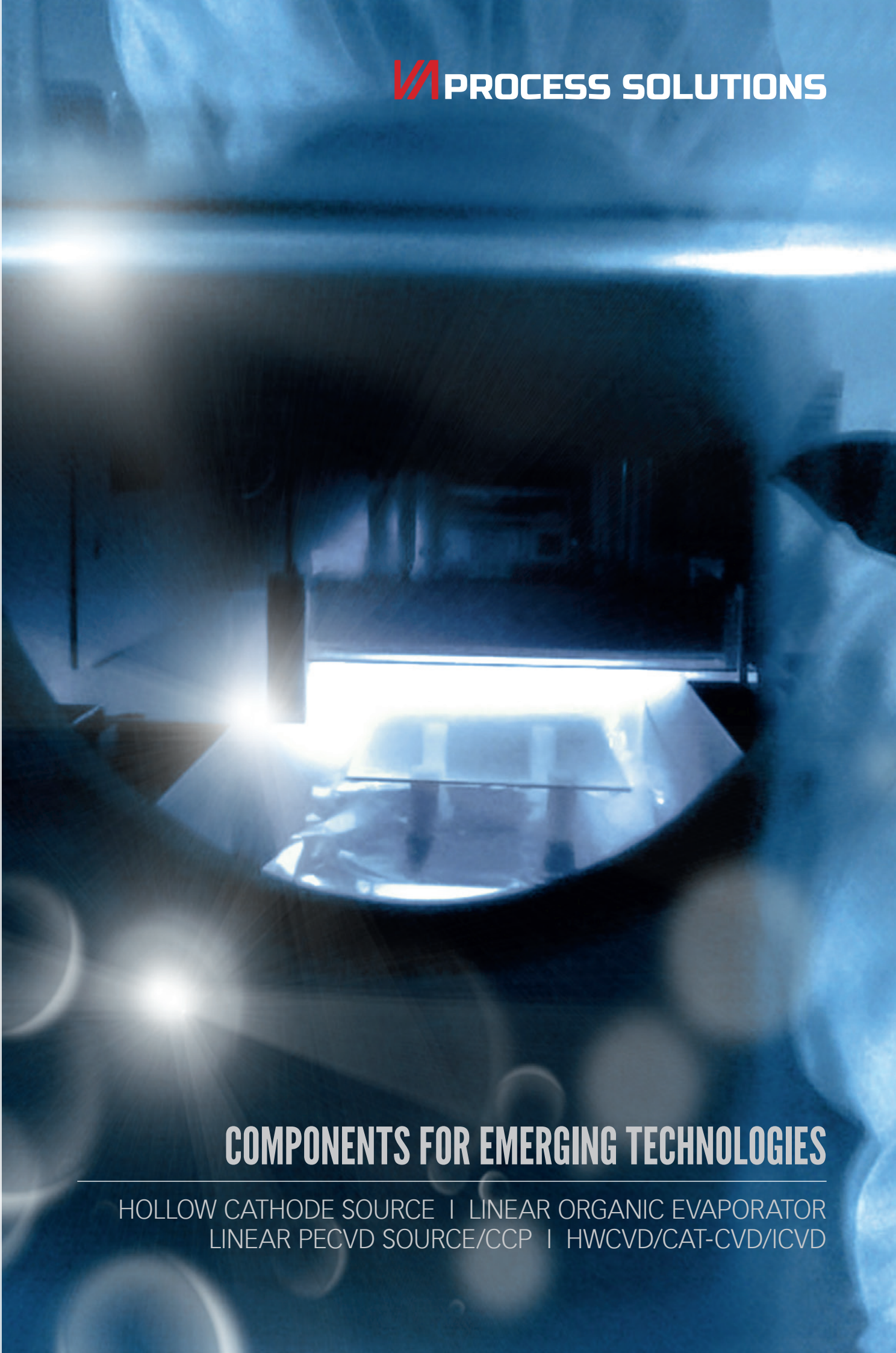
VON ARDENNE

PROVEN COMPONENTS. EXCELLENT RESULTS.



