



AACHEN TECHNOLOGY  
ENTREPRENEURSHIP  
CONFERENCE



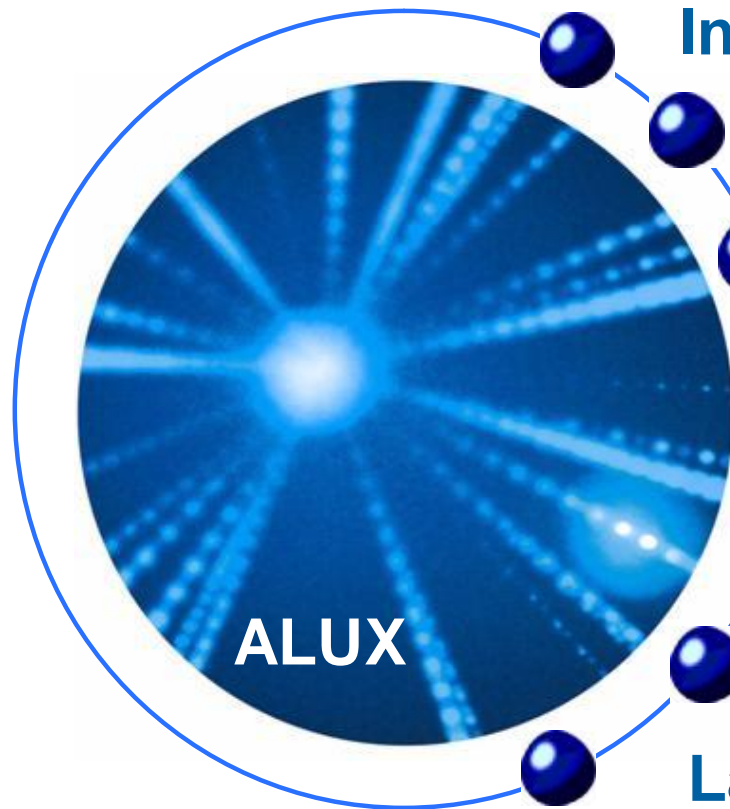
"Meeting Global Challenges"

# Solar Photovoltaics Market and Technologies



Dipl.-Ing.  
**Thomas Unger**  
Vertrieb & Marketing Hightech  
Leiter Marketing  
Optoelektronik - Photovoltaik - LED

**AIR LIQUIDE Deutschland GmbH**  
Hans-Günther-Sohl-Straße 5 · D-40235 Düsseldorf  
Fon: +49 (0) 211 6699-289 · Fax: +49 (0) 211 6699-367  
Mobil: +49 (0) 173 7039566 · E-mail: [thomas.unger@airliquide.com](mailto:thomas.unger@airliquide.com)



**ALUX**

**Introduction**

**How does it Work?**

**Approach is Different!**

**Clients Needs!**

**ALUX - Supply Chain**

**Specialty Gas Supply**

**Last not Least: Safety First!**

# The Air Liquide Group

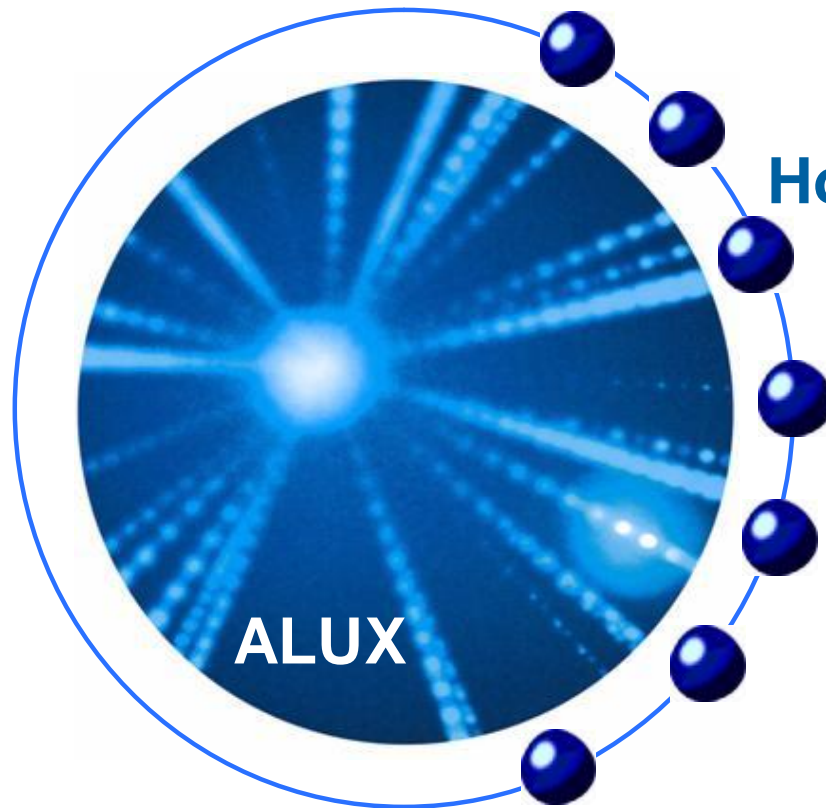


- **One of World's largest industrial gas supplier**
- **US\$ 12.5 bn sales per year**
- **More than 1 million customers ...**
- **... in more than 70 countries**
- **36 000 employees**
- **8 R&D centers (USA, Germany, France, Japan)**
- **Nearly 8,800 patents and 2,680 protected inventions**
- **360 000 shareholders**



