VON ARDENNE 📕

AEROSPACE

VACUUM COATING EQUIPMENT & EXPERTISE

Functional coatings for the aerospace industry with flexible & highly productive equipment for various applications

FUNCTIONAL COATINGS FOR THE AEROSPACE INDUSTRY WITH FLEXIBLE & HIGHLY **PRODUCTIVE EQUIPMENT**

Air traffic is growing steadily, and with it its impact on the environment and the climate. As a result, the demand for more fuelefficient, quieter and less polluting engines is also growing. Therefore, aircraft manufacturers and airlines worldwide have a high demand for efficient engines.

To meet these requirements, modern turbines have to withstand significantly higher combustion temperatures and temperature fluctuations than before. This can be achieved with coatings made of modern high-performance ceramics. VON ARDENNE offers optimal coating system concepts for this purpose.

In addition, there are already promising approaches to enable emission-free flying with hydrogen propulsion. For the necessary fuel cells, we offer coating solutions for metallic bipolar plates. Here, we benefit from over 60 years of experience in electron beam and over 50 years of experience in magnetron sputtering technology.

In addition to coating technology for thermal barrier coatings for aircraft engines and propulsion systems, we offer a wide range of coating equipment and customized solutions for

- · Optical coatings, including anti-reflection, infrared, transparent conductive oxides on flat and curved surfaces
- · Protective anti-corrosion/anti-wear/hard coatings
- Coatings for EMI/RFI shielding
- Coatings for space optics and telescopes

Depending on your unique requirements, we can tailor a suitable equipment platform that optimizes coating quality and cost per part for your application.

Proven equipment concepts with flexible design	
Experience with industrialization of new technologies	
More than 60 years of experience and expertise in electron beam technology	



\square **TURBINE BLADES**

Turbine Blade Coating With Modular and Reliable Equipment

As a manufacturer or coater of turbine blades, you have to master production processes at the edge of what is technically possible. And it is important that the ratio between costs, quality and delivery time is right. Above all, you expect high reliability and availability from your equipment.

With the TUBA, VON ARDENNE offers the optimal coating system for the thermal barrier layer systems of the next turbine generations. With this equipment, you benefit from over 60 years of experience with electron beam systems and technologies.

What are the advantages of turbine blade coating?

Air traffic is growing steadily and so are the demands on engines. They shall be quieter, save fuel and be low in emissions. To meet these reguirements, turbines have to withstand ever higher temperatures and temperature fluctuations.

This can be achieved with coatings made from high-performance ceramics. Such thermal barrier coatings contribute to longer turbine blade life and reduce fuel consumption.



Proven product quality advanced ceramics

Minimal disruption of production campaigns

Leading electron beam components



through expertise in coatings made from $\overline{\square}$

due to equipment that is easy to maintain



and over 60 years of technology experience

TUBA

Coating System for Turbine Blades





for stable high rate evaporation process	
Flexible design adapted to productivity requirement:	\square
single or dual feed, evaporation of one or two materials	
	\square





APPLICATIONS



TECHNICAL DATA

Substrates

Max. substrate length: ≈ 220 mm - 420 mm Max. weight: 100 kg Substrate rotation: 3 rpm to 60 rpm Substrate tilting: ± 45°

Heating Chamber

Final temperature: max. 1 200 °C

Coating Chamber

Number of evaporators: 2 Diameter of ingot: 63 mm Dynamic coating rate: $\approx 7.5 \,\mu\text{m.min}^{-1}$ Ingot capacity for each evaporator: 10 000 mm Substrate temp. during coating: 900 °C to 1 200 °C Atm: $O_2/Ar \ 10^{-3}$ mbar to 2 x 10^{-2} mbar

EB Guns

Max. acceleration voltage: 40 kV Power: 2 x 150 kW Average lifetime of solid cathode: \geq 200 h For emission-free flying with hydrogen engines, we offer coating solutions for metallic bipolar plates for the necessary fuel cells. In addition to coating technology for thermal barrier coatings for aircraft engines and propulsion systems, we offer a wide range of coating systems and customized solutions for optical coatings, coatings for space optics and telescopes, electrochromic coatings for aircraft windows and for electronics applications such as MEMS.

MSC1250 A2A Metal Strip Coating System

HISS Horizontal Coating System

MSC500B Metal Strip Coating System

XEAINOVA® L Inline Coating System



METALLIC **BIPOLAR PLATES**



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Minimize your manufacturing costs with highly productive coating solutions

As a manufacturer of bipolar plates for PEM fuel cell systems and electrolyzers, you are faced with the challenge of meeting the needs of a rapidly growing market. In addition, you have the task of raising the industrialization of your processes to a new level.

We offer you ideal solutions for cost-effective and highly productive manufacturing, tailored to your current and future requirements.

Our coating systems are based on platforms that allow you to scale from research and development to large-scale production.

Advantages of bipolar plate coating

Bipolar plates should be as durable, conductive and cost-effective as possible. To meet these requirements, metallic bipolar plates are coated with functional layers. PVD technologies are typically used for this purpose.