VA PROCESS SOLUTIONS

COMPONENTS FOR EMERGING TECHNOLOGIES

HOLLOW CATHODE SOURCE I LINEAR ORGANIC EVAPORATOR
LINEAR PECVD SOURCE/CCP I HWCVD/CAT-CVD/ICVD

PROVEN COMPONENTS.
EXCELLENT RESULTS.
FOR YOU.

OUT NOW!

Our components are now free to explore new horizons.

WITH YOU.

What are you looking for in a supplier of components and process solutions? Experience? Reliability? A proven track record?

VON ARDENNE equipment is used in over 50 countries. We have established an installed base of hundreds of coating systems worldwide, ranging from small tools to equipment for large-area coating applications.

Every day, our customers are facing the challenge of staying in a leading position. Why do they choose VON ARDENNE Process Solutions as their partner? Consider our **keys to success:**

Field Experience – Our technical team is comprised of engineers who have been there, in the field, delivering results. Not only does this mean we know what it takes to get the job done, in many cases we have done it before.

Simulation & Modeling – For new applications, we can guide the process design with extensive simulation and modeling capabilities. From mechanical stress, to thermal modeling, to magnetic field modeling, to charged particle motion, our team can simulate your process before we begin to ensure the highest chance of success.

Sampling Capability – VON ARDENNE has over 20 machines that are suitable for sampling. From small cluster tools to large in-line systems, we can use demonstration runs to further assure you that your process will deliver the results you need once installed.

In-House Assembly & Quality Control – VON ARDENNE builds all of our products in our facility in Germany. We conduct the most demanding quality and functional tests in the industry before shipping our products to you. We meet or exceed most of our competitor's specifications for technical performance and reliability.

Process Knowhow – By combining our hardware and process control solutions, we can deliver the highest performing processes to the most demanding specifications. Whether you are looking for the best material properties, high rates, uniformity, utilization, or all of the above we can deliver a process that meets your requirements.

Technology Knowhow – Beyond the local coating processes, VON ARDENNE offers state-of-the-art machine control solutions. From optical inspection to automated process adjustment, we add the final pieces of technology to make not only your local process run, but to make your machine perform – to deliver a product as you need it, when you need it.

Worldwide Competence Centers – A truly global organization, VON ARDENNE's subsidiaries can provide integration and startup support, service, and training. When you need it, help is always close at hand.

VON ARDENNE is more than a component supplier, we are a solution provider. Let us put our experience to work for you.

Mission – Our mission is to create value by bringing our industry leading technology and process experience to our customers.

We want to achieve that by offering state-of-the-art hardware solutions with best-in-class performance specifications and reliability. Furthermore, we offer advanced process control hardware and software solutions to control processes of single sources or in complex layer stacks settings.

It is our aim to deliver an excellent process result according to your specifications and timeline. And we are confident that we can offer you what you are looking for in a supplier.

Simulation-Driven Product Development

Vacuum System Dynamics for Complex Deposition Machines

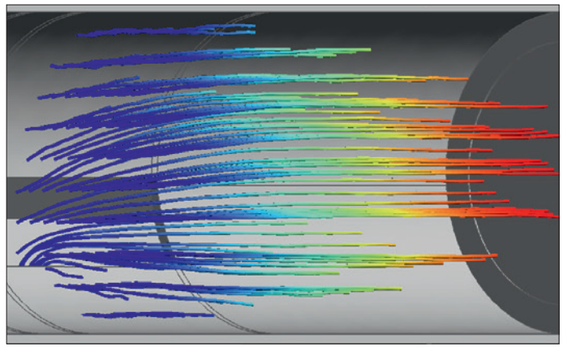
Matlab/SIMSCAPE

The conceptual design of complex and dynamic vacuum systems is extremely demanding. VON ARDENNE has accepted this challenge and has developed a MATLAB/Simscape library to model and simulate vacuum dynamics either for single compartments or overall simulations for complex vacuum deposition machines.VON ARDENNE has more than 40 years of experience in vacuum deposition and outstanding expertise in multiscale simulation to feature highly optimized system performance and to ensure best process quality originated from component design. We accelerate product development and upgrades by reducing the engineering effort with cutting-edge modelling and simulation for product planning for your individual process solution and feasibility studies for upgrading running systems.

