

VON ARDENNE 

**EQUIPMENT FOR  
HIGH-EFFICIENCY SOLAR CONCEPTS**

CS | HISS | XEA|nova 5.5 | XEA|nova L

EQUIPMENT FOR HIGH-EFFICIENCY SOLAR CONCEPTS

## Our History & Experience

VON ARDENNE was founded in 1991 as a spin-off of the former Manfred von Ardenne Research Institute. The company is based in Dresden, Germany, with subsidiaries in China, Japan, Malaysia, the USA, India and Vietnam.

The family-owned company develops and manufactures advanced coating equipment for the deposition of ultra-thin functional layers on materials such as glass, metal strip, wafers and polymer films. Two key technologies are applied by our equipment: magnetron sputtering and electron beam evaporation.

The major international manufacturers of crystalline and thin-film solar modules use our highly productive equipment for their production. We are also cooperating closely with them to develop the next generation of modules that will be even more efficient.

We have acquired an excellent process know-how based on the more than 300 coating systems we have installed for crystalline solar cells and thin-film solar module providers. This expertise has been incorporated into the development of coating systems for the next generations of high-efficiency solar cells.

VON ARDENNE is a major player in the n-type market with the modular **XEA|nova** wafer coating system, which can be configured according to the needs of our customers. Such coating systems for an overall capacity of more than 35 GW are shipped to production lines all over the world. The double-sided coating of wafers in just one coating cycle is just one of the features of this highly productive and flexible tool, which is suited for both standard and special wafer formats.

The two driving factors in the industry are increasing the productivity and lowering the manufacturing costs for the cells. Our latest coating system, the **XEA|nova L**, is designed to accommodate these factors.

This trend will continue to shape the development of the industry, which has the aim to consolidate the status of photovoltaics as a reliable and economic source of renewable energy. Therefore, VON ARDENNE will keep working on new high-efficiency cell concepts that will only be possible thanks to our highly productive and precise thin-film deposition technology.

With our flexible, modular **CS** and **HISS** platforms, we offer the ideal coating systems for research and development tasks as well as for pilot production.

MARKET  
LEADERSHIP

N-TYPE  
TECHNOLOGY

> 35 GW\*

THIN-FILM  
PHOTOVOLTAICS

> 34 GW\*

\*PROVIDED CAPACITY

## High-Efficiency Solar Cell Concepts

Investing in photovoltaics means investing in sustainable economic development while minimizing the dependency on fossil or nuclear energy sources. It also means securing ecologically benign growth. However, for PV to become a competitive source of electricity production, the levelized cost of electricity (LCOE) from PV would have to decrease below residential and wholesale electricity prices.

### Tandem Cells

The next major step beyond 28 percent cell efficiency will be taken with the help of tandem cell concepts. They feature a stacked cell structure with two diodes. The top cell can be applied to a functional silicon bottom standard cell by means of fully integrated layer stack application and thin-film deposition.

#### VON ARDENNE Scope of Supply

... High-performance TCO interconnection layer and the full stack of electrical active layers to build up tandem top cell: ETL, perovskites, HTL

### Heterojunction Technology - HJT

With this cell concept, highest conversion efficiencies can be reached by means of almost perfectly passivating amorphous silicon layers applied to both sides of the silicon wafer. This is one of the most elegant and simple cell structures to aim for maximum single junction cell power.

#### VON ARDENNE Scope of Supply

... High-performance TCO contact layers and metalization

### Interdigitated Back Contacts - IBC

This exclusive, highly efficient cell structure offers optimized light absorption by means of an unshaded cell front and electrically functional layers applied structurally to the cell rear.

#### VON ARDENNE Scope of Supply

... High-performance metalization layers and back side mirror combined with lowest cost of ownership

