Linde Electronics
Local Partner. Global Expertise.

Candice Fan, Associate Director, Strategic Alliance, Linde Electronics
Gas Ecosphere conference
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The Linde Group worldwide

- Operating in over 100 countries
- Revenue of 135 billion RMB
- 60,000 employees
- Reportable segments
  - Americas
  - EMEA
  - Asia/Pacific
Linde Gases – Leading industrial gases company in APAC

- Strong position in major industrial clusters in Asia/Pacific
- Solid track record of revenue growth built on a diverse portfolio of leading customers
Supplying electronic materials in mainland China and Taiwan
Working together …Local partner. Global expertise.

Linde Electronics
- Leading in electronic gases
- Serving global top semiconductor, solar, display and LED customers
- Part of the Linde Group – an international industrial gas and engineering company

Linde LienHwa
- Leading in electronic gases
- Mainly serving top tier customers in Mainland China and Taiwan for over 30 years

Total electronic bulk and special gas solution provider with local expertise and global network adding value to customers’ business
Linde LienHwa - Serving all of Asia with broad portfolio

LLH is a 50:50 joint venture company within The Linde Group

Leading electronics specialty gases and bulk gas supplier in Mainland China and Taiwan

Over 1,600 employees and largest industrial gases manufacturer in Taiwan

Production, warehousing, and trading capabilities
• Headquartered in Shanghai
• First international gases company in China in the 1980s
• Leading integrated gases player
• € 1.91 billion consolidated gases sales in 2016
• Around 5,000 employees
• Around 70 wholly-owned companies and joint-ventures
• More than 200 operational plants (including Taiwan)

• Industry-leading remote operations and distribution scheduling centers with nation-wide monitoring capabilities
• Asia-Pacific Research & Development Centre for new gases application technologies
• Plant, engineering, and fabrication centers in Hangzhou and Dalian
East Asia | Greater China
Long-term leading partnerships

- Oil/Petrochemicals
- Chemicals
- Metallurgy
- Electronics
- Healthcare
- Others
### China government initiatives

#### Made in China 2025
- 2.8b RMB invested in on-site and bulk 2015-2017
- ESG and wet chemical investments in Suzhou, Shanghai, Xiamen, Kunshan, and Zhenjiang
- SPECTRA-N nitrogen generators designed in Hangzhou and manufactured in Dalian

#### Internet+
- Linde digitalization initiative
  - Turn data into value
  - Convenience for the customer, enabled by things like virtual reality models of plants
  - Connect everything

#### Mass entrepreneurship and innovation
- Strategic investments with local partners to transfer technology and expand portfolio and capacity
- Partnering with domestic material producers to address global electronic market
- Capitalizing on regional infrastructure to support business growth

#### Beautiful China (ecological civilization construction) and supply-side structural reform
- SPECTRA-N® nitrogen generators leading in power efficiency and turndown ratios
- Material recovery – H₂SO₄ (sulfuric acid)
- Fluorine as greenhouse gas alternative for chamber cleaning
Linde Electronics mainland footprint

- North base
- West base
- East base
- South base

- Bulk gas customer site
- Linde ASU site
- ESG plant
- ESG warehouse
- Linde Engineering centers
Linde: Complete supply chain in a global market
Supply chain. Interlinked, comprehensive, customer-focused
Managing supply chain determines quality

Measure at each step, prevent defects, continuous improvement

Raw materials

Traditional quality focus

Electronics quality focus

Final product quality
Between the variability of the raw material source...

Liaoning Fluorspar: HF, NF₃, SF₆, CF₄, etc.

Guangxi Tungsten: WF₆, WCl₅

Yunnan Germanium: GeH₄, Ge₂H₆
...and the precision of manufacturing
Material suppliers like Linde are the quality gatekeepers.
Quality: Customers are driving tighter requirements

**Customers**
Expect Linde to meet purity specifications and control limits
Are even more concerned about unknown and uncontrolled impurities

**Example**
Specification: 50 ppm
Control limit: 20 ppm
Mean: 8 ppm

![Graph showing number of measurements vs. ppm impurities with the mean and control limits marked.]
Quality: local and consistent