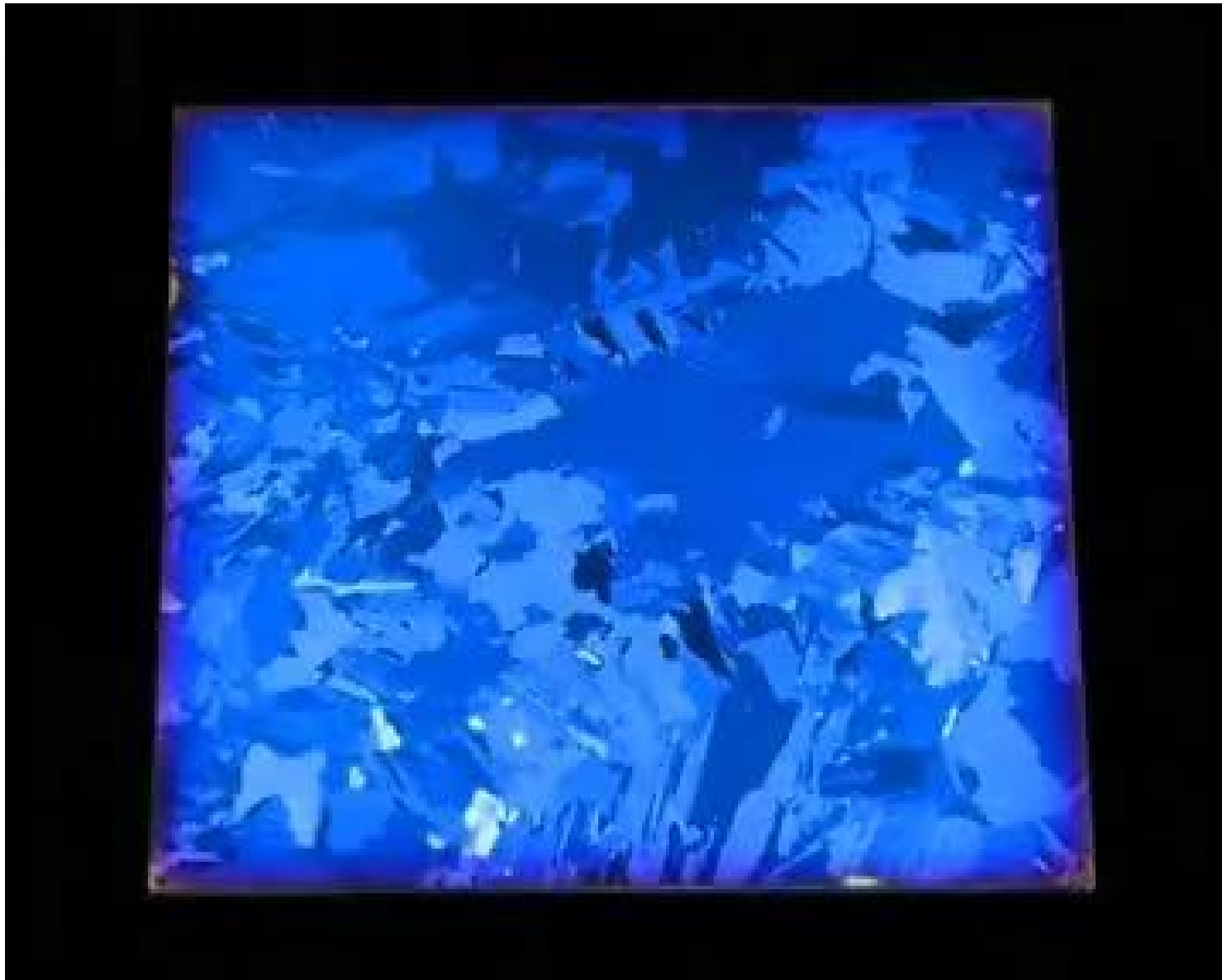
**Integrated solutions:** gas, associated products,  
and **value based** offers

