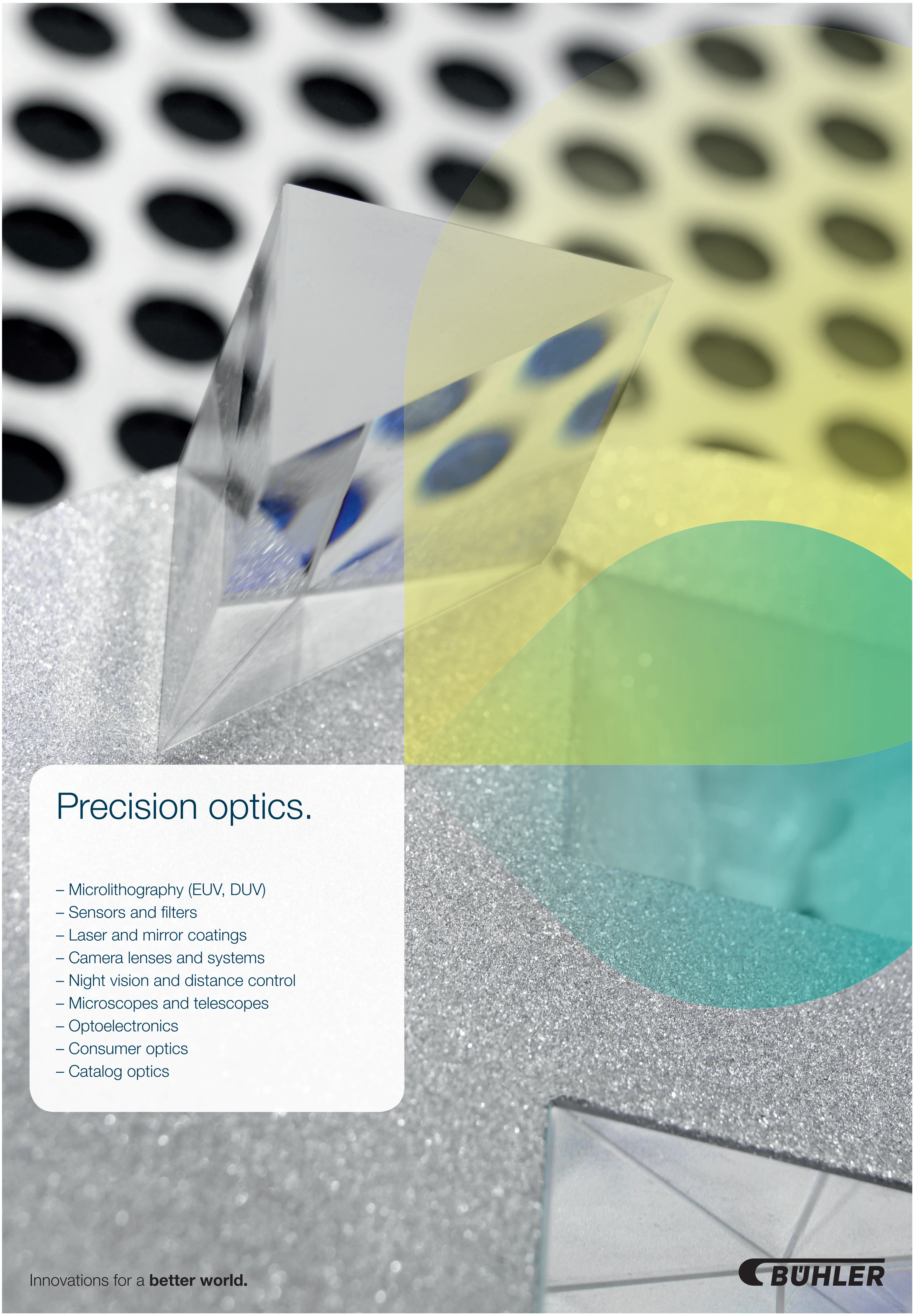


Precision optics.

- Microlithography (EUV, DUV)
- Sensors and filters
- Laser and mirror coatings
- Camera lenses and systems
- Night vision and distance control
- Microscopes and telescopes
- Optoelectronics
- Consumer optics
- Catalog optics

Innovations for a **better world.**

BÜHLER

Precision optics. **Our track record of pioneering achievement is unmatched.**

As one of the world leaders in thin-film technology, we develop and manufacture vacuum deposition equipment for a broad range of applications.

Originally, the foundation for the Bühler Leybold Optics company's present-day success was laid by inventors Ernst Leybold and Wilhelm Carl Heraeus 160 years ago. Today, we are a globally active high-tech company, with the business area's headquarters in Alzenau (Germany)and subsidiaries in Cary (USA) and Beijing (China). Worldwide, we employ over 300 employees dedicated solely to thin-film coating applications. A top priority for us is innovation leadership in key areas such as sputtering, PECVD, plasma-assisted evaporation, machine automation and related software, as well as world-class customer service.

Precision optics coatings is Bühler Leybold Optics' classic domain. We are proud that our numerous technological breakthroughs shaped the entire industry through the last decades up to today:

1975	First optical monitoring system for layer control
1984	First box coater with fully-automatic optical monitoring
1992	Invention of the Advanced Plasma Source APS
1998	Introduction of coating systems for production of telecom applications like DWDM filters
2003	Introduction of plasma-assisted magnetron-sputtering (PARMS) process technology in the HELIOS machine
2003	Introduction of the NESSY magnetron-sputtering system for EUV applications
2004	Introduction of intermittent optical monitoring directly on the calotte
2006	Introduction of HELIOS for bio-sensor market
2010	Introduction of the LION 300, an RF ion-source for high-quality filters
2011	Commercialization of NESSY mass-production system for EUV applications
2013	Laser coatings for laser applications
2014	Developed smallest and largest sputtering machine for precision applications – DEIMOS for astronomical mirror-coatings – STARpro for smallest optical filter production sizes
2015	HELIOS qualified for optical sensors in consumer optics and automotive applications
2017	Ion Beam Sputtering (IBS) for best quality coatings of high-end optics
2017	Ion Beam Sputtering (IBS) for best quality coatings of high-end optics
2018	Ion Beam Figuring (IBF) for ultra-precise corrective polishing of surfaces
2019	Horizontal In-Line Sputter-tool for head-up display
2020	Introduction of HELIOS 1200 for consumer electronics application

As the leader in this field, Bühler Leybold Optics invests unparalleled resources in research and development for sputtering, PECVD and evaporation technologies.

Solutions for precision optics. **Customer benefits are our daily business.**

With over 160 years' experience, Bühler Leybold Optics is a leading supplier of vacuum thin-film coating technology. Our state-of-the-art solutions include: precision; ophthalmic and automotive optics applications, architectural and automotive glass for a wide range of energy saving applications, and roll-to-roll plastic film coatings for packaging, electronic and safety applications. All of our solutions are tailored for our customers' specific market demands.

We are continuously improving our key-component technology and know-how to offer 1st class coating solutions, process expertise and customer services. Presently we focus on digitalization of our products, as well as digitization our company to continue offering the best solutions and serving our customers most efficiently.

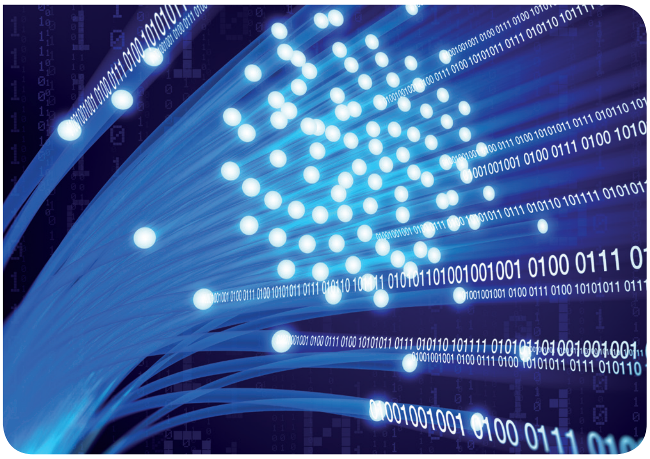
From anti-reflection coatings to complex interference filters, we support in the development of new products with optics technology. Every year we invest a significant amount on research and development to improve further our technology concerning quality, precision, sustainability, serviceability and the ecological footprint of our processes and machines. We like to welcome you in our state-of-the-art Application Center where you can test samples and processes to find the most suitable solution for your needs together with our experts.

We strive to maintain our benchmark position and to be an innovative and reliable partner for our customers.

I am looking forward to working together with you!

Sincerely yours,

Antonio Requena
Managing director
Bühler Alzenau GmbH
Business Area Leybold Optics




Self-Driving
48
mph
/Autonomous
/Sensing
/Communication
/Battery
/Navigation
/Mirrorless
/Ecology
Self-Driving
Mode

Leybold Optics – portfolio overview.
Solutions for every challenge.

