COATING SYSTEMS FOR THIN-FILM PV

SCALA
VISS
PIA|nova
GC120VCR
XENIA
VON ARDENNE provides advanced PVD coating equipment for all scales of production, from laboratory tasks to high-volume manufacturing. Our company was founded in 1991 as a spin-off of the Manfred von Ardenne Research Institute in Dresden, Germany.

With more than 55 years of experience in vacuum coating and over 40 years in magnetron sputtering, VON ARDENNE is one of the leading providers of equipment and technologies for PVD thin-film technology and vacuum processing.

We have installed more than 150 systems for customers within the thin-film photovoltaics industry, which is an equivalent of an installed manufacturing capacity of more than five gigawatts. This makes VON ARDENNE the market leader in production equipment for thin-film PV. The reliability and productivity of these systems are well proven in the PV industry. Most of the coating systems we have delivered so far were designed for substrate widths of up to 1.40 meters.

Currently, however, the importance of large-area formats and form factors in general is shifting in the thin-film photovoltaics industry. Typically, modules for CIGS or CdTe based cells are smaller in size as compared to Si-wafer based modules due to certain historical and technical reasons, such as the cell interconnection.

VON ARDENNE is quite familiar with the development and manufacturing of larger machines, as the company has been providing coating equipment for large-area coating applications that require much wider dimensions. Moreover, we provide systems that are necessary prior to large-scale production – such as the SCALA LabX stack development under pilot production conditions.

We have supplied vacuum coating equipment for the PV industry since 2004, primarily for thin-film coatings on glass. One of the most versatile coating systems VON ARDENNE offers for these applications is the XENIA®. This is a horizontal glass coating system for depositing thin films using sputtering technology. Its standardized subcomponents enable custom-made configurations. Three process chamber designs are available that allow processes without heating or with heating of up to 400 °C.

The VON ARDENNE GC120VCR is a vertical in-line coating system for the deposition of oxide thin-film multilayer systems and metal layers on flat substrates. The system uses carriers for the substrate transport and enables also custom-made configurations based on standardized subcomponents.

Based on the mentioned experience, VON ARDENNE has developed the XENIA. The coater is a very wide horizontal sputtering machine and can therefore process multiple substrates at the same time. It is especially suited for high-productivity applications at very low costs. All our coaters are equipped with the field-proven and leading VON ARDENNE sputtering technology.

It is VON ARDENNE’s mission to become one of the key equipment manufacturers within the photovoltaics industry. Therefore, we focus on high-efficiency and leading PV technologies and commit ourselves to the cost-effective use of solar power.

### CIGS Thin-Film Photovoltaics

- i-ZnO, ZnO:Al based front contact layers
- CuGa and in precursor layer
- SiO/Ny barrier layers and Mo metal back contact layers

### CdTe Thin-Film Photovoltaics

- Metal back contact layers based on Al, Cr, Mo, NbV
- TCO and intermediate layers

### Organic Photovoltaics

- Deposition by sputtering and VTE

Solar cells based on cadmium telluride (CdTe) constitute the major segment of the global thin-film module production. Transparent conducting oxide (TCO) layers are translucent and highly conductive to transport current efficiently. Intermediate layers help in both the growth and electrical properties between the TCO and CdTe.

The CdTe film acts as the primary photovoltaic layer and absorbs most visible light within the first micron of material. Together, these layers form an electric field that converts the absorbed light into current and voltage. A metal layer is deposited on the back to form electrical contacts.

Organic photovoltaics is a rapidly emerging technology with an improving cell efficiency. Furthermore, this technology shows a promising initial lifetime and potential for roll-to-roll manufacturing processes.

