

THE LINDE GROUP

Linde

Gas Supply to Large-Scale HB- LED Factories

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Linde Electronics



Introduction to Linde

About Linde. Global Market Leader in Gases and Engineering Solutions.

THE LINDE GROUP

Linde

—World leading gases and engineering company

—50,000 employees

—Presence in around 100 countries worldwide

—FY 2009 achieved sales of EUR 11.2 billion

The strategy of The Linde Group is geared towards earnings-based and sustainable growth and focuses on the expansion of its international business with forward-looking products and services.



About Linde LienHwa



Linde Greater China

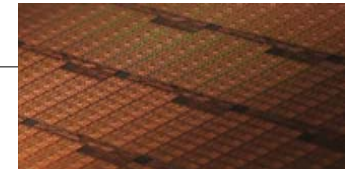
A box containing the Linde logo (THE LINDE GROUP and Linde) and the text "Linde Greater China".

LienHwa MiTac Group
(Taiwan)

A box containing the MiTAC logo (MiTAC and a red circle with white lines) and the text "LienHwa MiTac Group (Taiwan)".

联华林德
Linde LienHwa

Serving the Electronics Market in China

A central box containing the Linde LienHwa logo (联华林德 and Linde LienHwa) and the text "Serving the Electronics Market in China".

Semiconductor



TFT-LCD



Solar



LED

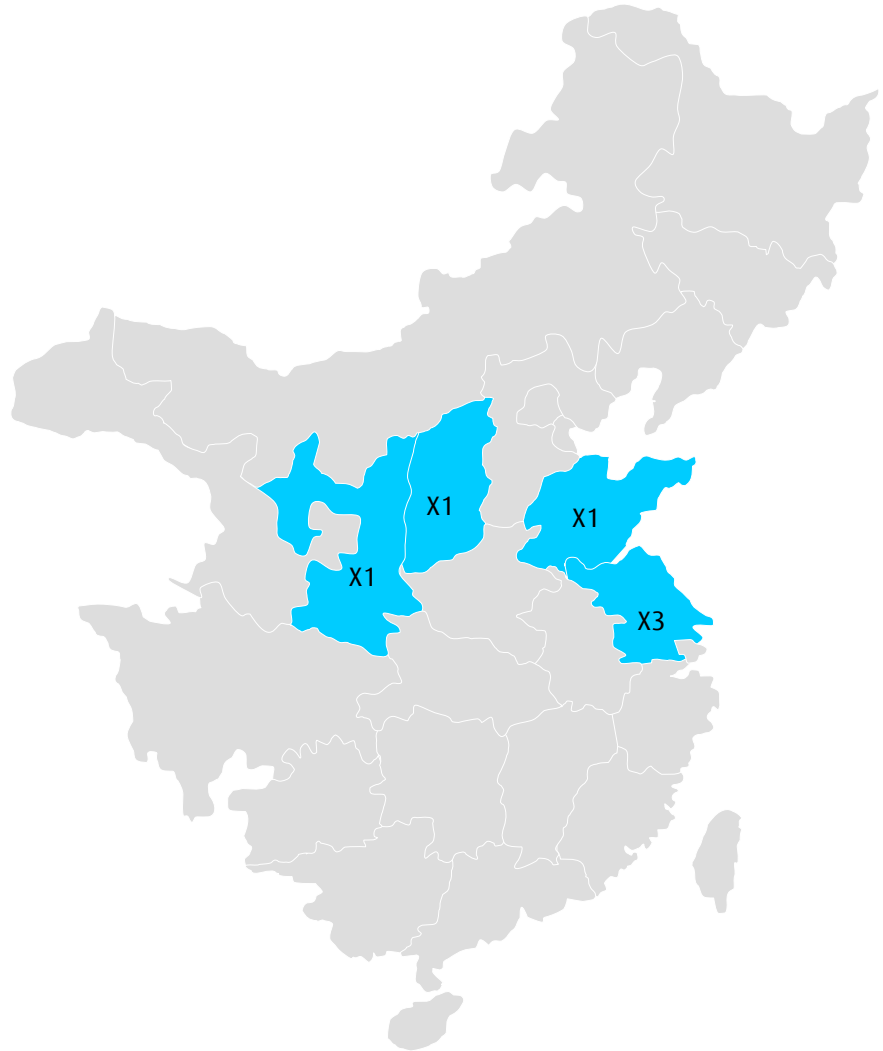
6 new LED customers



During 2010 Linde has been awarded gas supply contracts with six major LED manufacturers in China, including