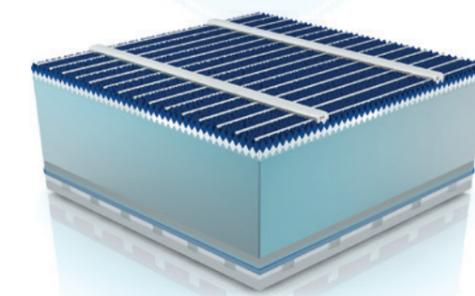
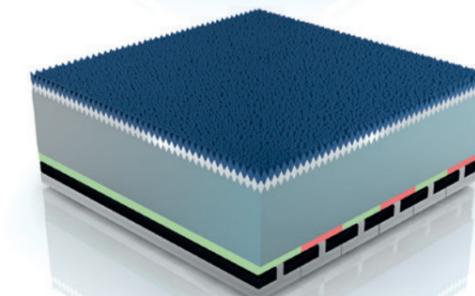
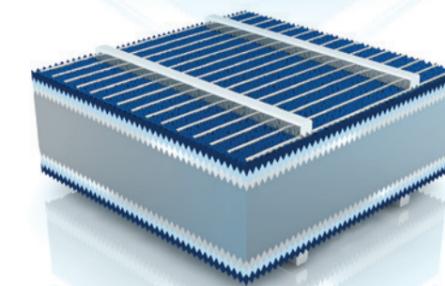
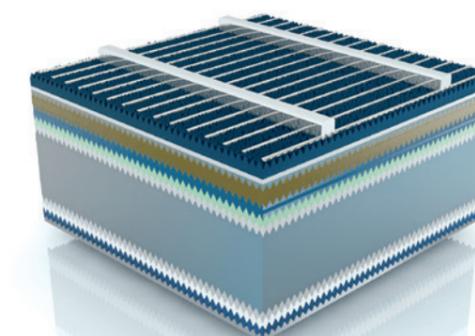
### Passivated Contacts Development

Next-generation PERC technology – this is what you could call such a structure which further minimizes local recombination centers. A smart scheme of functional passivating and contacting layers is applied at the rear side of the cell by means of highly scalable thin-film deposition techniques.

#### VON ARDENNE Scope of Supply

... Single-sided deposition of in-situ doped amorphous silicon as well as SiN layer for hydrogenation

In order to meet this market demand, manufacturers of PV components need to offer more efficient and more reliable products at lower prices. High conversion efficiency and high lifetime are key. For that reason, high-efficiency crystalline silicon solar cell technology will be introduced in production. All of the concepts require new high-quality thin films in order to build up appropriate cell structures applied by means of highly productive deposition methods. VON ARDENNE provides the necessary technology and equipment.



# Core Technology Based on a Long Tradition

## Industry-Proven, Reliable and Advanced Sputtering and Evaporation Technology

### Magnetron Technology

The main technology used for coating on VON ARDENNE equipment is magnetron sputtering. We develop and manufacture the necessary components such as magnetron sputtering sources in-house and have more than 45 years of experience with magnetron sputtering.

### VON ARDENNE Magnetrons

VON ARDENNE magnetrons are available for a wide range of applications. Thanks to many years of experience, we can offer a complete portfolio of solutions from RF and AC to DC processes, planar to rotatable applications and even magnetrons with integrated turbopumps such as the RDMT.

### VON ARDENNE Electron Beam Technology

VON ARDENNE develops and manufactures electron beam systems for melting, refining, evaporation or heat treatment. Our more than 60 years of experience are reflected in over 400 electron beam systems installed worldwide.

### Sputter Components and Technology



#### Magnet Bars

All magnet bars and magnet systems are similar in mechanical design and therefore interchangeable.



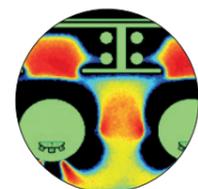
#### X-Series End Blocks

With our state-of-the-art X-Series end blocks, we offer both drop-in and cantilever solutions for our coating systems.



#### Process Control

The VON ARDENNE process control system VAPROCS2 controls the reactive magnetron sputtering of compound layers.



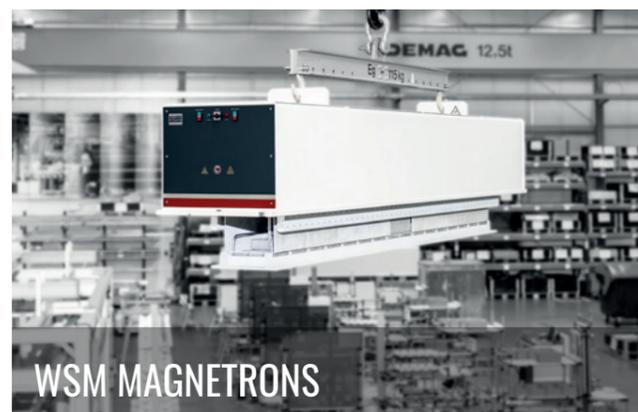
#### Dual Anode Sputtering

Dual Anode Sputtering (DAS) is an industrially proven coating technology. It can be applied for highly-resistive target materials such as intrinsic tin oxide (i-ZnO). The DAS method guarantees a good availability of the anode as it is cleaned periodically, even when dielectrics are sputtered.