For the PEM fuel cell, we went one step further and developed and validated our own carbonbased layer stacks. The aim was to meet the demanding range of requirements for bipolar plate coating in an optimal and scalable way.

We will support you from the research and development phase to the establishment of an industrial coating solution for bipolar plates.

Corrosion protection & long lifetime through electrochemical & mechanical resistance

Improved conductivity

due to reduced interfacial contact resistance (ICR)

Scalable processes

from R&D to mass production at low cost of ownership

\square **SMART GLASS**

Reliable coating of switchable glass at highest uniformity

As a manufacturer or coater of switchable glass, you need coating equipment that is adapted to your process. This also applies to processes with heated substrates. Here, it comes down to the best technical solution to ensure a consistent process with low energy requirements.

We offer coating systems tailored to your needs, with which you can apply transparent conductive oxide (TCO) coatings. An example of such coatings is indium tin oxide (ITO), which enables dynamic switching of an applied electrical voltage.

 \square **OPTICAL WINDOWS**

Incidence of light with a high transmittance through optical coating of various substrate formats

Optical windows allow the passage of light of certain wavelengths for opto-electronic systems. At the same time, they protect them from disturbing environmental influences. The shape and size of optical windows are almost arbitrary. They are often flat glass plates, which are optimized for maximum transmission in the desired frequency range at least by an antireflective coating (AR) on both sides.

With the OPTA X, we offer you a coating system that is ideally suited for this application. The system is suitable for a variety of geometric shapes of substrates. In addition, it offers the possibility of simultaneous and fast antireflection coating of front and back sides and the deposition of selective interference filters. The deposited layers are climate resistant and abrasion resistant.

Variety of substrates can be coated by adapting the equipment to different geometries

Cost & energy savings through simultaneous double-sided antireflection coating

Up to 50 % less manpower required due to fully automated recipe control, carrier handling & substrate loading



Market-leading experience with equipment for coating heated glas substrates	s
Expertise for transparent conductive oxides especially ITO	
Flexible equipment platform for vertical coating with & without carrier	

GC120VCR

/ertical Coating System







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Rotary Disk Coating

OPTA X

VISS Vertical Coating System





VISS Vertical Coating System



\square **LARGE-AREA OPTICS**



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Highest precision on large optical surfaces

with highest uniformity

Are you looking for coating solutions for large optical surfaces with extremely high requirements for applications such as astronomical reflecting telescopes? Our magnetron sputtering technology offers you the precision you need.

In telescope construction, single mirrors with a diameter of more than eight meters are used. Before coating, these mirror optics are polished to an accuracy of 20 nanometers. The subsequent deposition of highly reflective aluminum, gold, or silver layers must not worsen this deviation from the ideal parabolic or hyperbolic shape of the mirror. This means that it must also be coated with an accuracy of a few nanometers

We provide large-area and special coating systems precisely for this purpose.

 $\overline{\square}$ Highest reflectivity & enhanced durability through magnetron sputtering technology for metallic layers with protective coating

Contour-compliant deposition precision thanks to dynamic process control

Coating of large aperture surfaces through customized special designs

\square **OPTICAL INTERFERENCE FILTERS**

High-precision optical filters through special multilayer coatings

Lowest optical losses, preferably no absorption and scattering, high transmission in the filter passband, deep blocking in the filter stopband, steep, precise filter slopes - these are requirements for optical interference filters such as bandpass filters, dichroic filters, beam splitters, polarizing or notch filters.

The performance of cameras, projectors, telescopes and optical measurement technology is being improved continuously. This requires standardized components with improved interference optical coatings.

These multilayer coatings determine the specific component function. They also reflect light or selectively split it into partial beams. They block individual wavelengths or act as pass filters for a specific light frequency range.

manding filter depositions.

MEMS

Targeted deposition & combination for MEMS: Metallic, Non-Metallic, Optical & Semiconducting Layers

Micro-Electro-Mechanical Systems (MEMS) are tiny devices that combine mechanical and electronic components. They are used in a wide range of applications, including sensors, display technologies and microfluidics.

We offer you flexible vacuum deposition systems for MEMS manufacturing. They enable you to combine different technologies, such as etching, deposition of metallization, semiconductor and passivation layers, a post-treatment or even customized requirements, depending on the specific application.

Easy adaptat processes & due to flexibly

Floor space i due to compa

Cost-efficien due to fully a

OPTA X Rotary Disk Coating



\square **LENSES & OPTICAL DOMES**



Broadband anti-reflection & Selective Filters

through conformal coating on curved substrate surfaces

If you want to apply interference optical broadband antireflection coating or selective filter coatings to lens elements, these coatings must meet certain specifications for temperature and environmental stability.

This presents special challenges, such as uniform filtering along the curved substrate surface. Other challenges include an antireflection coating on both sides of the lens surfaces, an additional optical filter function, and a climateresistant, mechanically stable lens coating with improved shift behavior of the filter through denser layers.

