COATING SYSTEMS FOR PRECISION OPTICS

FROM R&D TO MASS PRODUCTION
**OUR HISTORY & EXPERIENCE**

With 60 years of experience with electron beam processes and 45 years in magnetron technology, both for industrial production and for research and development, VON ARDENNE is one of the leading providers of equipment and technologies in PVD thin-film technology and vacuum process technology. Thanks to this expertise, we have managed to supply over 500 vacuum coating systems to our customers all over the world. We are well prepared to turn your product property requirements into efficient and competitive coating solutions based on various modular assembly systems like batch, cluster, inline or drum coater configurations.

Precision optics have been in increasing demand for the last couple of years. This market will grow even further advanced by mega trends such as autonomous driving, the internet of things, virtual reality but also new solutions for communication technology, medical or measuring technology.

**APPLICATIONS**

**SENSORS**

Optical sensors are increasingly being manufactured. Depending on their application, they can vary tremendously. Currently, LIDAR (light detection and ranging) sensor technology for autonomous driving is a booming application.

**DISPLAYS**

The optical properties of displays can be specifically influenced. Depending on the application, these properties can be contradictory such as the reflection specifically created for head-up displays and anti-reflection coatings for tachometers.

**AUTOMOTIVE INFOTAINMENT**

The infotainment technology in modern vehicles goes far beyond the classic radio and is increasingly becoming a crucial design feature for the car manufacturers and their makes with more and more new features.

**CAMERA SYSTEMS**

The number of camera systems produced every year has skyrocketed. Even though they are so small that they can hardly be seen, like those built into phones, they are packed with the most sophisticated thin-film technology.

**MICROSCOPES/ BINOCULARS**

Even though they could almost be called "old" products, the coatings in microscopes and binoculars are crucial for the performance of these products. This is especially true for special technology combinations, such as luminescence microscopy.

**TELESCOPES**

The further away the objects that shall be observed, the higher are the requirements for the applied thin-film technology. This is especially true for large and space telescopes.

**LASER OPTICS**

Laser applications have become indispensable for the industry, for instance in metal-cutting machines. A precondition for their use is durable and non-destructive optical systems.

**RESEARCH & DEVELOPMENT**

The increasing number of applications requires extensive research and development, also for equipment manufacturing and key technologies, which must meet new requirements. Applications with new requirements are, for instance, lateral and vertical gradient layer technologies and the coating of free-form surfaces with specified local layer thickness distribution. This demand has created a dynamically growing scientific field.

**LAYER SYSTEMS**

**FUNCTIONS OF THE LAYER SYSTEMS**

- Anti-reflection
- Anti-scratch
- Bandpass filter with a very low angle shift and wide stopband
- Uncoupling of spectra/spatial reflectors/dichroics
- Filters for LIDAR applications
- Filters for facial recognition
- Highly reflective mirrors
- Cold-light mirror
- Edge filter with very steep edge
- Polarizing filter
- Ultra-thin bandpass filters in UV-VIS-IR range
- Rugate filters
- Special mirrors (e.g. ELV, X-ray)
- Beam splitter
- Anti-smudge (easy-to-clean)
- Notch filters

**MATERIALS**

Depending on the product requirements, materials ranging from simple SiOx/SiNx systems to complex combinations of various metals and oxynitrides can be applied.

Typical Layer Materials / Coating Processes

- High refractivity: SiN, Nb2O5, TiO2, ZrO2, HfO2, Ta2O5, Cr2O3, amorphous Si
- Low refractivity: SiO2, Al2O3
- Layer compositions with variable refraction index: SiO2Ny, TiO2Ny, Al2O3Ny, Hf2O2Oy
- Metallic layers: Cr, Al, Si, Au
- Transparent conductive layers: ITO, AZO

**THE QUALITY OF OUR LAYER SYSTEMS**

Our layer systems as a whole stand for a high-precision product. Thus, every single deposited layer must meet very high requirements concerning their properties, such as uniformity, color fastness, low occurrence of defects, roughness and reproducibility.

All process components that are used must meet the high VON ARDENNE quality standards. Thereby, it is ensured that the process stability can be maintained over long campaign times. Furthermore, contamination can be prevented, and it is ensured that the components do not exceed their designated lifetime.

Even in the engineering phase, the final optical properties are tuned and aligned with the process window. In quality control, the characteristic values are tested with the help of in situ measurement. This allows for an integrated finetuning of the coating aiming for a perfect product.

**TECHNICAL DETAILS - EXAMPLES**

**Example of the uniformity of a coating process with Ta2O5 layer thickness distribution**

**Scanning electron microscope (SEM) image of a rugate filter based on SiO2/HfO2 with sinus-shaped refractive index modulation and a refractive index travel varying across the sample (apodized design)**
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. 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.