All centered on **technological innovation**

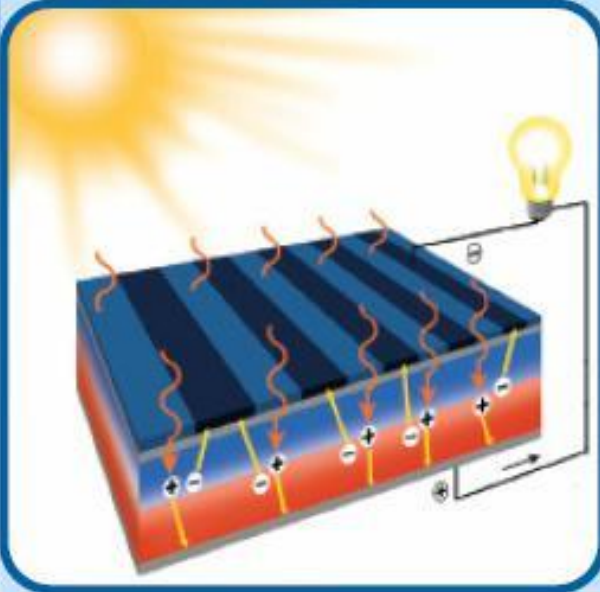


## Solar Cells – How does it Work?

# Solar Cell - How does it work ?

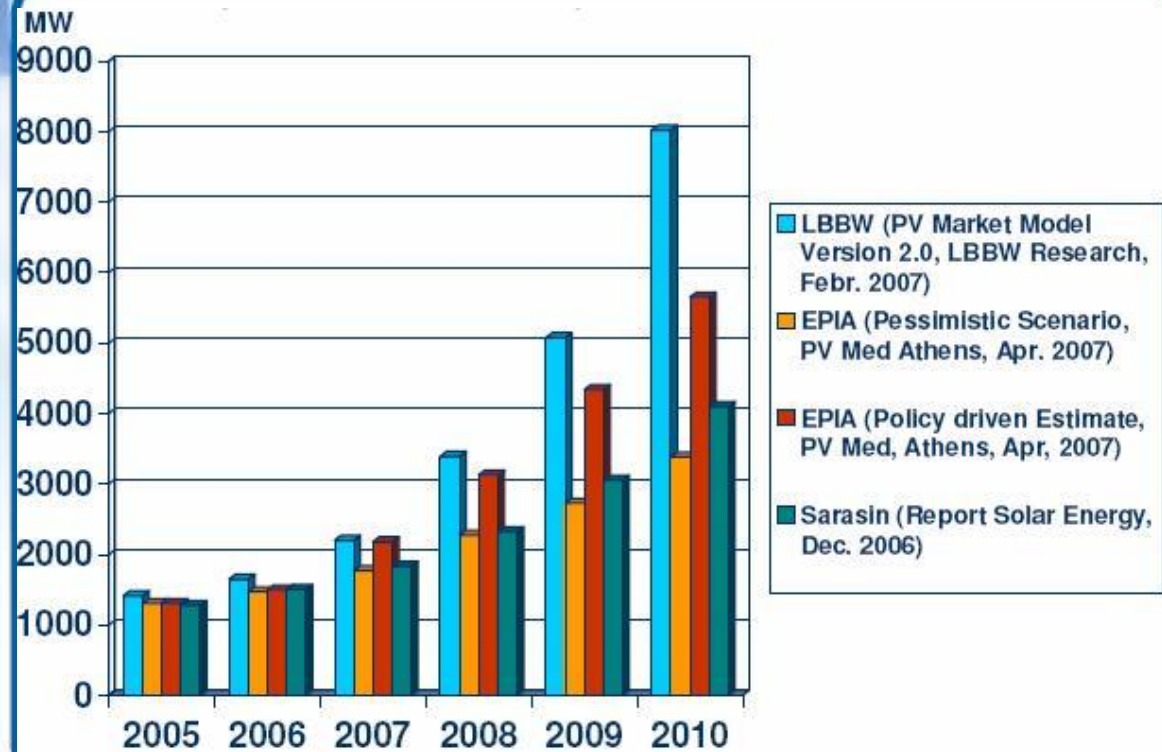


## How Solar Cells Work ?

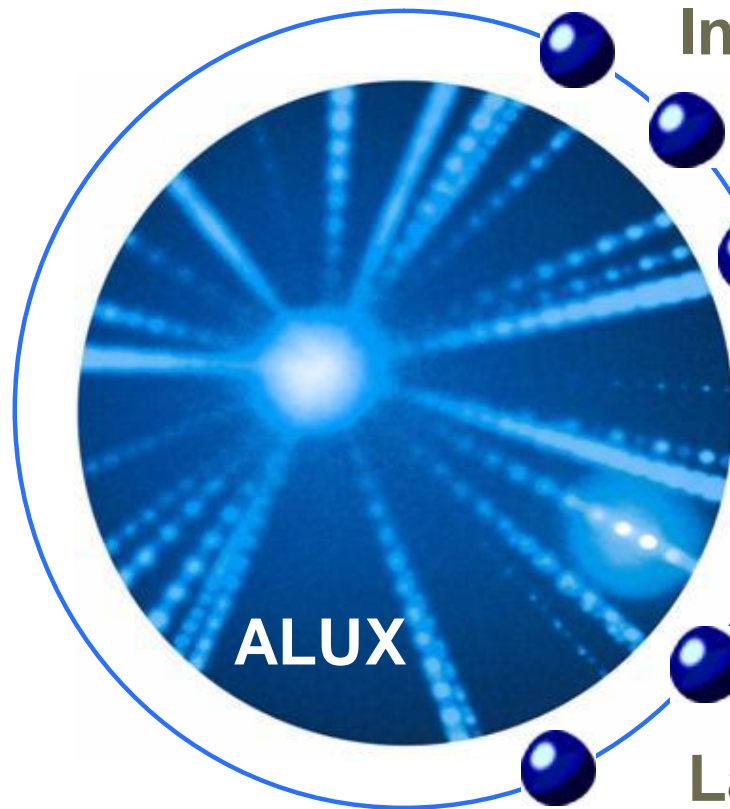


Solar radiations (photons) are absorbed on a semi-conductor material, generating free charge carriers (electrons and associated holes). A specific configuration of the solar cell (n-p junction) enables separation and transportation of the charge carriers and finally collection of a DC current flow.