For such requirements we offer the OPTA X an alternative to the vapor deposition process.

 \square Direct application of filters to lens elements with concave & convex surfaces $\overline{\square}$

Dense coatings for front lenses with high abrasion & weather resistance

Single & double-sided coating of heavy lenses with large diameters

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We offer you coating systems for such de-



$\overline{}$ Highest layer thickness precision and reproducibility of deposition \square Sophisticated filter deposition on two- & three-dimensional substrates $\overline{\square}$ Suitable for target materials for all wavelengths from UV to IR

OPTA X

Rotary Disk Coating

VISS Vertical Coating System





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s saved act design	
equipment utomated concept	



for Research, Development & Production





EQUIPMEN



HISS

Highly Flexible & Scalable Inline Systems for horizontal substrate transport

Double-sided or single-sided coating to suit your substrate & process requiremen	nts
High process flexibility due to compatibility with various process ur	nits
Easily adaptable to your requirements through flexible configuration options	





MSC1250 A2A Proven system for metal strip coating with high productivity Very high productivity $\overline{\mathbf{A}}$ due to leading PVD technology Continuous coating process $\overline{\checkmark}$ with automatic coil exchange in atmosphere Flexible equipment options for pretreatment & coating

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MSC500B The Perfect First Step into Metal Strip Coating Double-sided coating possible

due to free strip guidance in the process a	rea
Easy maintenance	
and repair	
Short downtime	
for coil change	



Small foot print $\overline{\checkmark}$ due to vertical chamber orientation $\overline{\mathbf{A}}$

Low defect rates due to vertical orientation



OPTA X	
Highly productive double-sided coating for demanding optical layer systems	
Highest precision through homogeneous coatings on optical components	2
Highest quality through clean, low-defect optical coatings	2
Variable product adaptation: layer systems & component geometry	2



VISS

Highly flexible & scalable inline systems

for vertical processes & medium productivity

Scalable

through modular design

Easily adaptable to your requirements through flexible configuration options

Loading without touching the substrate front side

due to carrier transport



CLUSTER SYSTEME

Highly flexible & scalable cluster systems

for research, development & production

Scalable through modular design	\leq
Adapted to your needs	
through flexible configuration	
Helps you reduce operating costs through flexibility	

EQUIPMENT

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JOINT TESTING, SAMPLING & IMPROVEMENT From Simulation to Pilot Production



Sampling & Layer Development With a wide range of equipment

In our Technology & Application Center, we work with you and for you on the next generation of your coating applications.

From the simulation of layer stacks and their functionality, to sample production on a laboratory and pilot scale, to the measurement and evaluation of coating and substrate properties, we are prepared to meet a wide range of requirements. This gives you the opportunity to test the function of the coating for your product in advance on relevant sample sizes.

Gaining knowledge through simulation of layer composition & properties	
Sampling & qualification of properties from a single source	
Targeted integration of coating steps	

into your value chain



SIMULATION Helps You Understand Your Process

You want to accelerate your product development. And you know that the answer is multi-physical simulation and modeling. You want accurate results. But which solution is right for you? We can accelerate your product development and upgrade process by reducing engineering effort with state-of-the-art modeling and simulation. This allows you to design your custom vacuum solution or perform feasibility studies for upgrading a running system.

We have outstanding expertise in multiscale simulation and have leveraged it to ensure highly optimized system performance and best process quality.





CLOSE TO YOU! THERE FOR YOU AROUND THE GLOBE



First-class technology, quality and productivity are the key to your success and an integral part of our plants. VON ARDENNE equipment is used in more than 50 countries. We have installed over 550 coating lines worldwide and support them from our local service locations or our headquarters in Dresden. For questions or issues of any kind, we assist you by phone, personally on site or by remote support.

Customer training center

at our headquarters in Dresden



so that you get everything from a single source



DIGITALIZE YOUR WORKFLOWS WITH DIGITAL SERVICES & PRODUCTS

With **VA INDIGO**, we support you in digitalizing your workflows regarding machine operation - from installation and training to operation, maintenance and troubleshooting to service and support.

The world is getting more and more digital and the industry with it. An important aspect of this development is the digitalization and networking of machines, logistics, periphery systems and resources based on collecting, analyzing and transferring data. This will enable the optimization of not just one production step but a complete value chain. Furthermore, it will open new ways of providing products and services.

Based on this global development, we will help you meet future requirements such as autonomy, connectivity, productivity, predictability and flexibility. And we will help you launch into the next era of production.

OUR PORTFOLIO



& Monitoring



ANALYSIS SUITE Data Review & Analysis

Optimized use of resources through automated processes Higher yield & lower costs for quality & damage management Enables larger product portfolio with more profitable products



JIGITAL SERVICES







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.

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COMPREHENSIVE SERVICE PORTFOLIO

✤ VON ARDENNE service hubs around the world
 ✤ On-site service

C Remote access by our technology department

• Regular technical and technological trainings

⊕ Spare & wear part warehouse close to customers

Or 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.



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.



vonardenne.com

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

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



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