#### Trimming & Shimming

A web-based trimming and shimming software is available. It enables the quick optimization of the thickness uniformity of single layers. Upon request, an online adjustable magnet bar can be offered.



# Features and Benefits of VON ARDENNE Equipment

## Modular, Scalable and Flexible Design Based on German Engineering

### Individual Process Chambers

The process chambers can be configured individually based on the flexible VON ARDENNE compartment system. They have a scalable design and can be configured according to the requirements of our customers. The components of our systems are fitted with what has proven in the industry for many years.

### Transport System

The substrate transport system used in our equipment can be either carrier-less or carrier-based depending on the process and the requirements of the customer. The customer can also choose between systems with a horizontal or a vertical substrate transport.

Furthermore, there are two drive modes, one for use in vacuum and one for operation under atmospheric pressure. The substrates can be transported either as a single item or as multiple items in a batch.

### Heating Control System

The VON ARDENNE advanced heating control system is the first solution worldwide for the reliable and even heating of substrates before and during the coating process. The system is characterized by easy operation and helps increase the efficiency of the production process and lower operating costs. The reliable and quick setting of the substrate temperature within narrow tolerances and the high temperature uniformity shorten the ramp up time and minimize breakage and scrap.

The VON ARDENNE advanced heating control system is a standard component for heating treatment.

### Cooling System

The VON ARDENNE solution for the critical phase of the temperature treatment is our uniquely designed substrate cooling station that is positioned downstream the vacuum chambers. It cools by means of the air convection principle.

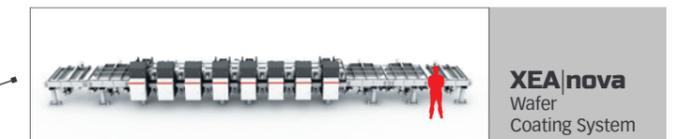
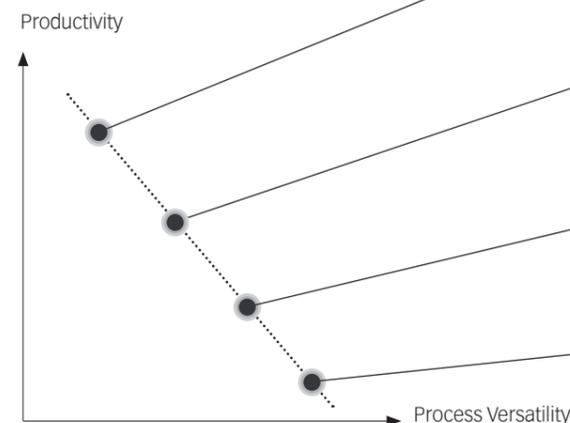
#### Benefits

- ... Quick setting of substrate temperature shortens ramp up time
- ... High temperature uniformity
- ... Reliable temperature control even during standby and transport system failures (gap handling, jam)
- ... Minimized glass consumption during conditioning
- ... Fast cool down of system in case of failures or maintenance
- ... Good fault tolerance in case of failure of heaters or other components

### Scalability

VON ARDENNE provides advanced PVD coating equipment, key components and technology expertise for all scales of production, from laboratory tasks to high-volume manufacturing.

Our laboratory-scale coating systems and pilot production tools use the same key components as our systems for industrial production, however at a smaller scale. Thus, our customers can test their applications under laboratory conditions and save time when they scale their products up to a larger productivity or for mass production.



## APPLICATION

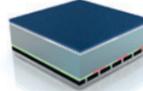
### HJT

... High-performance TCO contact layers and metalization



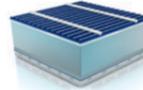
### IBC

... High-performance metalization layers and back side mirror combined with lowest cost of ownership



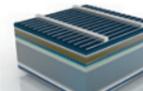
### Passivated Contacts

... Single-sided deposition of in-situ doped amorphous silicon as well as SiN layer for hydrogenation



### Tandem Cells

... High-performance TCO interconnection layer and the full stack of electrical active layers to build up tandem top cell: ETL, perovskites, HTL



Our cluster systems are based on a platform with many modular units. Therefore, every tool can be configured according to your specific applications. On top of that, special features can be integrated to meet your demands. Thanks to this flexibility, VON ARDENNE cluster systems will help you reduce your cost of ownership.