## Solar Cell Production Trend



\*Daube: Kooperationsforum PV - Dünnschichttechnologien



**Introduction**

**How does it Work?**

**Approach is Different!**

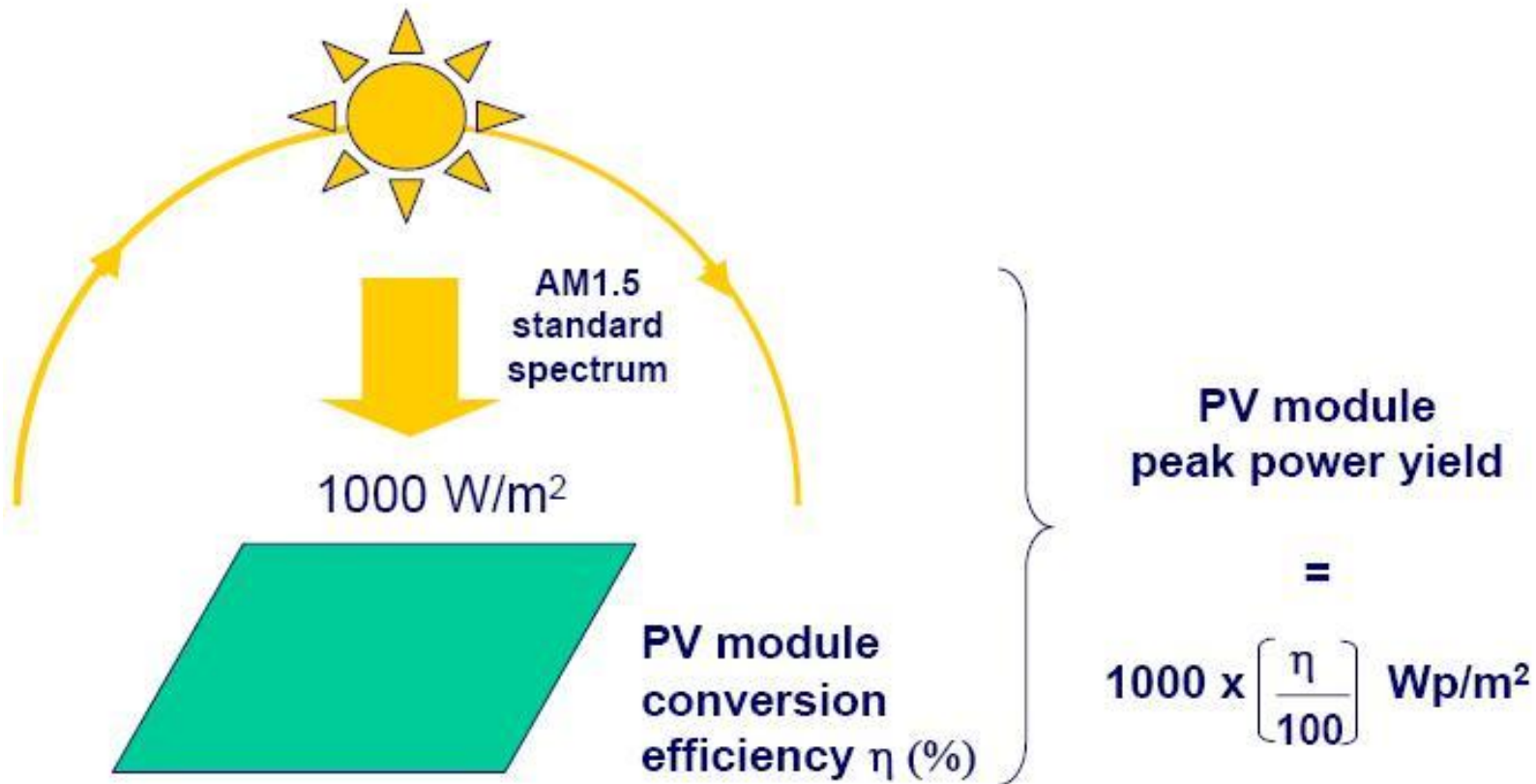
**Clients Needs!**

**ALUX - Supply Chain**

**Specialty Gas Supply**

**Last not Least: Safety First!**

# Measurement of PV-Production

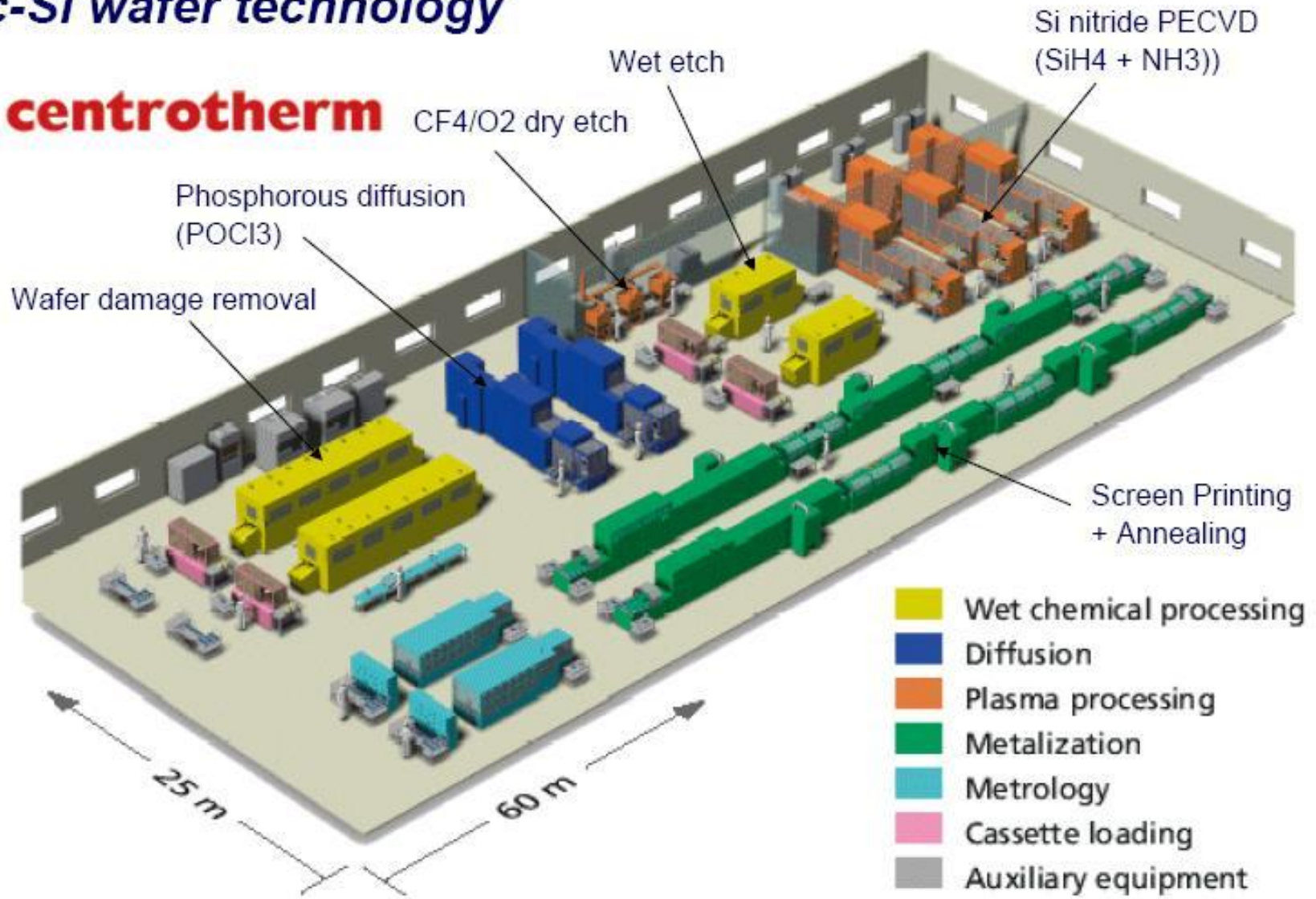


Laboratory Cell efficiency		→	Commercial Module efficiency	
crystalline Si solar cells	$\eta = 23 \%$		crystalline Si modules	$\eta \approx 12-14 \%$
film solar cells (lab)	$\eta \approx 12 \%$	thin film modules	$\eta \approx 6-8 \%$	

# Crystalline Silicon Wafer Fab-Layout

## c-Si wafer technology

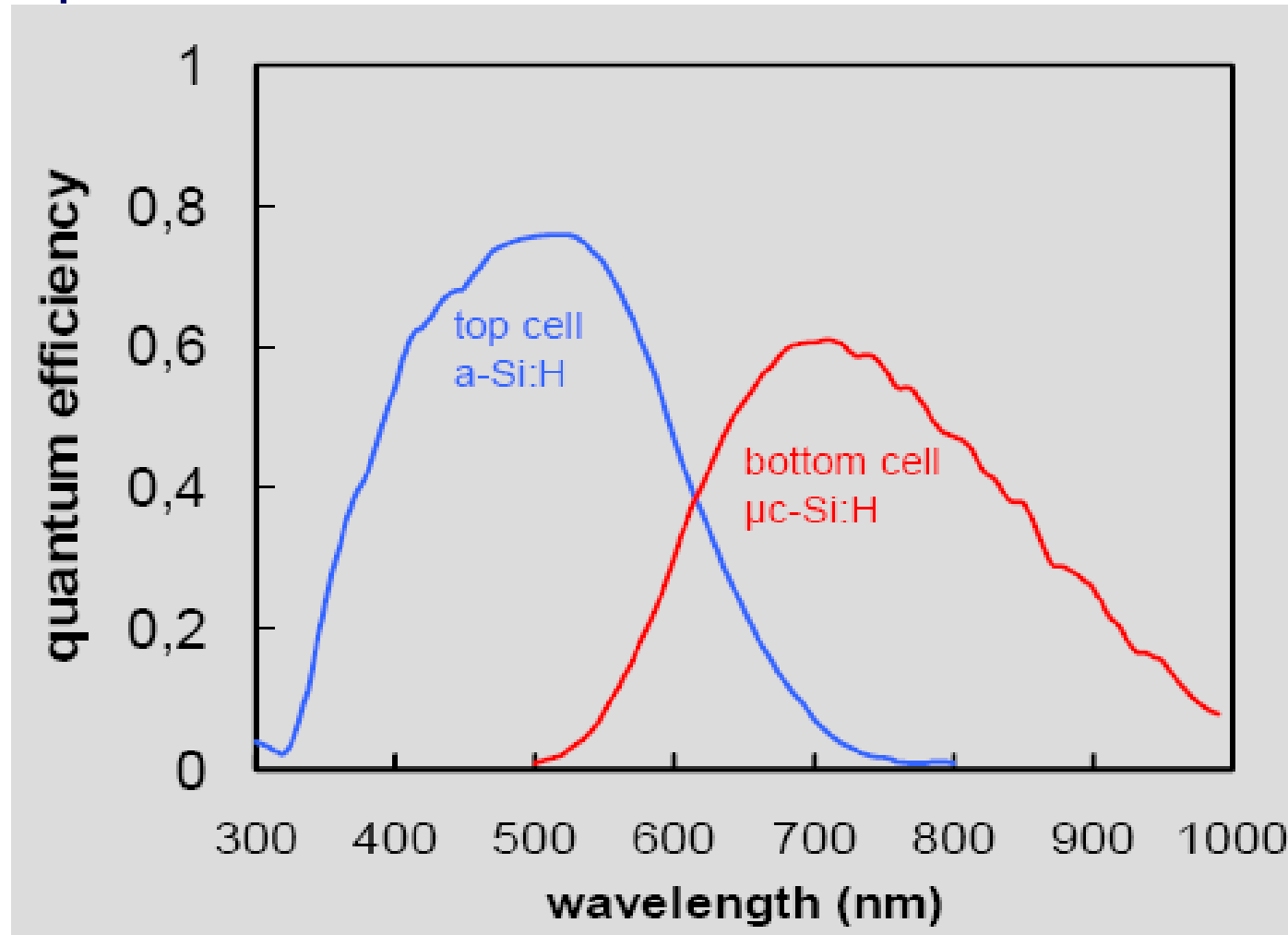
**centrotherm**





# Tandem-Cell or Double Junction

a-Si /  $\mu\text{c-Si}$



\*Bunte: Kooperationsforum PV - Dünnschichttechnologien

# Triple Junction

a-Si / a-SiGe /  $\mu\text{c-Si}$

- stable mid-Layer a-SiGe
- wide range of light absorption
- higher efficiency
- theroretic ~ 17%