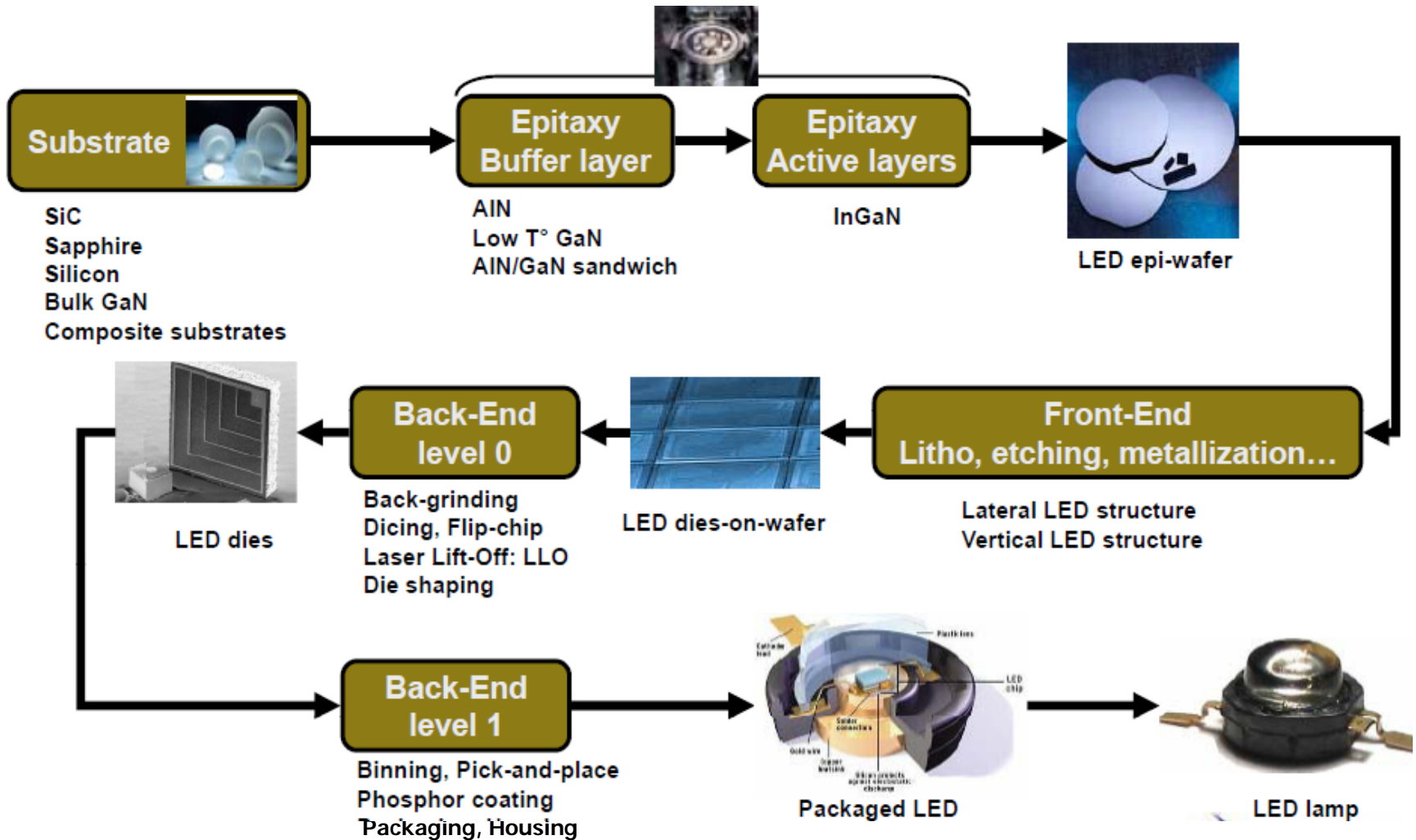
Three Taiwan invested LED fabs in Jining(ShanDong), Suzhou(JiangSu) and Changzhi(ShanXi)

