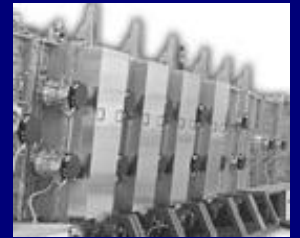
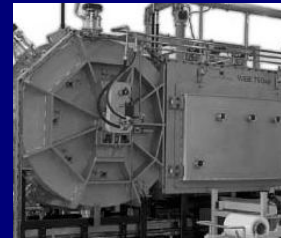




LEYBOLD OPTICS

Advanced Equipment for Thin Film PV Coatings on Glass



Presented by : Joerg Hahn

Visit our booth at: A1C2

- Company Profile
 - Solar Division
- Vacuum Equipment for Thin Film
 - Sputter Tools
 - PECVD Tool
- Summary

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Cary, US
Sales, operations,
support
30 employees



Alzenau, Germany
Sales, production,
operations, R&D, support
300 employees

Dresden, Germany
Sales, production,
operations, R&D, support
100 employees



Beijing, China
Sales, operations,
R&D, support
100 employees



LEYBOLD OPTICS

More than
2,300 systems
installed

● manufacturing locations ● subsidiaries



OPTICS



GLASS & SOLAR

Core Competences

Precision Optics

Optoelectronics

Ophthalmics

Capacitor

Packaging

3D Plastics

Special Systems

Sputtering

Evaporation

PECVD

Photovoltaics

Flexible Cells

Glass

Display

Special Systems

Customer Support

Spare Parts

Consumables

Components

Used Equipment and Upgrades

Division Glass & Solar

Photovoltaics



Glass



Division Optics

Precision Optics



Ophthalmics



3D Plastics



Flexible



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Overlapping Competencies

- Proper understanding of market needs
- Sophisticated product portfolio
- Present in all key market technologies

Supplier \ Technology	SiTF	CIGS	CdTe	HiT
Leybold Optics	😊	😊	😊	😊
Competitor I	😊			
Competitor II			😊	😊
Competitor III		😊	😊	

Solid Equipment Experience

- Proven equipment design
- Production experience and know-how
- Production and R&D equipment with same base

Equipment \ Technology	SiTF	CIGS	CdTe	HiT
CVD				
PVD (Sputter & Evaporation)				
High/Rapid Temperature Process				
Lab Systems				

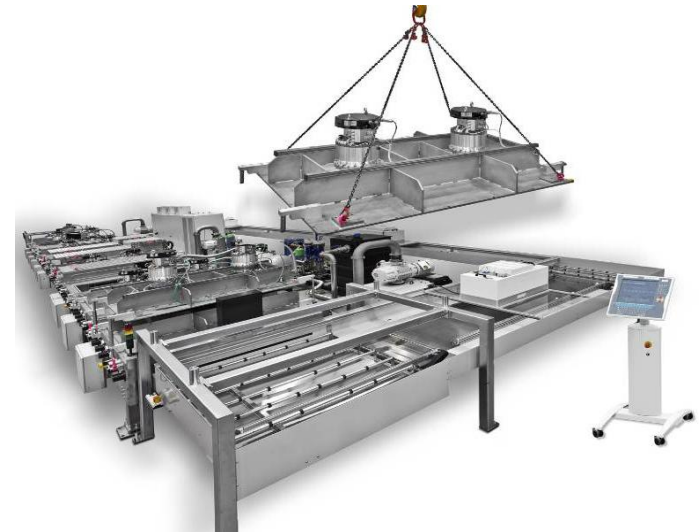
		THIN FILM PHOTOVOLTAIC CELLS			
Applications	Layers		TF-Silicon	CdTe	CIS
Anti-reflective layer	Si ₃ N ₄ , TCO	Sputter	x		x
Front contact	TCO - AZO	Sputter	x		x
Absorber	Cu-Ga, In	Sputter			x
Absorber	Si	PECVD	x		
Selen Layer	Se	Evap			x
Chalcogenization		RTP			x
Back contact	Cr-Al	Sputter	x	x	
Back contact	Mo	Sputter			x
Adhesion Layer	SiO ₂ , SiO _x	Sputter	x		
Buffer layer	iZnO	Sputter/Evap			x
Barrier Layer	Si ₃ N ₄	Sputter			x