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 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 and even magnetrons with integrated turbopumps.

VON ARDENNE offers several equipment platforms for the sputter coating of substrates used in optics. The platforms have in common that their design is modular and that their functionality and productivity can be adapted to their specific tasks. They are configured according to the specifications of the customer. Apart from the available standard modules, we can offer special solutions for your requirements.

The platforms can be distinguished by their specific properties as they are designed for different applications.

The OPTA X is suited for the most sophisticated tasks. It enables the use of various technologies and creates excellent layer properties and stable layer stacks, especially for multilayer systems with a high number of individual layers.

The inline systems HISS, VISS and GC120VCR are production systems for high-volume manufacturing with a limited number of layers. Their distinguishing features are the coating direction and their productivity, and they are available in different configurations ranging from single end to inline with an integrated carrier return system and automatic loading and unloading of the carrier. Therefore, they offer potential for a low cost of ownership.

The great advantage of the different platforms is their scalability. Because of that, they are suitable for fields of application ranging from research and development to the production of smaller series to high-volume production. Beyond that, the use of proven VON ARDENNE components facilitates the scaling and the process transfer even further.
OPTA X ROTARY DISK COATING SYSTEM
FOR SOPHISTICATED LAYER SYSTEMS

The OPTA X is our system for the most sophisticated layer systems, especially for optical multi-layer systems with a high number of layers. The coating is done horizontally, and different processes are available for an optimal coating: Meta Mode, CARS*, reactive and non-reactive sputtering. The system has five ports that can be used to integrate magnetrons and/or plasma sources. In-situ measurement technology is also available for monitoring and adjusting the coating process. The OPTA X is equipped with a modular automatic handling system that enables a safe loading of the system with various substrates that are passed through the system in customized carriers. Depending on the process and productivity requirements, different module types, such as magazine load locks or pre- or post-treatment chambers, can be combined.

**TECHNICAL DATA**
Subject to change without notice due to technical improvement.

<table>
<thead>
<tr>
<th>SUBSTRATE</th>
<th>DEPOSITION SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Type of transport</td>
</tr>
<tr>
<td>glass, polymers, metals</td>
<td>glass, polymers, metals</td>
</tr>
<tr>
<td>280 mm x 320 mm</td>
<td>up to 200/300 mm</td>
</tr>
<tr>
<td>Diameter</td>
<td>Thickness</td>
</tr>
<tr>
<td>70 mm</td>
<td>70 mm</td>
</tr>
</tbody>
</table>

**APPLICATIONS**

**CONFIDENTIAL EXAMPLES**

**OPTA X FOR CATALOG OPTICS**

**LAYER STACKS (H/L)**

- TaO$_5$/SiO$_2$ (CARS*/Meta Mode)
- HfO$_2$/SiO$_2$ (RF/Meta Mode)

**PROCESS-UP CONFIGURATION**

- 3 target materials
- 2 dual rotary cathodes
- 1 dual planar cathode
- 1 ion source

**PROCESS-DOWN CONFIGURATION**

- Upon request

**FEATURES**

- On-carrier subrotation possible
- In-situ adjustable magnet bars (rotary targets)
- Exchangeable shaper

**TECHNICAL DATA**
Subject to change without notice due to technical improvement.

<table>
<thead>
<tr>
<th>TRANSPORT</th>
<th>SYSTEM CONTROL &amp; SOFTWARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of transport</td>
<td>industry PC/SPS module</td>
</tr>
<tr>
<td>robot, carrier</td>
<td>User interface</td>
</tr>
<tr>
<td>Windows 10 with</td>
<td>control software/ Siemens SPS</td>
</tr>
<tr>
<td>MES link</td>
<td>SECS/GEM</td>
</tr>
</tbody>
</table>

**DIMENSIONS AND WEIGHT**

- Total system size (L x W x H): at least 5 m x 5 m x 3 m
- Total system weight: depending on configuration

**OPTIONAL**

- Optical in-situ measurement, VA PROCOS process control system, plasma treatment of substrate, substrate heating, combination with other process chambers, additional load locks, more on request

*Fraunhofer IST
The **HSS** 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 **HSS** can be configured according to your needs. We offer various basic configurations of the system such as the single-ended version for a smaller production scale.

