

Plasma Technology Introduction

2010/11/15

劉品均

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Outline

- **Company Profile**
- **What is Plasma?**
- **Plasma application in Solar**



公司基本資料

Profile

- ▶ 公司成立於 2005 12月
- ▶ 公司實收資本額: €168 million / USD\$219 million
- ▶ 隸屬 UMC 集團 (NYSE:UMC)

Products

- ▶ a-Si Thin Film Modules
- ▶ uc-Si Tandem Thin Film Modules
- ▶ Building-Integrated Photovoltaic (BIPV)

Capacity

- ▶ 2 Production plants
- ▶ 2010 Capacity : 120 MW
- ▶ 2011 Capacity : 140 MW



公司重要里程碑



- 2007/06: 一廠動土
- 2008/05: 一廠落成暨量產
- 2008/07: 產品通過IEC及ISO認證
- 2009/04: 二廠落成暨量產
- 2009/04: 產品通過UL及CEC認證
- 2009/07: 加入PV CYCLE 成為會員
- 2009/08: 產品獲得 Munich Re認可投保
- 2009/10: 產品通過CQC認證
- 2009/12: Tandem 雙結產品量產
- 2010/03: 成為Bank list of DKB



NT-130~140 Specifications

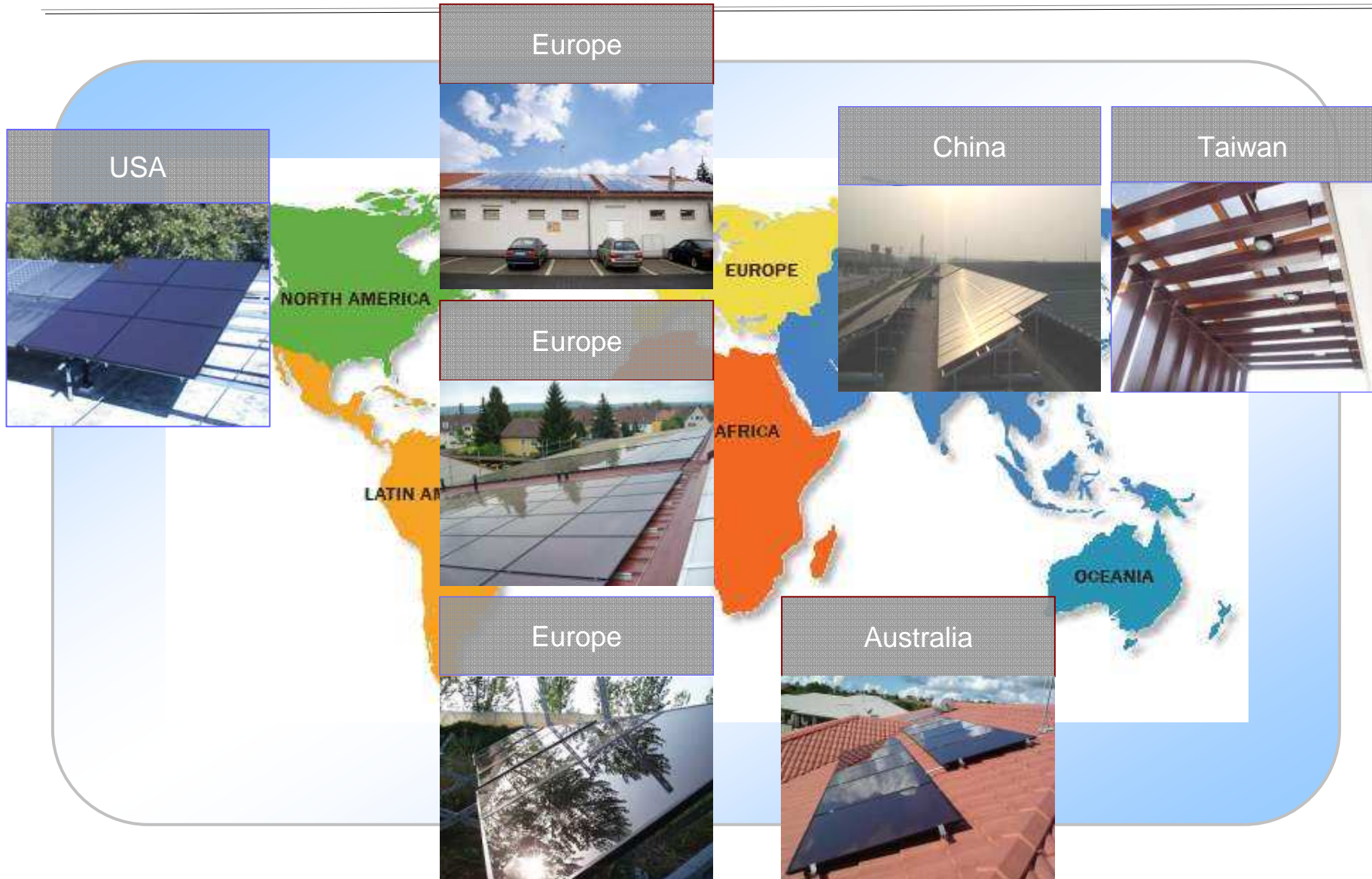
Specifications:

