

# Material Supply Innovations

## Safe, sustainable and cost efficient solutions.

Andreas Weisheit  
2011

THE LINDE GROUP

*Linde*

# Agenda



**The Linde Group**

**Innovative gas supply solutions**

**Innovative PECVD chamber clean**

**Our References**

The World's Leading Gas and Engineering Company  
11.2bn Euro sales. Present in more than 100 countries.



### Gases Division

Leading Global Supplier  
of Industrial Gases



### Engineering Division

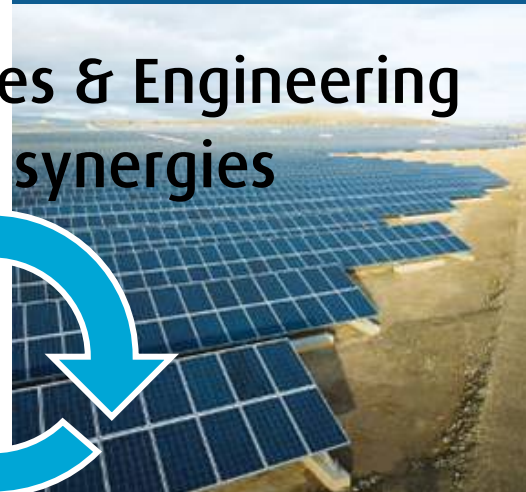
Engineering &  
Contracting Specialist

## GROWTH

### Emerging markets



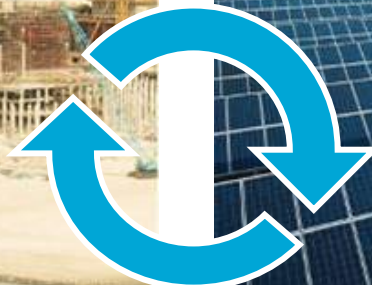
### Clean energy



### Healthcare



Leveraging Gases & Engineering  
business synergies



# Linde Offering to the Solar Industry

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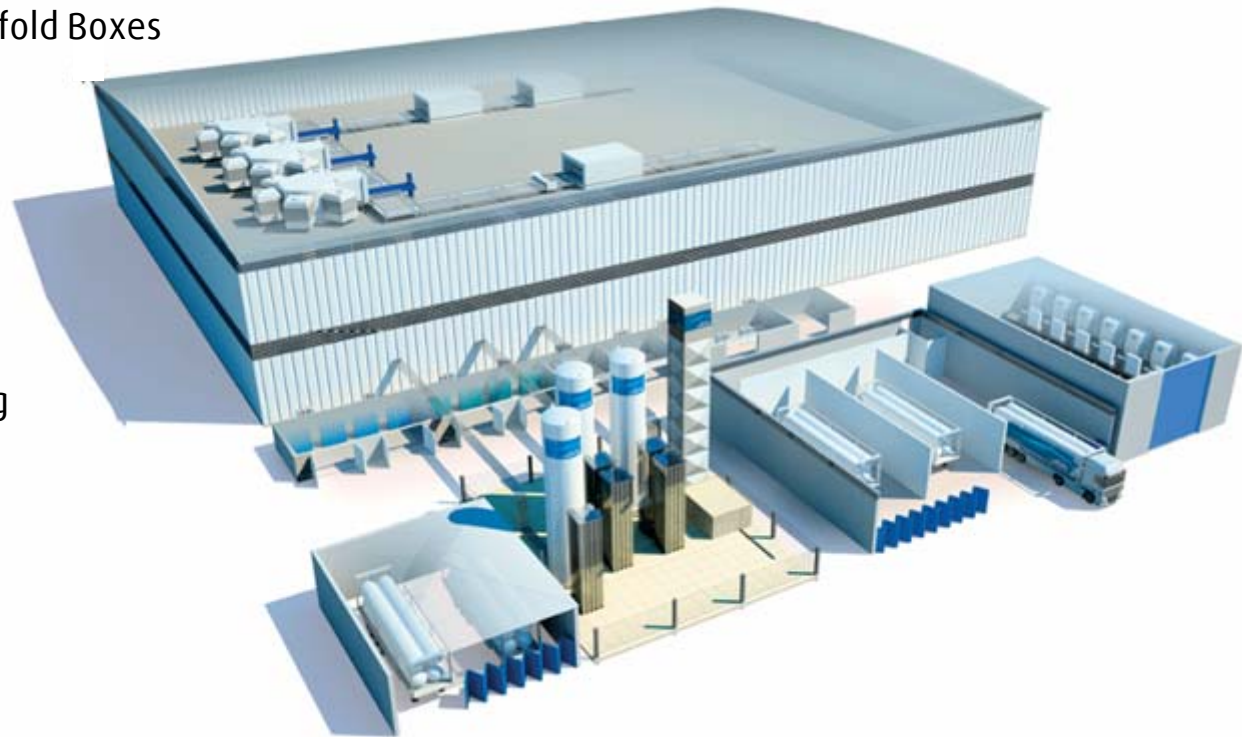
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## Turnkey scope