Systems for rigid as well as flexible substrates

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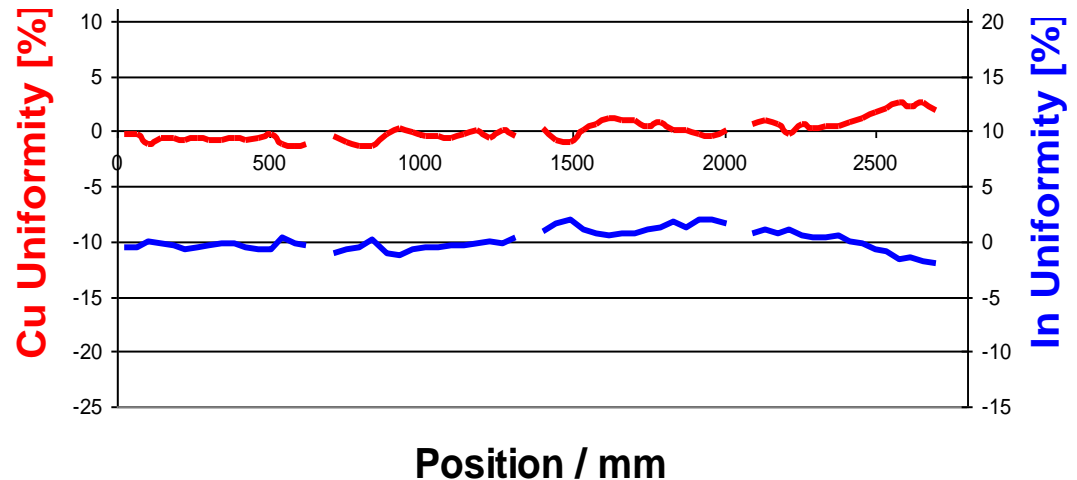
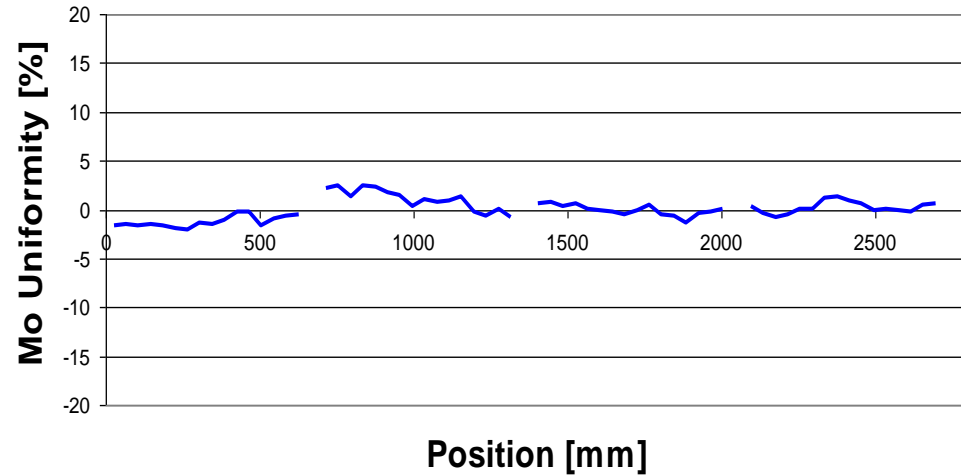
High throughput solutions for large substrates

- **Concept:** modular system, sputter down
- **Magnetron cathodes:** planar, cylindrical
- **Pre cleaning:** linear ion source
- **Heating:** double side
- **Layers:** Cu-In-Ga, AZO
- **Target size:** (for H1700)
 - **planar:** 1,700 × 250 mm²
 - **cylindrical:** 1,700 mm × 165
- **Cycle time:** < 200 s for two substrates
- **Transport system:** Both carrier free / with carriers
- **Substrate size:** Common market and customized formats
- **Target material:** AZO ceramic tube targets, CuGa alloy, In metallic



Excellent thickness distribution of sputtered films



- Proven technology
- Reproducible Thickness
- Up-scaling potential





- Low CoO due to rotatable cathodes
- No back side coating due to carrier concept
- Avoiding particles due to vertical system (7°)
- Easy and fast maintenance due to cathode concept
- Substrate Size: e.g. 1200 x 600 mm², 1100 x 1400mm² and others
- Tact time per substrate: << 60 s
- Layers: i-ZnO, AZO, Absorber layers,

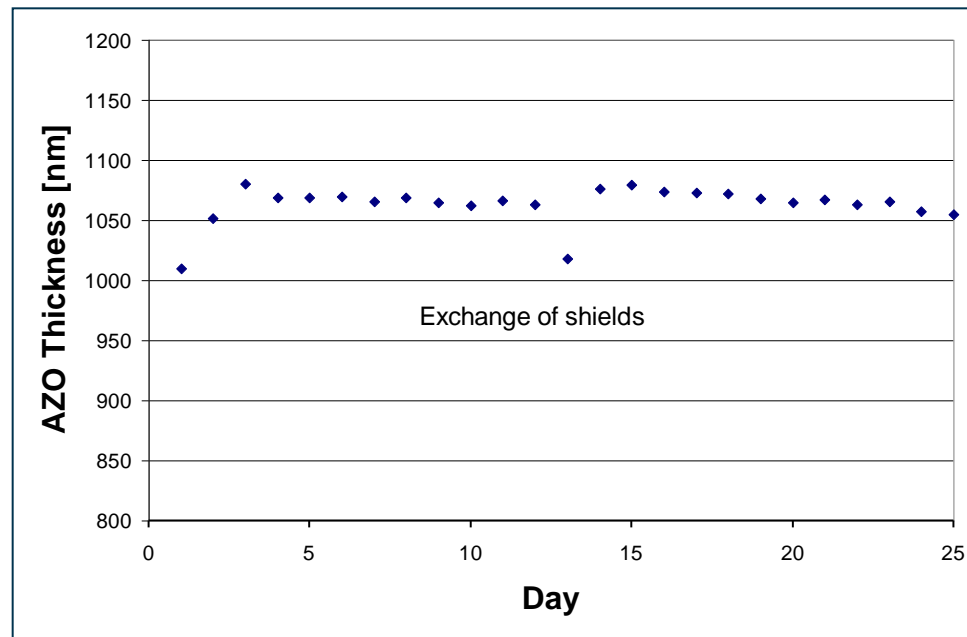
> **40%** on target costs saving through rotatable cylindrical sputter magnetron

	Target Utilization	Life Time	Targets p.a.	Target Costs	Annual Costs
	25%	75h	1024 pcs	4,450 €	4,558,972 €
	70%	343h	225 pcs	10,500 €	2,361,994 €