Organic photovoltaics might be especially interesting for the building-integrated PV market because of the ability to make efficient transparent devices and the availability of absorbers in several different colors.
CORE TECHNOLOGY BASED ON A LONG TRADITION

INDUSTRY-PROVEN, RELIABLE AND ADVANCED SPUTTERING TECHNOLOGY

FEATURES AND BENEFITS OF VON ARDENNE EQUIPMENT

MODULAR, SCALABLE AND FLEXIBLE DESIGN BASED ON GERMAN ENGINEERING

1. PROVEN 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 40 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 gained from designing and installing advanced sputtering equipment, we can offer a complete portfolio of solutions from RF and AC to DC processes, planar to rotatable applications.

- RSM/RSM-RSMT Magnetrons
- WSM/WSMT Magnetrons
- RDM/RDM-RDMDIM Magnetrons
- SSM/SSM-SSM Magnetrons

1974 - First ring gap discharge at von Ardenne Research Institute

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 (VAprocos) controls the reactive magnetron sputtering of compound layers.

2. 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 our systems are fitted with have proven in the industry for many years.

All compartments are identical to provide a maximum of flexibility.

3. 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.

TRANSPORT SYSTEM

- Vertical Coating System (VISS)
- Modular Coating System (SCALA)
- Glass Coating System (GC120VCR)
- Water and Glass Coating System (CLUSTER SYSTEM)
- XENIA
- PIA|nova
- Vertical Coating System (VISS)
- Modular Coating System (SCALA)
- Glass Coating System (GC120VCR)
- Water and Glass Coating System (CLUSTER SYSTEM)

4. HEATING AND COOLING

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, e.g. in the coating systems PIA|nova®, GC120VCR and XENIA.

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.

- Cooling system for critical phases
- Cooling system for critical phases
- Cooling system for critical phases
- Cooling system for critical phases
- Cooling system for critical phases

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

5. SCALABILITY

VON ARDENNE provides advanced PVD coating equipment, key components and technology expertise for all scales of production, from laboratory tools 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.
The SCALA is a modular vacuum coating system with a carrier-based substrate transport. 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 SCALA can be configured according to your needs. We offer two basic configurations of the system.

The SCALA LabX is a single-ended tool for horizontal batch processing with or without load lock. It is ideally suited for process and application development at laboratory scale.

The SCALA PilotX, on the other hand, is designed for horizontal inline operation and therefore suitable for pilot production.

**HIGH PROCESS FLEXIBILITY**

The process chamber can be configured with planar or rotatable magnetrons. Ion 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.

**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 new processes or requirements. Therefore, our customers are able to act very dynamically and to adapt to the evolution of their product.

**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
- Others on request

**TECHNICAL DATA**

Subject to change without notice due to technical improvement.

**TARGET**

- Material: metals, ceramics
- Utilization: planar > 25 %, rotatable > 75 %

**SUBSTRATE**

- Material: glass, polymers, silicon wafers
- Dimensions (L × W), approx.: 400 mm × 400 mm

**DEPOSITION SYSTEM**

- Deposition type: DC, pulsed DC, AC
- Magnetron type: planar, rotatable
- Substrate temperature range: RT / 200 °C / 350 °C
- Substrate potential: floating
- Number of independent process gases: 4 (e.g. Ar, Ar/O₂, N₂, O₂)

**TRANSPORT**

- Type of transport: inline, carrier-based
- Orientation of substrate during deposition: horizontal
- Conveyor speed: ≤ 1.5 m/min

The vertical inline sputter system VISS is an appropriate, modular solution for vertical deposition processes when scaling up from laboratory use to production. The tool is available either as a single end inline or for continuous processing and is uniquely suited for scaling up to substrate sizes of approximately 400 mm × 400 mm.

The substrates are transported by a carrier system, which is tilted vertically by seven degrees. The substrates can be loaded without touching their front side.

