order of magnitude! The data suggests that device performance was greatly improved when the silicon concentration was reduced below  $1 \times 10^{16}$  atoms /  $\text{cm}^3$ . A performance factor of 1.5 was attained when the silicon was reduced to  $0.5 \times 10^{16}$  atoms/ $\text{cm}^3$ .

NOTE: Performance Factor = Mobility x Sheet Concentration OM refers to organometal medium – OMA™, IO refers to inorganic medium – In2Go™

## Purifier Models / Sizes

NANOCEM® In2GO™ Purification medium is available in a wide variety of hardware configurations for point-of-use, distribution, source and bulk purification applications:

Model	Maximum Flow Rates In N <sub>2</sub> Service			Maximum Allowable Working Pressure#	
	slpm	(NM <sub>3</sub> /hr)	Media Volume	psig	(Mpa)
L-Series	50-150	(0.9-9)	300, 500, 2000 ml	500	(3.55)
A-Series*	50-150	(3-9)	60, 300, 500, 2000 ml	500	(3.55)
H-Series	50	③	500 ml	500	(3.55)
HP-Series	50	③	300, 500 ml	2,850	(19.8)
MS-Series	150-1000	(9-60)	4, 8, 16, 32 liters	350	(2.51)
WK-Series*	10 75-800	0 (4.5-48)	50, 55 ml	1000 500	(3.55)
	1000		300, 500, 700, 2500, 5000 ml 9 liters	350	(2.51)

\*Drop-in replacement available for competing hardware designs.

\*\*Maximum flow rates will be lower for WK-Series purifiers with built-in poppet valves.

\*\*\*Maximum allowable pressure is 150 psig with the endpoint sensor.

## Options

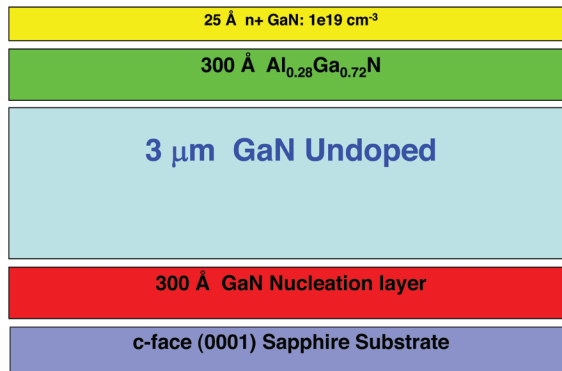
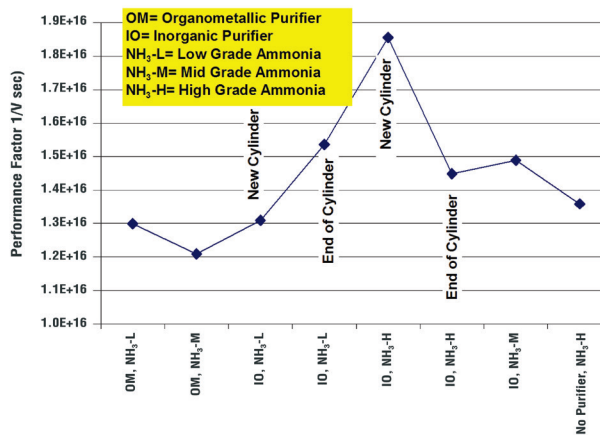
Standard: 0.003  $\mu\text{m}$  particle filter with 99.9999999% retention for ammonia service. Filter factory-installed on models up to 4-liters capacity and WK-Series; provided in separate package with 8, 16, & 32 liter models (MS Series).\*\*\* Manual & Air-Operated Bypass Modules

**Endpoint:** Available for L-Series, A-Series, H-Series, MS-Series. Not available for HP-Series, WK-Series.

\*\*\* NOTE: A particulate filter is required for the removal of particulates in the gas

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Performance Factors with OMA™ and In2Go™ Media



[www.us.nipponsanso.com](http://www.us.nipponsanso.com)

Tel: 800-416-2505

email: [mathesonales@us.nipponsanso.com](mailto:mathesonales@us.nipponsanso.com)