Cylindrical Sputter Magnetron

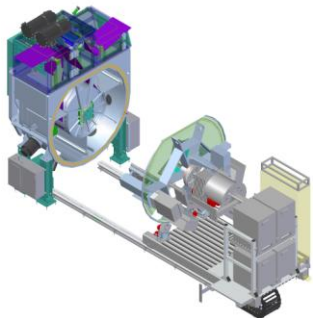
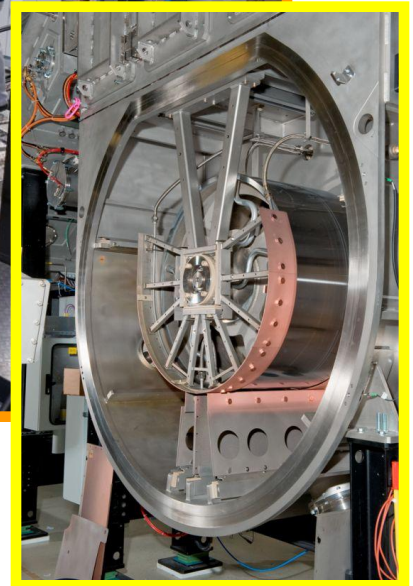
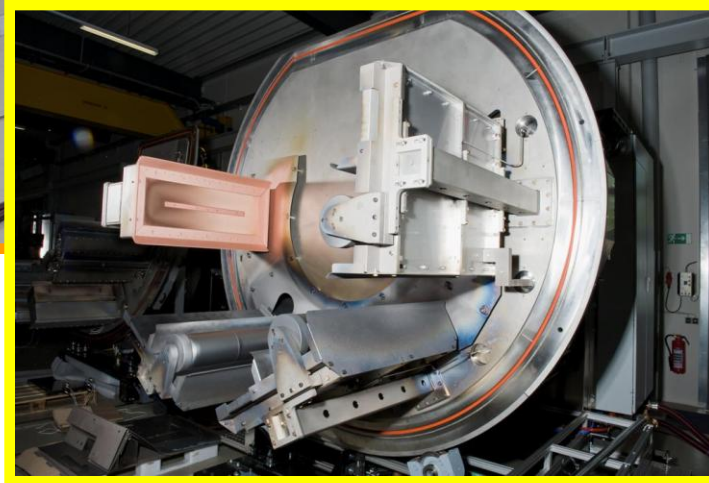
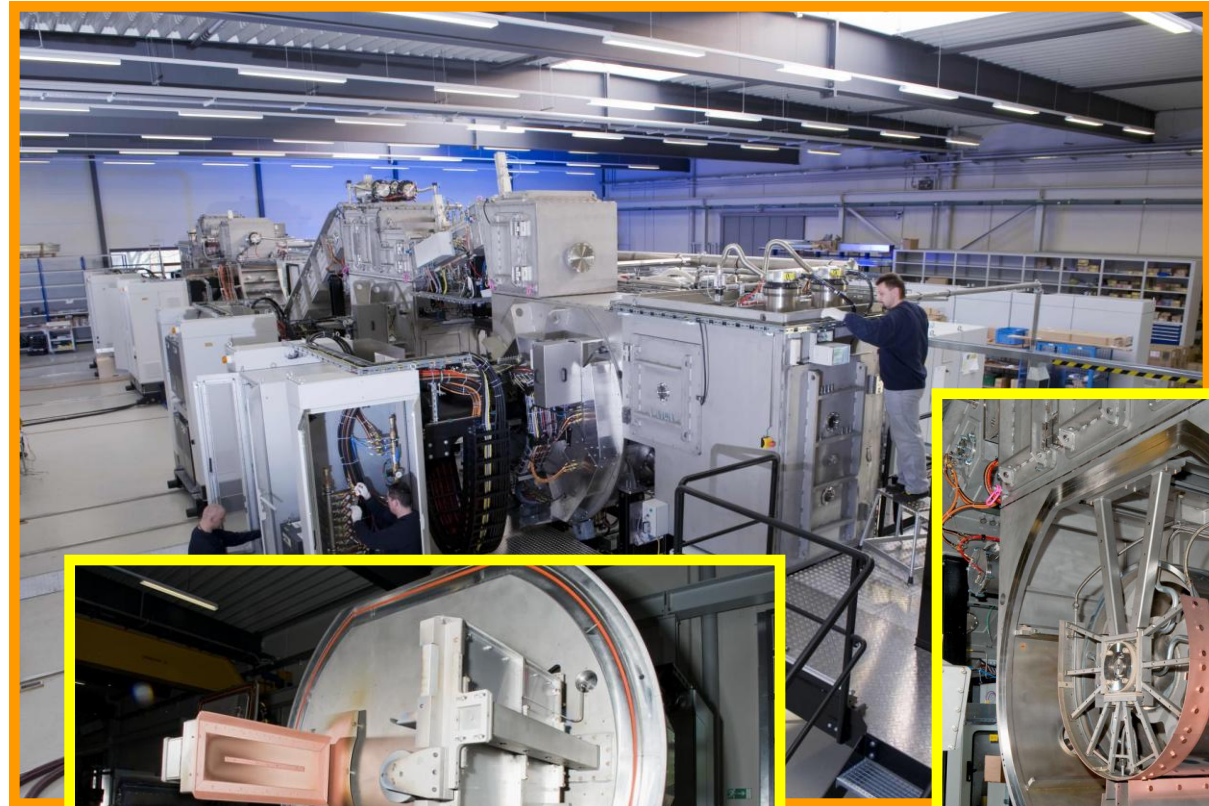
- Higher sputter rates (150 nm*m/min)
- No re-deposition zones
- TCO resistivity not subject to target lifetime

- Sputtering of AZO and i-ZnO are proven processes with excellent reproducibility
- Cylindrical magnetron sputter cathodes are the preferred choice due to its low production costs

