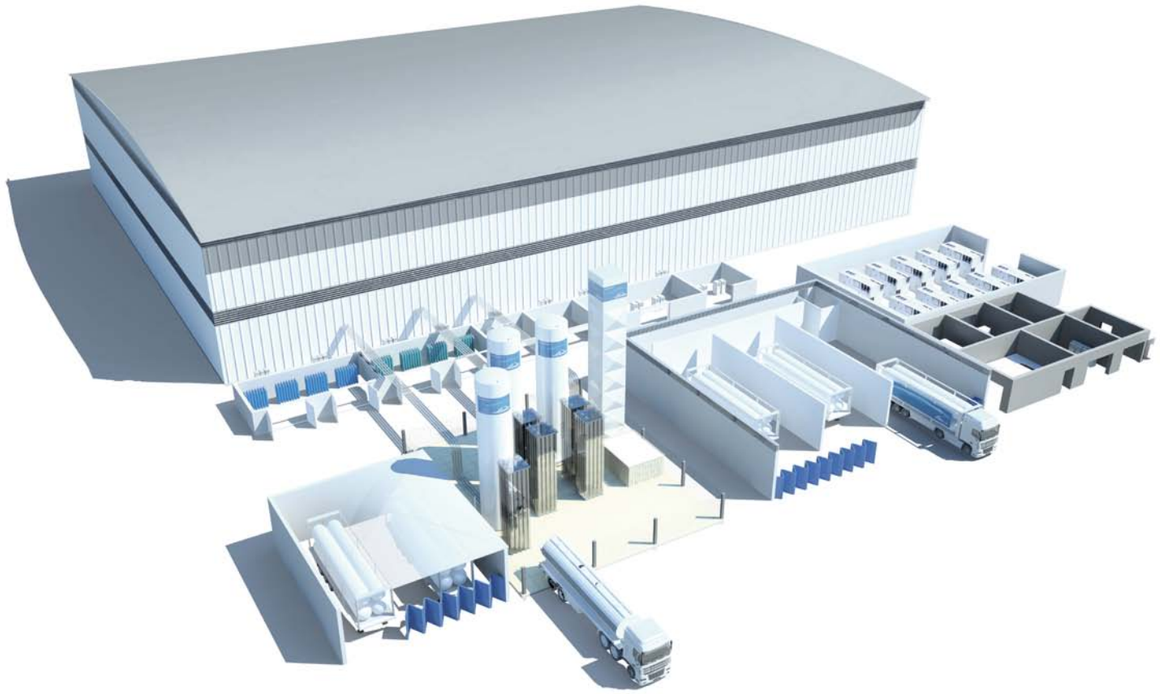

THE LINDE GROUP
Linde
Simple logic.
Delivering smarter semiconductor manufacturing through innovative gas technology.

Image courtesy of Micron Technology Inc.

Committed to electronics. Offering semiconductor manufacturers a full range of bulk and special gases for maximum flexibility and efficiency to any wafer fab in the world.

The semiconductor industry is one of the most dynamic, sophisticated and competitive markets worldwide. As it continues to grow, so does the demand for ultra-pure gases and chemicals.

Fab operators need a reliable and responsive partner with the reach and technological capabilities to keep abreast of the latest trends, manage costs and reduce environmental impact. They also need a single point of contact for the wide range of specialist materials used in the production process who can deliver locally and has the backing of a global supply chain.



Reliable partner

Linde is the technology partner of choice for global semiconductor manufacturers. Drawing on decades of experience in primary materials, our semiconductor knowledge is second to none with major gas supply projects designed and installed with the leading semiconductor manufacturers in every major manufacturing geography.

We develop unique value-added capabilities for semiconductor manufacturing. Our innovative technologies and solutions are backed by a global supply chain to bring manufacturers smarter, lower-cost and more sustainable semiconductor manufacturing processes.

We complement our electronic materials portfolio and global supply chain with turnkey capabilities for larger semiconductor fabs. These on-site facilities ensure a continuous, monitored and flexible supply of gas. Standardised and modular designs provide the added benefit of maximum cost efficiencies and reliability.

Materials for semiconductor manufacture

Although requirements may vary from one process to another, the following table shows the main bulk and electronic special gases used in the semiconductor manufacturing process. Exact requirements will vary depending on the process and manufacturing region:

Linde bulk and electronic special gases supply

Bulk gases	Electronic special gases
Nitrogen	Silane source gases
Hydrogen	Nitride/oxide growth
Argon	Doping and implants
Oxygen	Metal and dielectric etch
Helium	Excimer laser lithography gases

Reliable on-site solutions for nitrogen generation

For a typical large semiconductor fab, nitrogen demand can be as high as 30,000 Nm^3/h, so the Linde SPECTRA™ N 30,000 is the generator of choice.

The combination of patented technology, integrated engineering design and highly flexible operation ensures that Linde's world-renowned range of SPECTRA N nitrogen generators provide the most cost effective and reliable means of delivering ultra-high purity nitrogen available today.

Our SPECTRA N nitrogen generators are optimised to keep your total cost of ownership as low as possible. In addition, our on-site gas generators provide the benefit of continuous delivery, seven days a week, 24 hours a day.

- Ultra-high purity 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 nitrogen 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

The SPECTRA system minimises space and installation requirements through integrated package design. The packaged unit ensures a plant is quickly assembled and easily connected to power and water services.

Flexible solutions for advanced semiconductor manufacturing

Linde is committed to the development of premium materials

Linde is committed to providing a full range of isotope products and gases that are important in meeting the Advanced Materials requirements of the latest semiconductor manufacturing processes.