LEYBOLD OPTICS SYRUSpro series
Our SYRUSpro vacuum coater series sets the industry benchmark in production and R&D. This classic evaporation system produces excellent coatings at extremely competitive deposition rates and is also available in special configurations for infrared (IR) and ultraviolet (UV) wavelength regimes.

Page 8

LEYBOLD OPTICS ARES series
High productivity, lowest cost of ownership, production-proven. These are the highlights of the ARES series that has been developed to meet the requirements of mass-production-oriented markets, especially in Asia.

Page 14

LEYBOLD OPTICS HELIOS series
The HELIOS series sputtering tool is a flexible platform for fast, precise and fully-automated thin-film coatings. It specializes in high-quality optical coatings featuring very low absorption and scattering.

Page 16

LEYBOLD OPTICS IBS
LEYBOLD OPTICS IBS Technology is a proven technology for lowest absorption and scattering capabilities for high-end optical applications.

Page 20

LEYBOLD OPTICS NESSY series

The NESSY series is our latest-generation magnetron-sputtering system mainly used for the production of extreme ultraviolet (EUV) mirrors under ultra-high vacuum (UHV) conditions – for mass production and product development.

Page 22

LEYBOLD OPTICS DEIMOS

Astronomical substrates of up to 4.5 m in diameter can be precisely sputtered within DEIMOS coaters, achieving highest reflectivity and durability values. The ease of substrate exchange is another noteworthy advantage.

Page 26

LEYBOLD OPTICS STARpro

Based on a single-reactive magnetron configuration, the STARpro allows the manufacture of multiple-layer stacks consisting of SiO_2 and Si_3N_4. Its versatility combined with its ultra-compact design makes it a perfect choice for small production runs.

Page 28

LEYBOLD OPTICS DLC

This high-vacuum coater uses plasma-enhanced chemical-vapor deposition (PECVD) technology for material deposition. The diamond-like carbon coatings produced are mainly used for optical- and thermal-imaging systems.

Page 30

LEYBOLD OPTICS IBF series

This ion beam figuring (IBF) technology is a dry error correcting and polishing process for the production of high-performance optics. While conventional polishing techniques reach their limits IBF is the ideal solution to achieve ultra-precise surface finishes.

Page 38

SYRUSpro series.
Unsurpassed performance and productivity.

1 Planetary systems, calottes or full-domes

2 Proprietary optical monitoring systems

3 Optimized heater assembly (bottom and/or top)

4 Ergonomic human-machine interface

5 Pre-installed processes

6 Network integration and remote access

7 Customized thermal evaporator setups

8 Proprietary electron-beam guns

9 Proprietary plasma sources

Applications:

- Edge filters (short and long pass)
- Notch filters
- Narrow bandpass filters
- Dichroic color filters
- Polarization beam splitters
- (Super) AR coatings
- Endoscopes
- Laser mirrors
- Cold-light mirrors
- TCO layers
- Self-assembled nanostructures

SYRUSpro series – the benchmark for 24/7 optical-filter volume production

The SYRUSpro series is quite simply the industry benchmark in production and R&D. Decade-long perfection of plasma-ion-assisted deposition (PIAD) technology enables excellent coatings at extremely competitive deposition rates from deep-ultraviolet (DUV) via visible spectrum (VIS) up to the infrared (IR) spectral range.

Based on a large variety of proprietary components and Bühler Leybold Optics process control, the SYRUSpro series is customized to meet the most challenging individual needs.

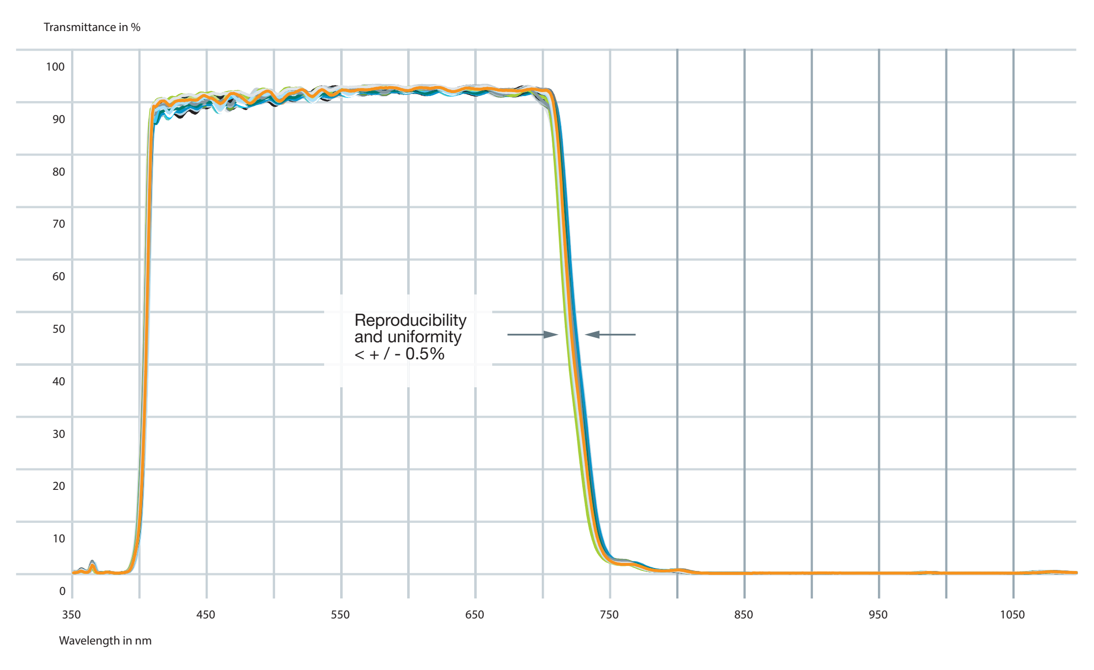
With optical and/or physical monitoring to control layer growth, Bühler Leybold Optics' SYRUSpro series delivers extremely high spectral performance and unmatched reproducibility at lowest cost-per-piece, thus maximizing the return-on-investment.

Key benefits:

- Far IR to deep UV wavelength spectrum
- Co-evaporation from two sources, with dual-rate and thickness control
- Leybold Optics LION and APSpro ion sources
- Integrated proprietary optical monitoring system
- Outstanding versatility through variety of options
- Eight different chamber sizes (700 up to 2800 mm)
- Substrates up to 1.1 m in size
- Fully modular and customizable concept
- Benchmark in cost-per-piece

Unique reproducibility and precision

Reproducibility and uniformity of 5 consecutive batches and 5 substrates for each run distributed over a single calotte of a UV-IR-cut filter produced in a SYRUSpro 1510.



The 25 different curves show only minimal deviations – a remarkable result.

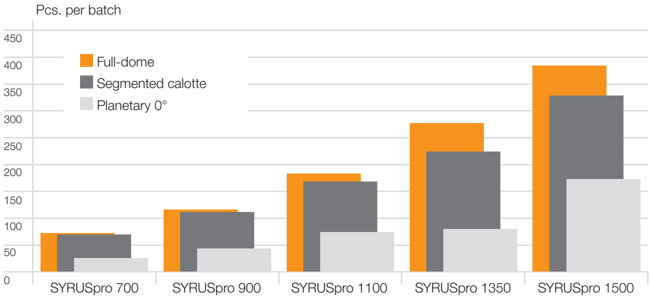
SYRUSpro series.
Manifold options and peerless flexibility.

SYRUSpro series – a universe full of options
The enormous range of options in the equipment of a SYRUSpro coater is one of its key features that make the difference and allows a perfect match to customer needs. The process library and the company's experience with challenging specifications for IR, DUV and even extreme wavelength regimes are unrivaled in the industry.

Ultimately, it is the wealth of knowledge and experience that allows the Bühler Leybold Optics process experts to realize the one configuration that best matches the specific customer requirements. They understand the often complex interrelationships and come up with the ideal coater – almost always a SYRUSpro.

Broadest portfolio and experience in the market
Able to offer up to 8 different chamber sizes, Bühler Leybold Optics has the broadest experience to provide the perfect matching solution for any kind of business case.