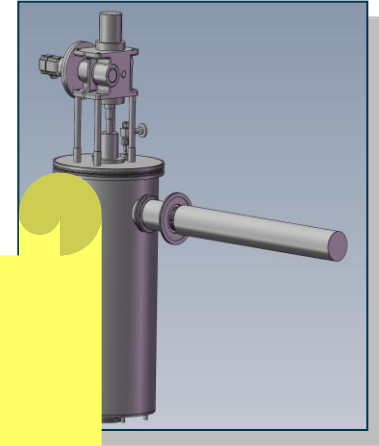
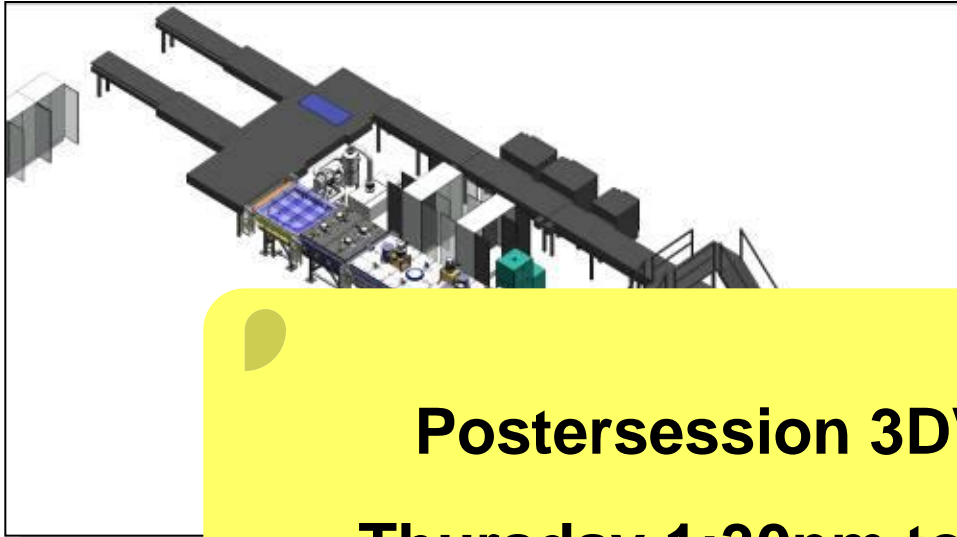


Aluminium doped zinc oxide (AZO)

Application Flexible Solar Cell



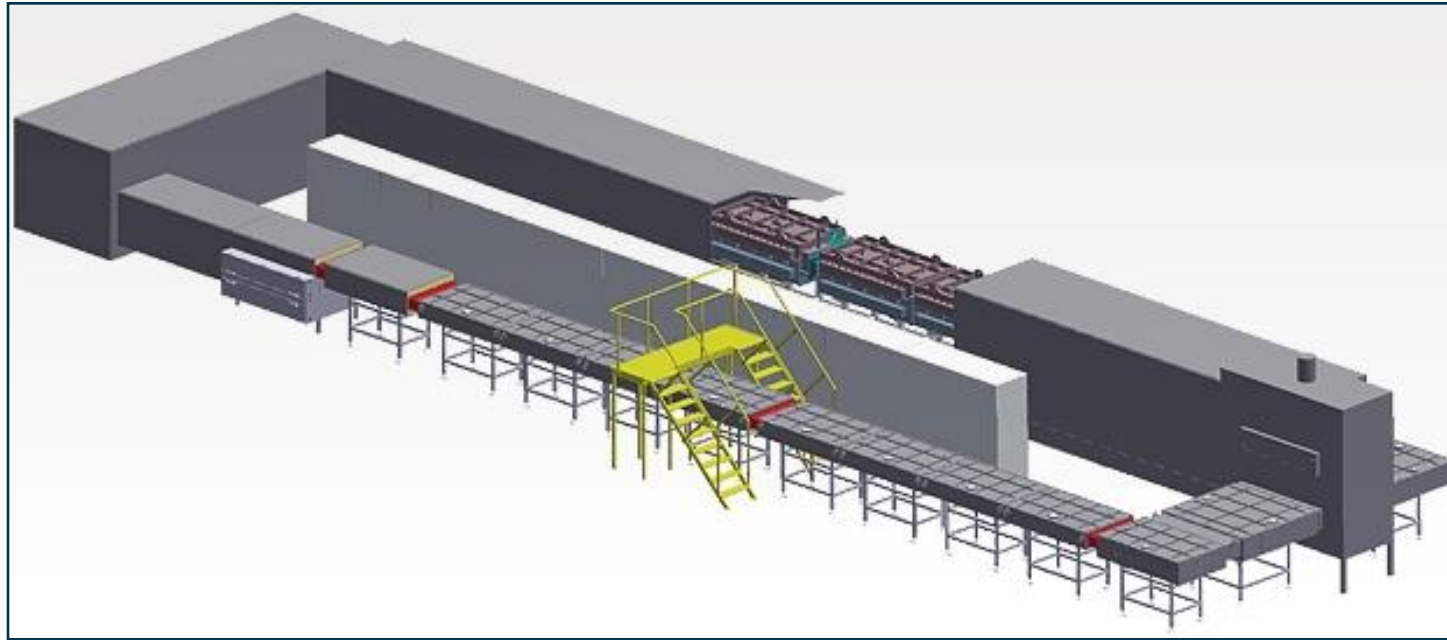
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Postersession 3DV.2 am
Thursday 1:30pm to 3:00pm

Poster ID: 3DV.2.14

- Line
- E
- F
- 7 and below thickness distribution over substrate width (600mm)
- Advanced temperature management (hot-wall principle)
- Substrate size: Common market and customized formats
- Cycle time less 50 s / substrate
- Reproducibility < 3,5% within 2 hrs productions



- **Fast and uniform heating process**
- **Heating under inert or reactive gas environment possible**
- **Cooling and absorption of excess selenium**
- **Substrate size: Common market and customized formats**
- **Substrate thickness on request**
- **Cycle time less 140 s / substrate**

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Single Equipment vs. Turn Key Solutions

Turn Key solutions are reasonable for the initial choice, there is no questions about that, especially...