- Neo-Neon in Yangzhou
- Focus Lighting Technology in Suzhou
- Walsin United Technology in Xi'an.



Gases in LED Manufacturing

LED Process Flow



MOCVD - Main materials used

Process gases:

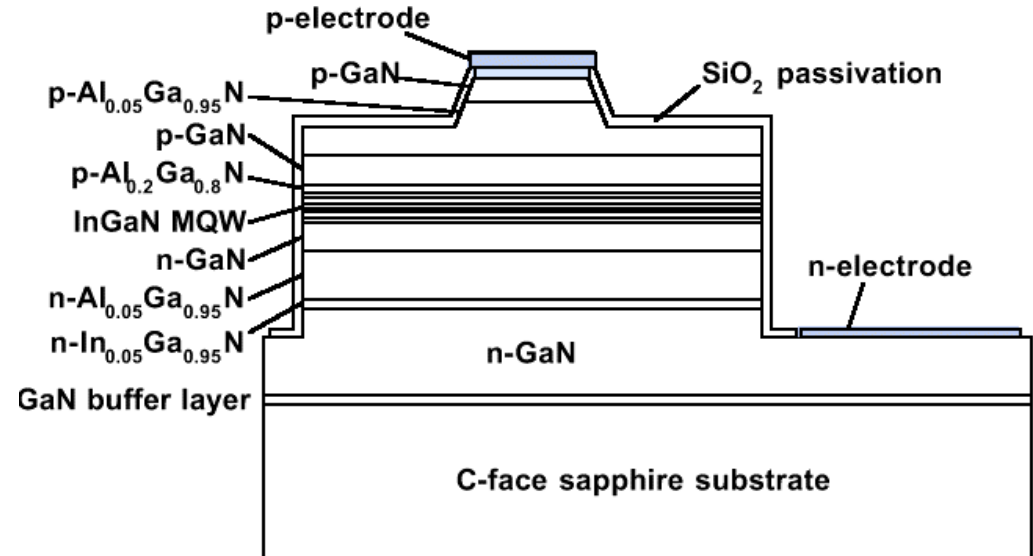
- N2 Source: High Purity NH3
- Dopants: Boron and Phosphine
- Etch Gases: NF3, SF6, CF4
- Diluant: Hydrogen
- Pump and Vent Gas: Nitrogen
- Others: SiH4, N2O, CH4, He

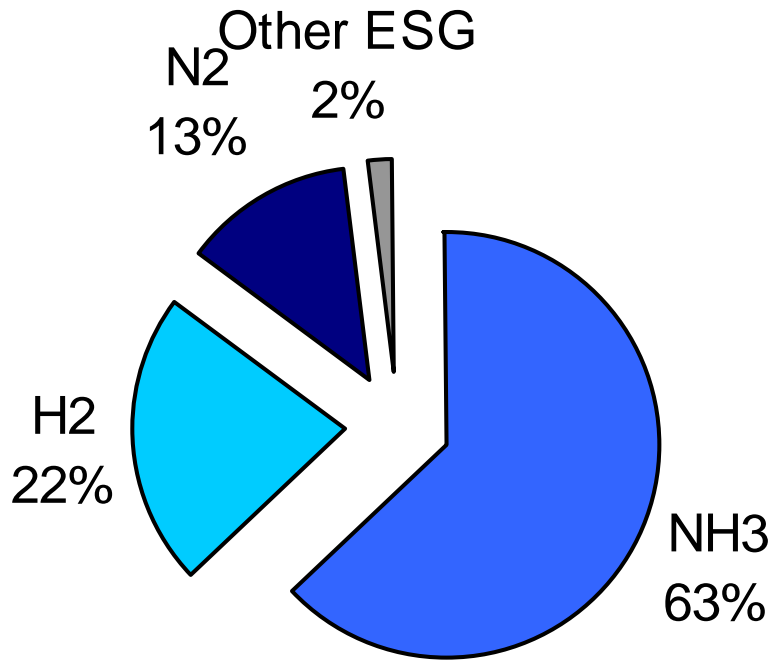
Organometallics:

