

THE LINDE GROUP

Linde

Crystal clear.

Delivering smarter TFT-LCD manufacturing
through innovative gas technology.

Offering TFT-LCD manufacturers a full range of bulk and special gases for maximum flexibility and efficiency.

The manufacture of TFT-LCD (thin-film transistor – liquid crystal display) flat panels calls for very large quantities of ultra high purity bulk and electronic special gases. As demand increases given the dynamic pace of the growth in this industry, TFT-LCD manufacturers need the reliability and flexibility of a strong and knowledgeable partner. They also need a single point of contact for the wide range of specialist materials used in the production process that can deliver locally but has the backing of a global supply chain.





Reliable partner

As a leading supplier of the TFT-LCD flat panel industry, Linde has dedicated process gas production facilities in China, Korea and Taiwan and a bulk gas support infrastructure throughout Asia. We supply the full range of gases required for TFT-LCD manufacture in all package sizes, with additional on-site generation for very large gas requirements. Linde delivers unique value-added technical solutions to help TFT-LCD customers meet environmental and cost targets, including on-site fluorine systems to replace nitrogen trifluoride (NF₃) for PECVD chamber cleaning applications.

Our offering includes:

- On-site generated gases
- Bulk gases
- Electronic special gases
- Turnkey engineering and installation
- Total gas and chemical management
- Process and application support

Building on our position as the leading gas supplier to the Chinese electronics market, we are executing on-site and bulk gas projects for the first two Gen 8 TFT-LCD fabs in China. These projects include the full gas infrastructure and on-going gas supply. Benchmark projects such as these demonstrate Linde's commitment to enable growth in the rapidly expanding TFT-LCD market through leading gas technology and innovation.

Materials for TFT-LCD manufacture

Although requirements may vary from one process to another, the following table shows the main bulk and electronic special gases used in the TFT-LCD manufacturing process:

Linde bulk and electronic special gases supply

Bulk gases

Argon

Helium

Hydrogen

Nitrogen

Oxygen

Electronic special gases

Ammonia

Carbon dioxide

Fluorine (on-site generation)