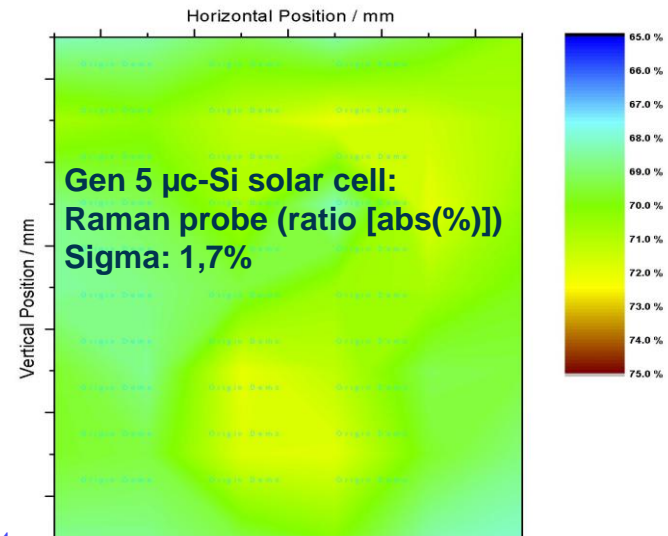
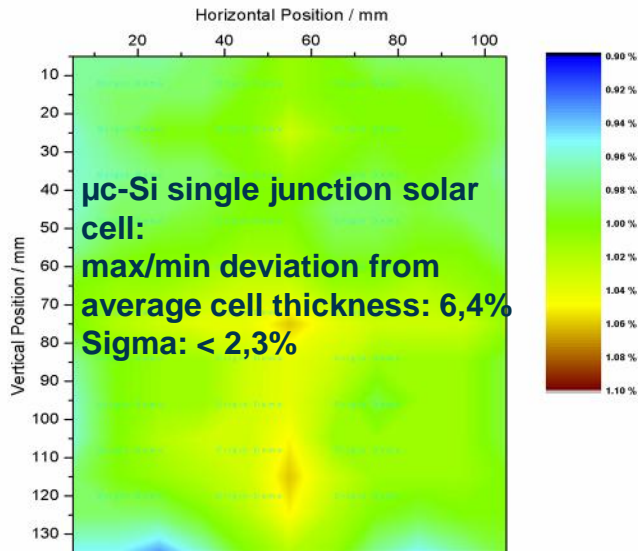
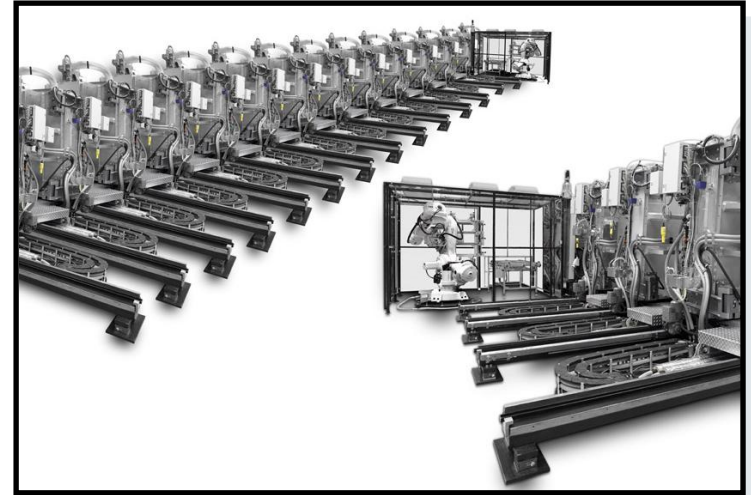
- ... if you **like to pay** for a market entry with a ready solution
- ... if you **like to pay** for capacity commitment
- ... if you **need to pay** for process know how

BUT, with Turn Key Solutions are also many painful lessons learned...

Therefore the Single Equipments are the best choice for

1. Expansions of existing lines
2. Upgrade existing and implementation independent process
3. Free choice of best available equipment

- Maintaining substrate temperature
- Continued vacuum during process
- Carrier free
- Rigorous gas separation
- High flexibility in process sequence
- Manufacturing friendly
- Insitu Cleaning
- Best available μ -Si layer uniformity and crystallinity