J. Krc, B. E. Pieters, M. Zeman *et al.*,  
EU-PVSEC, Dresden, 2006

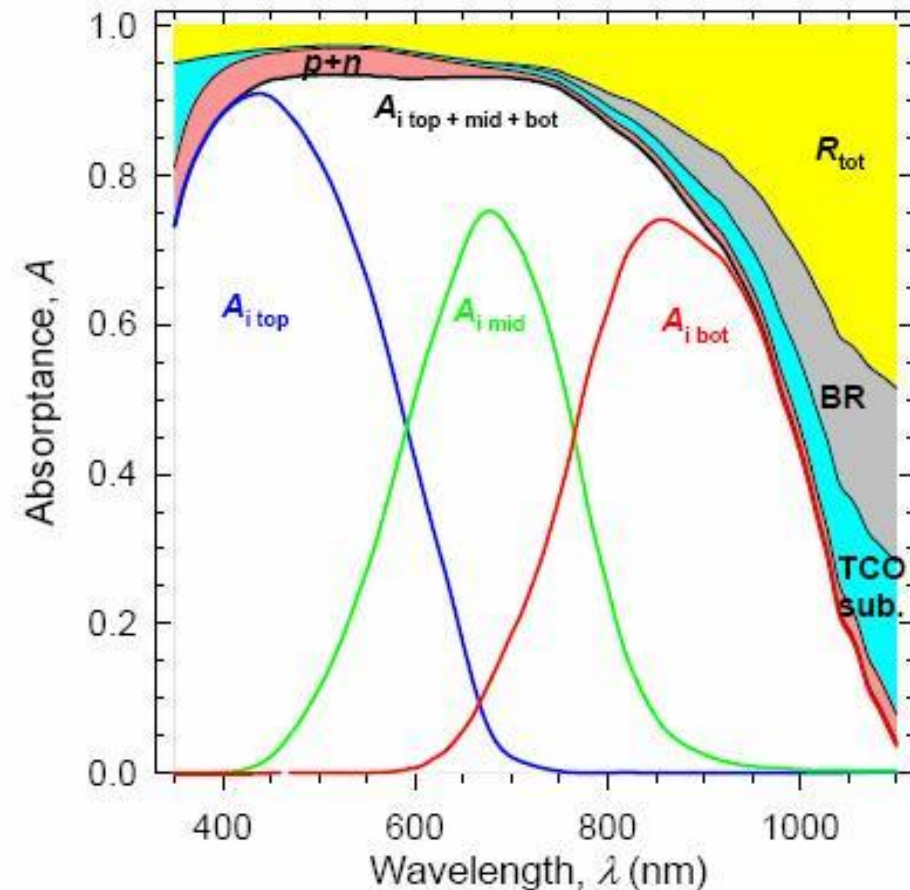
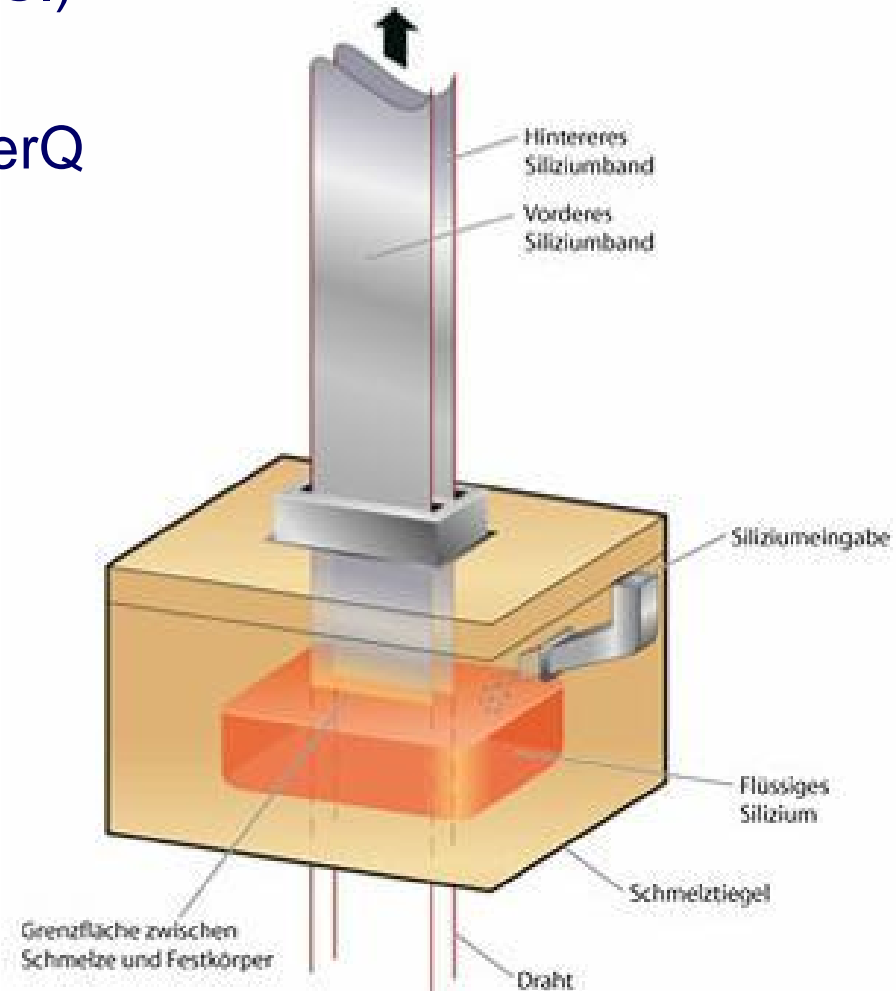


Fig. 1(b): Absorption losses and absorptances in the absorber layers for the optically improved a-Si:H/a-SiGe:H/ $\mu\text{c-Si:H}$  solar cell ( $d_{\text{i top}} = 110 \text{ nm}$ ,  $d_{\text{i mid}} = 280 \text{ nm}$ ,  $d_{\text{i bot}} = 2.1 \text{ mm}$ ).

# String-Ribbon-Process

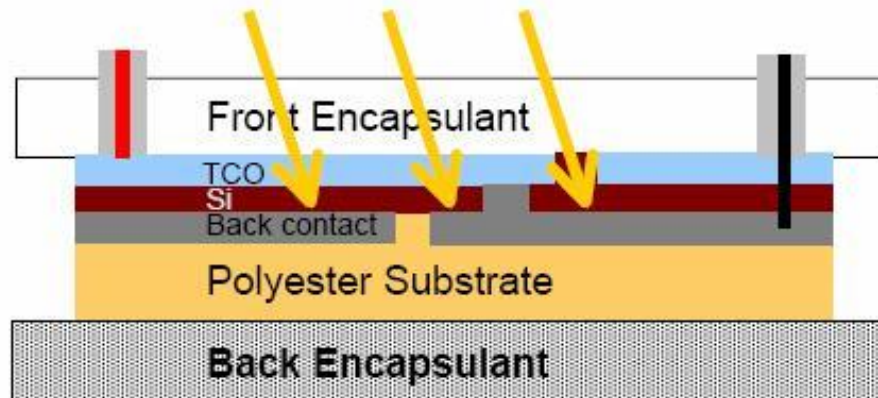
Patent: EverGreen Solar (U.S.)