Laser mixtures

Nitrogen trifluoride

Sulphur hexafluoride

Nitrous oxide

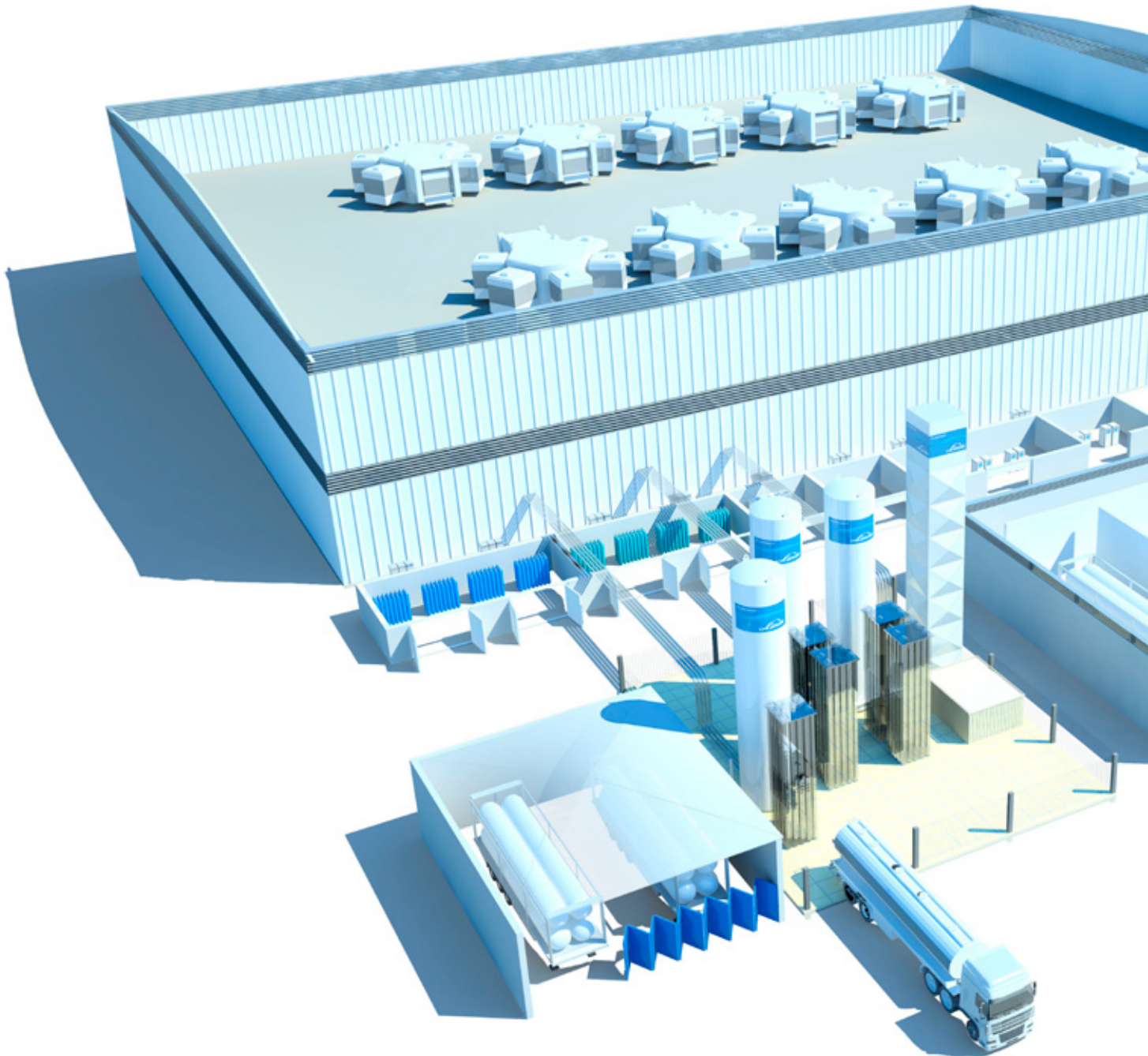
Phosphine mixtures

Silane

Chlorine

Exact requirements will vary depending on process equipment and technology.

High efficiency, environmentally sustainable gas solutions.