- Ga Source: Trimethyl Gallium
- Aluminum Source: Trimethyl Aluminum
- Indium Source: Trimethyl Indium

Solids

- Gold, nickel, ITO & other contact metals





High Purity NH3 drives majority of gas cost

Hydrogen is a critical co-reactant/diluant gas to control the surface reaction

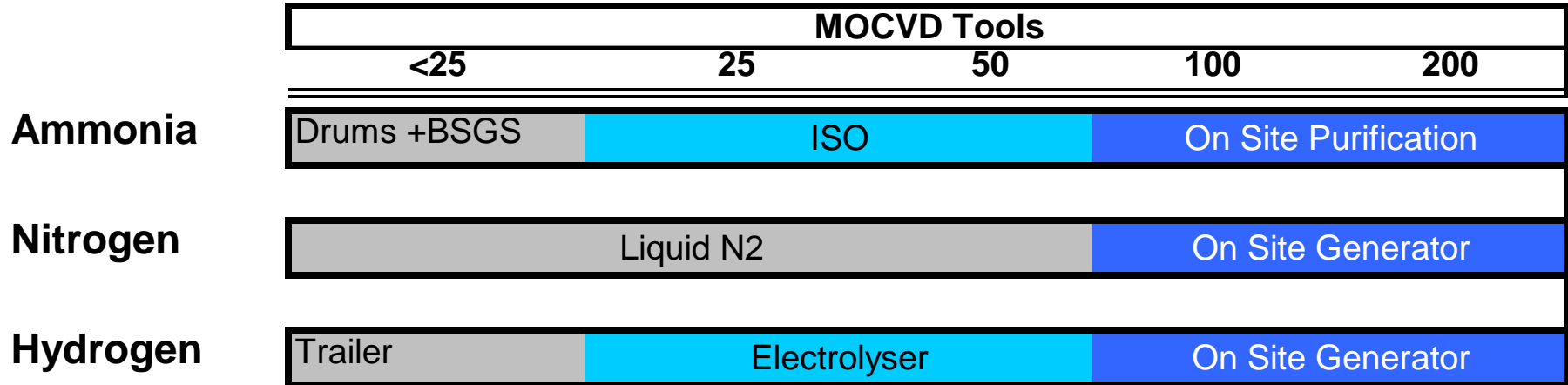
Nitrogen primarily used for Vacuum pump purging and chamber venting

Other ESG's are the dopants and etch gases

*Gases represent 5% of LED Chip Manufacturing.
Cost is important but performance is critical*

Critical Materials Supply

Larger scale fabs require more on-site solutions



MOCVD Tools	25	50	75	100	200
NH3 (TPA)	250	500	750	1000	2000
Hydrogen (m3/hr)	100	200	300	400	800
Nitrogen (m3/hr)	500	1000	1500	2000	4000

Nitrogen: Variable size on-site generators for all size LED fabs

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Threshold for N²-Onsite depends on proximity of fab to an ASU

Liquid assist plants use delivered liquid N₂. Compressor plants can operate without Liquid N₂