- in Germany:
- EverGreen + QCells = EverQ

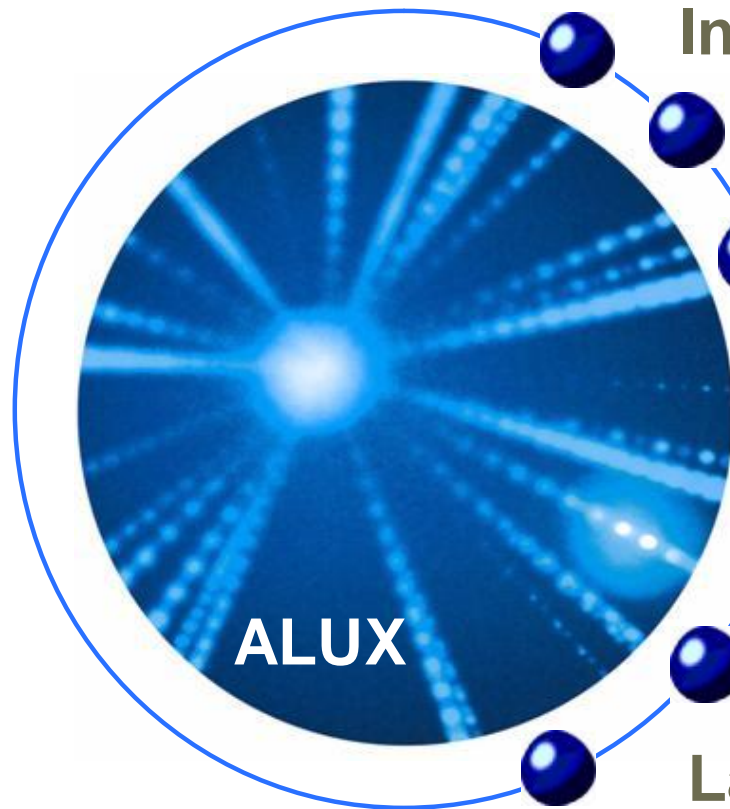


# Roll-to-Roll pilot production

- Roll-to-Roll Pilot Line
- 30 wide Al foil
- APCVD TCO:  $\text{SnO}_2:\text{F}$
- PECVD: a-Si:H
- Temporary Superstrate Concept:



30 cm



**Introduction**

**How does it Work?**

**Approach is Different!**

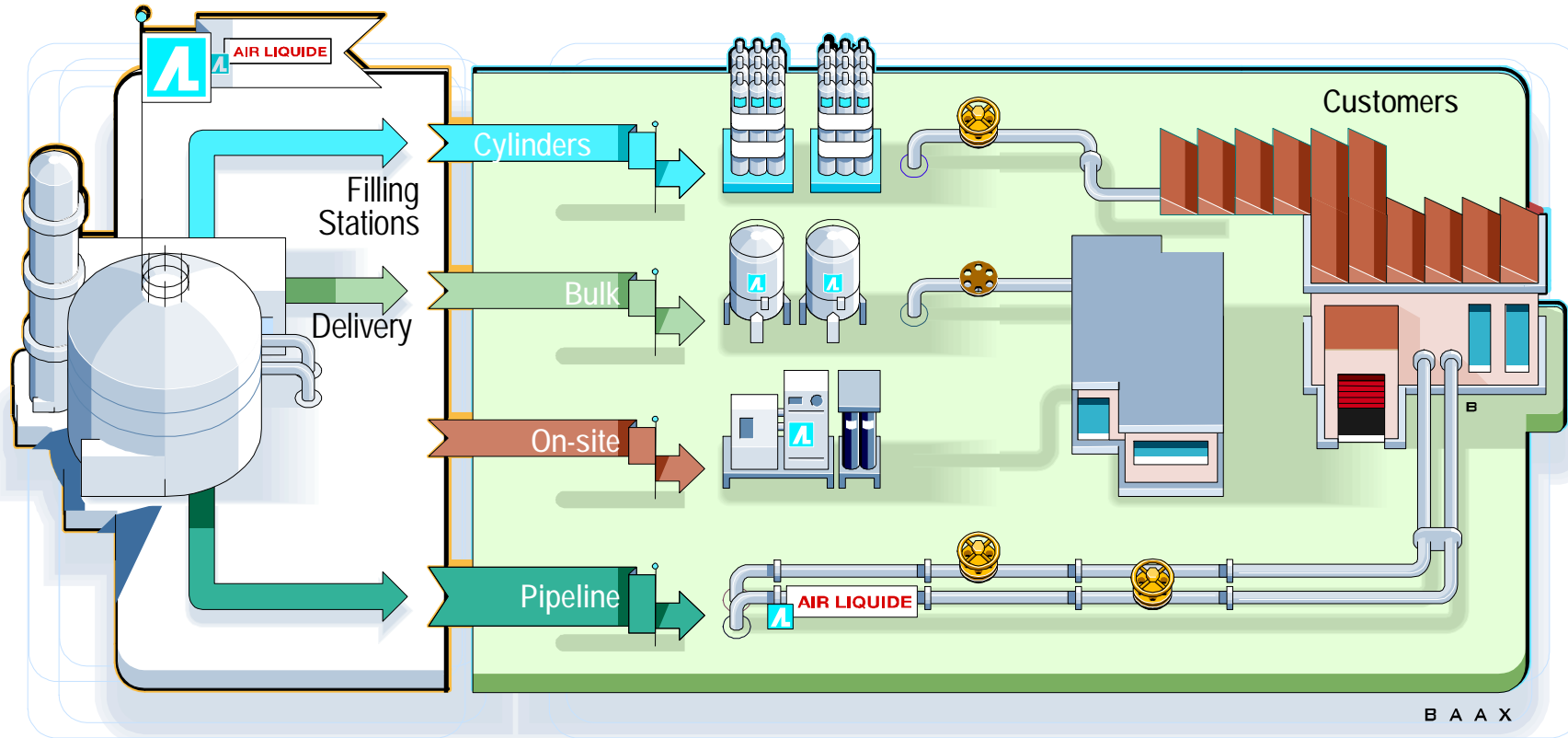
**Clients Needs!**

**ALUX - Supply Chain**

**Specialty Gas Supply**

**Last not Least: Safety First!**

# ALUXSUPPLY offers several supply modes



***Oxygen, Nitrogen, Argon, Hydrogen, Carbon Dioxide***

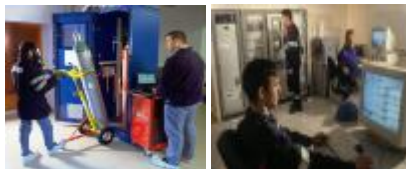
# ALUX™ offer to the PV - Industry



Cylinder/BULK/APSA

## ALUXSUPPLY

- Bulk**
- APSA N<sub>2</sub> on-site generators**
- Specialty gases**
- Liquid chemical (e.g. POCl<sub>3</sub>)**
- Wet chemicals**