Electronic special gases

Ammonia
Sulphur hexafluoride
Phosphine mixtures
Laser gases



Bulk compressed gases

Hydrogen
Helium

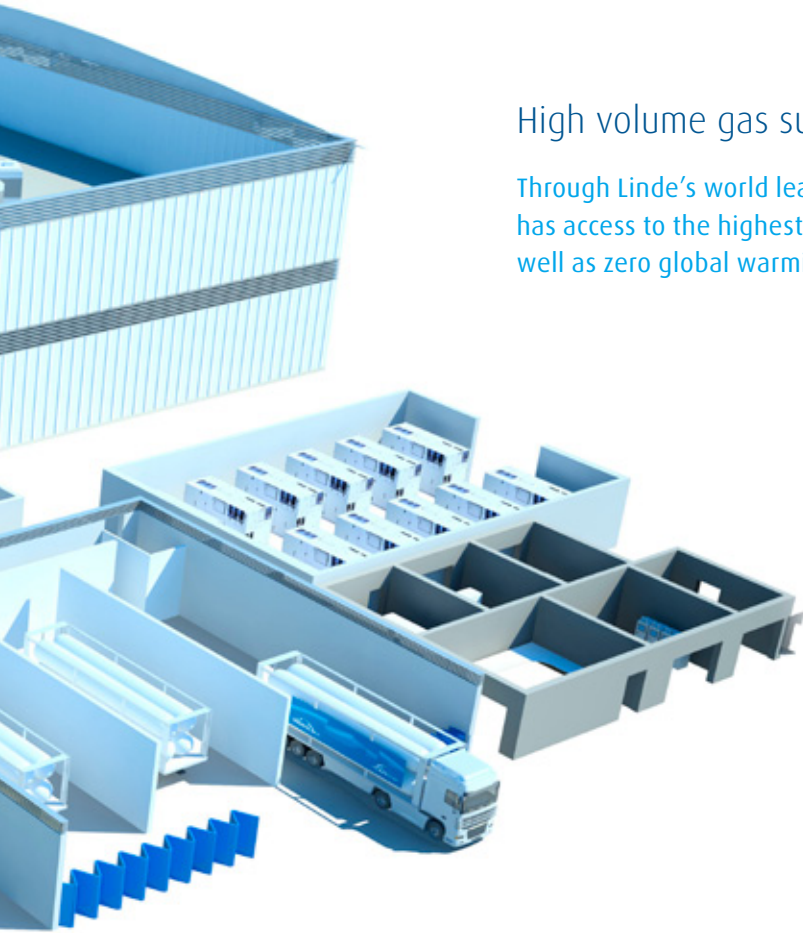


SPECTRA on-site nitrogen generator



Bulk liquefied gases

Argon
Oxygen



High volume gas supply, low carbon footprint.

Through Linde's world leading gas technology, your large scale TFT-LCD facility has access to the highest efficiency SPECTRA nitrogen generators available, as well as zero global warming fluorine chamber-cleaning solutions.



Bulk electronic special gases

- Silane
- Nitrogen trifluoride
- Nitrous oxide



On-site gas and chemical management



On-site fluorine generation

High volume gas supply, low carbon footprint.

SPECTRA-N generators



For a typical large TFT-LCD fab, nitrogen demand can be as high as 30,000 Nm³/hr, so the Linde SPECTRA-N 30,000 is the generator of choice.

- Ultra-pure gaseous and liquid nitrogen with less than 1 part per billion (ppb) impurities without the need for external purification
- Cost effective solution using an innovative vapour recompression process. Significantly lower power consumption than conventional N₂ generators
- Flexible turndown capabilities to meet facility ramp-up requirements
- Continuous remote operation with minimum downtime under standard operating conditions
- More than 40 SPECTRA-N plants installed worldwide

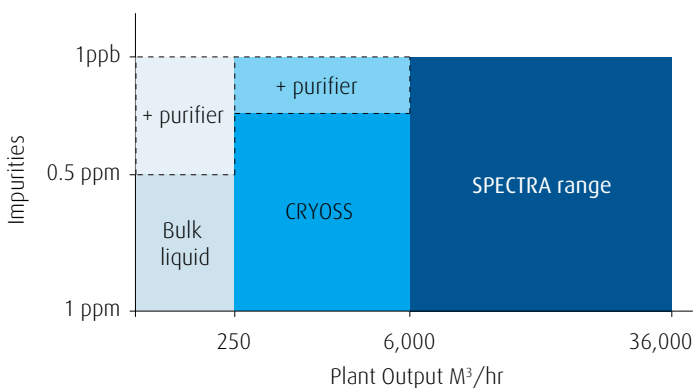
On-site fluorine generators



For a typical large TFT-LCD fab, chamber-cleaning gas demand can exceed 300 tonnes/year. Fluorine from Linde's Generation-F[®] systems can completely replace the use other F-based cleaning gases.

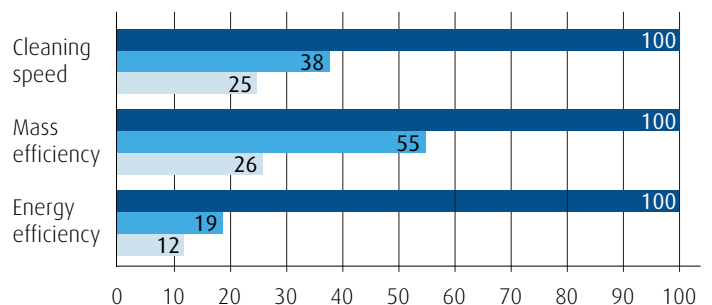
- Modular generators, meeting all flow and volume requirements for the largest scale fabs
- Lowest cost-per clean for plasma-enhanced or thermal CVD tool dry chamber-cleaning
- Up to 50% reduction in cleaning time, minimising downtime
- Global Warming Potential of F₂ is zero (NF₃ GWP= 17,200)
- On-demand generation eliminates large volume, high pressure storage
- More than 30 Generation-F[®] systems installed worldwide