Loading capacity Ø 65 mm lenses



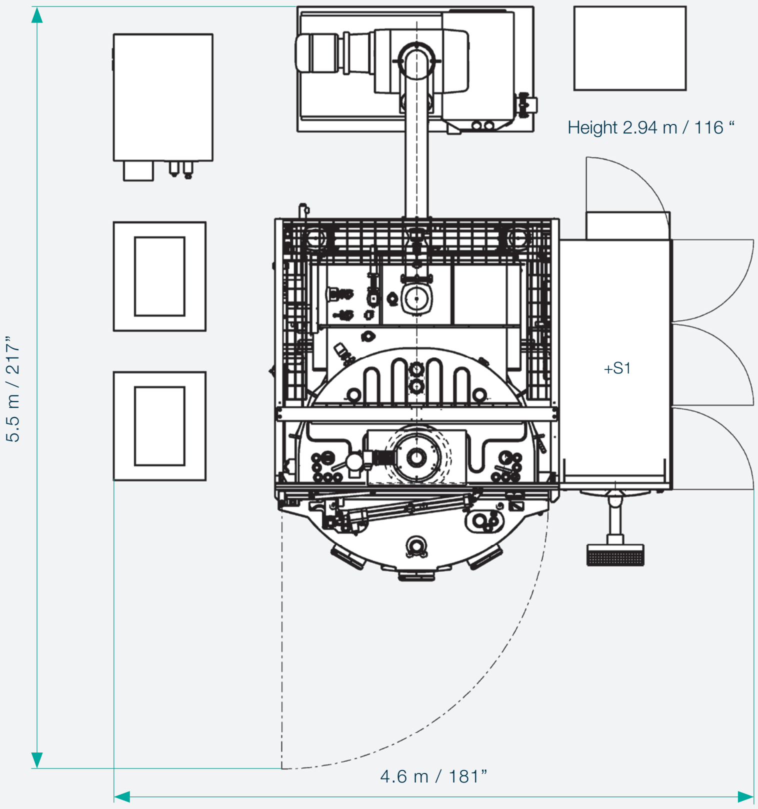
Enlargement of chamber size is only possible with adequate components so as not to compromise coating quality.

Technical data

SYRUSpro	**700**	**900**	**1100**	**1350**	**1500**	**1950**	**2100**	**2800**
Coating technology	Ion-assisted deposition (IAD), plasma-ion-assisted deposition (PIAD)							
Coating materials	Every commonly used material (dielectrics, metals, fluorides, sulfides)							
Chamber width [mm]	700	900	1100	1350	1500	1950	2100	2800
Chamber width [inch]	28	36	44	53	61	77	83	110
Floor space [m^2]	11.2	16.4	17.3	20	25.9	38	41	55
Floor space [sq.ft.]	121	177	186	215	279	409	441	592
Loading capacity Ø 65 mm								
Calotte [pcs.]	71	115	183	277	384	*	*	*
Segmented dome [pcs.]	3 x 23	3 x 37	4 x 42	4 x 56	6 x 54	*	*	*
Planetary system [pcs.]	25	43	73	79	112	*	*	*

(*) To be defined in accordance with customer requirements

SYRUSpro 1510



Pumping systems:

- Fore-vacuum:
  - Standard pumps
  - Dry pumps
- High-vacuum:
  - Turbomolecular pumps
  - Diffusion pumps
  - Cryogenic pumps

Heating systems:

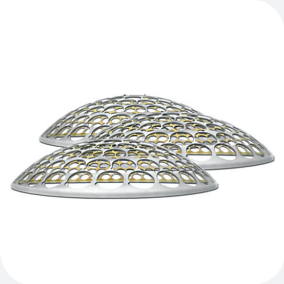
- Precise temperature ramp-up
- Optional:
  - Front or rear-side heating
  - Ceramic or metal heaters
  - Control via thermocouple or pyrometric, intermittent on substrate
  - High- or low-power sources
- High-temperature option (> 400° C)

Premium components for SYRUSpro.

Substrate holders

Pallet substrate holders for
flat rotation

Segmented domes in variety
of configurations



High-precision full-domes for
fast loading times

Planetary drive-systems with
double-rotation

Evaporators

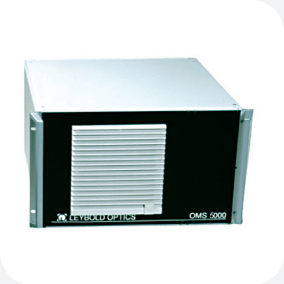
LEYBOLD OPTICS HPE 12/10
mid-size electron-beam gun

LEYBOLD OPTICS HPE 12
large-volume electron-beam gun

Single-boat thermal-resistance
evaporator

Triple-boat thermal-resistance
evaporator

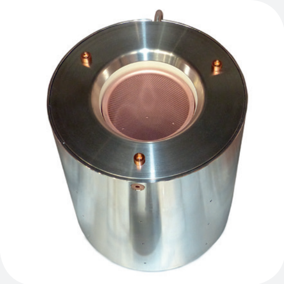
Optical monitoring



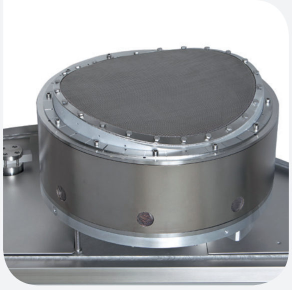
Single-wavelength monitoring system
LEYBOLD OPTICS OMS 5100

Broadband optical-monitoring system
LEYBOLD OPTICS WB-1000

High-power plasma sources



LEYBOLD OPTICS APSpro with
LaB6 cathode



LEYBOLD OPTICS LION 300
based on ECWR

ARES series.
Getting the optimum in value for your investment.

1 Quartz-crystal monitoring

2 Optical monitoring system

3 Visualization in Chinese

4 Network connection and remote access

5 Fully-modular concept

6 Compact footprint

7 Proprietary ion sources

8 Proprietary electron-beam guns

9 Optimized equipment configuration

ARES series – cost-effective production with high performance
The ARES series is Bühler Leybold Optics' system for cost-optimized mass-production of optical components especially designed for East Asian countries.

The configuration is thoroughly streamlined according to the specific application, but never compromising on quality – a smart choice for the savvy investor.

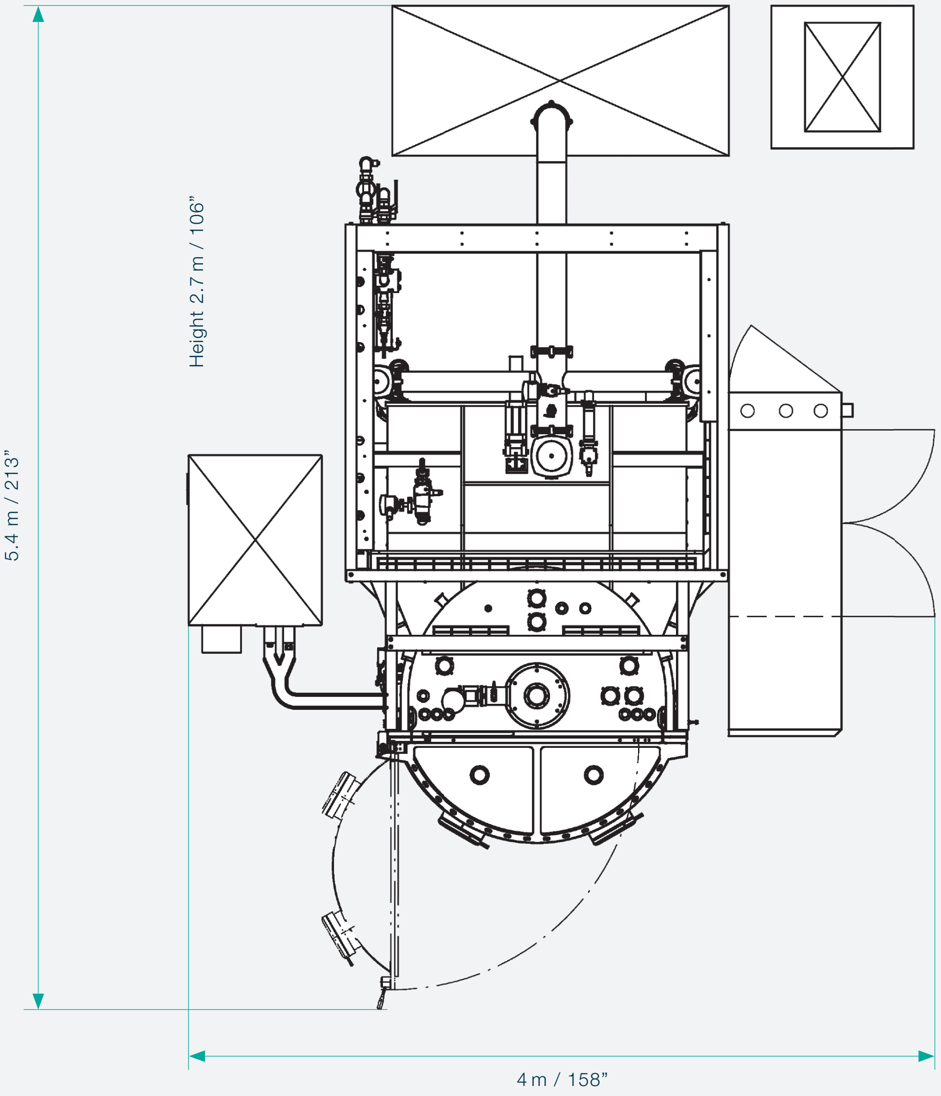
Applications:
- AR coatings
- Anti-fingerprint coatings
- Color filters
- Edge filters
- Cold-light mirrors
- Touch screens