Low-Pressure Gas Flow for Best Gas Distributions

DSMC – Direct Simulation Monte Carlo

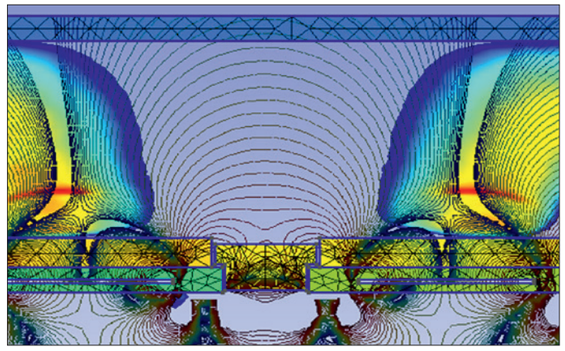
The simulation of low-pressure gas distributions in process cambers requires special numerical methods and a highly computational effort. The DSMC method is applied already in the construction and design phase at VON ARDENNE in order to achieve the best gas distributions.



Plasma Process and Magnetic Field for Excellent Film Growth

PICMC – Particle in Cell Method

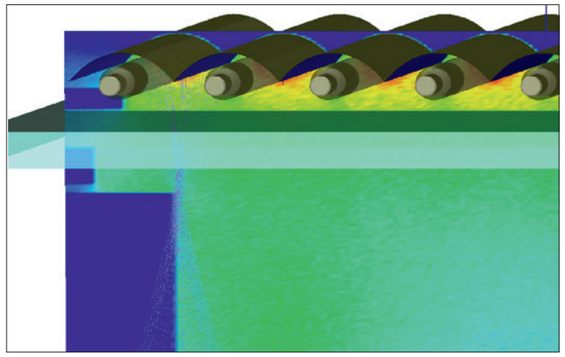
Cutting-edge thin-film technology is characterized by film homogeneity, high target utilization, film-optimized process design and other technological requirements. At VON ARDENNE, plasma and magnetic field simulations are used to analyze and improve the decisive physical process responsible for the film growth.



Optical Simulation for Outstanding Film Properties

Ray Tracing and Thin-Film Properties

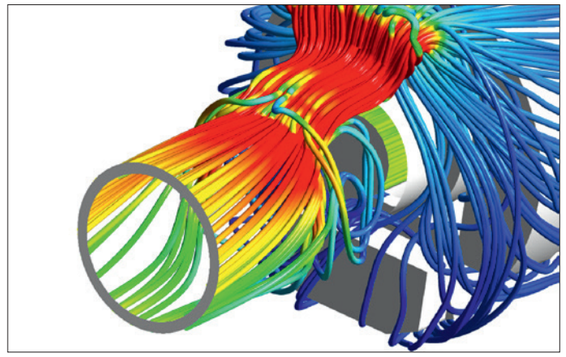
Optical simulations are widely used to achieve the most efficient design for VON ARDENNE equipment with flash-lamp based annealing and patterning technology. Furthermore, the parameters of thin films are optimized using simulation methods so that the overall optical properties meet the requirements.



Finite Element Simulations for Best Coating Results

Mechanical, Thermal, CFD, Multi-Physics

FE simulations for the analysis and optimization of different physical processes in combination with many years of experience are essential prerequisites for VON ARDENNE coating systems to meet the high quality requirements of our customers.