Model	NT-140AX	NT-135AX	NT-130AX
Nominal Power [W][$\pm 5\%$]	140	135	130
Open Circuit Voltage [V]	78.4	78.4	77.6
Short Circuit Current [A]	2.59	2.52	2.45
Maximum Power Voltage [V]	62.3	62.3	62.2
Maximum Power Current [A]	2.25	2.17	2.09
Initial Values	Pmax : Refer to installation manual Voc : Approximate 4% higher than stablized voltage		
Maximum System Voltage [V]	1000	1000	1000
Dimensions [mm]	1414 * 1114 * 35.3	1414 * 1114 * 35.3	1414 * 1114 * 35.3
Weight [kg]	20.5	20.5	20.5
Connector	MC	MC	MC
Cable Length [mm]	1000	1000	1000
Cable size [mm ²]	2.5	2.5	2.5

Temperature coefficients:

Nominal Power [W]	-0.28 %/ $^{\circ}$ C
Open Circuit Voltage [V]	-0.32 %/ $^{\circ}$ C
Short Circuit Current [A]	0.07 %/ $^{\circ}$ C

World wide Installations



USA



Europe



China



Taiwan



Europe



EUROPE

AFRICA

OCEANIA

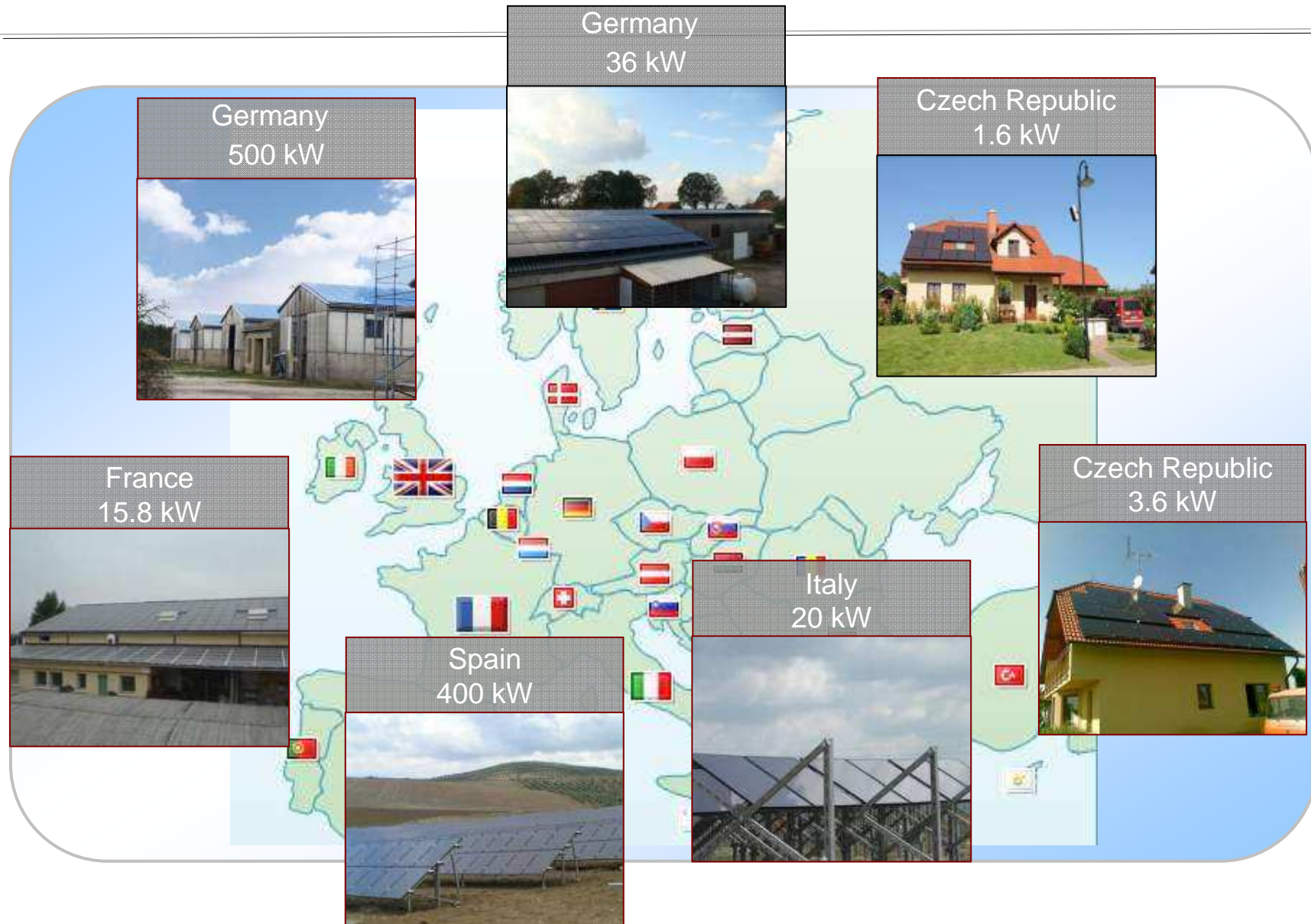
Europe



Australia



European Installations



MW Scale Installations

On-Site Photo



Project Info

Location: Blankenberg, Germany
Capacity: 1.11MW
Module: NexPower NH-100AT
Inverter: Kaco Powador Megawatt
-Station
Grid-Connection: Dec. / 2009

Geographic Location





1.55MW TF Tandem Power Station In Germany **Glasewitz**





1.55MW TF Tandem Power Station In Germany **Glasewitz**





亞洲最大的單一薄膜光伏電站 (17.5兆瓦)





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Introduction

- 電漿 (PLASMA) : 包含有氣體分子、離子、電子的等中性 (quasi-neutral) 氣體，且這些氣體具有集體行爲 (Collective Behavior) 。
- PLASMA = 電漿 = 等離子體 \longrightarrow 輝光放電 (Glow Discharge)
- 游離電漿：
 - 全游離電漿：太陽,核融合電漿 (Fusion Plasmas)
 - 部分游離電漿：氙氣頭燈、半導體與光電製程電漿、電漿顯示器。