Key benefits:
- Optimum CAPEX performance ratio
- Optimized for East Asian requirements
- High throughput

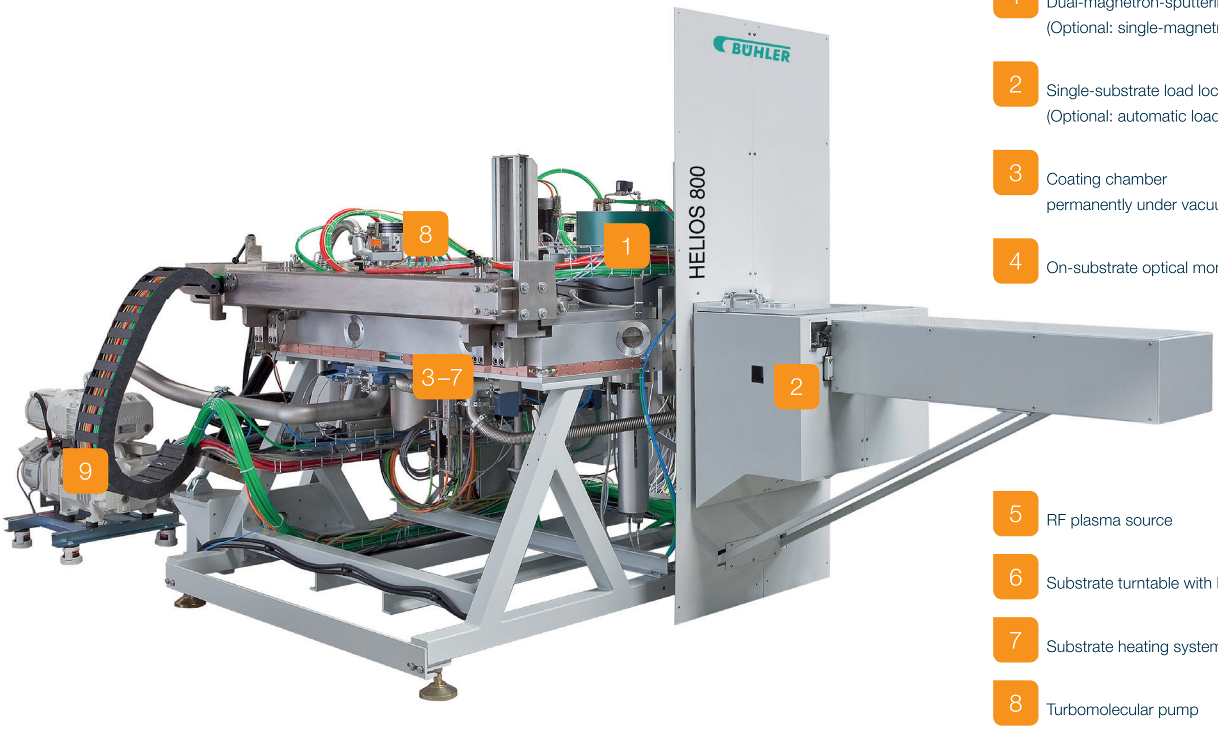
Technical data

Systems	**ARES 700**	**ARES 1100**	**ARES 1350**	**ARES 1500**	**ARES 2000**
Coating materials	All commonly used dielectrics, metals, fluorides, sulfides				
Coating technology	Ion-assisted deposition (IAD) / Plasma-ion-assisted deposition (PIAD)				
Chamber diameter [mm]	700	1100	1350	1500	1960
Chamber diameter [inch]	28	44	53	61	77
Floor space [m^2]	11.2	20	23.7	25.9	38
Floor space [sq.ft.]	121	216	255	279	409
Loading capacity Ø 65 mm					
Calotte [pcs.]	71	186	277	324	*
Segmented dome [pcs.]	3 x 23	4 x 42	4 x 63	6 x 54	*
Planetary system [pcs.]	25	73	79	112	*

ARES 1350



HELIOS series. **High-precision, high-yield coaters for top-grade products.**



1. Dual-magnetron-sputtering-modules (Optional: single-magnetron)
2. Single-substrate load lock (Optional: automatic loading/unloading)
3. Coating chamber permanently under vacuum
4. On-substrate optical monitoring
5. RF plasma source
6. Substrate turntable with high-speed drive
7. Substrate heating system
8. Turbomolecular pump
9. Dry fore-vacuum pump

HELIOS series – the ultimate sputter coaters
This flexible sputter platform is ideal for fast, precise and fully-automated thin-film deposition. It specializes in high-quality optical coatings, featuring very low absorption and scattering.

Unsurpassed optical performance is ensured by the extremely dense, smooth, stoichiometric, and amorphous layers. Ultimate precision in layer-growth control is facilitated by an optical monitoring system for in-situ on-substrate measurements.

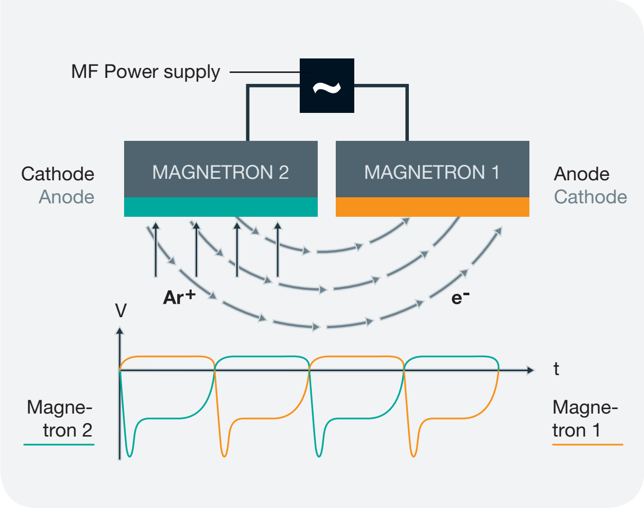
Key benefits:
- PARMS process technology
- No arcing and µ-arcing
- High and stable deposition rates
- On-substrate optical monitoring
- Extremely high process stability
- Thickness precision down to ultra-thin layers
- Filters with over 200 layers and 20 µm thickness
- Optimal film oxidation, high density and low loss
- Co-sputtering for intermediate index tuning
- Rapid prototyping and short time-to-market
- Fast (un)loading without breaking the vacuum

Applications:
- Laser-line filters
- Steep-edge filters
- Single- and multi-notch filters
- Laser mirrors
- Chirped mirrors
- Thin-film polarizers
- Beam splitters
- Bio sensors

PARMS process technology

The plasma-assisted reactive magnetron-sputtering (PARMS) technology allows for the deposition of metal oxides with high- and low-refractive indices by combining mid-frequency (MF) and radio-frequency (RF) sputter technologies over two magnetrons.

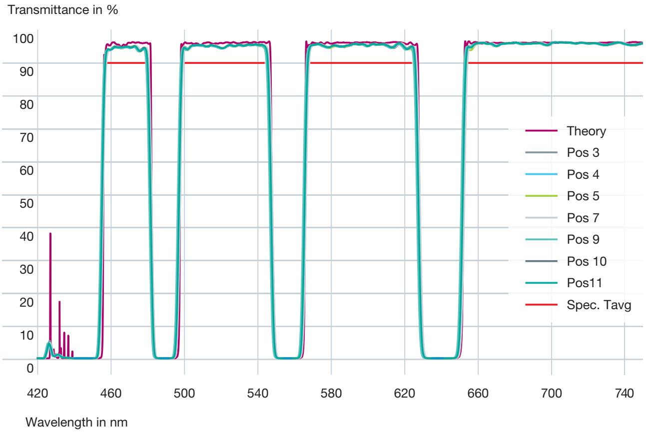
Parms technical principle:



On-substrate optical monitoring

The LEYBOLD OPTICS OMS 5100 is the premium tool for in-situ optical monitoring. The optical thickness of the coated layer is measured either on a stationary test-glass or – for more accuracy – directly on the substrate via intermittent mode.

4-fold-notch filter, AOI = 10°



One example of how theory and prototype coating of an advanced notch filter perfectly matches when produced with HELIOS coaters.