## ALUXSERVICE

- On-site material management**
- Engineering & Installation**
- Analytical services**
- Gas detection**



Purification Purity Control

## ALUXPURIFICATION

- H<sub>2</sub> & NH<sub>3</sub> purifiers**
- H<sub>2</sub> & NH<sub>3</sub> purity monitoring**
- Recycling**



Gas Cabinet Chemical Dispenser

## ALUXDISTRIBUTION

- Gas cabinets (GC)**  
(Carriers & Specialty gases)
- GC gas vent cartridges**  
(Specialty gases)
- Liquid phase vaporization**  
(Bulk NH<sub>3</sub> and SF<sub>6</sub>)
- Liquid chemical refilling**  
(POCl<sub>3</sub>)
- Wet chemical dispenser unit**

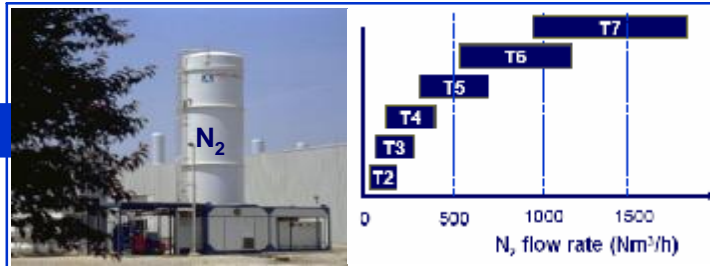


Plasma Detoxal

## ALUXABATEMENT

- Dry scrubbing**  
(Doping exhaust)
- PFC plasma abatement**  
(Etch exhaust)
- Burner/wet scrubber**  
(PECVD exhaust)
- Catalytic scrubber**  
(MOCVD exhaust)

# A scalable offer As you expand



**APSA™ N<sub>2</sub> on-site generation**



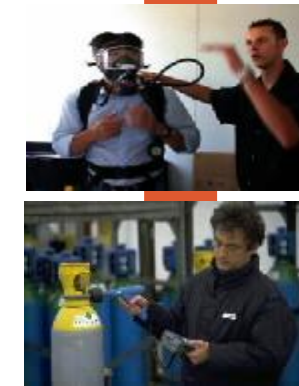
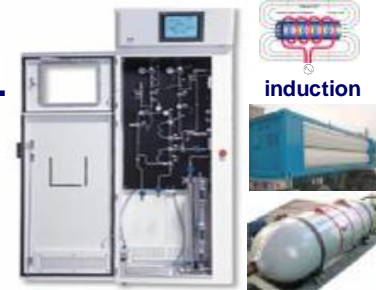
**Adapted packaging  
Multi-Sourcing**