- On-site Gas Generation ( $N_2$ ,  $H_2$ ,  $F_2$ ,  $O_2$ )
- Bulk Gas Supply Systems ( $N_2$ ,  $H_2$ ,  $O_2$ , Ar, He)
- Bulk Specialty Gas Systems ( $NH_3$ ,  $SiH_4$ ,  $NF_3$ )
- Specialty Gas Cabinets ( $NH_3$ ,  $PH_3$ ,  $CH_4$ , TMB,  $B_2H_6$ )
- Valve Distribution Boxes, Valve Manifold Boxes
- Piping to the tools
- Gas Leak Detection, Gas Monitoring
- Compressed Dry Air

## Value Added Services

- Application know-how & Engineering
- Process Optimisation
- Own Research & Development
- Engineering & Hook-up Planning
- Permitting
- Total Gas & Chemical Management



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# Global Linde Silane Footprint

HOW do we deliver Silane ?

- Linde's supply chains provide maximum security of supply & flexibility for our customers.
- Dedicated trailer fleet and buffer stocks in place across the continents.

WHERE are LINDE Sources?

USA (> 1000MT Source)

Supplies to	China, Taiwan
	Europe
	USA

EUROPE (>300 MT Source)

Supplies to	Europe
	China
	Taiwan

KOREA (>1500 MT Source)

Supplies to	China
	Taiwan
	Europe

WHY use Global Silane?

- Linde have access to silane sources in 3 continents with >2000 MT contracts in place.
- Independent locations provide mitigation of currency and political risk.

# Lowest Cost of Ownership by on-site dopant blending

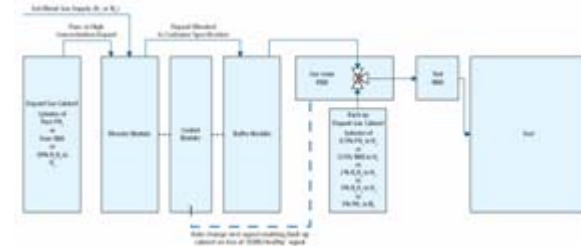
WHAT are Dopants?

*Dopant gases are typically delivered as 0.5...5% mixture in H<sub>2</sub>.*

Dopant gases are hydrides from group III (e.g. TMB) or group V (e.g. PH<sub>3</sub>) elements that can alter the electrical properties of a semiconductor layer and make it p(+) or n(-) conductive.

HOW do we deliver it?

Dynamic Dopant Blending Systems use pure hydrides and H<sub>2</sub> available from the tankfarm to make the mix



WHY use DDBS?

- ✓ **Safety**      Less cylinder handling steps
- ✓ **Cost Reduction**      Reduced cost of ownership
- ✓ **CO<sub>2</sub> Footprint**      Eliminates cylinder shipping



# On-site Hydrogen Supply

The experience of the world's leading Hydrogen engineers.