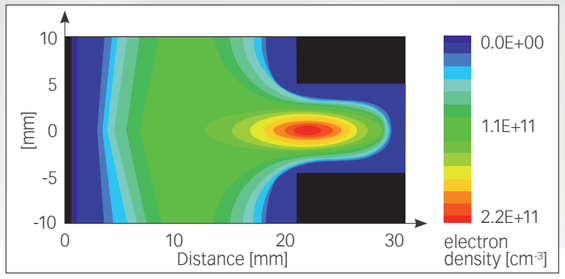
HCS Hollow Cathode Source

VON ARDENNE has developed a broad portfolio of plasma treatment sources. Surface treatment is often used as pre-treatment in the process of record (POR) in order to clean, remove or activate the topmost sheet and to create an optimal interface for the next layer that is to be deposited. This is necessary because the substrate surface is often not well defined and shows various residues, like oxides and hydroxides of the substrate material, water from the environmental air moisture, adsorbed gases and residual contaminants from previous processes. These impediments may prevent a reliable mechanical or functional layer attachment. Two of our components for surface treatment are the Linear Ion Source **LION**® and the **HCS**.

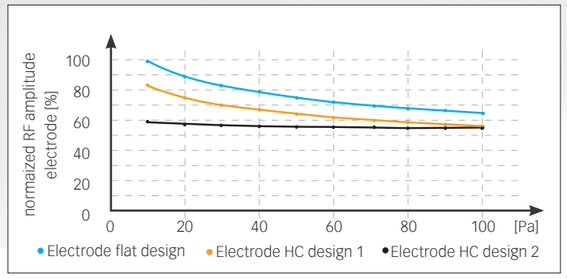
The patented **Hollow Cathode Source HCS** is characterized by a hollow structure and an integrated anode. Species generation is extensively independent from the substrate or, respectively, the carrier and occurs in front of the cathode. The substrates can either be electrically conductive or insulating.

The electrons are confined between the potential drops on the cathode's trench walls. This increases the gas ionization and, therefore, the plasma density. The superposing of plasma in the trenches result in a very intense, bright plasma below the electrode plate.

Cross section of plasma generation principle in a HCS structure



RF amplitude stability in a broad pressure range at constant power, at constant electrode-substrate distance and at constant gas flow



FEATURES

- Hollow cathode design, substrate-independent
- High electron densities and ionization efficiencies facilitate a high radical density for processing
- Scalable source for surface cleaning, activation and etching
- Coating of thin films is applicable for certain front part designs
- To be used for moving and static substrates
- Continuous sheet by sheet, carrier by carrier or roll-to-roll processing
- Integrated gas shower with optional cross flow feature
- Front part: quickly changeable, highly adoptable trench design
- Conventional CCP can be mimicked (flat front, integrated gas shower)
- Operation modes: face-up, face-down and vertical
- freely adjustable electrode distance to match process

BENEFITS

- Simple & scalable design for robust behavior & easy customization
- Can compete with CCP and ICP in high density plasma processing and at lower costs compared to ICP
- RF and VHF processing
- Low generator power
- Low discharge voltage for gentle processing
- Maintenance free (recommended sealings exchange after 5 years)
- Broad process window:
  - Working pressure depends less from electrode-substrate distance
  - RF amplitude is nearly constant over a broad pressure range
  - A change in bias and RF amplitude by alternating RF power is less pronounced compared to conventional CCP CVD

TECHNICAL DATA

Subject to change without notice due to technical improvement.

Effective substrate width	up to 3300 mm
Power supply	13.56 MHz up to 80 MHz
Substrate temperature	up to 400°C (higher on request)
Electrode distance	*manually adjustable*
Operation pressure	1 Pa to 1000 Pa = 0.01 mbar to 10 mbar
Treatment gases	C_xF_y, NF_3, SF_6, H_2, O_2, Ar, F_2, etc.
Electron density/energy	10^9 cm^{-3} to 10^{11} cm^{-3}/ 1eV

LOE Linear Organic Evaporator

The VON ARDENNE **LOE** is a component that thermally evaporates organic material in a closed crucible. The vapor is distributed through a heated pipe in the direction across the substrate and released to the substrate through a linear nozzle array.