Disilane

Disilane application is increasing in semiconductor memory (DRAM & NAND flash) for silicon deposition in advanced technology nodes (below 45nm). It is a preferred alternative to silane for deposition purposes.

Linde is a leading supplier of disilane to the memory, logic and foundry producers. We have heavily invested in the necessary infrastructure to consolidate and capture growth in this sector.

The benefits of using disilane include:

- Lower decomposition energy and lower temperature compared to silane
- Enables faster deposition rate
- More uniform film layer of deposition (lower defect rates)

These factors are key drivers for increased usage in advanced nodes due to tighter thermal budget and smaller device geometries.

Isotopes

With devices consistently becoming smaller and more powerful, semiconductors are required to handle higher voltages. This creates excessive heat and eventually device failure.

In order to deal with these heat issues, leading electronics companies are turning to isotopically enriched compounds such as deuterium gas, deuterated silane, deuterated ammonia and $^{11}BF_3$. The incorporation of these compounds leads to enhanced performance, increased yields, less waste, optimal efficiencies, and more durable chips.

Linde has developed several deuterium based products which help our customers manage these new demands and can improve the life of a device by up to 50 times.

Linde has also introduced boron 11 enriched diborane $^{11}B_2H_6$ as an alternative to natural (non-enriched) diborane. The elimination of boron 10 from diborane in small scale devices is essential to increasing the life of the device and the elimination of certain defects.

On-site fluorine generator for chamber cleaning

Atomic layer deposition system for 200 mm wafers inside Class 1000 cleanroom

Drawing on decades of experience in primary materials, Linde develops unique value-added capabilities for semiconductor manufacturing through our global Centre of Excellence network.

Ultra-high purity carbon dioxide (CO_2)

As semiconductor manufacturers continue to reinforce their need for high quality and reliability of supply chain, Linde has commissioned a new carbon dioxide (CO_2) purification unit at its electronics gases facility in Medford, USA that is designed to produce CO_2 with purity above 99.9997 percent primarily for semiconductor applications.

The Medford plant utilises a multiple-stage distillation process to produce several grades of CO_2, including an ultra-low hydrocarbon grade for specialised on-wafer CO_2 cleaning operations. This grade relies on a proprietary cylinder preparation process which assures final hydrocarbons are at low part-per-trillion levels and are not deposited on wafer or mask surfaces which would have a negative impact on yield.

This investment in a completely integrated ultra-high purity CO_2 purification system enables Linde to fully manage the availability and overall quality for this key material.

Rare and halogen gases

Enabling developments in deep ultraviolet (DUV) lithography, our Alpha (US) plant has pioneered high-purity halogen gas mixtures for 248nm and 193nm excimer lasers. Additional areas of expertise include xenon recycling and isotopically enriched gases and chemicals.

Lithography gases

Innovative SPECTRA lithography gases and gas mixtures enable the operation of lasers in thousands of the world's wafer steppers and scanners. Our customers include all of the major global laser, stepper and scanner manufacturers as well as many of the world's largest semiconductor manufacturers. They benefit from the development of new technologies and innovations driven by our Centres of Excellence such as the one for SPECTRA lithography gases in Alpha, USA and can rely on the highest quality laser gases coupled with in-depth knowledge of critical gas technologies.

Fluorine technology for clean chamber cleaning

Our Inju (Korea) facility is pioneering the latest generation of low-cost, modular fluorine generators. This zero-carbon technology is growing in importance as the industry faces increasingly stringent environmental legislation.

We are also involved in joint development programmes with major customers, OEMs, academic bodies and industry consortia.

Committed to electronics through partnerships, innovation and investment.

The Linde Group is a world-leading gases and engineering company with around 50,500 employees in more than 100 countries worldwide. The strategy of The Linde Group is geared towards long-term profitable growth and focuses on the expansion of its international business with forward-looking products and services. Linde acts responsibly towards its shareholders, business partners, employees, society and the environment – in every one of its business areas, regions and locations across the globe. The Group is committed to technologies and products that unite the goals of customer value and sustainable development.

For more information, visit The Linde Group online at www.linde.com.

Linde Electronics helps electronics companies achieve these goals with a full range of bulk and specialty gases, supply systems and on-site services. Innovative technologies and solutions enable smarter, lower-cost and more sustainable manufacturing choices by replacing ozone-depleting gases with climate-neutral options and eliminating hazardous cleaning materials. Inspired by a goal of zero accidents and incidents, this Business Area combines global service and supply capabilities with turnkey solutions to maximise operational safety and environmental efficiency.

For more information, visit Linde Electronics online or send us an email:

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

Linde Electronics sales offices

North America

North America (Linde)
Phone +1.908.329-9700
Phone +1.800.9320624

Asia

China (Linde LienHwa)
Phone +86.21.6105-9888
ext -9456

India (BOC India)
Phone 1.800.3456789 (Toll Free)
Phone +91.33.30411500

Korea (Linde)
Phone +82.2.780-9331

Malaysia (Linde)
Phone +60.379.554-233

Philippines
(Linde Philippines Inc.)
Phone +63.2.702-7500

Singapore
(Linde Gas Singapore)
Phone +65.6861.3678

Taiwan (Linde LienHwa)
Phone +886.2.2786-6000

Thailand (Linde)
Phone +66.2.338-6253

Europe & Middle East

France (Linde)
Phone +33.472.476610

Germany, Continental Europe
& Middle East (Linde)
Phone +49.89.7446-1122

Italy (Linde Gas Italia)
Phone +39.029.037-31

United Kingdom & Ireland (BOC)
Phone +44.800.020800

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

Linde AG
Gases Division, Seitnerstrasse 70, 82049 Pullach, Germany

Linde Electronics Semiconductor 1.1_0712