Plasma Parameters

➤ 電漿參數:

- ◆ 電漿密度 (n) : 每單位體積的粒子數(cm^{-3})
- ◆ 電漿電位 (v) : 主電漿區相對於腔體(通常為接地)的靜電位(V)
- ◆ 電子溫度(T_e) : 即表示電子的平均動能(eV)
- ◆ 電漿頻率(ω_p) : 電漿的自然震盪頻率(Hz)

$$f_p(\text{Hz})=9000(n)^{1/2}$$

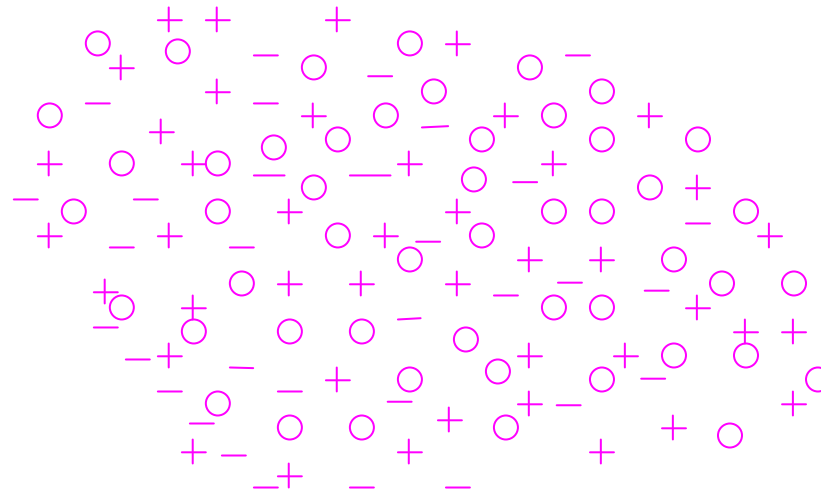


Neutral, electron and ion in plasma

○ neutral

— electron

+ ion





Plasma Parameters

一般輝光放電的電漿參數

	粒子質量 (g)	粒子溫度 (eV)	粒子平均速度 (cm/sec)
中性原子	6.6×10^{-23}	1/40(20°C)	4.0×10^4
正離子	6.6×10^{-23}	0.04(500k)	5.2×10^4
負電子	9.1×10^{-28}	2(23200k)	9.5×10^7

Thermal velocity

$$V_{th-e} = \sqrt{\frac{8kT_e}{\pi m_e}} \approx 1.5 \times 10^6 \text{ m/s}$$

$$V_{th-i} = \sqrt{\frac{8kT_i}{\pi m_i}} \approx 1.5 \times 10^3 \text{ m/s}$$



Gas Ionization Energy

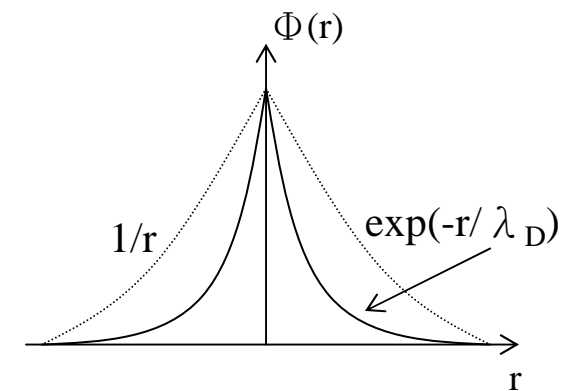
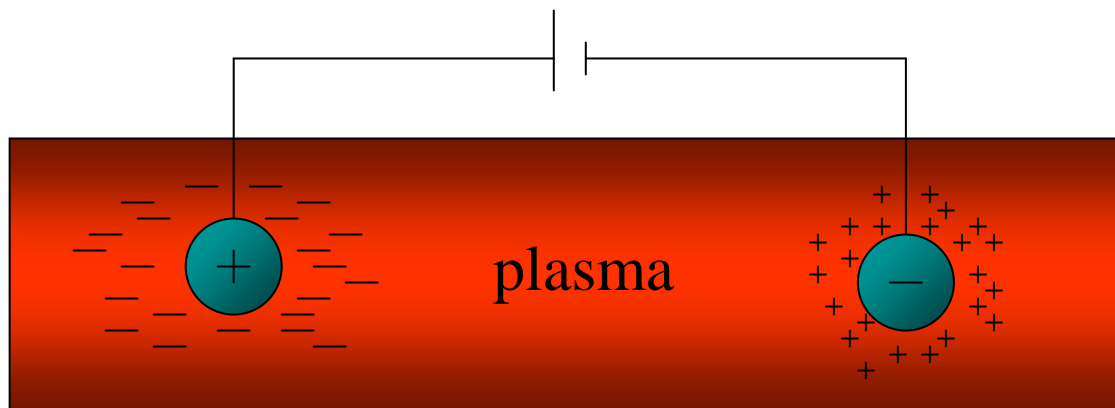
元素	游離能(eV)	半穩態能量(eV)
氦(He)	24.588	19.8;20.96
氖(Ne)	21.565	16.62;16.72
氩(Ar)	15.760	11.53;11.72
氙(Kr)	14.000	9.87;10.51
氙(Xe)	12.130	8.28;9.4

➤ Collective Behavior :

電子、離子在電場的相互作用下產生集體行爲。

➤ Debye Shielding effect :