All parts that are in contact with the organic vapor – primarily crucible and nozzle pipe – are made of ceramics that are completely inert to the OLED materials. The crucible and nozzle pipe are heated to a temperature above the condensation point of the organic materials.

The surfaces facing the substrate are shielded by directly cooled copper parts to minimize the thermal load on the OLED substrate. The system enables the inert loading and unloading of air-sensitive evaporation materials.

This component can be used for the evaporation of thermally sensible organic materials on rigid or flexible substrates for OLED or organic solar cell applications.

Beyond that, the tool can be used for the evaporation of small molecule organics for OLED devices. Another possible application is the evaporation of PbI2 and other perovskite materials for the manufacturing of perovskite photovoltaic cells.

Furthermore, the Linear Organic Evaporator can be used to create easy to clean (ETC) coatings by the evaporation of water and oil repellent perfluoropolyethers and other ETC chemicals.

FEATURES

- Evaporation of small-molecule materials
- Evaporation of solid or fluid precursors
- Single, co-, or triple evaporation
- Vertical or horizontal operation
- Substrate width up to 1200 mm

BENEFITS

- Linear organic source enables inline processing of organic devices at high throughput
- Optimized thermal design minimizes heat impact on evaporant and substrate for processing of sensitive organics
- Superior homogeneity and stability of rate allows precise optimization of organic stacks to produce highest efficiency OLED and OPV devices
- High material utilization of costly organics keeps product costs in acceptable range
- 100 % inert materials in vapor path

TECHNICAL DATA

Subject to change without notice due to technical improvement.

Source setup	single and co-evaporation
Substrate width	300 mm to 1200 mm
Source-to-substrate distance	120 mm to 250 mm
Operating temperature	100 °C to 700 °C
Dynamic deposition rate Alq_3	200 nm*m/min
Dynamic deposition rate α-NPD	200 nm*m/min
Cross thickness homogeneity	± 2 %
Rate stability	± 2 %
Crucible volume	250 cm^3 to 2000 cm^3

LINEAR PECVD SOURCE/CCP

Apart from physical vapor deposition (PVD) sources, VON ARDENNE offers various chemical vapor deposition (CVD) sources. The CVD technology enables certain layer characteristics which can either not be obtained with PVD at all, or only at high effort and costs. VON ARDENNE supplies physically-enhanced CVD (PECVD) sources with particular, tweaked matchboxes and generator systems, as well as gas supply systems.

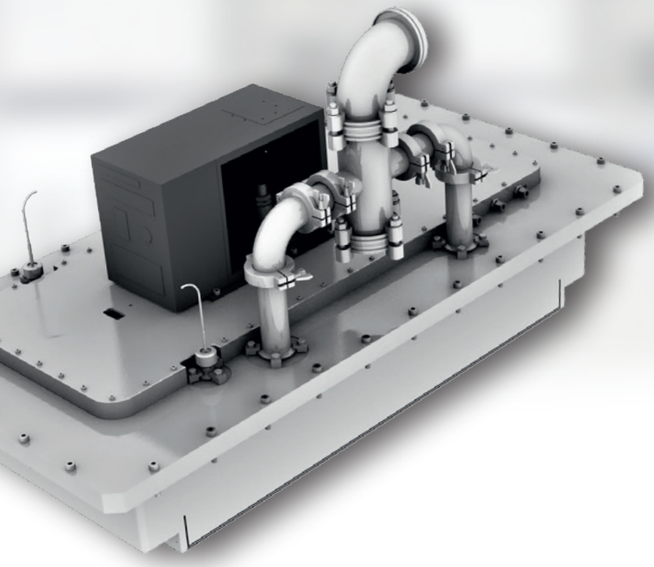
Remark: For static mode PECVD chambers and sources, please consult the VON ARDENNE Modular Process Systems brochure.