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- Substrate potential: floating
- Number of independent process gases: 4 (e.g. Ar, Ar/O₂, N₂, O₂)

**TRANSPORT**

- Type of transport: inline, carrier-based
- Orientation of substrate during deposition: vertical
- Transport speed, max.: ≤ 1.5 m/min

**CLEANING OF CHAMBER**

- Cleaning principle: mechanical exchange of shields
- Cleaning cycle: 7 to 25 days, depending on configuration

**UTILITIES & SUPPLY**

- Power (phase/voltage/frequency): 3 AC/230 V, 400 V, 480 V/50 Hz, 60 Hz
- Power consumption: depending on configuration
- Cooling system: water cooling, separated cooling circuit
- Cooling supply: primary supply by customer
- Venting system: 1 system per lock chamber
- Venting medium: ambient air, compressed dry air
- Process gases: cabinets or central supply by customer

**SYSTEM CONTROL & SOFTWARE**

- Computer hardware: PLC, Siemens S7
- User interface: VON ARDENNE user interface
- MES link: according to specifications

**SYSTEM DIMENSIONS**

- Total system size (L × W × H), depending on configuration
- Total system weight, depending on configuration
**PIA nova® HORIZONTAL GLASS COATING SYSTEM**

**INDUSTRY-PROVEN, RELIABLE STANDARD PRODUCTION TOOL**

The PIA nova® is our modular coating platform for solar applications. It allows VON ARDENNE to offer standard, yet flexible, manufacturing equipment for depositing thin films using physical vapor deposition (PVD) technology.

VON ARDENNE has incorporated its vast process know-how into this platform, gained from over 100 industry-proven glass and photovoltaic coating systems. The PIA nova® is our answer to customers looking for productive and flexible production equipment combined with tried and tested technology and design.

**HORIZONTAL SUBSTRATE TRANSPORT**

The substrates are transported horizontally through the chambers combined with a sputter-down arrangement.

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**TECHNICAL DATA**

Subject to change without notice due to technical improvement.

<table>
<thead>
<tr>
<th><strong>TARGET</strong></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>metals, ceramics</td>
</tr>
<tr>
<td>Utilization</td>
<td>planar &gt; 30%, rotatable &gt; 80%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SUBSTRATE</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Material</td>
<td>glass</td>
</tr>
<tr>
<td>Dimensions (L × W), max.</td>
<td>1650 mm × 1400 mm</td>
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<tr>
<td>Thickness</td>
<td>1.8 mm (1.4 mm) to 4 mm for glass</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DEPOSITION SYSTEM</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposition type</td>
<td>DC, pulsed DC, AC</td>
</tr>
<tr>
<td>Magnetron type</td>
<td>planar, single or dual rotatable</td>
</tr>
<tr>
<td>Sputter arrangement</td>
<td>sputter down</td>
</tr>
<tr>
<td>Substrate temperature range</td>
<td>RT / 200 °C / 400 °C</td>
</tr>
<tr>
<td>Substrate potential</td>
<td>floating</td>
</tr>
<tr>
<td>Number of independent process gases</td>
<td>up to 4 (Ar, O₂, N₂, X)</td>
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<tr>
<th><strong>TRANSPORT</strong></th>
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<tbody>
<tr>
<td>Type of transport</td>
<td>inline</td>
</tr>
<tr>
<td>Orientation of substrate during deposition</td>
<td>horizontal, LEL, SEL</td>
</tr>
<tr>
<td>conveyor speed</td>
<td>≤ 3.5 m/min</td>
</tr>
</tbody>
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**HEATING TECHNOLOGY**

There are three fundamental process chamber types for processes:

- without heating (option to preheat)
- with heating up to 200 °C
- with heating up to 400 °C

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**GC120VCR VERTICAL GLASS COATING SYSTEM**

**INDUSTRY-PROVEN PRODUCTION TOOL WITH SMALL FOOTPRINT**

The GC120VCR is a vertical inline coating system for the deposition of metal and oxide thin-film multilayer systems on flat glass substrates or other materials.

As a leading developer and manufacturer of vacuum coating equipment for large-area applications, VON ARDENNE has incorporated its broad knowledge and expertise in PVD technologies into the GC120VCR platform. The reliability of this system is well proven in the PV industry.