一種電漿的基本特性，即電漿具有將電位遮蔽的效應。



Sheath Formation

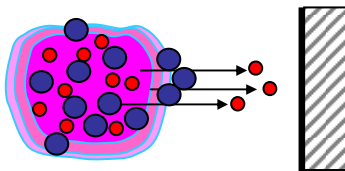
Particle flux to a surface:

$$\Gamma = \frac{nV_{th}}{4}$$

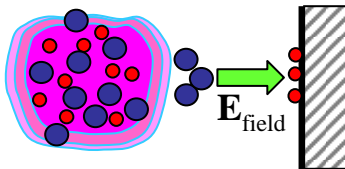
Thermal velocity of electrons and ions: $V_{th-e} \gg V_{th-i}$

Flux imbalance:

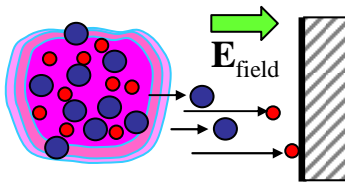
$$\Gamma_{electron} \gg \Gamma_{ion}$$



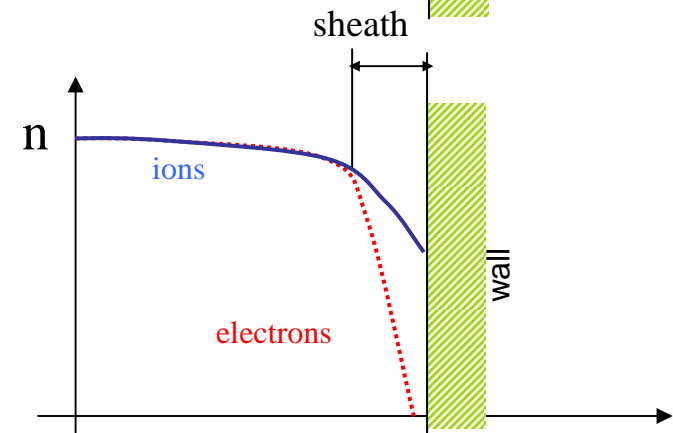
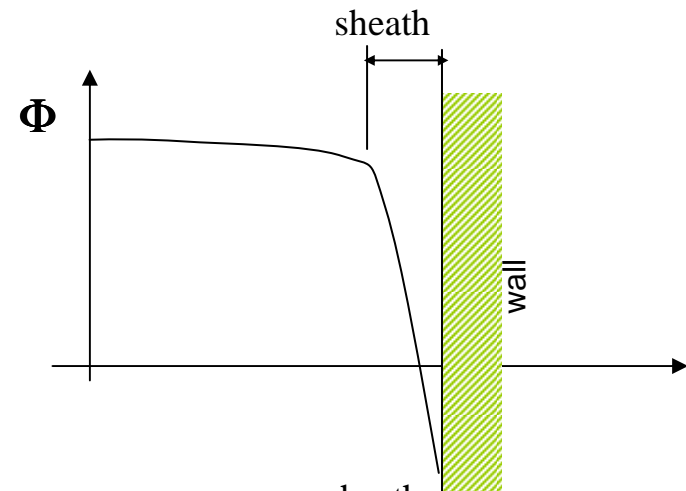
1) electrons escape to the wall due to higher thermal velocity



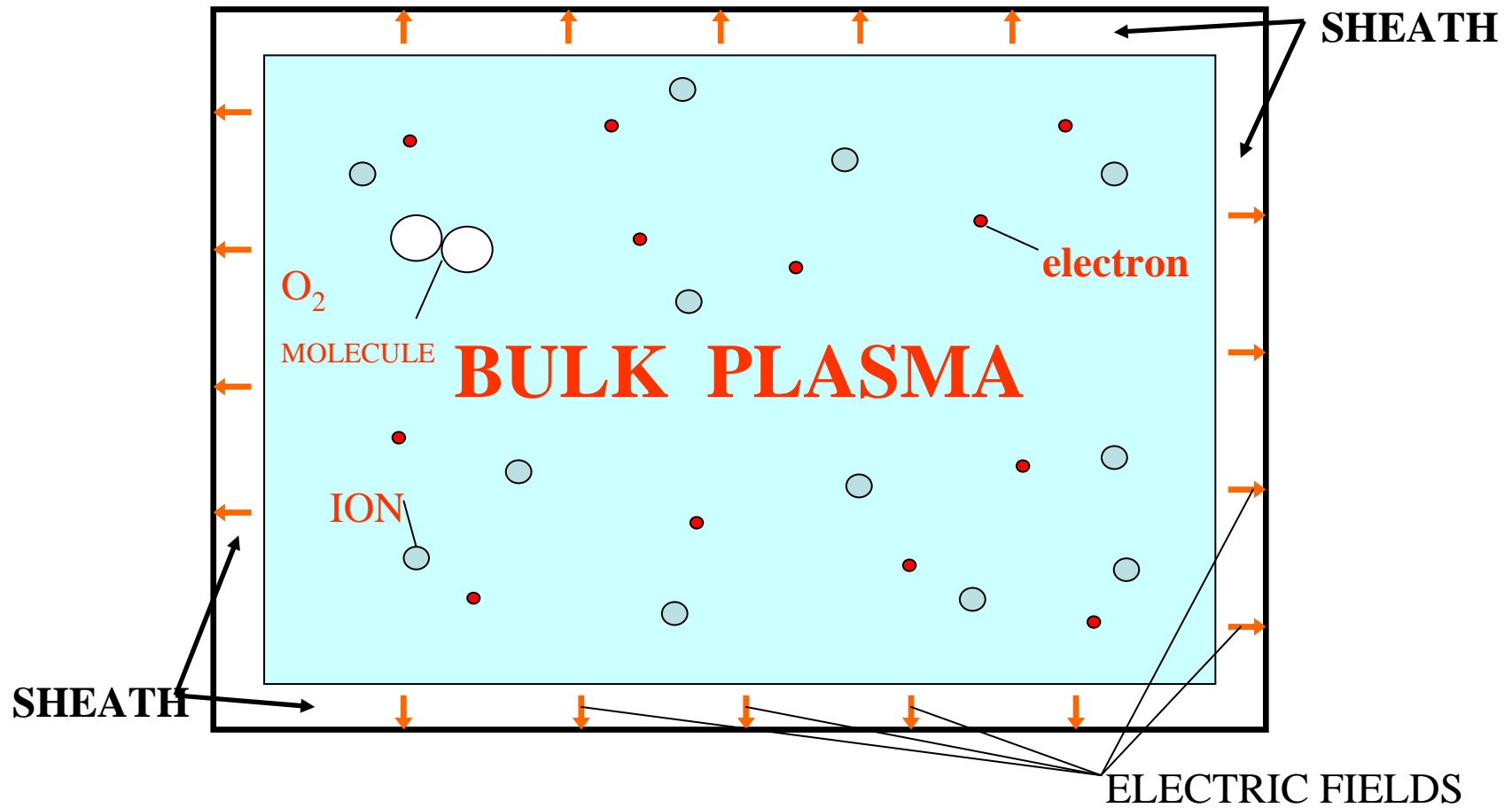
2) wall charges negatively* until electric field is created due to charge separation