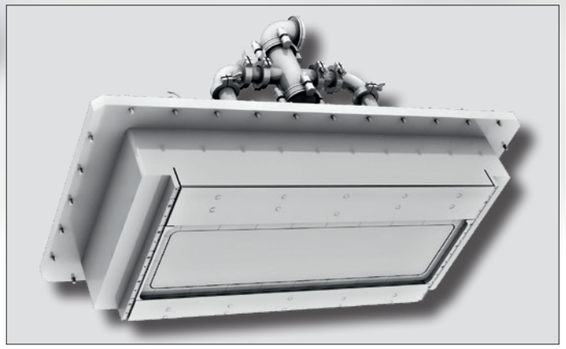
The Linear PECVD source is similar to standard static capacitively coupled plasma electrodes. However, this particular VON ARDENNE source is run in inline dynamic mode: The substrate, carrier or web is permanently moved past the electrode and continuously coated.

Even though it requires major mechanical and electrical efforts to coat large substrates homogeneously in static mode by CCP CVD, the linear PECVD source reduces the parameter space in a one-dimensional task. Even deposition scenarios with the application of very high frequencies (VHF) for higher deposition rates can be neatly dealt with. In principal, all static lab-scale CCP CVD processes can be easily transferred to high-throughput dynamic coating by this PECVD source.

The CCP CVD source is equipped with an integrated sidelong gas supply and distribution system and a process gas extraction system. The harmonized interplay of gas supply, electrode and gas extraction permits homogeneous coating on the moving substrate. The source can be cleaned by standard etching methods, facilitating the use of gases like O_2, SF_6, NF_3, F_2 or C_xF_y.

It is available in steel or aluminum. The particular, tweaked matchbox is an integral part of this device. Thermocouples provide additional process surveillance.





FEATURES

- Capacitively coupled dynamic PECVD for moving substrates
- Continuous sheet by sheet, carrier by carrier or roll-to-roll processing
- Integrated sidelong gas distribution system
- Integrated process gas extraction system
- Free operation modes: face-up, face-down and vertical
- Adjustable electrode distance to match process
- For plasma chemical etching, surface engineering and material deposition

BENEFITS

- Scalable high-throughput option for all state-of-the-art CCP CVD processes
- Dynamic deposition on various substrates
- Enables high layer homogeneities
- Permits large area deposition at RF and VHF
- Long campaign deposition runs for different set-ups and materials
- High durability
- Maintenance free (recommended sealings exchange after 5 years)
- No starting layer on substrate

TECHNICAL DATA

Subject to change without notice due to technical improvement.

Substrate width	up to 3300 mm
Power supply	13.56 MHz to 80 MHz (higher on request)
Substrate temperature	up to 400°C (higher on request)
Electrode distance	*manually adjustable*
Operation pressure	1 Pa to 1000 Pa = 0.01 mbar to 10 mbar
Process gases	SiH_4, H_2, NH_3, C_xH_y, SF_6, O_2, NF_3, F_2, C_xF_y, etc
Doping gases	Dopant hydrides (B_2H_6, PH_3, etc.) , TEB, TMB, TMP
Layer thickness inhomogeneity	± 1 % to 3 %

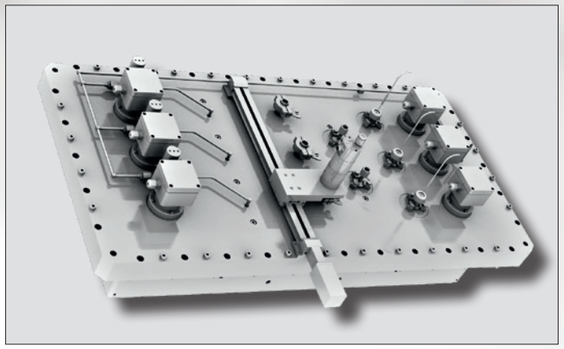
HWCVD/CAT-CVD/ICVD

Pioneered by Prof. Matsumura in 1983, catalytic CVD is a very effective deposition technology. Driven by a hot wire, precursor molecules are exothermically dissociated, activated and finally deposited on a substrate. This deposition method is not plasma enhanced, therefore accelerated ions do not exist. A very smooth, highly conformal deposition with very low internal layer stress can be accomplished at high deposition rates.