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WHICH  
Technology for  
Hydrogen?

Multiple on-site generation technologies: Electrolysis, Steam Methane Reforming, Methanol cracking.

- High reliability and lowest cost of ownership.
- Quick installation and ease of maintenance.
- Conventional and reliable catalyst systems, proven reactor & PSA technology.



HOW do we  
deliver it?

Capacities  
from <50 to  
>1000 NM<sup>3</sup>/hr

Proven technology =

The Leading on-site  
Hydrogen supply



WHY use LINDE?

Linde Hydrochem – manufacturers of over 200 Steam Methane Reformers.  
Linde Installed record of Electrolysers





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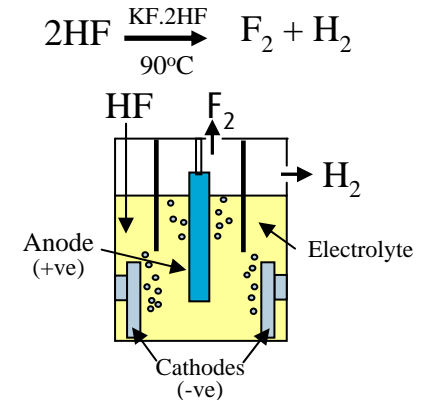
## WHAT is Fluorine?

*Fluorine is the active ingredient in all silicon chamber cleaning.*

Fluorine gas (F<sub>2</sub>) is a faster and environmentally friendly replacement for Greenhouse Gases like NF<sub>3</sub> used to clean waste silicon from CVD process chambers

## HOW do we deliver it?

Generation-F®  
On-site Fluorine  
Generation  
Systems



## WHY use Fluorine?

- ✓ **Productivity** Faster chamber cleaning improves PECVD tool throughput, typically between 4 and 12%
- ✓ **Cost Reduction** Direct material cost saving of **>15%**
- ✓ **Sustainability** F<sub>2</sub> has **Zero Global Warming Potential**, eliminates risk of Green House Gas emissions and lowers overall CO<sub>2</sub> footprint