Technical data

System			**HELIOS 400**	**HELIOS 800**
Technology			Plasma-assisted reactive magnetron-sputtering (PARMS)	
Applications			DC sputtering (optional: HF sputtering)	
Coating material			SiO_2, Nb_2O_5, Ta_2O_5, ZrO_5, HfO_2, AlO_3, Si_3N_4	
Capacity			12* pcs. at Ø 125 mm / 5”	12* pcs. at Ø 200 mm / 8”
			16* pcs. at Ø 100 mm / 4”	
Source positions (max. 4)	1 and 2	(standard)	Dual-magnetron	Dual-magnetron
	3	(optional)	Single-magnetron	Dual-magnetron
	4	(standard)	RF plasma	RF plasma
	Coating Ø	(standard)	≤100 mm / ≤ 4”	≤ 200 mm / ≤ 8”
		(optional)		≤ 150 mm / ≤ 6”
Layer monitoring	Time control		Yes	Yes
	Optical monitoring		LEYBOLD OPTICS OMS 5100 LEYBOLD OPTICS BBM	LEYBOLD OPTICS OMS 5100 LEYBOLD OPTICS BBM
Dimensions	Width x length x height		5.7 m x 3.4 m x 2.6 m 223” x 134” x 102”	7.3 m x 6.2 m x 3.0 m 288” x 242” x 118”
Site requirements	Electric power		46 kVA	110 kVA
	Line voltage		400 VAC, 50/60 Hz	400 VAC, 50/60 Hz
	System weight		3420 kg	4200 kg

(*) One substrate less when optical monitoring is used

HELIOS 800. **High-precision, high-yield coaters for mass production.**

1 Dual-magnetron-sputtering modules
2 RF plasma source
3 On-substrate optical monitoring
4 Coating chamber permanently under vacuum
5 Automatic loading system with three load locks
6 Electrical control cabinet with graphical user-interface (GUI)

HELIOS 800 with autoloader – well established in semiconductor industry
The highly precise coating capabilities paired with the automatic loading system makes the HELIOS 800 machine an ideal choice for coating 8” wafers from glass or silicon material. Due to the availability of three loading locks, the machine can be prepared for three continuing and unattended production runs, thus perfectly matching the demands for mass production applications. Of course the machine can be delivered with a SECS/GEM interface for data exchange and remote control via customers host and data analyzing system.

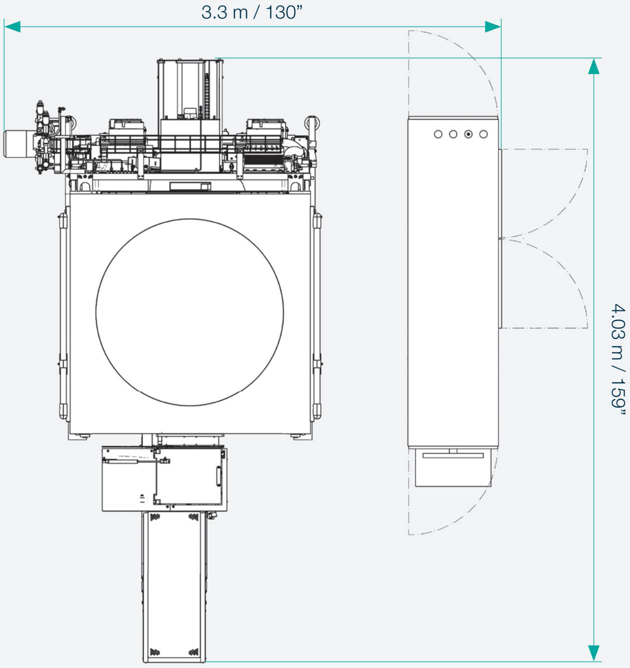
For processes where frequent changes of the monitoring glass are needed, the loading lock can be easily prepared for automated exchange of the glasses without operator intervention. In such the machine can be prepared and started during the first shift and run production during the next both shifts without any support from the outside.

Key benefits:
- Direct on wafer sputtering
- Optical monitoring with automated test slight exchange
- Unattended operation until the process has been finished
- SECS/GEM Interface

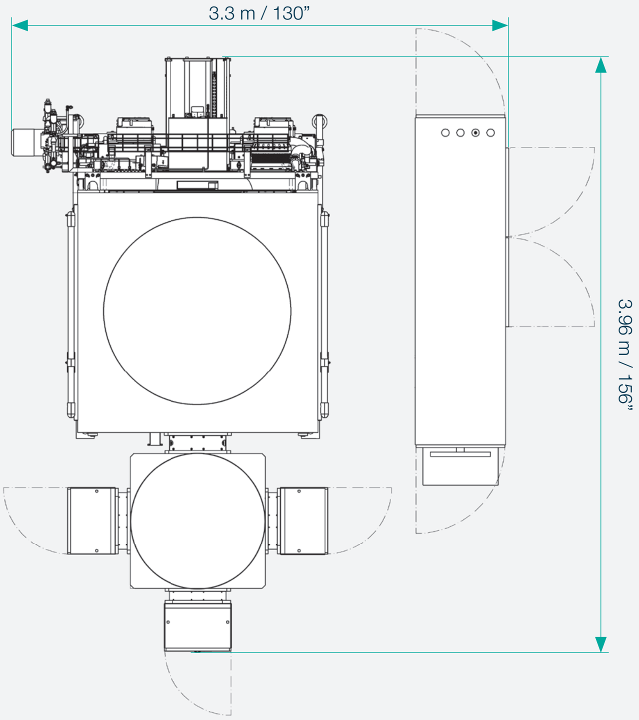
Applications:
- Laser-line filters
- Steep-edge filters
- Single-/multi-notch filters
- Laser mirrors
- Chirped mirrors
- Thin-film polarizers
- Beam splitters
- Bio sensors
- Consumer electronics
- ADAS sensoric

Floor layout: comparison single-load lock and autoloader

Single-load lock



Autoloader



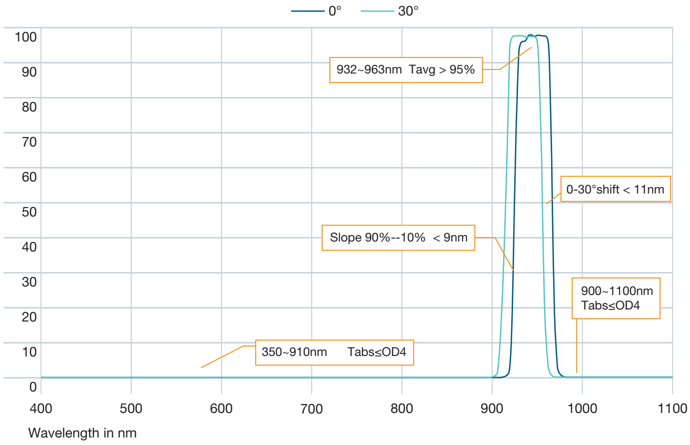
Si:H_2 Process

The optical properties of magnetron sputtered Si-layer can be adjusted by adding hydrogen (H_2) to the coating chamber, thus achieving highly transparent layers at 830 nm.

Bandpass filters (Si:H_2/SiO_2) with low angle shifts were manufactured on HELIOS 800.

Low angle shift filter

Example of how theory and prototype coating of an advanced low angle shift filter perfectly matches when produced with HELIOS 800.



LEYBOLD OPTICS IBS.
Ultra-high precision thin-film coatings.

1	Ion-beam source
2	Target tower
3	Coating chamber
4	On-substrate optical monitoring
5	High-vacuum pump
6	Dry pre-vacuum pump
7	Otional Load Lock (not shown)

With LEYBOLD OPTICS IBS 1400 and 1600, Bühler Leybold Optics offers an ion-beam sputtering system for the production of high-precision optical coatings. The technology is well known for extremely low-loss optical coatings and is therefore especially suitable for the production of laser optics.

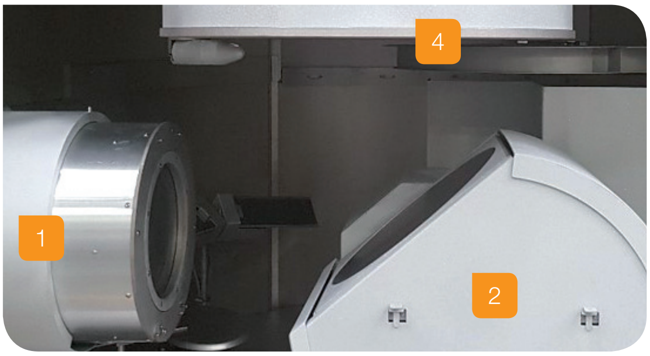
Key benefits:
- Lowest scatter values and defect densities
- Coating of substrates up to Ø 600 mm
- Highest uniformities of ±0.3 %
- Lowest defect densities due to mask-less deposition & operation without shutter
- Coating of curved & large substrates
- Highest flexibility of target material

Options:
- Automatic load lock system
- Additional RF plasma assist source
- Broad Band Monitoring (BBM)

The machine is a batch type system, optional with an automatic load lock system and equipped with an extremely powerful 3-grid RF ion-beam source to be able to produce also large substrates with corresponding quality and speed.