### Technical Data

**Subject to change without notice due to technical improvement.**

#### Substrate
- **Material:** glass, polymers, metals
- **Coating width:** 400 mm or 600 mm
- **Length:** up to 1100 mm

#### Deposition System
- **Deposition type:** DC, pulsed DC, AC, RF
- **Magnetron type:** planar, rotatable
- **Plasma source:** glow discharge device, inverse sputter etcher (ISE) or ion source
- **Sputter arrangement:** up, down
- **Substrate temperature range:** RT to 300 °C
- **Substrate potential:** floating
- **Number of independent process gases:** 4 (e.g. Ar, Ar/O₂, N₂, O₂, H₂)

#### Transport
- **Type of transport:** carrier-based, optional: carrier return system, stocker
- **Loading:** optional: automatic loading and unloading by robot

#### System Control & Software
- **Hardware:** industry PC / SPS module
- **User interface:** Windows 10 with WICON control software
- **MES link:** SECS / GEM

#### Dimensions and Weight
- **Depending on version (400/600) and configuration**

#### Optional
- Plasma pre-treatment, process technology, VA PROCOS process control system, optical in-situ measurement, easy-to-clean module (ETC), more on request

---

The **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 up to 600 mm x 2400 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.

### Technical Data

**Subject to change without notice due to technical improvement.**

#### Substrate
- **Material:** glass, polymers, metals
- **Size (L x W):** max. 600 mm x 2400 mm

#### Deposition System
- **Deposition type:** DC, pulsed DC, AC, RF
- **Magnetron type:** planar, rotatable
- **Plasma source:** glow discharge device, inverse sputter etcher (ISE) or ion source
- **Sputtermodus:** vertical
- **Substrate temperature range:** RT
- **Substrate potential:** floating
- **Number of independent process gases:** 4 (e.g. Ar, Ar/O₂, N₂, O₂, H₂)

#### Transport
- **Type of transport:** carrier-based, optional: carrier return system, stocker
- **Loading:** optional: automatic loading and unloading by robot

#### System Control & Software
- **Hardware:** industry PC / SPS module
- **User interface:** Windows 10 with WICON control software
- **MES link:** SECS / GEM

#### Dimensions and Weight
- **Depending on version (400/600) and configuration**

#### Optional
- Plasma pre-treatment, process technology, VA PROCOS process control system, optical in-situ measurement, easy-to-clean module (ETC), more on request
## 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

### CLOSE PARTNERSHIP
VON ARDENNE entertains a close network of partners for even more profound R&D work and to identify future technologies. It consists of:
- Fraunhofer Institutes such as IPMS, FEP and ISE
- Institutes of the Helmholtz Association (Jülich, Berlin)
- Universities (Dresden, Kiel, 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.

### 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.

### COMPREHENSIVE SERVICE PORTFOLIO
- VON ARDENNE services hubs around the world
- On-site service (on request)
- Remote access from our technology department (if required)
- Regular technical and technological trainings offered
- Spare & wear part warehouse close to customers
- Lifecycle extension of wear parts

### UPDATES & RETROITS
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.

---

## GC120VCR VERTICAL COATING SYSTEM

**INDUSTRY-PROVEN PRODUCTION SYSTEM WITH A 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.

Due to its vertical and carrier-based design, the GC120VCR has a small footprint and requires fewer maintenance intervals.

The maintenance-friendly design of the system enables easy access to the magnetron environment for target exchange and maintenance.

### TECHNICAL DATA

Subject to change without notice due to technical improvement.

<table>
<thead>
<tr>
<th>SUBSTRATE</th>
<th>TYPE OF TRANSPORT</th>
<th>ORIENTATION OF SUBSTRATE</th>
<th>TRANSPORT SPEED</th>
<th>CYCLE TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>inline, carrier-based</td>
<td>vertical, LEI, SEL</td>
<td>≤ 3.5 m/min</td>
<td>30 s</td>
</tr>
<tr>
<td>Dimensions</td>
<td>DC, pulsed DC, AC</td>
<td>planar, single or dual rotatable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>glass, polymers, metals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8 mm (1.4 mm) to 4 mm (others on request)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DEPOSITION SYSTEM

<table>
<thead>
<tr>
<th>Deposition type</th>
<th>Magnetron type</th>
<th>Sputter arrangement</th>
<th>Substrate temperature range</th>
<th>Substrate potential</th>
<th>Number of independent process gases</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC, pulsed DC, AC</td>
<td>planar, single or dual rotatable</td>
<td>vertical</td>
<td>RT / 200 °C / 400 °C</td>
<td>floating</td>
<td>up to 4 (Ar, O₂, N₂, X)</td>
</tr>
</tbody>
</table>

### SYSTEM CONTROL & SOFTWARE

<table>
<thead>
<tr>
<th>Computer hardware</th>
<th>User interface</th>
<th>MES link</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC, Siemens S7</td>
<td>VON ARDENNE user interface</td>
<td>according to specifications</td>
</tr>
</tbody>
</table>

### SYSTEM DIMENSIONS

<table>
<thead>
<tr>
<th>Total system size (L x W x H)</th>
<th>Total system weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>customized x 13 m x 3.5 m</td>
<td>depending on configuration</td>
</tr>
</tbody>
</table>
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.