# Linde Delivers: F<sub>2</sub> Cleaning in European Photovoltaics



Experience in Electronics Applications

Successful Development Program in PV

Implementation in manufacturing



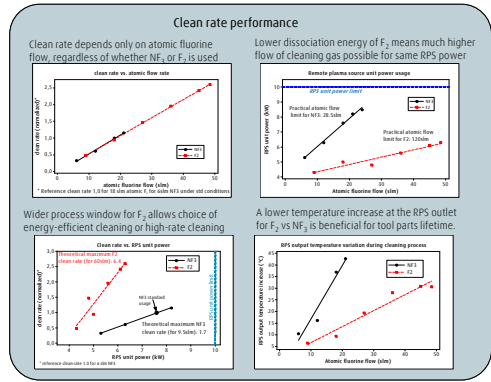
300mm Semiconductor



LTPS Displays



Large area TFT-LCD

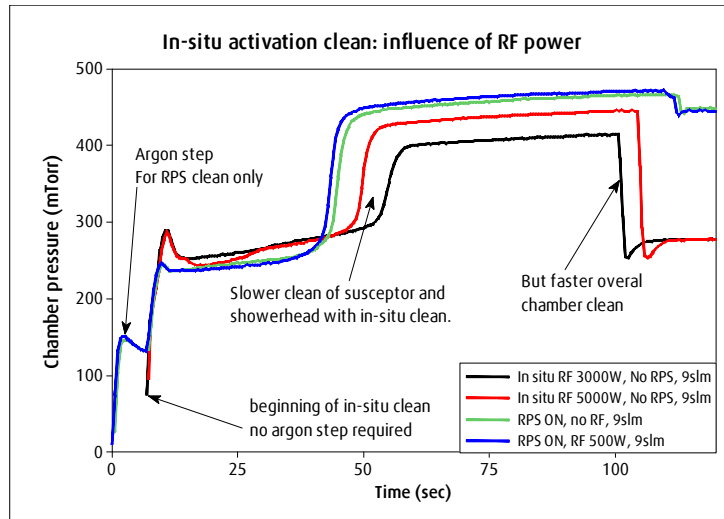


Full scale demonstration



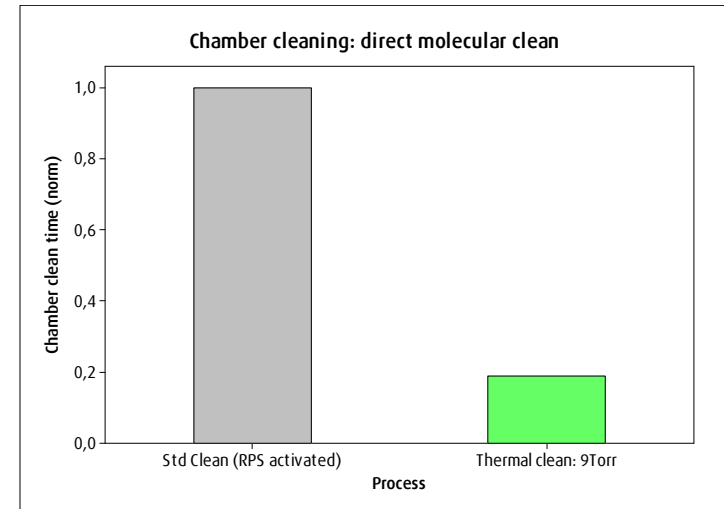
High volume manufacture

## In-situ activated clean



- High dissociation by RF plasma.
- Chamber clean shorter than with RPS activation.
  - Higher uptime
  - lower cleaning costs
  - Lower CAPEX & maintenance

## Direct molecular clean



- F2 is reactive with silicon at temperature  $<200^{\circ}\text{C}$ .
- No plasma activation required (no RPS).
- 80% clean time reduction achieved.
- No ion bombardment, 'gentle' clean.
  - Lowest Cost of Ownership

- **Never experienced an F<sub>2</sub> leak or fire, in > 10 years.**

Fluorine reactivity is well understood and managed safely at low pressures, low velocities and with proprietary system designs.  
Complete surface passivation ensures system durability.  
Linde F<sub>2</sub> Systems operate at < 1.5 bar.
- **On-site systems operated in > 12 electronics customer facilities since 2001 with no F<sub>2</sub> incidents.**
- **Linde's Intellectual Property – Patents, trade secrets and know-how ensure long term safe, reliable, high purity operation**

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# In Electronics, in all major sectors, Linde's strategy is closely linked to the most dynamic growth leaders.



## Semiconductor

First choice for the top semiconductor manufacturers.

Linde is currently executing major gas supply projects for each of the top 3 semiconductor manufacturers with a combined investment value of >Eur200m

- # in logic (USA)
- # in memory (KOR)
- #1 in Foundry (TW)

## Photovoltaic

➤ First choice for thin film customers the world over:

- Oerlikon (7/11)
  - AMAT (8/11)
  - ULVAC (2/4)
  - Apollo (4/4)
- First choice for the global #1 module maker in c-Si (China)
- First choice as a technical partner:
- Thin film JDPs
  - c-Si JDPs
- First choice for emerging regions
- India (>75%)

## LED

First choice in Asia

- Taiwan – customers are #1 and #2 HB LED makers.
- China – currently executing gas supply projects for 6 major new fabs
- China – Just executed the first Grade 7.0 domestic Ammonia plant.
- Europe & USA – long-term contracts with #1 in each region.

## TFT-LCD

First choice in China

- Currently executing the first 2 Gen 8 TFT fabs in China with a combined investment value of >Eur45m

First choice for F2



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Thank you for your attention

Linde Electronics.

The power behind tomorrow's technologies