LEYBOLD OPTICS IBS – the ultimate ion-beam sputter coater for your laser, medical, metrology, microscopy and telecom application.

IBS Equipment – a view in the coating chamber

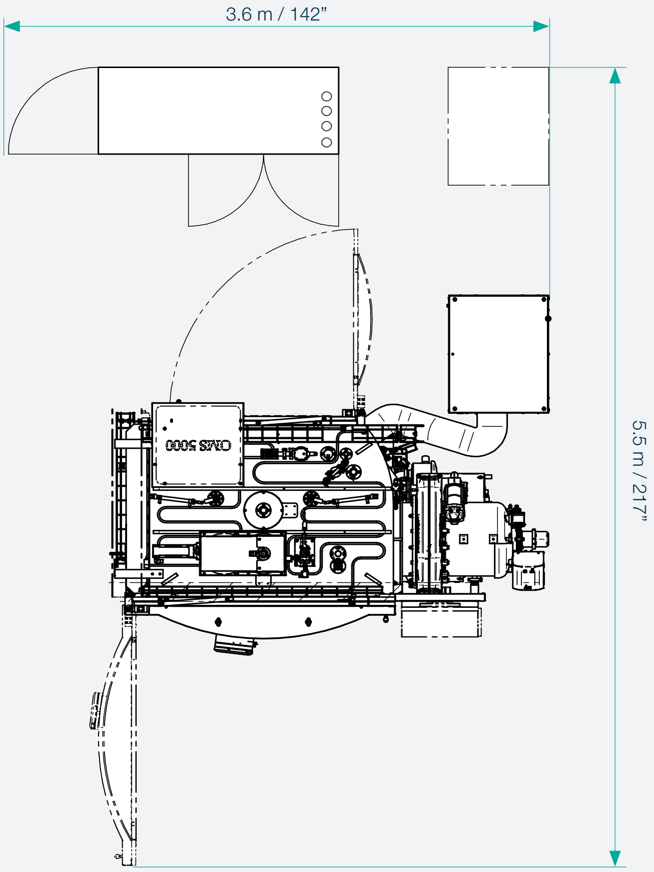


Technical data

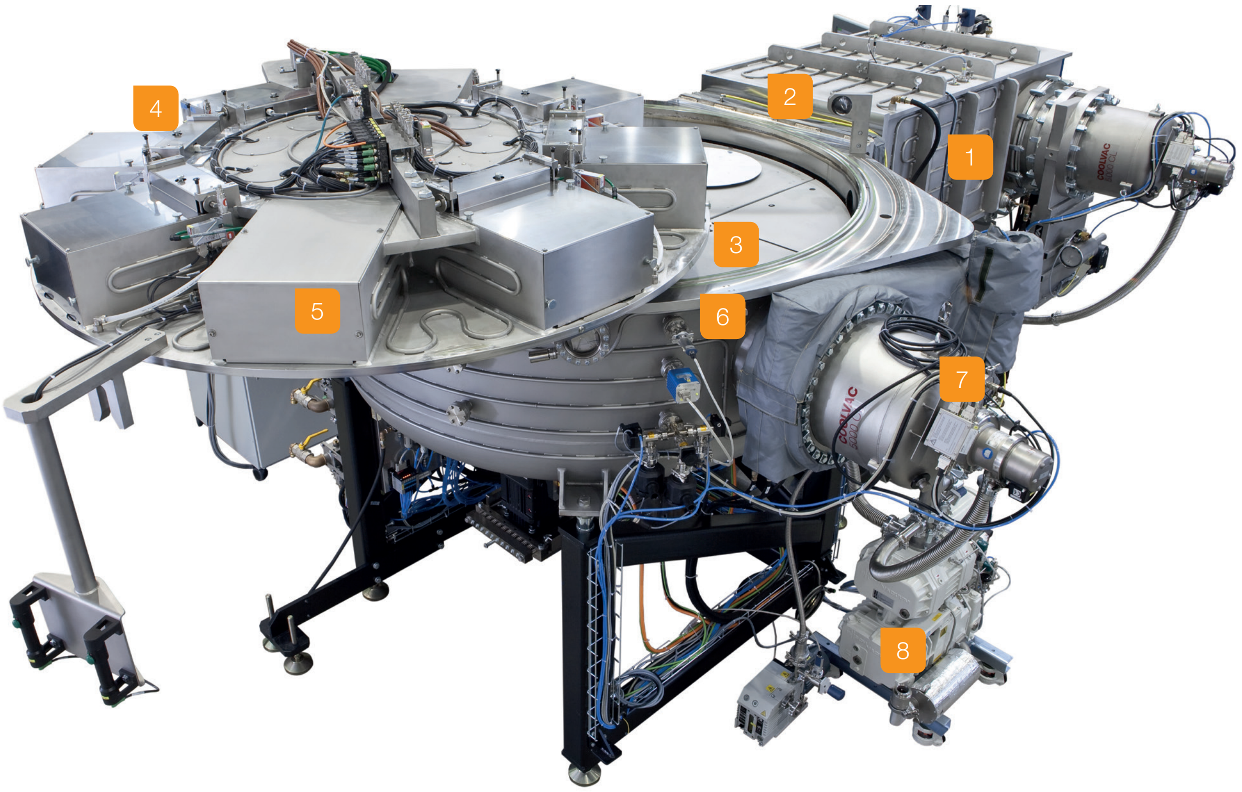
Systems			LO IBS 1400	LO IBS 1600
Coating Technology			Ion beam sputtering with 3-Grid RF source	
Systems	High precision (HP)	Laser application	1 x diameter 400 mm substrate	1 x diameter 600 mm substrate
		Telecom application	1 x diameter 304 mm (12") substrate	
	High throughput (HT)	Medical/Metrology/ Microscopy	4 x diameter 350 mm substrate	
Coating materials			Metallic / dielectric material	
Target configuration			3 – Target assembly	
Sources		Sputter source	3 Grid RF 220 mm	
		Assist source	LION 100 RF (Single Grid)	
Layer monitoring		Time control	Yes	
		Optical monitoring	LEYBOLD OPTICS OMS 5100 Optional: LEYBOLD OPTICS BBM	
Vacuum system		Pre-vacuum pump	Oil-free pump system	
		High-vacuum pump	Cryo-pump system	Turbo molecular pump system
Floor space		[m]	3.3 x 5.1 x 2.9	3.5 x 5.4 x 2.9
		[inch]	130 x 200 x 114	134 x 212 x 114
Site requirements		Electric power	60 kVA	66 kVA
		Line voltage	400 V AC, 50/60 Hz	
		System weight	6700 kg	7000 kg

Markets & applications:

- Laser optics
  thin-film components:
  - AR/HR (antireflex/mirror)
  - Gyroscope mirrors
    (Lowest total losses scattering and absorption, Highest reflection)
  - Various coatings for laser components
- Medical, Metropoly, Microscopy
  thin-film components:
  - Bandpass filters
  - Beam splitters
    (polarizing, non polarizing)
  - Edge filters
  - Dielectric mirrors
  - Metal/Dielectric mirrors
- Telecom
  thin-film components:
  - LAN-WDM
  - CWDM
  - DWDM



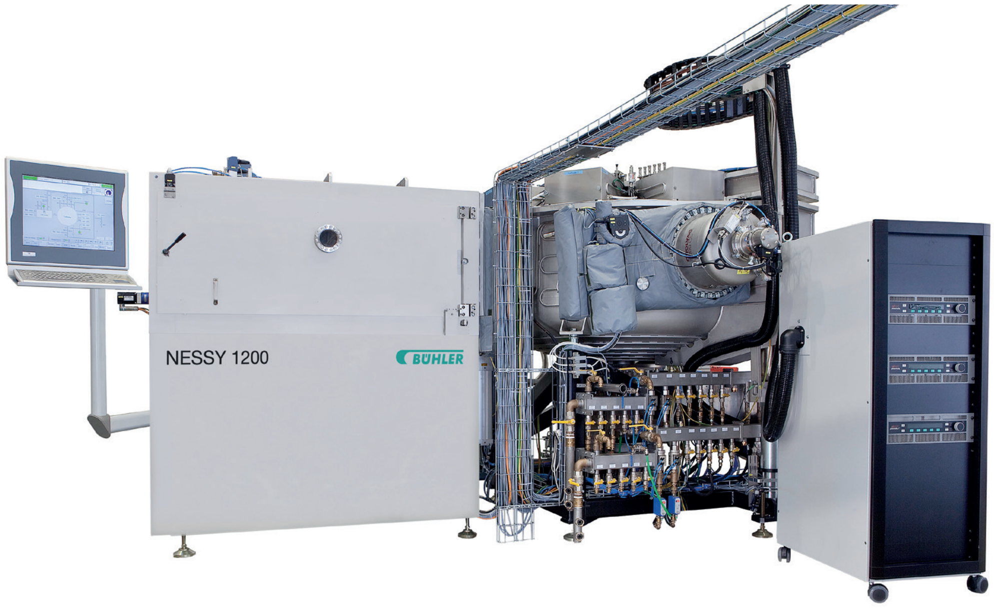
NESSY series.
The sputter equipment for EUV applications.