3) accelerated ions / retarded electrons arrive at the wall at an equal rate preserving charge neutrality



Plasma in a chamber



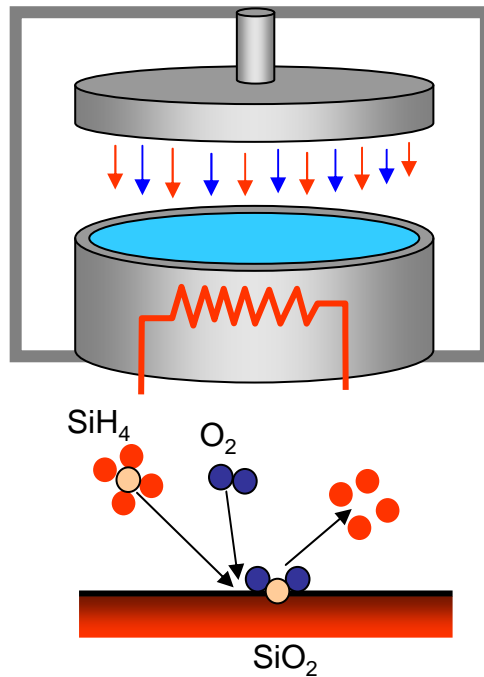


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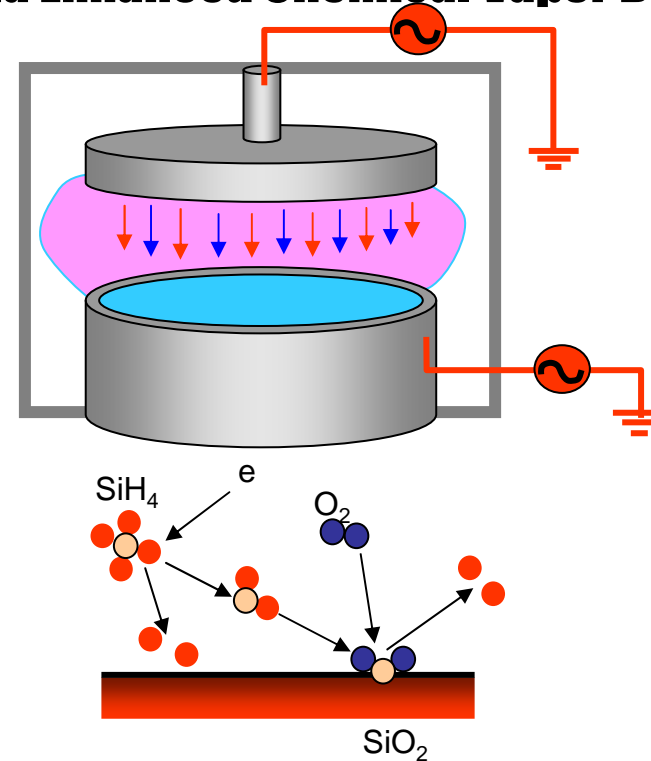
Plasma Deposition