### Load Lock with Transfer Unit



### Load Lock with Magazine



### Load Lock



### Etching



### Heater



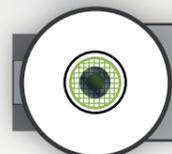
### ALD



### PECVD



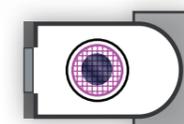
### Evaporation



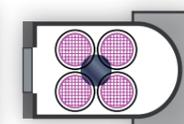
### Rotatable Magnetron



### Sputtering planar



### Sputtering focal



### Loading/Unloading Station

The entry load lock chamber enables substrate loading without venting the process chambers of the system.

Different versions are available featuring single substrate storage or a substrate magazine.

A load lock with a transfer unit can optionally be equipped with a heating or/and a glow discharge module.

### Pre-/Post-Treatment Chambers

The pre-treatment chambers can be fitted with components for preparing the substrate for the coating process such as: glow discharge device, inverse sputter etcher, ion source or heater.

The heater can be combined with all the other components mentioned here.

### Coating Chambers

The coating chambers can contain different process modules. The available coating processes are sputtering (planar or focal), thermal and e-beam evaporation, PECVD and ALD.

For sputtering, the process chambers can be used with standard VON ARDENNE planar magnetrons, magnetrons with a rotating magnetic field or third-party magnetrons, e.g. double ring magnetrons (Fraunhofer FEP).

Additional components such as heaters and measuring instruments for monitoring or controlling the process can also be integrated.

### Transfer Chambers

The transfer chambers are equipped with an automatic handling system, which enables a safe transport of the substrates and carriers through the individual chambers of the system.

For a higher throughput, 6- and 8- port chambers can be equipped with double-arm robots.

## Determine your process and recipe

The success of our modular process systems is based on their highly flexible and broad configuration range, our technological experience and know-how, and on our in-house developed and manufactured key components.

## Select pre-, post-treatment and deposition source technology

Depending on the required tool configuration, a VON ARDENNE system may include one or more of the listed components. Due to their modular design, the systems can also be upgraded or retrofitted with these components after the initial system installation.

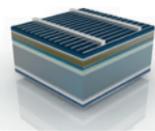
# HISS Modular Coating System

R&D and Pilot Production for High-Efficiency Solar Cells

## APPLICATION

### Tandem Cells

... High-performance TCO interconnection layer and the full stack of electrical active layers to build up tandem top cell: ETL, perovskites, HTL



### HJT

... High-performance TCO contact layers and metalization



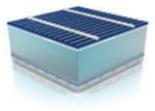
### IBC

... High-performance metalization layers and back side mirror combined with lowest cost of ownership



### Passivated Contacts

... Single-sided deposition of in-situ doped amorphous silicon as well as SiN layer for hydrogenation



HISS LabX

The **HISS** is a modular vacuum coating system for the horizontal processing of substrates.

In the configuration specified here, it is primarily designed for crystalline photovoltaics applications on silicon wafers. However, it can also be adjusted for thin-film photovoltaics applications on glass or other applications on various flat substrates.

With the **HISS**, you can benefit from our experience gained from hundreds of coating systems that we have delivered to the PV industry. It is the perfect choice if you are looking for highly flexible production equipment with a small or medium throughput equipped with proven technology.

Thanks to its modular design, the **HISS** can be configured according to your needs. We offer two basic configurations of the system.

The **HISS LabX** is a single-ended tool for horizontal batch processing. It is ideally suited for process and application development at laboratory scale.

The **HISS PilotX**, on the other hand, is designed for horizontal inline operation with an automated carrier return system, which makes it suitable for pilot production.

## High Process Flexibility

The process chamber can be configured with planar or rotatable magnetrons or with process components for thermal evaporation. Pre-treatment or heating and cooling units are available upon request. All auxiliary chambers, like entry/exit, buffer and transport chamber, can be upgraded in a similar manner.

## Proven Process Components

Our proven process technology guarantees excellent layer properties and coating uniformity.