Using hot wires to do plastic polymerization out of the monomer phase without solvents is referred to as initiated CVD or iCVD, respectively, if a thermally labile initiator is additionally fed into the stream of monomers. This production method was initially explored by Prof. Karen K. Gleason. It allows controlling finely the possible reaction pathways and fully retaining the polymer characteristic. By depositing polymers from the vapor phase, many wetting and solution effects are avoided, and conformal films can be created.

VON ARDENNE offers hot wire sources for catalytic CVD and iCVD applications. For inline and dynamic deposition processes a particular line source is available. It consists of a especially designed source flange and a quick to install wire subcomponent, which facilitates shorter downtimes by simply exchanging the entire subcomponent, if necessary.

In order to have a longer productive coating time, the HWCVD source can be equipped with independent sub-sources. In the case of wire degradation, a currently running sub-source can be switched off while another sub-source overtakes the process. The source can optionally be equipped with a pyrometric measuring device for e.g. precise wire temperature readings.



FEATURES

- Inorganic (e.g. SiH_4) and organic (e.g. C_xH_y, plastic monomers) precursors usable
- Integrated gas distribution system
- Continuous sheet by sheet, carrier by carrier or roll2roll processing
- Free operation modes: face-up (limited), face-down (limited) and vertical
- Adjustable wire distance to match process
- Integrated thermocouples
- Optional pyrometer for process control and surveillance

BENEFITS

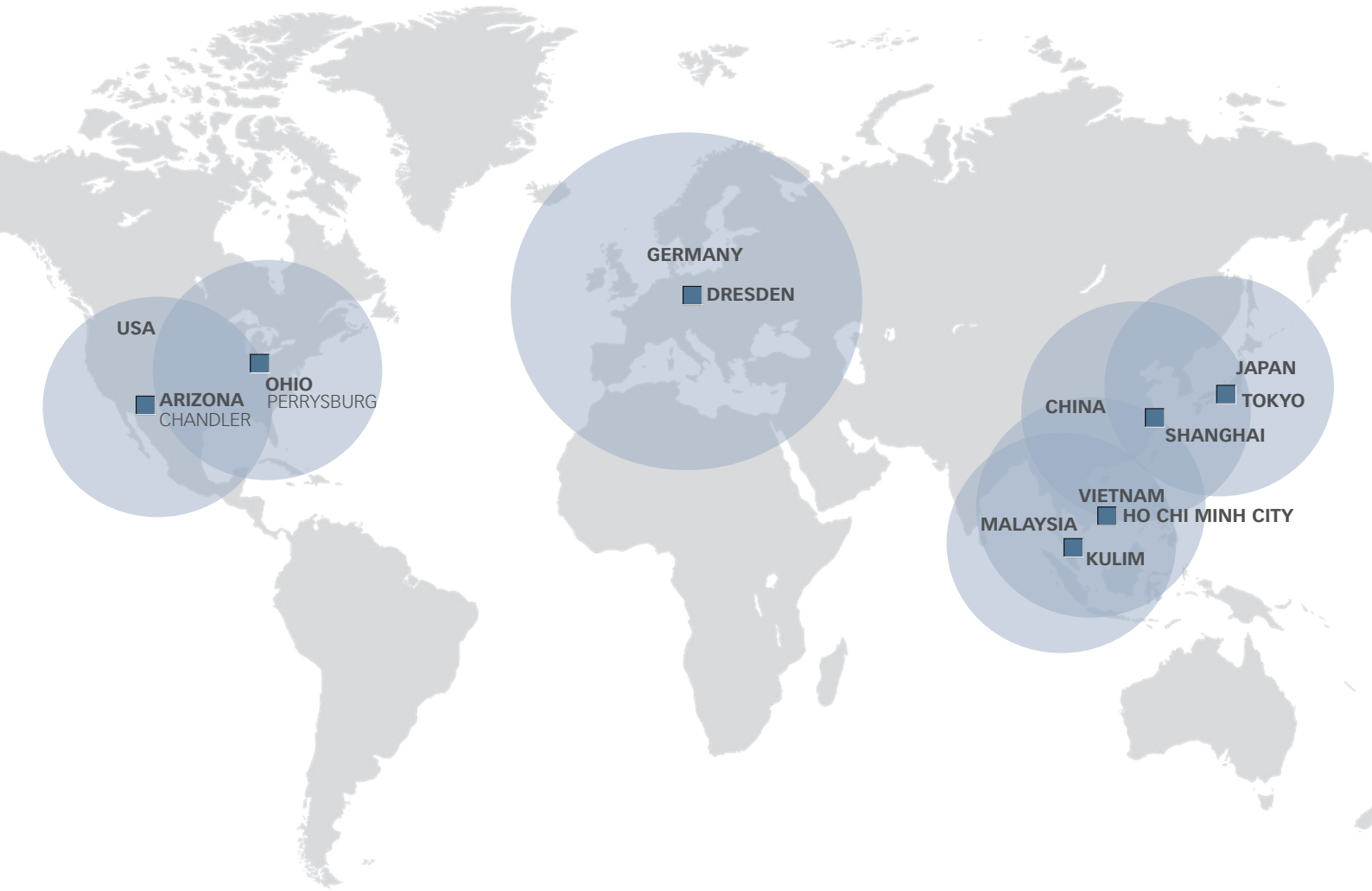
- Divided source design with separated wire mounting for quick exchange and quick process restart – the uptake flange simply stays on the lid or door
- Wires can be energized in selectable form which can be used to prolong coater's productive uptime
- No plasma process: No ion bombardment, no field accelerated electrons and therefore smooth and highly conformal layer deposition with low internal stress
- Inherently free of dust
- Deposition rate up to factor 10 higher than PECVD processes
- No RF equipment
- High gas utilization of 40 % to 80 % and very low parasitic deposition in pumps and ductwork