Chemical Vapor Deposition



- Gasses flow onto wafer
- Activation energy provided by hot surface

Plasma Enhanced Chemical Vapor Deposition



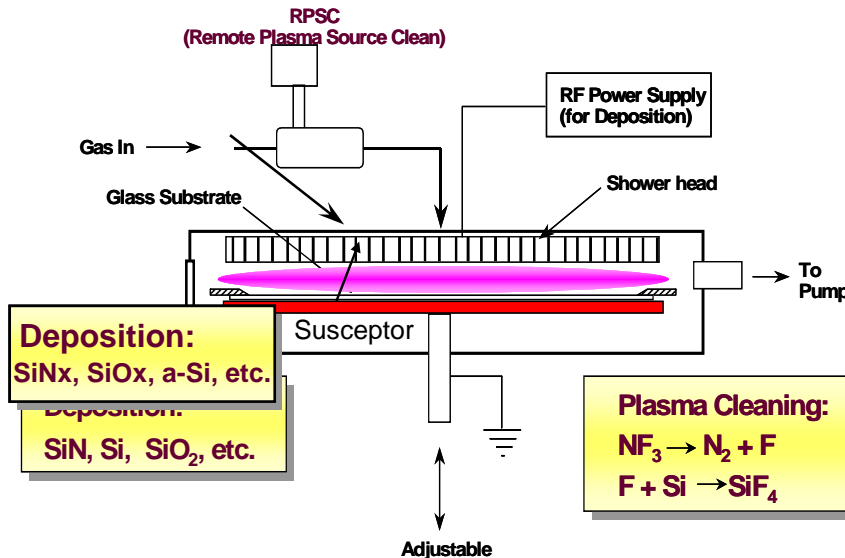
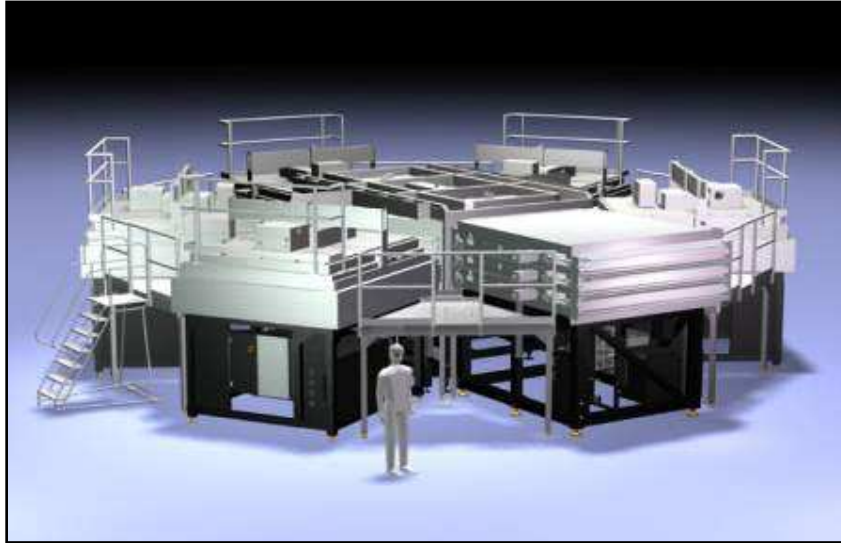
- Gasses flow onto wafer
- Activation energy provided by plasma
- Wafer temperature remains colder
- Deposition rate is much higher



AKT-50K PECVD
2160 x 2460 mm²



AMAT- 60k TFS PECVD (CVD)



Spec

AC Power

Voltage: 440v 50/60hz

Power (Max): 1,000 KW

Power (Ave): 760 KW avg

Water

PCW flow (max): 43 m³/h

DI flow (max): 5 m³/h

DI flow (ave): 4.5 m³/h

Gases

SiH₄, H₂, N₂, Ar, CH₄, TMB,
PH₃, NF₃, He

Physical Properties

17m x 17m x 3m (WxLxH)

Total Weight: 151,000 KG

Point Loads: 2,000-3,000 KG

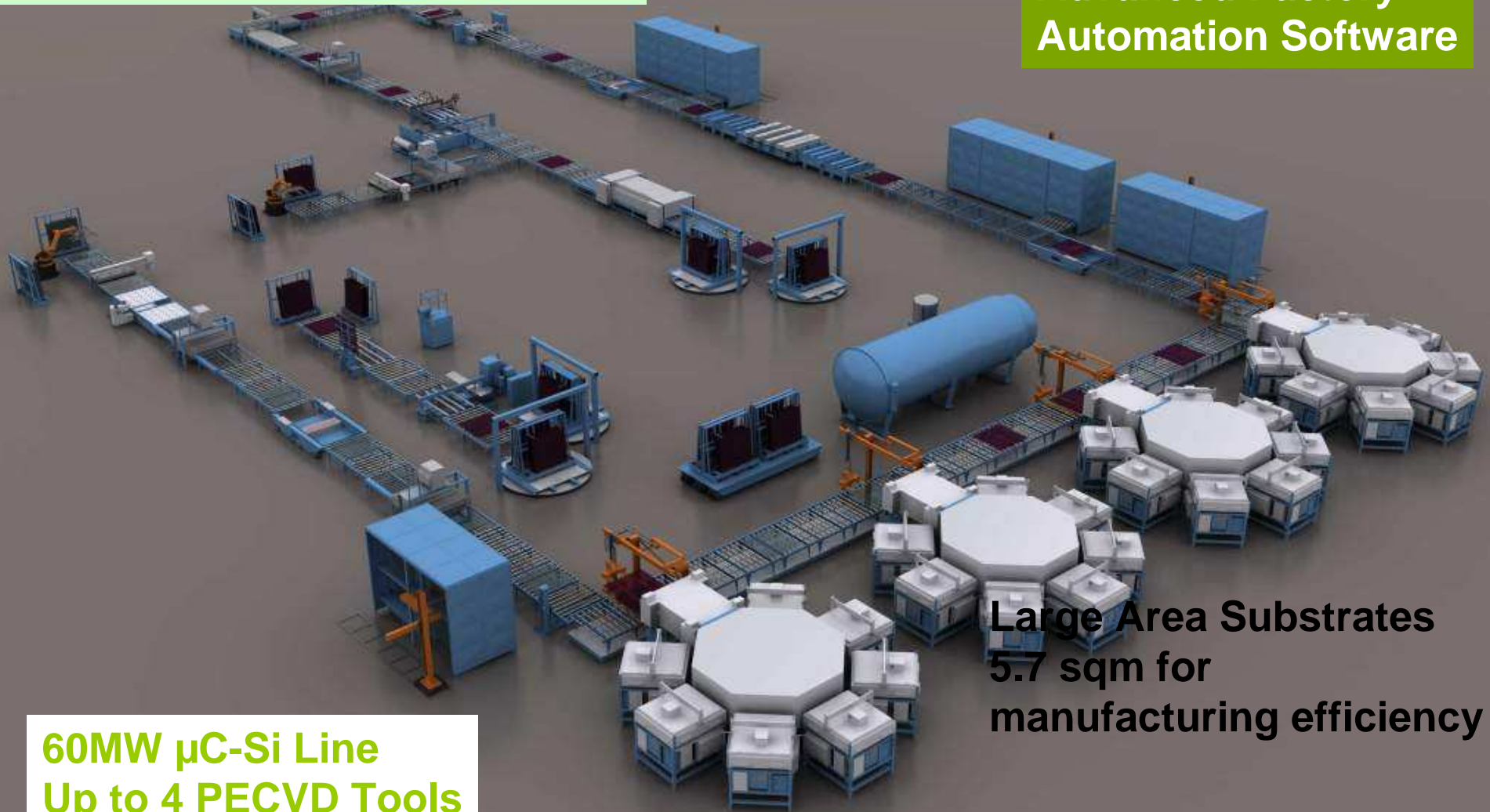
Noise: < 80 dB (A-scale), 1m
from pump frame