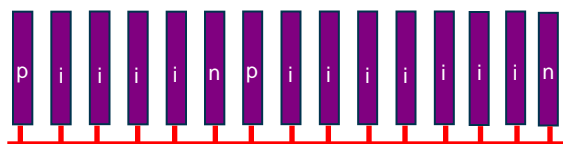


Leybold Optics

	a-Si	μc-Si
P	1	1
I	4	7
n	1	1

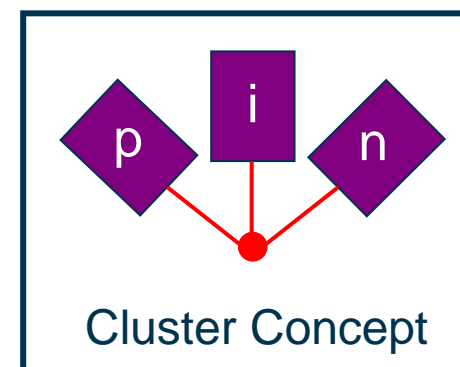
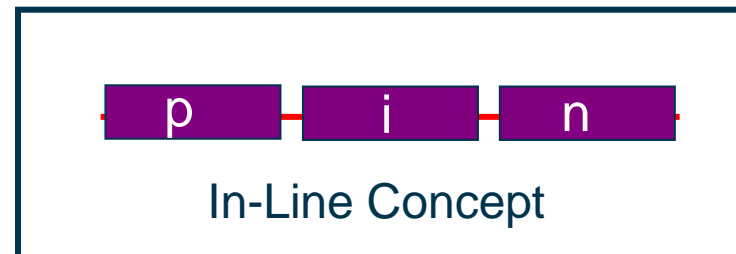
Σ

15



Linear Cluster

Others

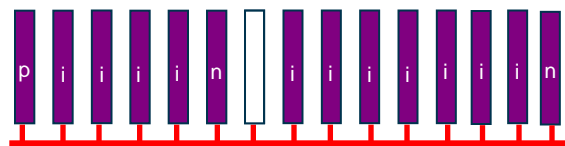


Our Advantage #1:
Highest Redundancy

Leybold Optics

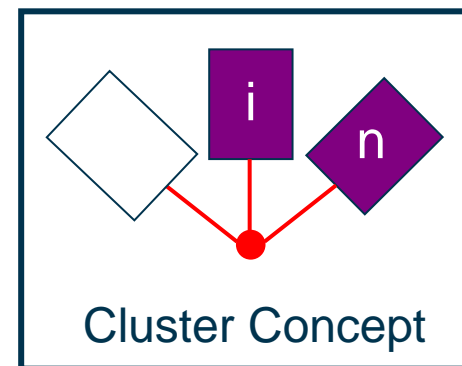
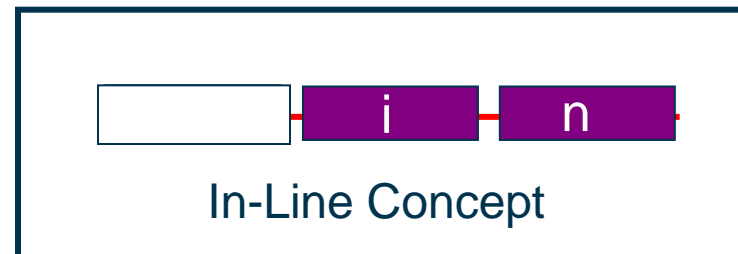
	a-Si	μc-Si
P	1	7
I	4	
n	1	

Σ 15



Linear Cluster

Others



Our Advantage #2:
Continues Production Run

Innovation Prize 2010 for “Dual-Frequency-Technology”

Exclusive License for Leybold Optics For Dual Frequency Technology (EAE effect)

Informationsdienst Wissenschaft

Sie sind hier: Home > Pressemitteilung: Bochumer Physik-Dekan erhält ...

Pressemitteilung

Bochumer Physik-Dekan erhält Plasma-Innovationspreis

Dr. Josef König, Pressestelle
Ruhr-Universität Bochum

17.12.2009 08:42



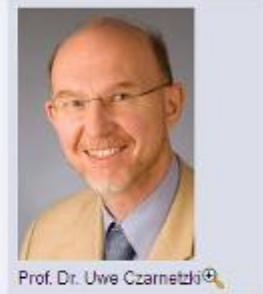
Entdeckung des “Elektrischen Asymmetrie-Effekts” wird gewürdigt
EPS Plasma Physics Innovation Prize 2010 für Uwe Czarnetzki

Prof. Dr. Uwe Czarnetzki, Dekan der Fakultät für Physik und Astronomie der Ruhr-Universität Bochum, wird für die Entdeckung des “Elektrischen Asymmetrie-Effekts” von der Europäischen Physikalischen Gesellschaft (EPS) mit dem “Innovationspreis für Plasmaphysik” ausgezeichnet. Seine Entdeckung führte letztlich zu einem innovativen Verfahren zur Kontrolle von industriellen Plasmen. Das Anwendungsspektrum der aufgrund dieser Entdeckung entwickelten Technologie reicht von der Solarzellenproduktion über Oberflächenfunktionalisierung

bis zum Halbleiterätzen in der Mikroelektronik. Der mit 3.000 Euro dotierte Preis wird im Juni 2010 bei der EPS Konferenz verliehen.

Zwei neuartige Charakteristika

Der Elektrische Asymmetrie-Effekt wurde erstmals in symmetrischen kapazitiv gekoppelten Radiofrequenzentladungen bei der Überlagerung der Grundfrequenz ($f = 13,56$ MHz) mit einer geradzahlig Harmonischen (2f, 4f, etc.) untersucht. Die gezielte Erforschung der zugrundeliegenden Physik dieses Effektes und die aus diesem Verständnis erfolgte Optimierung führten schließlich zu einem innovativen Verfahren zur Kontrolle von industriellen Plasmen. Das neue Verfahren zeichnet sich vor allem durch zwei neuartige Charakteristika aus: Zum einen ist erstmals eine wirkliche unabhängige Regelung der beiden wichtigen Prozessparameter Ionenenergie und Ionenfluss möglich. Zum anderen ist das Verfahren vor allem anwendbar auf großflächige Entladungen, die für moderne industrielle Anwendungen bedeutsam sind. Das Verfahren ist über RUBITEC, die RUB-Verwertungsgesellschaft, patentiert und an der Umsetzung zur effizienteren Produktion von Solarzellen wird mit einem industriellen Partner (Leybold Optics GmbH) gearbeitet. An der Erforschung waren neben Mitgliedern des Lehrstuhls für Plasma- und Atomphysik, insbesondere Dr. Brian Heil, auch Kollegen aus der Elektrotechnik (Prof. Dr. Ralf Peter Brinkmann, Dr. habil. Thomas Mussenbrock) sowie von der Hungarian Academy of Science in Budapest (Dr. Zoltan Donko) beteiligt.