On-site nitrogen generation - ECOVAR plants



On-site fluorine generation

Overall performance Fluorine vs. Nitrogen trifluoride vs. Sulphur hexafluoride



All data shown on a comparative basis where F₂ = 100%

■ F₂ ■ NF₃ ■ SF₆



Display trends – higher resolution, new effects

The display industry is developing high resolution mobile displays, larger area displays and new effects such as 3D TV. These require higher performance transistors in the backplane of the display. Improvements in electron mobility can be achieved by switching from the current amorphous silicon transistors to low temperature polysilicon (LTPS) or transparent amorphous oxide semiconductor (TAOS). LTPS is preferred for mobile displays as it has the highest performance, but due to its higher costs is less suited for large displays where TAOS is more cost effective.

Transistor type	Electron mobility(m ² /Vs)	Cost	Manufacturing challenges
a-Si	1	low	very low
TAOS	5-10	medium	high
LTPS	>30	high	low

Linde has a range of solutions to meet the requirements of both LTPS and TAOS.

- LTPS uses XeCl excimer lasers for annealing after the silicon deposition - Linde offers high performance Spectra laser gases for this application.
- For TAOS, Indium Gallium Zinc Oxide (IGZO) is the most promising candidate for the active layer of the transistors. This requires a change in both passivation and insulation layers from silicon nitride to silicon oxide, using nitrous oxide. Linde is the world leading manufacturer of N₂O plants with more than 50 years experience in the design, development and production of turnkey plants with installations in more than 80 countries across all 5 continents. This expertise combined with continuous development allows Linde N₂O plants to produce high purity electronics grade (>99.9995%) with industry leading capacity and efficiency. Linde has recently added to its N₂O capacity in Asia specifically to meet the demand from the display industry.

Linde Electronics. Innovation - Service - Leadership

Leading. Linde Electronics is part of The Linde Group, the leading gases and engineering group of companies with over 49,000 employees working in more than 100 countries worldwide.

Linde's mission is to enable smarter, lower cost and more sustainable electronics manufacturing through innovative technologies and solutions.

We believe in the concept of zero accidents and incidents, striving to create a safe and effective working environment for our people and our customers.

We wish to ensure long term customer satisfaction and loyalty by consistently providing products and services that meet each customer's expectations for quality.

We develop and promote technologies, products and services that are environmentally sustainable.

To find out more about Linde Electronics, visit us online or send us an email:

**www.linde-gas.com/electronics
electronicsinfo@linde.com**

Linde Electronics Sales Offices

North America

North America (Linde) +1 908 329 9700
+1 800 932 0624

Asia

China (Linde LienHwa) +86 (0)21 6105 9888 ext 9456
India (BOC India) +1 800 345 6789
Korea (Linde) +82 (0)2 780 9331
Malaysia (MOX-Linde) +60 (0)379 554 233
Philippines (Linde Philippines Inc.) +63 (0)2 702 7500
Singapore (Linde Gas Singapore) +65 (0)6861 3678
Taiwan (Linde LienHwa) +886 (0)2 2786 6000
Thailand (Thai Industrial Gases) +66 (0)2 338 6253

Europe & Middle East

France (Linde) +33 (0)4 72 47 66 10
Germany, Continental Europe & Middle East (Linde) +49 (0)89 7446 1122
Italy (Linde Gas Italia) +39 (0)029 037 31
United Kingdom & Ireland (BOC) +44 (0)800 02 0800

For all regions not listed, please refer to **www.linde-gas.com/electronics** or contact us at **electronicsinfo@linde.com**