TECHNICAL DATA

Subject to change without notice due to technical improvement.

Dep. rate silicon (a-Si/µc-Si)	1 nm/s to 12 nm/s *
Dep. rate Si_xN_y	3 nm/s to 7.3 nm/s **
Dep. rate PTFE	2.2 nm/s to 6.1 nm/s ***
Substrate width	up to 1600 mm (higher on request)
Power supply	DC or AC (50 Hz to 60 Hz)
Substrate temperature	up to 400 °C (higher on request)
wire distance	*manually adjustable*
Operation pressure	10^{-3} to 10^{1} mbar
Layer thickness inhomogeneity	± 1 % to 3 %

Ref. literature:
*) A.H.Mahan/ Solar Energy Materials & Solar Cells 78 (2003) 299–327
**) R.E.I. Schropp / Thin Solid Films 595 (2015) 272–283
***) Hilton G. Pryce Lewis†, Jeffrey A. Caulfield‡, and Karen K. Gleason*† / Langmuir, 2001, 17 (24), pp 7652–7655



PRODUCT TOPICS | PRODUCT INDEX | COMPONENTS

www.vonardenne.biz

WHO WE ARE & WHAT WE DO

VON ARDENNE develops and manufactures industrial equipment for vacuum coatings on materials such as glass, wafers, metal strip and polymer films. These coatings give the surfaces new functional properties and can be between one nanometer and a few micrometers thin, depending on the application.

Our customers use these materials to make high-quality products such as architectural glass, displays for smartphones and touchscreens, solar modules and heat protection window film for automotive glass.

We supply our customers with technologically sophisticated vacuum coating systems, extensive expertise and global service. The key components are developed and manufactured by VON ARDENNE itself.

Systems and components made by VON ARDENNE make a valuable contribution to protecting the environment. They are vital for manufacturing products which help to use less energy or to generate energy from renewable resources.

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