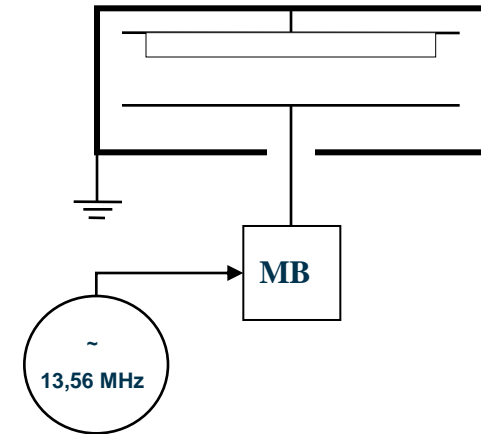


Prof. Dr. Uwe Czarnetzki

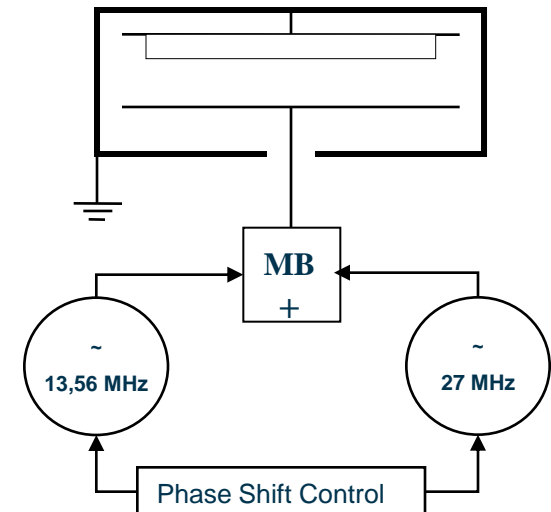
<http://idw-online.de/de/news349305>

EAE: Electrical Asymmetry Effect

Conventional RF capacitive coupled reactor



Reactor with Plasma excitation by EAE technique

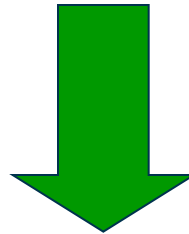


Same Chamber Design Remains!

EAE: The Advantages

EAE technique allows to create “new plasma properties”

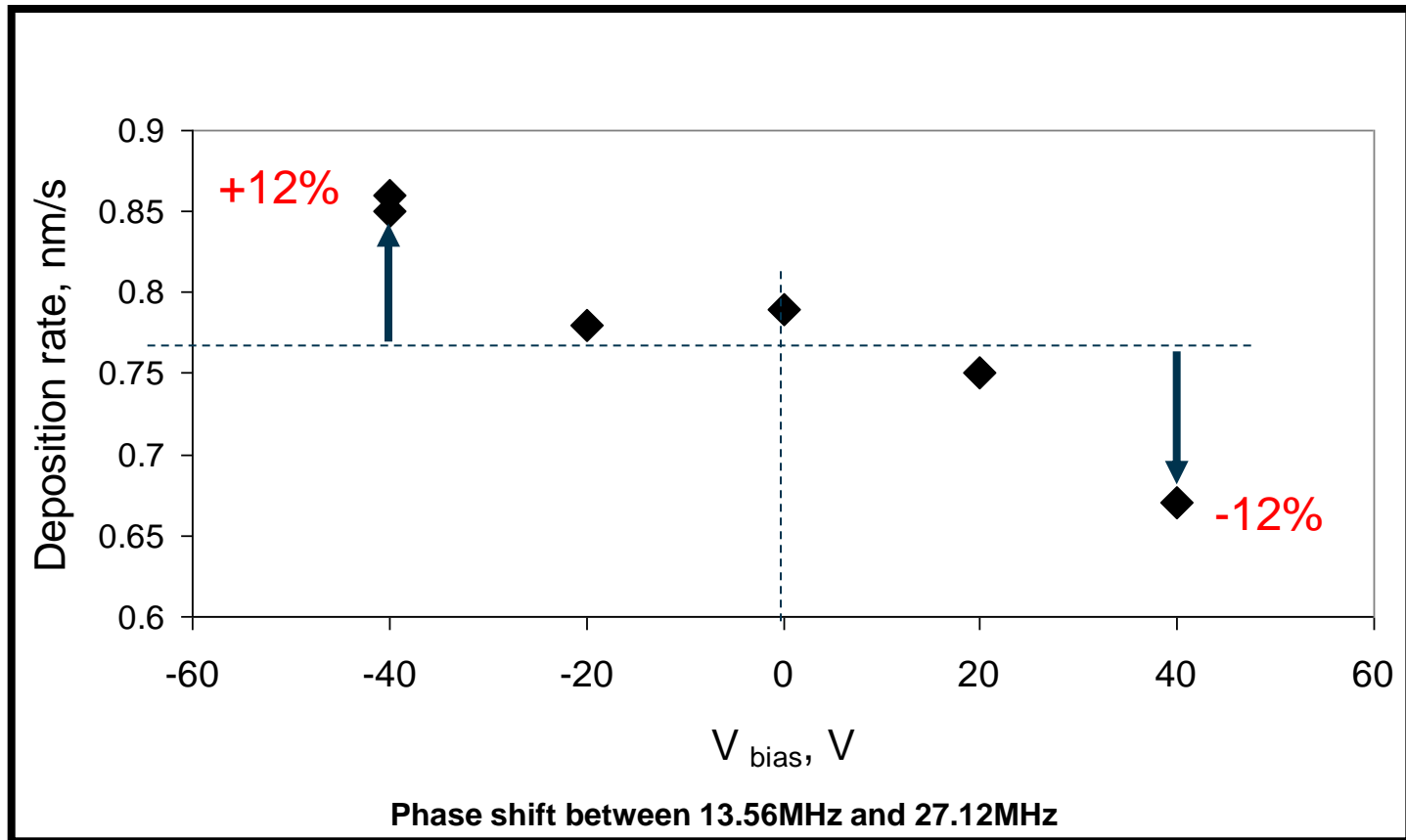
- Significant reduction of ion bombardment
- Optimized plasma positioning between both electrodes