## Heating

For transparent conductive oxides like ITO or other special applications, the substrate temperature can be precisely controlled in order to achieve reproducible and ideal layer characteristics by optional active heating or cooling.

## Process Chamber

A process chamber can be equipped with process stations either in a sputter down or a sputter up arrangement or with process components for thermal evaporation. It enables simultaneous or sequential processing of different material compositions, which is particularly suited for R&D purposes.

## Flexible and Dynamic Design

The standardized subcomponents enable custom-made configurations with a high degree of flexibility. That means that the system can be adapted to changing processes or requirements by adding e.g. additional sputter stations or even compartments. Therefore, our customers are able to act very dynamically and to adapt to the evolution of their products.



## TECHNICAL DATA

Subject to change without notice due to technical improvement.

### GENERAL FEATURES

Wafer compatibility	all common formats: M2, M4, M6, M10 and G12
Throughput	
HISS LabX:	≈ 60 wafers/hour
HISS PilotX:	≈ 1200 M2 wafers/hour; ≈ 1400 M4 – M6 wafers/hour
Substrates	silicon wafers, metal plates, polymer films, glass, plastics ...
Substrate size	6" (standard), other substrate sizes possible
Substrate thickness	≤ 20 mm
Coating area on carrier	
LabX	≈ (520 x max. 900) mm <sup>2</sup> , e.g. (3 x 5) M2 – M4 wafers
PilotX	≈ (500 x 1,000) mm <sup>2</sup> , e.g. (3 x 6) M2 wafers ≈ (520 x 900) mm <sup>2</sup> , e.g. (3 x 5) M4 – M6 wafers

### SPUTTERING SYSTEM

Magnetron type	single or dual rotatable, planar
Sputter arrangement	sputter-up, sputter-down, double-sided
Deposition type	DC, pulsed DC, AC, RF
Thermal evaporation source	linear
Number of independent processes	on request
Gases and media	e.g. Ar, Ar/O <sub>2</sub> (max. 20 % O <sub>2</sub> ) Ar/H <sub>2</sub> (max. 2.8 % H <sub>2</sub> )

### OPTIONAL FEATURES

Substrate heating	
Pre-treatment (e.g. Ion etching,...)	
Automated substrate loading & unloading	
Automated carrier return system	
Controlled heating and cooling unit (CHU)	
Dry air supply (CDA)	
Carrier storage racks	
Movable carrier stacker	
Others on request	

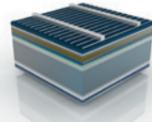
# XEA|nova L Wafer Coating System

## High-Volume Mass Production for HJT, IBC and Passivated Contacts

### APPLICATION

#### Tandem Cells

... High-performance TCO interconnection layer and the full stack of electrical active layers to build up tandem top cell: ETL, perovskites, HTL



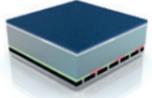
#### HJT

... High-performance TCO contact layers and metalization



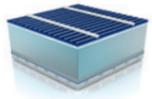
#### IBC

... High-performance metalization layers and back side mirror combined with lowest cost of ownership



#### Passivated Contacts

... Single-sided deposition of in-situ doped amorphous silicon as well as SiN layer for hydrogenation



The XEA|nova L is an inline coating system based on our proprietary large-area coating technology. The system is wider than the XEA|nova and can process more substrates at the same time. Therefore it is especially suited for high productivity applications at very low costs. It is suited for silicon wafers or other small and even very thin substrates.

Thanks to its modular design, the XEA|nova L can be equipped with rotatable magnetrons for the sputter deposition of high-performance TCO layers or several other materials, such as metals and metal oxides. It can also be adapted for other deposition technologies. The substrates can also be pre-treated by cleaning or etching, either under vacuum or before it enters the vacuum.

VON ARDENNE is also working on introducing single-sided passivated contacts processed by means of high-rate soft sputtering into mass production. The necessary sputtering process technology will be designed to fit into the XEA|nova L platform.

### Highest Economy of Scale

Due to its large width, the productivity of the tool is exceptionally high while the process utilization is brought to a maximum. Thus, the XEA|nova L offers best cost of ownership by providing applicable economy of scale.

### Process Chamber

The process chamber enables simultaneous processing of different material compositions, such as TCO's, TCO stack layers and/or combinations of TCO, metal oxides and metal stacks.