3-D Rendering of SunFab™ Thin Film Production Line Standard Layout

Adopted Proven Glass Industry Tools and Techniques

Automated Line with Advanced Factory Automation Software

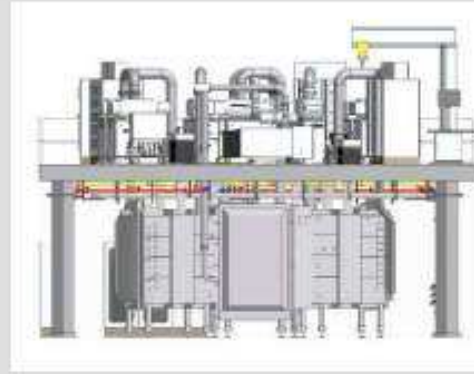
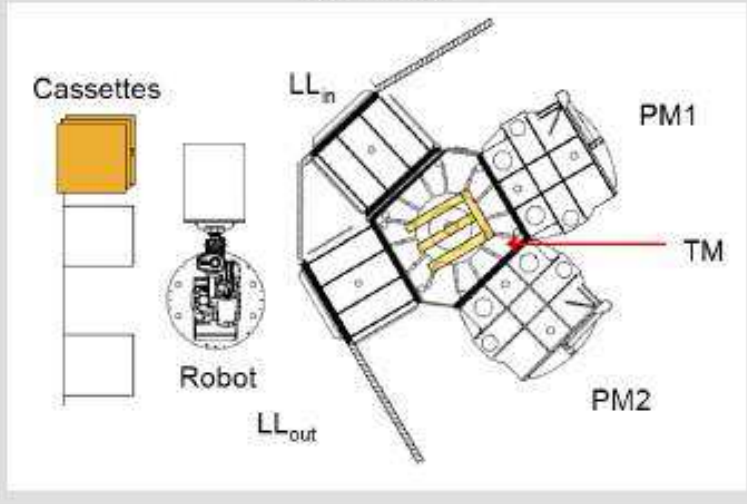


**60MW μ C-Si Line
Up to 4 PECVD Tools**

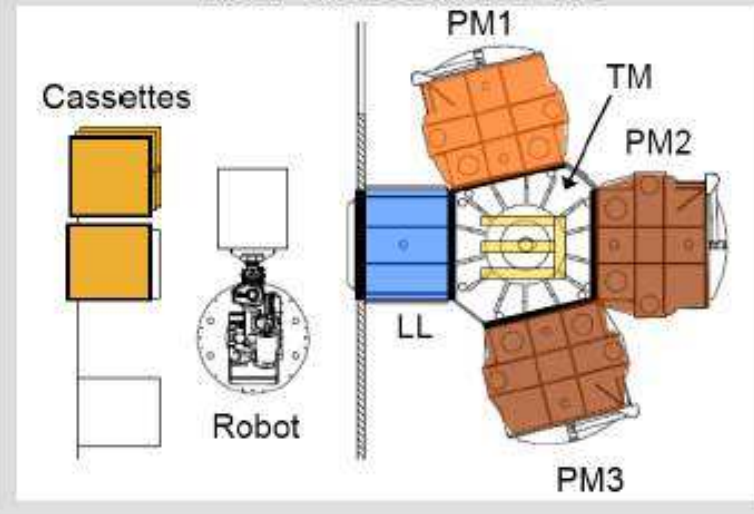
**Large Area Substrates
5.7 sqm for
manufacturing efficiency**