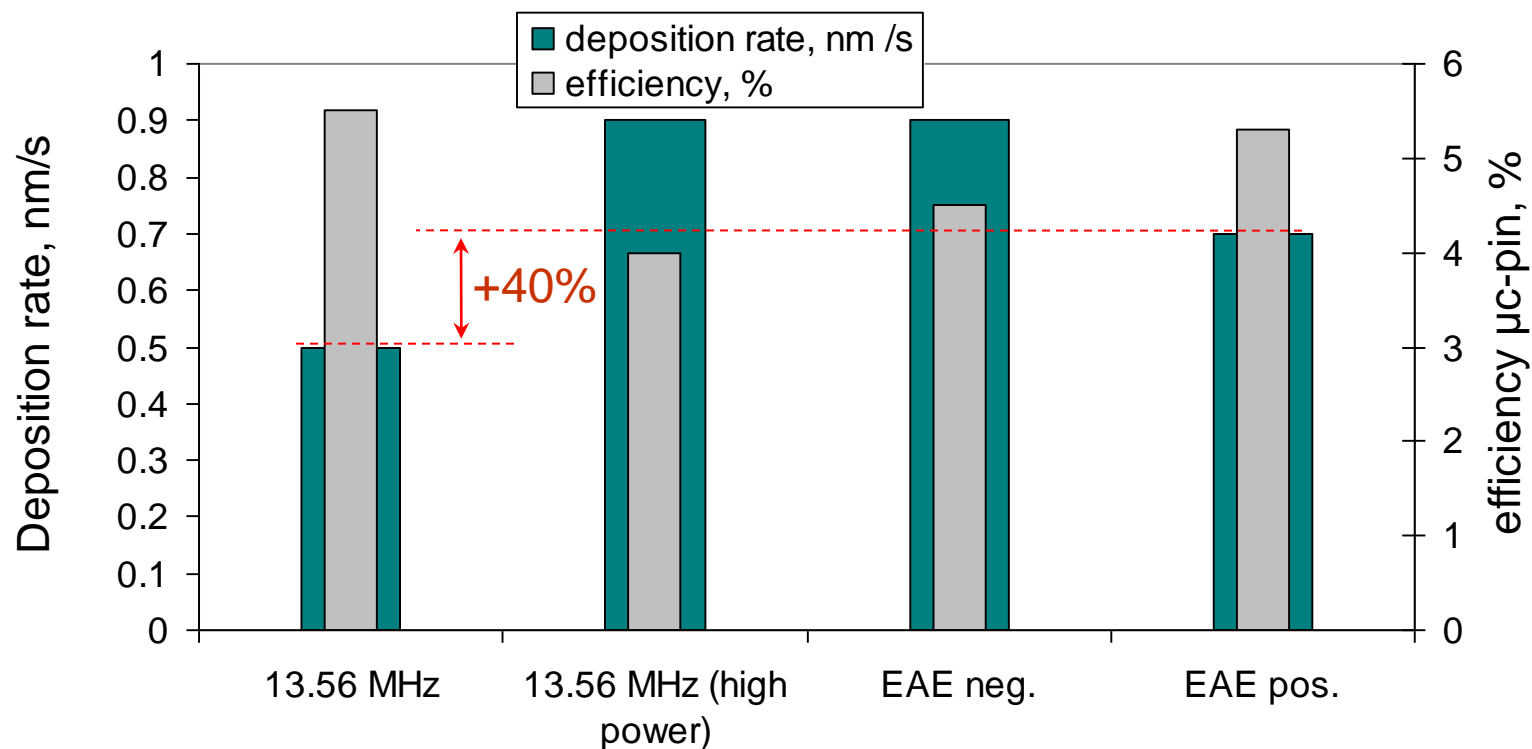
Consequences:

- Higher deposition rate
- Better uniformity,
- Better (closer) process control.

EAE: Deposition Rate of $\mu\text{-Si:H}$ i-layer as a function V_{Bias}



EAE: Significant improved of deposition rate at constant efficiency



- Company Profile
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 - PECVD Tool
- **Summary**

- **We clearly understand the requirements from each market segment due to our portfolio synergies**
- **Our core competences are the key technologies for PV manufacturing**
- **Our Tools are strong positioned and well proven in the Thin Film market**
- **Our single equipment strategy fully support customers “Cherry Picking” approach**

- **Close customer contacts through our World wide presence, especially in key market areas**



PVSEC 2011, Hamburg, Germany

You are welcome at our booth

September 5th to 8th

Visit our booth at: A1C2



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Thank you for your attention