Typical lead time of small plants is 12-18 months

Initial production ramp is managed by Liquid N₂ tanks

Back up is by Liquid N₂ tanks

Pipeline possible based on location



Packaged Liquid-assist plants
250-2500 Nm³/hr



Packaged Compressor plants
350-3500 Nm³/hr

Hydrogen – large consumption drives on-site generation

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Up to 50 Tools



- < 250 Nm³/hr
- Tube trailer/Electrolyser
- 3-6 months Leadtime

50-250 Tools



- 250-1000 Nm³/hr
- Small SMR
- Tube trailer back-up
- ~12 months leadtime

> 250 Tools

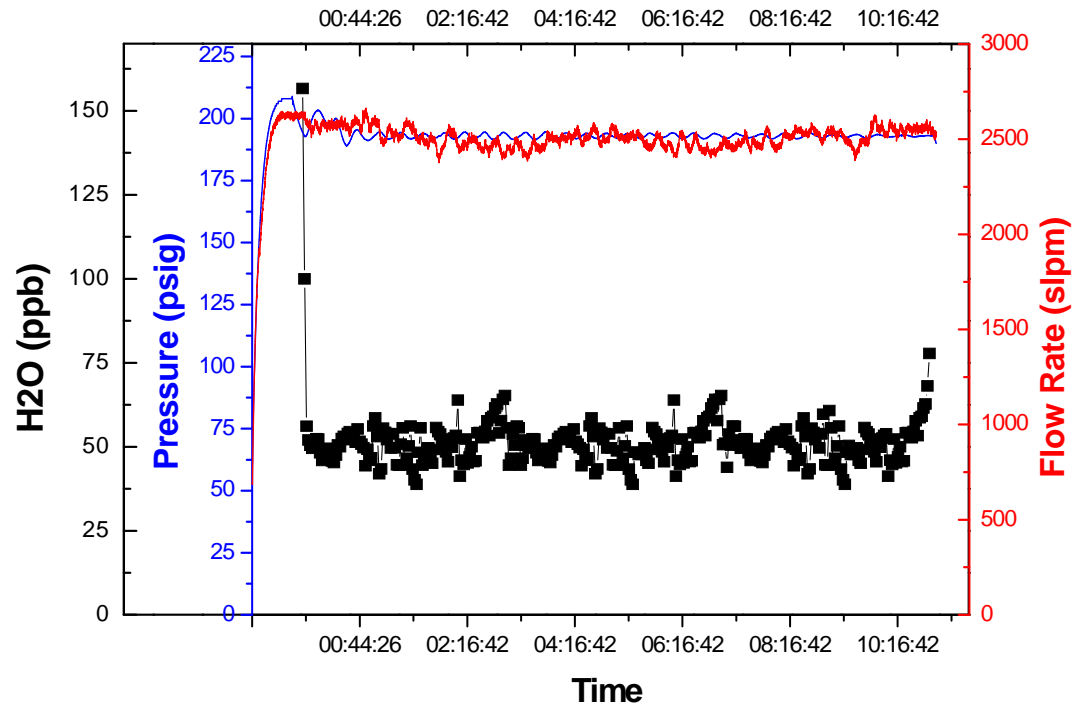


- 1000-4,200 Nm³/hr
- Large SMR
- 18-24 months leadtime

LED performance depend upon stable purity and large fabs require high flows at stable pressure



- Moisture is a killer impurity. Supply NH3 needs to be below 100 ppb H2O
- Purity Stability is important. Variations in purity affect yeild and purifier lifetime
- Large fabs require high flow rate, 2500 SLPM typical for 50+ tools



Ammonia Supply and Delivery Chain: Must maintain stable purity up to the MOCVD tool