KAI1200

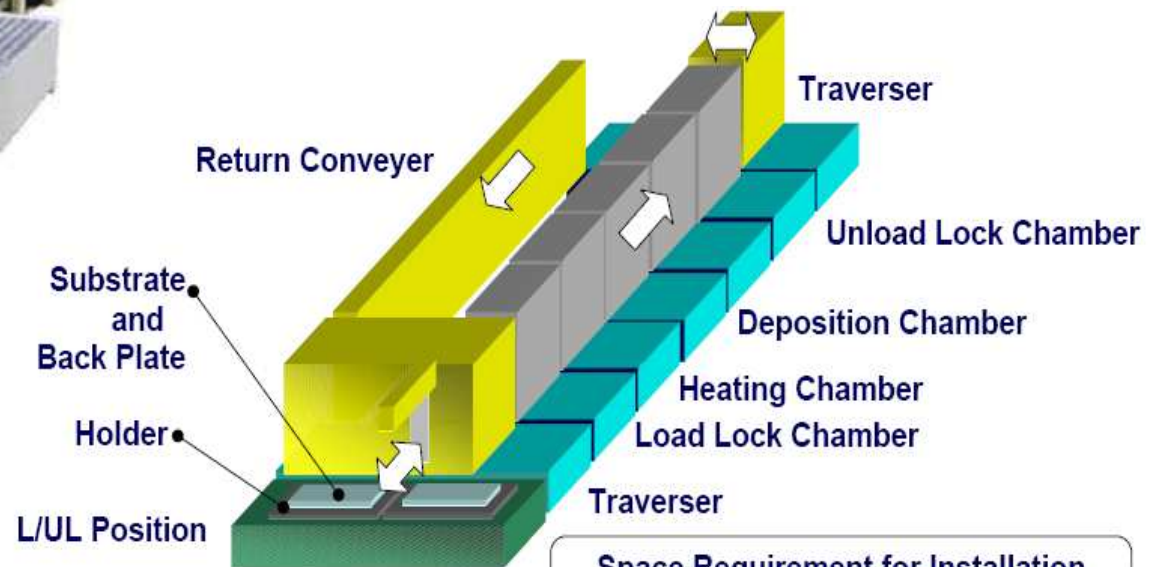


Next Generation KAI



LL – Load lock TM – Transport module PM – Process module

ULVAC- PECVD



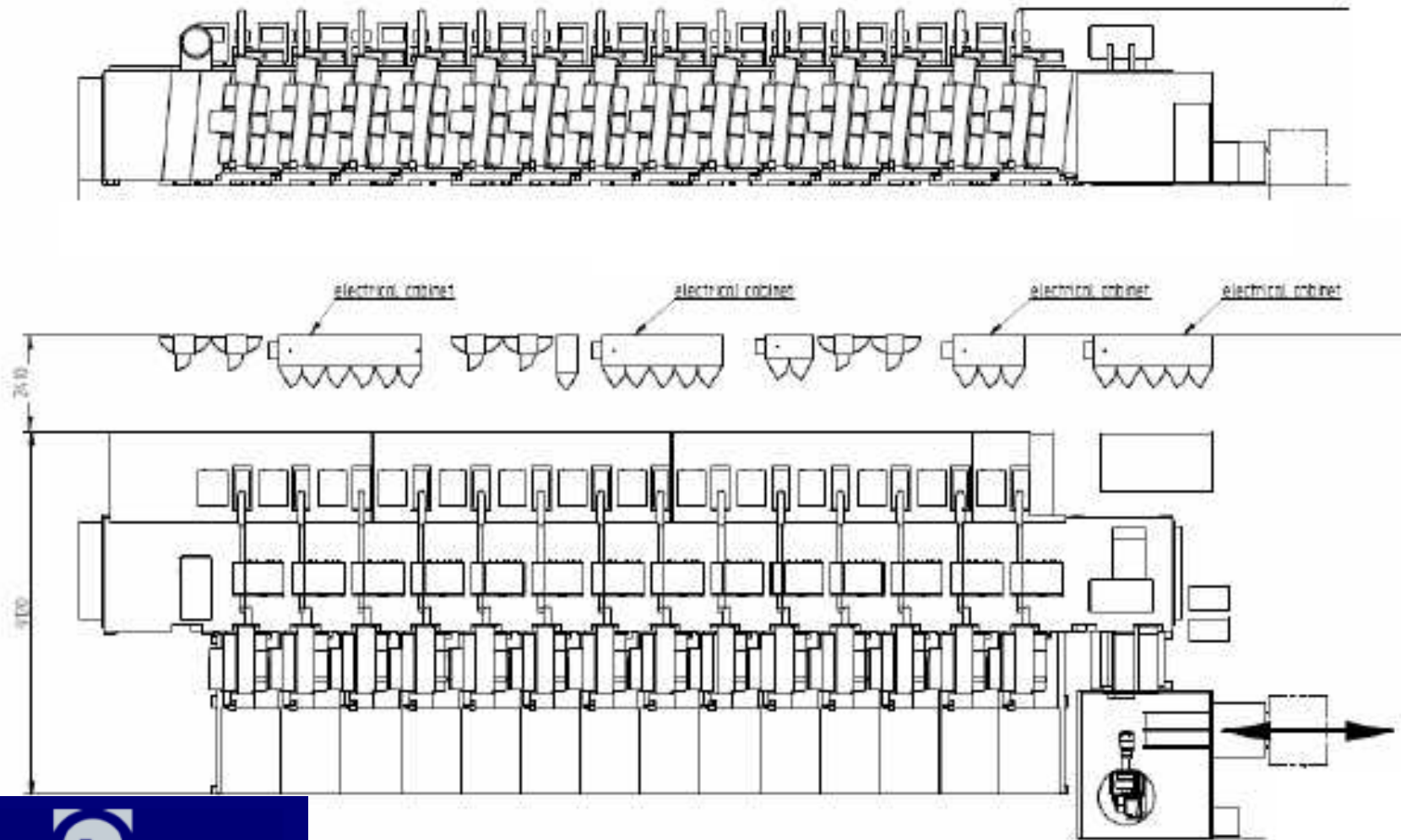
Space Requirement for Installation
14000 × 49000 × 4000H



LEYBOLD OPTICS PECVD



LEYBOLD OPTICS PECVD





Summary

- **NexPower will be the next superstar in TF solar.**
- **Plasma technology popularly used in IC/FPD/Solar ...**
- **PECVD is one of the keys for high CE solar.**