**3000 Kg SiH<sub>4</sub> max.**

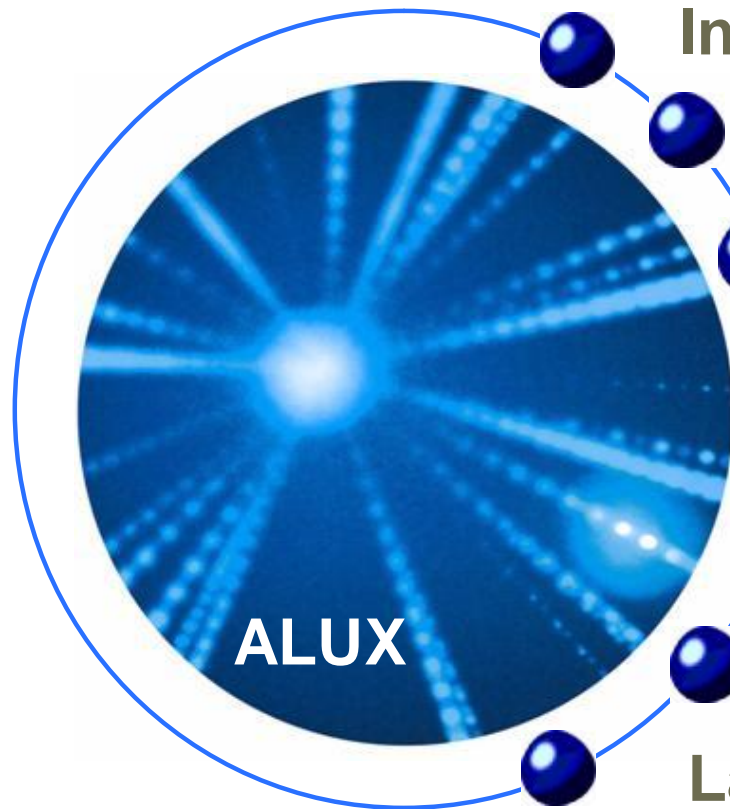


**192 Kg SiH<sub>4</sub> max.**



**E&I**  
High flow solutions

**Services**  
Safety, Reliability



**ALUX**

**Introduction**

**How does it Work?**

**Approach is Different!**

**Clients Needs!**

**ALUX - Supply Chain**

**Specialty Gas Supply**

**Last not Least: Safety First!**

# ALUXSUPPLY is the bulk specialty gases offer

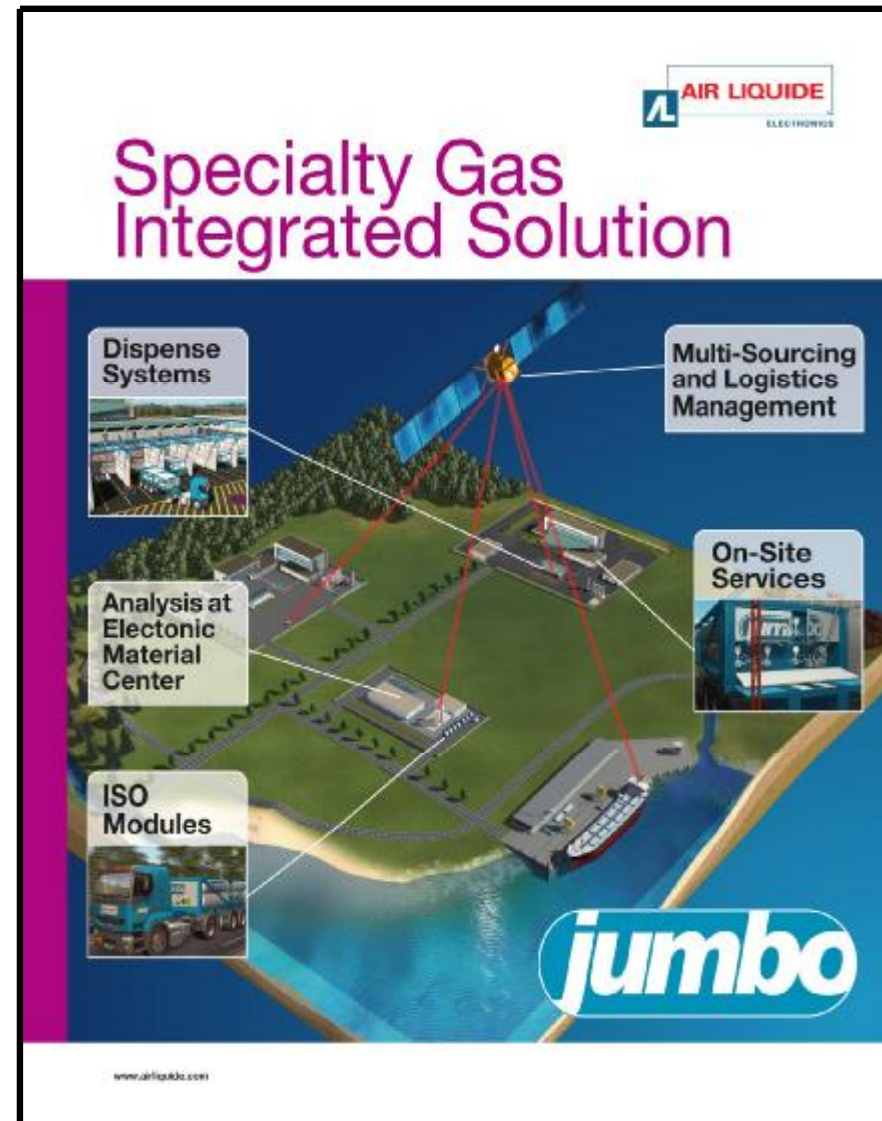


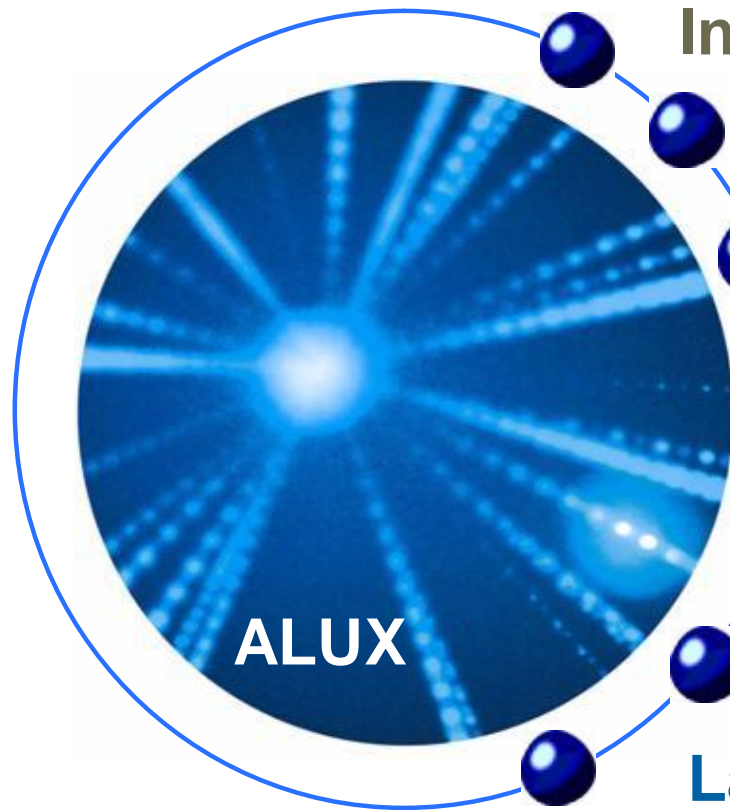
## ALUX provides with Jumbo concept...

- a Multi-sourcing, logistics management
- a AL local analysis at Materials Center
- a AL containers for AL supplied product
- a AL on-site dispense system
- a containers change-out by AL staff
- a Emergency Response

## Typical Jumbo - Products:

- a  $\text{SiH}_4$ ,  $\text{NH}_3$ ,  $\text{NF}_3$





**ALUX**

**Introduction**

**How does it Work?**

**Approach is Different**

**Clients Needs**

**Supply Chain**

**Specialty Gas Supply**

**Last not Least: Safety First!**

**Silane Safety Seminar**  
**Nov. 2<sup>nd</sup> 2007 Singapore**

**Bulk Silane Delivery System Safety  
for Photovoltaic**

**Chairmen of Panel-Discussion:**

**Dr. Jean-Paul Barbier**



**AIGA**

**Asia Industrial  
Gases Association**

**In co-operation with:**



# Our strong commitment to safety



**Safety first**

"Safety is and will remain our highest priority"

**AIR LIQUIDE**

**Benoit POTHIER**  
Chairman of the Management Board

The poster features a central image of a man in a white hard hat and a woman in a white lab coat, surrounded by various safety-related icons and photos of industrial workers and equipment.

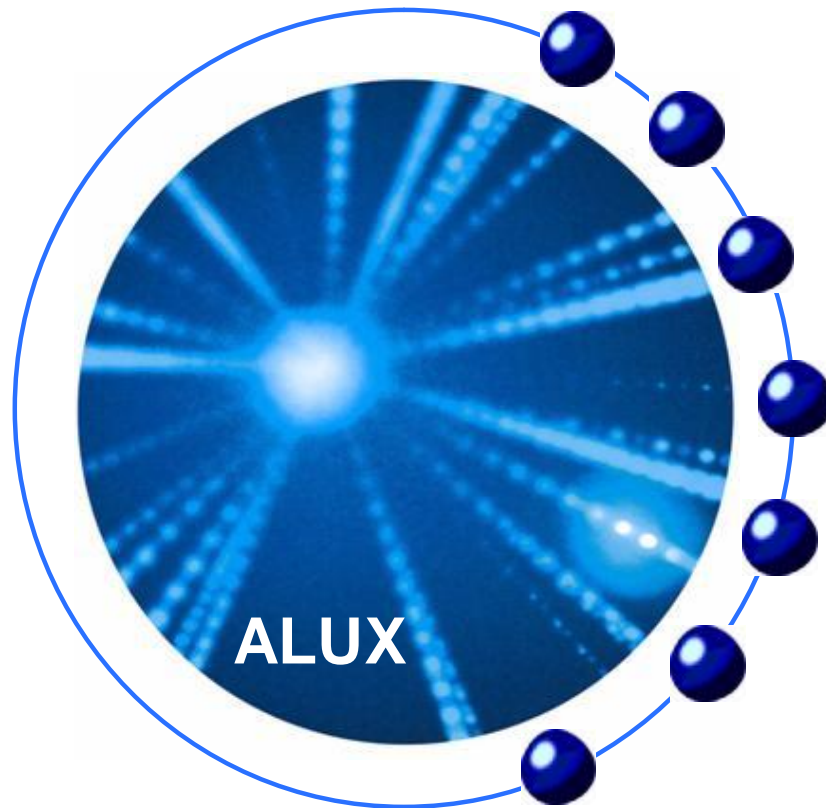
## ALUX - Team



**Training School**



**Practical exercises**



**Thank you for  
Your Attention !**