Requirements

MERCHANT PRODUCT



Moisture purity
critical
<150ppb H₂O

BULK DELIVERY



Container size,
Quality
and availability

DISPENSE & PURIFY



High flow rate
~2,500 slm
For 50 tools

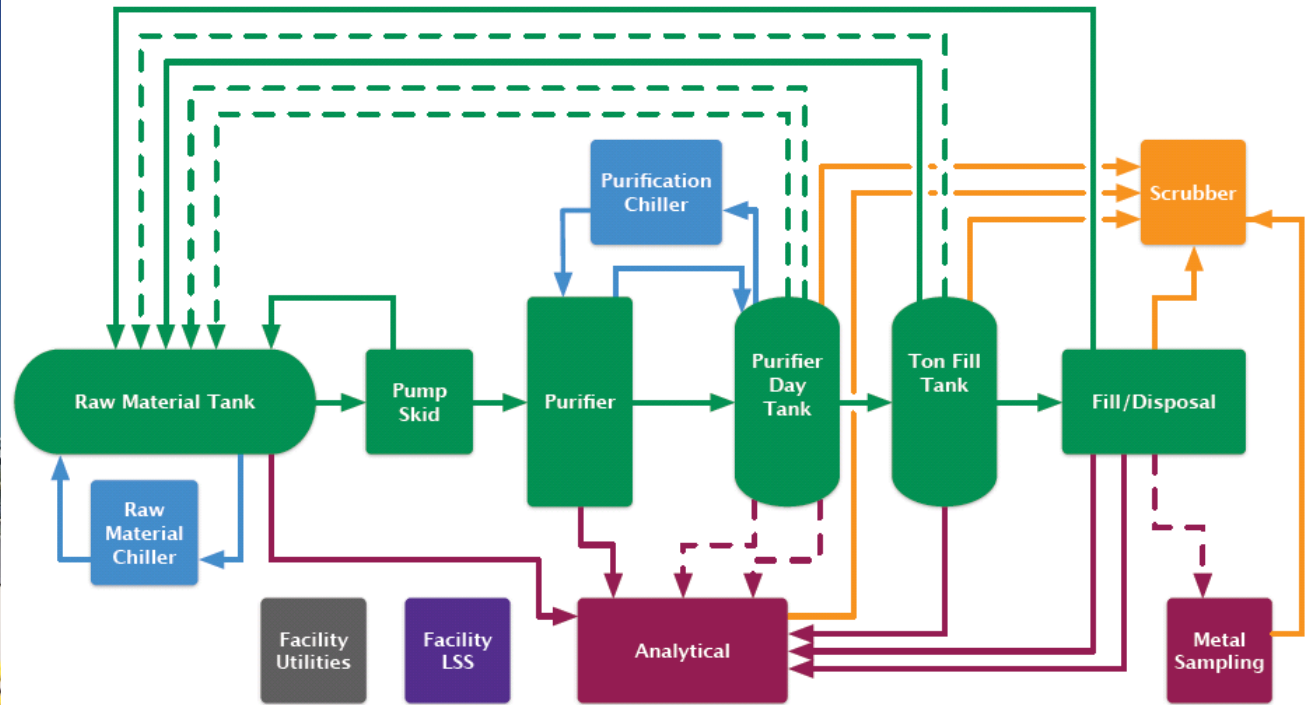
MOCVD Needs



10 t/yr, 50 slm
Per tool
20 to 100 tools per fab

Linde has multiple supply modes to meet LED fab needs as capacity ramps

The first UHP Ammonia Purification Plant in China



- Fractional distillation to purify crude Ammonia via Linde's patented Y-Column purification system, which removes both heavy and light contaminants.
- Capacity: 500 metric tonnes per year
- Purity: Grade 7 and above - >99.99999 % pure. < 50ppb Moisture
- Supply in Cylinders, Y-Tons, T-Drums and ISO tanks

Scalable NH3 delivery solutions

Linde UHP Plants



Drums



ISOs



BSGS



MOCVD Reactor



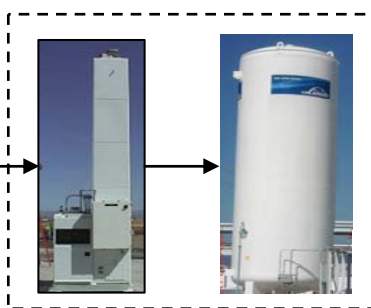
Purifier



Agri Grade SOURCE



On-site Purification



99.99999%

Gases are a very important component of large-scale LED manufacturing

Stable Purity, Low Moisture and Reliable High Flows are critical for good device yield

Linde Lien Hwa provides scalable full turnkey solutions in China which allows scale up from small (< 20 MOCVD) to large (> 100 MOCVD) HB-LED fabs