Copy-exact procedures to produce consistent results

Suzhou Electronics Facility

Taichung Electronics Facility
Why Quality Management Systems (QMS)

Manufacturing facilities can detect, contain, and prevent excursions

**Customer requirements**
- To supply consistent product quality
- To prove process control with data
- Customer audits and scorecards

**ISO requirements**
- Measurement systems plan/control
- Process control
- Use of statistical techniques
- Action (MRB/DRB) plan

**Continuously improve**
- Customer satisfaction
- Customer confidence
- Accuracy of cost/profit assessments
- Productivity
- Product/process quality

**Promote efficient manufacturing habits**
- Reduces cost of operation
- Reduces hidden costs
- Allows time for valuable activities
- Improves accuracy of long-term planning
Quality: Collaborative approach

We achieve electronics industry quality standards with close collaboration throughout the supply chain
Integrating global and domestic supply chains
China ports

- Tianjin port
- Qingdao port
- Lianyungang
- Shanghai port
- Ningbo port
- Hong Kong port

- North China base
- West China base
- East China base
- South China base

Distances:
- 1800 km
- 1600 km
- 1400 km
- 1200 km

China: 5,500 km
Importing electronic materials into China takes 10 – 50 days.
China raw material processor locations

- Shanghai port
- Anhui
- Jiangxi
- Jiangsu
- Zhejiang
- Sichuan
- Henan
- Hebei
- Shandong
- Tianjin

Distances:
- 500 km
- 1000 km
- 1500 km
- 2000 km
- 2500 km
Delivering quality requires control across the full supply chain

Material providers like Linde are the quality gatekeepers

- Raw materials
- Chemical production
- Purification
- Blending
- Analysis
- Distribution
Business continuity planning case studies
Supply chain. 2011 Tōhoku earthquake and tsunami

What happened

• Most powerful earthquake ever recorded in Japan (magnitude 9.0/9.1) off the coast of Japan in March, 2011
• Triggered tsunami waves up to height of 40.5 meters
• Costliest natural disaster in history
• Many Southeast Asia semiconductor fabs that relied on Japanese sources caught off-guard and closed down for weeks due to lack of ESGs

Linde Electronics response

• Quickly introduced already qualified Chinese sources to electronics customers for quick qualification and adoption
• Recommended that customers qualify at least two sources offered by Linde to avert this disaster again
• Business Continuity Planning on standard checklist for internal supply and supplier qualification
Major supply disruptions can change how we do business

Tianjin Port Explosion: 2015

What happened

- A series of explosions at a hazardous chemicals container storage station at the Port of Tianjin in a densely populated area in northern China
- Halt of acceptance of hazardous cargo (import and export) at Tianjin and other Chinese ports (except Shanghai)

Linde Electronics response

- Worked with experienced third-party logistic partners, evaluated trade lanes on various metrics including cost and cycle time
- Established a primary and secondary DG trade lane for each bid involving import/export to China and both trade lanes became a feature of the product offer
Supply chain. China and the 2008 Olympics

What happened
- Chinese government block of hazardous materials into multiple ports during the 2008 Olympics

Linde Electronics response
- Materials trucked in – added two months extra delivery time
  - Required a lot of advanced planning
Supply chain. Business continuity planning

• Assess where and how to invest to diversify supply chain on multiple continents

• Do procurement forecasting and planning with customers and suppliers to meet demands

• Acquire two sources for raw materials and have customers qualify both sources

• Establish footprint closer to customer with on-site and local supply plants

• Coach suppliers on Statistical Quality Control (SQC) and Statistical Process Control (SPC) to help them avert disaster at multiple points in the supply chain
Supply chain. Business Continuity Planning

- Conduct Business Continuity Planning (BCP) with alert nodes in proactive processes
- Identify potential supply gaps by plotting product-source mapping
- Create raw materials, manufacturing, transportation, and labor shortage contingency plans
- Develop supply gap mitigation and implementation plans
Long-term success across the supply chain
Long-term success is integrating global expertise
Local partner. Global expertise.

Start with global expertise
- Know-how
- Production
- Logistics
- Quality
- Safety
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Invest in domestic capability
• R&D
• Production
• Distribution
• People
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Partner with local raw materials suppliers
- Implement quality standards
- Secure supply chain