1	Heated load lock
2	Handling for loading/unloading
3	Planetary substrate drive with sub-rotation and speed profiles
4	Chamber lid for ease in service
5	Magnetron-sputtering cathodes PK 600
6	Adjustable sputter distance
7	Cryo pump
8	Dry pre-vacuum pump set

Key benefits:

- Extremely consistent layer-thickness uniformity
- UHV base pressure: < 9 * 10–9 mbar
- Outstanding, defect-free film quality
- Statistical layer precision in subatomic range (e.g. 7 nm +/- 0.25 %)
- Suited for numerous materials (including Mo and Si for EUV mirrors)
- Advanced layer functions (e.g. diffusion barrier and capping layers)
- Adjustable sputter distance
- Substrate height including carrier up to 240 mm
- Substrates sizes up to Ø 660 mm



NESSY series – sputtered layers with ultimate precision

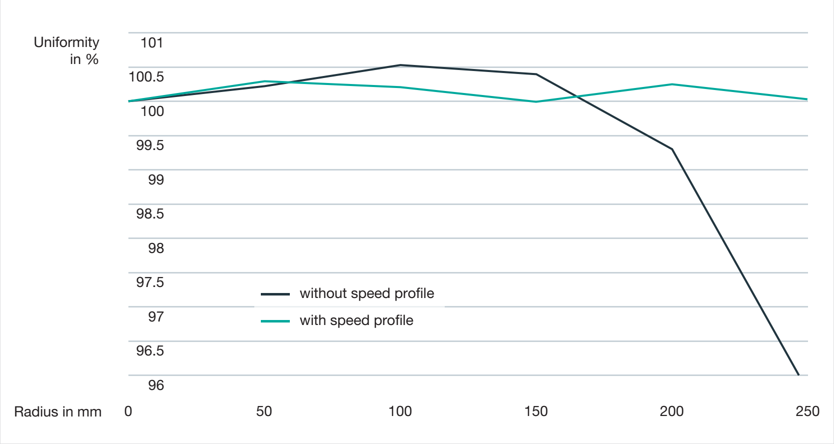
This magnetron-sputtering system used for ultra-high vacuum regimes (UHV) excels with unmatched levels of layer precision through its unique substrate handling with double rotation. Thus it is an ideal tool for the production of mirrors in the x-ray or extreme-ultraviolet (EUV) spectral range. The reflectance values realized on multi-layer stacks come close to the theoretical threshold with economic cost-per-piece ratios in parallel. As such the NESSY platform is equally suited for both series production and for product development at the technological limit.

Application potential

Extreme layer specifications like molybdenum/silicon multi-layer mirrors with maximum reflectance at a wavelength of 13.5 nm, which are of crucial importance as condenser or projector mirrors in lithography equipment, can be realized using the NESSY series. The potential of the NESSY series, however, stretches way beyond this highly specific use. The wide variety of sputtered materials, together with the ability to handle large or complex-shaped substrates, makes the NESSY series ideally suited for the development of novel applications and components. If you have ideas and requirements at the edge of today's technological feasibility, just contact us – we'll accept the challenge!

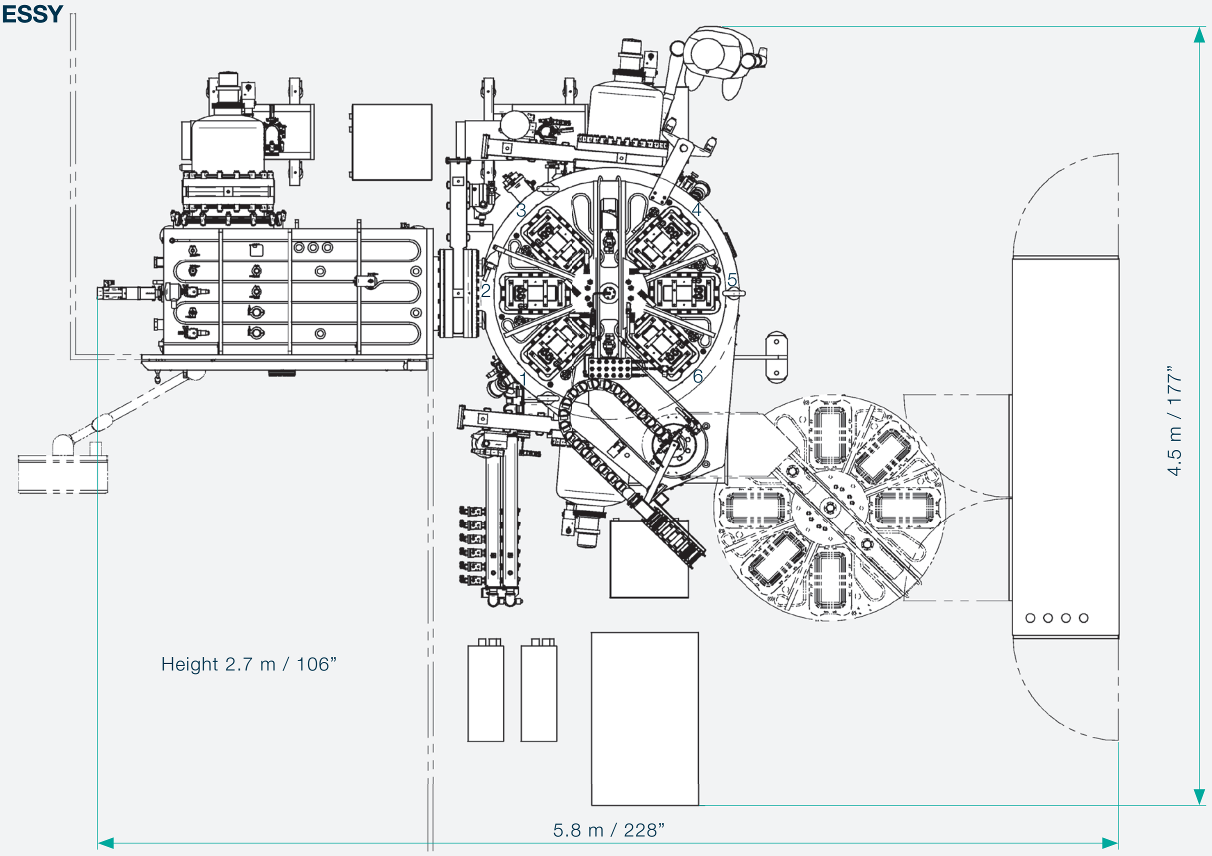
Unmatched thickness uniformity

Excellent stability of sputter process and extreme levels of layer-thickness precision is a result of careful management of the substrate movement and minimized mechanical tolerances at the substrate holder. With additional double-rotation and varying speed profiles, the NESSY series bridges the gap to the subatomic uniformity values necessary in, for example, EUV optics applications.



Uniformity of molybdenum single layer measured by optical density.
The data show ± 0.15 % over 450 mm diameter in the optimized case.

