COATING SYSTEMS FOR PRECISION OPTICS
FROM R&D TO MASS PRODUCTION
A crucial prerequisite for precision optics to function is high-precision coatings that make use of the interference properties and, thereby, provide the desired characteristics. Thanks to its experience in developing and manufacturing vacuum coating equipment, the VON ARDENNE Group possesses a profound understanding of the physical processes that are necessary for vacuum coating and extensive expertise in how to use them for a multitude of different applications.

This knowledge is the basis for the development of many different equipment platforms, that are distinguished by the technology they use, their productivity and flexibility. VON ARDENNE coating technology solutions cover the whole spectrum of requirements, from research and development to pilot production to mass production.

**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 farther away the objects that are 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.

**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/echelons
- 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. EUV, X-ray)
- Beam splitter
- Anti-smudge (easy-to-clean)
- Notch filters

**MATERIALS**

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

**Typical Layer Materials/ Coating Processes**

- High refraactivity:
  - SiNx, Nb2O5, TiO2, ZrO2, HfO2, Ta2O5, Cr2O5, amorphous Si
- Low refraactivity:
  - SiO2, Al2O3
- Layer compositions with variable refraction index:
  - SiOxNy, TiOxNy, AlxOyNy, HfOxNy
- Metallic layers:
  - Cr, Al, Sn, Ag, 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 fine-tuning of the coating aiming for a perfect product.

**TECHNICAL DETAILS - EXAMPLES**

- Example of the uniformity of a coating process with Ta2O5
- Scanning electron microscope (SEM) image of a bandpass filter
- SEM image of a rugate filter based on SiOx/HfO2, 18 layers
- Table of layer thicknesses in %

*In cooperation with Fraunhofer*
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 OPTA X is distinguished by its 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 TOMA X is a drum coater, which is also suited as a workhorse to be used for the deposition of multilayer systems with many layers.

The 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.

The equipment portfolio includes the following systems:

- **OPTA X**: designed for the most sophisticated tasks, enabling the use of various technologies and creating excellent layer properties and stable layer stacks, especially for multilayer systems with a high number of individual layers.
- **TOMA X**: a drum coater, also suited as a workhorse for deposition of multilayer systems with many layers.
- **HISS, VISS, GC120VCR**: production systems for high-volume manufacturing with a limited number of layers, offering coating direction and productivity options.

The technical data for each system is as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>OPTA X</th>
<th>TOMA X</th>
<th>HISS</th>
<th>VISS</th>
<th>GC120VCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Substrate orientation</td>
<td>horizontal</td>
<td>vertical</td>
<td>horizontal</td>
<td>vertical -7°</td>
<td>vertical -7°</td>
</tr>
<tr>
<td>Max. substrate size</td>
<td>280 mm x 320 mm</td>
<td>300 mm x 1200 mm</td>
<td>600 mm x 1100 mm</td>
<td>600 mm x 2400 mm</td>
<td>1200 mm x 1550 mm</td>
</tr>
<tr>
<td>Productivity</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>mass production</td>
</tr>
</tbody>
</table>

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.

The technical data for OPTA X include:

- **Substrate**: Glass, polymers, metals
- **Size**: 280 mm x 320 mm
- **Diameter**: up to 200/300 mm
- **Thickness**: 70 mm
- **Deposition System**: DC, pulsed DC, AC, CARS*, meta mode, reactive sputtering, RF planar, rotatable inductively coupled
- **Plasma source**: RF / 300 °C
- **Substrate temperature range**: Floating
- **Substrate potential**: Floating or fixed
- **Number of independent process gases**: 4 (e.g., Ar, Ar/O₂, N₂, O₂, H₂)

*Fraunhofer IST*
The **TOMA X** is a modular platform for flexible multilayer coating tasks. It is designed for the most sophisticated layer systems, especially optical multilayer systems on substrates with varying sizes. During the coating process, the substrates are in **special carriers** that can be fitted to the respective substrates. The coating direction is **vertical** and different coating methods such as reactive or non-reactive sputtering are applied. Furthermore, the surfaces of the substrates can be cleaned and activated by means of plasma pre-treatment before the coating.

**Five ports** 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 modular design of the **TOMA X** enables the processing purely in batch mode. In combination with automatic handling in a transfer chamber, this ensures a user-friendly, safe loading of the system and increases the process reliability by a permanent conditioning of the process chamber. The system can always be upgraded, so that it can adapt to increasing demands.

The **HISS** 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 **HISS** 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.

The **HISS** offers a high process flexibility as 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.

The **HISS** is flexible and dynamic in design as the system with standardized subcomponents enables custom-made configurations. That means that the system can be adapted to new processes or requirements. Therefore, our customers are able to act very dynamically and can adapt to the evolution of their product.

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**TECHNICAL DATA**

Subject to change without notice due to technical improvement.

**SUBSTRATE**
- Material: glass, polymers, metals
  - Size: 300 mm × 1200 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: vertical, up, down
- Substrate temperature range: RT/300 °C
- Substrate potential: floating
- Number of independent process gases: 3 (Ar, Ar/O₂, N₂, O₂, H₂)

**TRANSPORT**
- Type of transport: carrier-based, optional: transfer chamber with robot
- Optical in-situ measurement, VA PROCOS process control system, plasma pre-treatment of substrate, more on request

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**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/300 °C
- Substrate potential: floating
- Number of independent process gases: 4 (Ar, Ar/O₂, N₂, O₂, H₂)

**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
VISS VERTICAL COATING SYSTEM
HIGHLY FLEXIBLE INLINE SYSTEM

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 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.

**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)

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

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.

**SUBSTRATE**
- Material: glass, polymers, metals
- Dimensions (L x W): max. 1550 mm x 1200 mm (others on request)
- Thickness: 1.8 mm (1.4 mm) to 4 mm (others on request)

**DEPOSITION SYSTEM**
- Deposition type: DC, pulsed DC, AC
- Magnetron type: planar, single or dual rotatable
- Sputter arrangement: vertical
- Substrate temperature range: RT / 200 °C / 400 °C
- Substrate potential: floating
- Number of independent process gases: up to 4 (Ar, O₂, N₂, X)

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

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**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

**TECHNICAL DATA**
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**DEPOSITION SYSTEM**
- Deposition type: DC, pulsed DC, AC
- Magnetron type: planar, single or dual rotatable
- Sputter arrangement: vertical
- Substrate temperature range: RT / 200 °C / 400 °C
- Substrate potential: floating
- Number of independent process gases: up to 4 (Ar, O₂, N₂, X)

**TRANSPORT**
- Type of transport: inline, carrier-based
- Orientation of substrate: vertical, LEL, SEL
- Transport speed: ≤ 3.5 m/min
- Cycle time: 30 s

**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 × 13 m × 3.5 m
- Total system weight: depending on configuration

**TECHNICAL DATA**
Subject to change without notice due to technical improvement.
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 MAGNETRON SPUTTER SOURCES**
- Circular magnetron
- Rectangular magnetron
- Cylindrical magnetron

**VON ARDENNE PRE-TREATMENT COMPONENTS**
- Inverse sputter etcher
- Glow discharge device
- LION ion source

**VON ARDENNE SIMULATION SOFTWARE AND PROCESS CONTROL SYSTEMS**
- Simulation
- VA PROCOS 2 process control system
- WICON control software

**IN-HOUSE TECHNOLOGY & APPLICATION CENTER**
- Sample coatings of customer applications
- Development of customized layer stacks
- Product & process verification and optimisation
- 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, sss 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

**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.
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.