**GOOD MAINTAINABILITY**

The optimized machine design enables easy access to the magnetron environment for target exchange and maintenance.

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<td>Materials</td>
<td>metals, ceramics</td>
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<tr>
<td>Utilization</td>
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<th></th>
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<tbody>
<tr>
<td>Material</td>
<td>glass</td>
</tr>
<tr>
<td>Dimensions (L × W), max.</td>
<td>1550 mm × 1200 mm (others on request)</td>
</tr>
<tr>
<td>Thickness</td>
<td>1.8 mm (1.4 mm) to 4 mm (others on request)</td>
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<tr>
<td>Magnetron type</td>
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</tr>
<tr>
<td>Sputter arrangement</td>
<td>vertical</td>
</tr>
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<td>Substrate temperature range</td>
<td>RT / 200 °C / 400 °C</td>
</tr>
<tr>
<td>Substrate potential</td>
<td>floating</td>
</tr>
<tr>
<td>Number of independent process gases</td>
<td>up to 4 (Ar, O₂, N₂, X)</td>
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<th><strong>TRANSPORT</strong></th>
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</tr>
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<tbody>
<tr>
<td>Type of transport</td>
<td>inline, carrier-based</td>
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<tr>
<td>Orientation of substrate</td>
<td>vertical, LEL, SEL</td>
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<tr>
<td>Transport speed</td>
<td>≤ 3.5 m/min</td>
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<tr>
<td>Cycle time</td>
<td>30 s</td>
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</table>

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**CLEANING OF MAGNETRON CHAMBERS**

Cleaning principle: mechanical exchange of shields
Cleaning cycle: 7 to 35 days, depending on configuration
The XENIA is an inline coating system based on our proprietary large-area coating technology. As the coater is very wide and can therefore process many substrates at the same time, it is especially suited for high productivity applications at very low costs. It is suited for large-area glass substrates.

The XENIA benefits from our experience gained from delivering more than 150 coating systems to the photovoltaics industry. It is the perfect choice for customers looking for highly productive and flexible production equipment combined with proven technology and design.

**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 XENIA offers best cost of ownership by providing applicable economy of scale.

**INDIVIDUAL PROCESS CHAMBERS**
The process chamber can be equipped with five or more different process stations in a sputter down arrangement. It enables simultaneous processing of different material compositions from metallic and ceramic targets.

**TECHNICAL DATA**
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<table>
<thead>
<tr>
<th>TARGET</th>
<th>Utilization</th>
<th>materials, ceramics, planar &gt; 30%, rotatable &gt; 80%</th>
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<tr>
<td>SUBSTRATE</td>
<td>Material</td>
<td>glass</td>
</tr>
<tr>
<td>Dimensions (L × W), max.</td>
<td>2 000 mm × 2 400 mm</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>1.8 mm (3.4 mm) to 4 mm</td>
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<tr>
<td>Orientation of substrate during deposition</td>
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<tr>
<td>Conveyor speed</td>
<td>≤ 4.5 m/min</td>
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**CLEANING OF MAGNETRON CHAMBERS**
Cleaning principle: mechanical exchange of shields
Cleaning cycle: 7 to 35 days, depending on configuration

**UTILITIES & SUPPLY**
Phase: 3 phases
Voltage: 230 V, 400 V, 480 V
Frequency: 50 Hz to 60 Hz
Power consumption: depending on configuration
Cooling system: primary cooling water supply by customer
Cooling supply: ambient air, compressed dry air or N₂
Venting medium: central supply by customer or local gas cabinet

**SYSTEM CONTROL & SOFTWARE**
Computer hardware: PLC, Siemens S7
User interface: VON ARDENNE user interface
MES link: according to specifications

**SYSTEM DIMENSIONS**
Total system size (L x W x H): customized (min. 20 m x 16.5 m x 3.5 m)
Total system weight: depending on configuration
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.