### Precise Temperature Control of Substrates

For transparent conductive oxides like ITO or other special applications, the substrate temperature can be precisely controlled in order to achieve reproducible and ideal layer characteristics by optional active heating or cooling.

### Edge Exclusion, Full Area, All Around & Bevel

The innovative VON ARDENNE carrier concept is very flexible and enables the deposition on substrates with full or partial edge exclusion. Furthermore, the substrate can be coated on the full area and all around, including the bevel.

### Convenient and Quick Maintenance

The optimized machine design enables easy access to the process environment and the auxiliary chambers.

### Flexible and Dynamic in Production

The standardized subcomponents enable custom-made configurations with a high degree of flexibility. That means that the system can be adapted to changing processes or requirements. Therefore, our customers are able to act very dynamically and to keep their production in accordance with the evolution of their product.

### TECHNICAL DATA

Subject to change without notice due to technical improvement.

#### GENERAL FEATURES

Throughput	
XEA nova L8:	8000 wph (M6), 6600 wph (M10), 4700 wph (G12)
XEA nova L10:	10000 wph (M6), 8300 wph (M10), 6000 wph (G12)
XEA nova L12:	12000 wph (M6), 10000 wph (M10), 7000 wph (G12)
Si wafer size	M2, M4, M6, M10, G12 & half- or triple-cut formats
Si wafer thickness	≥ 120 μm
Coating area on carrier	≈ (1.5 x 2.3) m <sup>2</sup> , e.g. (9 x 12) for M6 wafers

#### SPUTTERING SYSTEM

Magnetron type	single or dual rotatable, planar
Sputter arrangement	sputter down and sputter up
Deposition type	DC, pulsed DC, AC
Number of independent processes	unlimited
Gases and media	e.g. Ar, H <sub>2</sub> , O <sub>2</sub> , N <sub>2</sub> , H <sub>2</sub> O, X
Target utilization	up to 85 %, depending on process & material



#### OPTIONAL PROCESS FEATURES

Substrate heating  
Pre-treatment (e.g. Ion etching ...)  
Alternative deposition technologies upon request

#### OPTIONAL FEATURES

Automated substrate loading & unloading  
Automated carrier return system  
Controlled heating and cooling unit (CHU)  
Dry air supply (CDA)  
Carrier storage racks  
Others on request

#### AUTOMATION OPTIONS

Configuration single- or double-end  
Automation system fully automatic  
Substrate feeding cassette, box, other

# OUR STRENGTHS



## IN-HOUSE TECHNOLOGY & APPLICATION CENTER

- ... Sample coatings of customer applications
- ... Development of customized layer stacks
- ... Product & process verification and optimization
- ... Testing of new technologies and components



## GLOBAL PROJECT EXPERIENCE

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 for several markets.



## CLOSE PARTNERSHIP

VON ARDENNE has a network of partners for even more profound R&D work and to identify future technologies. It consists of:

- ... Fraunhofer Institutes such as IPMS, FEP, IST and ISE
- ... Institutes of the Helmholtz Association (Jülich, Berlin)
- ... Universities (Kiel, Dresden, Sheffield)
- ... Companies such as FAP GmbH, scia Systems GmbH



## PROFESSIONAL SIMULATION SUPPORT

We offer professional simulation technology to ensure best process quality with regards to plasma, heat and cooling. Furthermore, our simulation tools help demonstrate, develop and improve layer properties and define or optimize processes, details and the performance of our systems.



## COMPREHENSIVE SERVICE PORTFOLIO

- ... VON ARDENNE service hubs around the world
- ... On-site service
- ... Remote access by our technology department
- ... Regular technical and technological trainings
- ... Spare & wear part warehouse close to customers
- ... Lifecycle extension of wear parts



## UPGRADES & RETROFITS

As soon as your business is growing, your VON ARDENNE equipment will grow accordingly - thanks to its modular design and the upgrades we provide. We will also supply you with the necessary technology upgrades if you decide to change your applications.

Furthermore, when your equipment is ageing, we will retrofit your systems with new components, no matter if they are VON ARDENNE or third-party machines.



PRODUCT TOPICS



PRODUCT INDEX



COMPONENTS



vonardenne.com

## 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.



SALES CONTACTS



SERVICE CONTACTS

## WORLDWIDE SALES AND SERVICE

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