NESSY

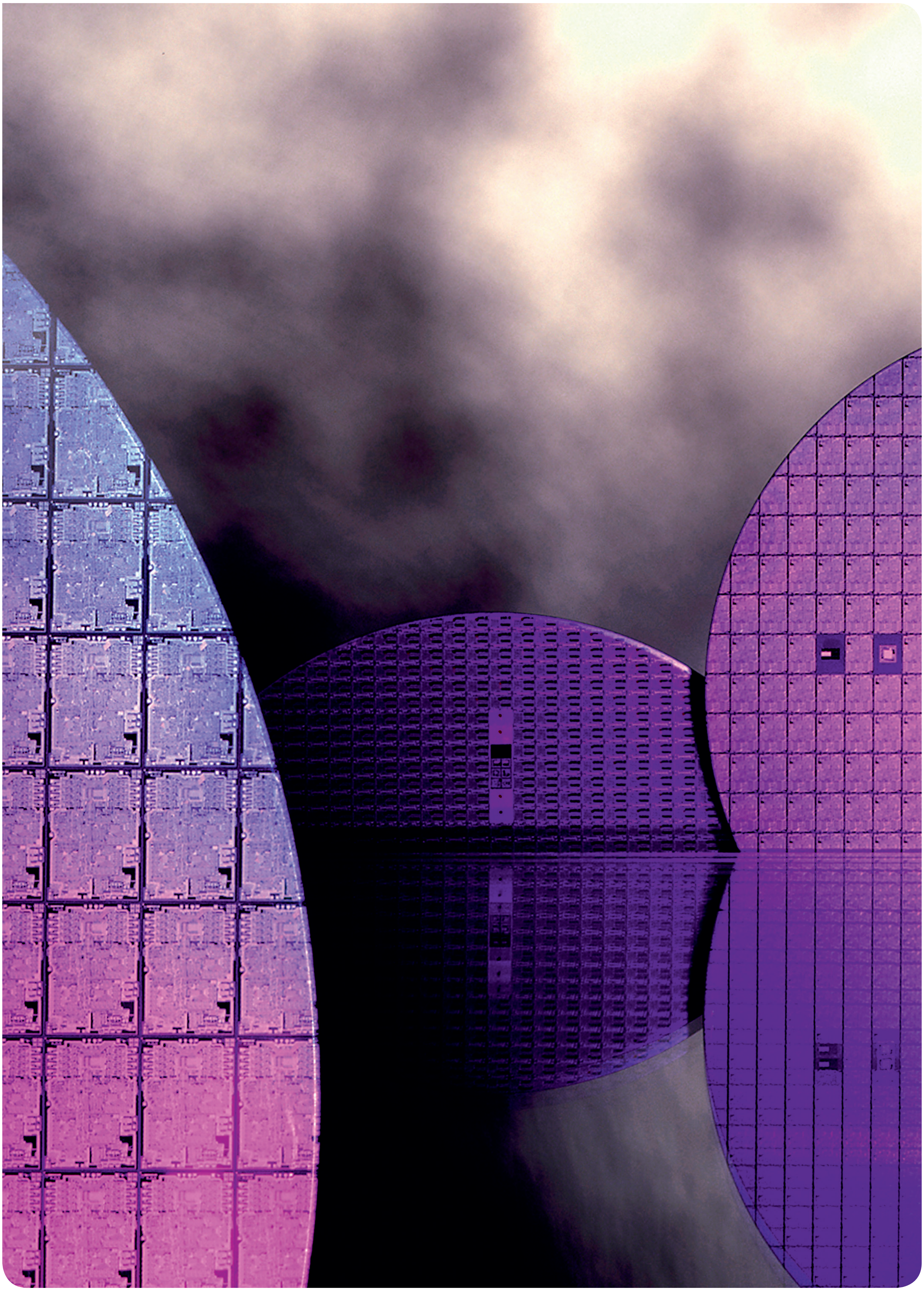


Technical data

Systems		NESSY 1200	NESSY 1900
Coating technology		DC or DC pulsed sputtering (optional: RF sputtering)	
Coating material		Mo, Si, Cr, Sc and different materials for diffusion-barrier layers and capping layers	
Sputter source		Up to 6 PK	Up to 6 PK
		250 mm x 100 mm	600 mm x 125 mm
Base pressure		$9 * 10^{-9}$ mbar	$9 * 10^{-9}$ mbar
Planetary-drive speed		0 – 5 rpm	0 – 5 rpm
Rotation-table speed*		0 – 500 rpm	0 – 500 rpm
Loading capacity (standard)		1 x Ø 200 mm / 8”	1 x Ø 300 mm / 12”
		max. 20 kg (incl. carrier)	max. 30 kg (incl. carrier)
Loading capacity (optional)		n.a.	1 x ≤ Ø 660 mm / 26”
			max. 100 kg* (incl. carrier)
Floor plan layout **	Footprint	5.8 m x 4.5 m / 228” x 177”	7.0 m x 6.5 m / 276” x 256”
	System height	2.7 m / 106”	2.9 m / 114”
Site requirements	Electric power	94 kVA	94 kVA
	Line voltage	400 VAC, 50/60 Hz	400 VAC, 50/60 Hz
	System weight**	7500 kg	9700 kg

(*) For heavy substrates the rotation speed is limited

(**) System weight and dimensions can change in accordance with customer requirements



DEIMOS 5500.
High-quality coatings for astronomical mirrors.

1 Movable lower chamber-half

2 4 magnetrons for metal and dielectric layers

3 Wide opening for substrate exchange

4 For curved substrates up to Ø 4.5 m

DEIMOS 5500 – the new sputter coater for substrates up to Ø 4.5 m / 15 ft.
The DEIMOS 5500 vacuum coating system is designed for the coating of astronomical mirrors by means of sputter technology. Typically, aluminum (Al) and silver (Ag) targets are used to form protective and enhancing layers in order to achieve the highest reflectance and durability.

Prior to processing, both the substrate and the chamber will be pre-cleaned by either mid-frequency (MF) or direct current (DC) glow discharge.

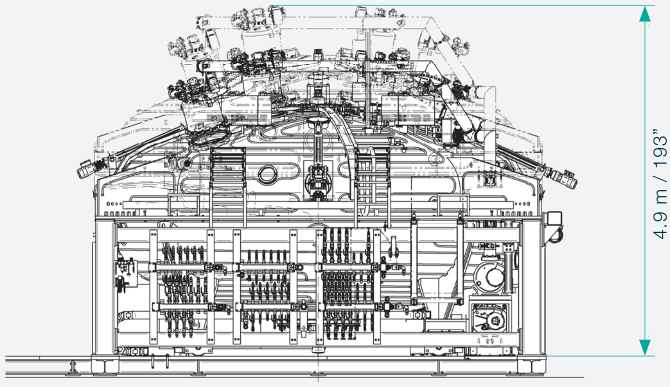
For easy substrate exchange, the lower chamber-half is mounted on a rail system so that it can be easily moved to a clear space to allow access for the substrate handling crane.

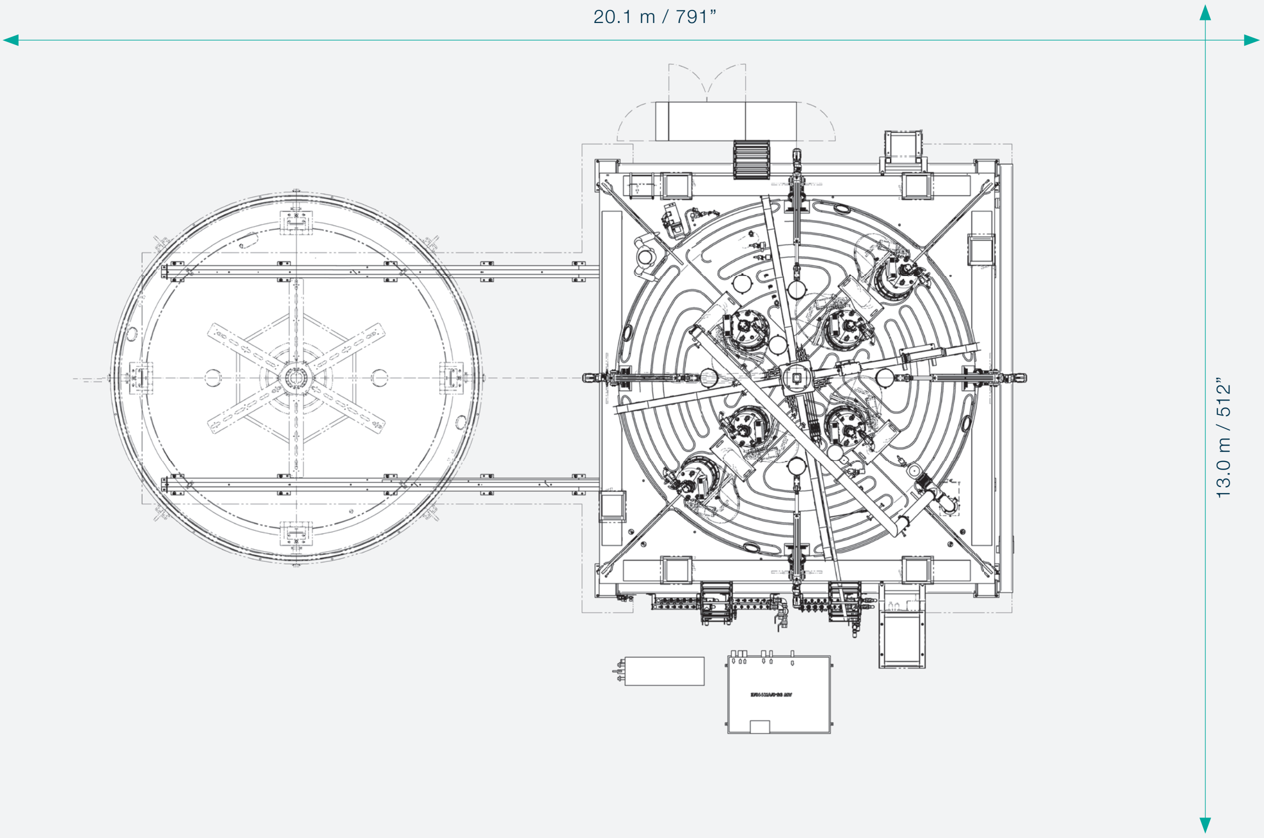
Key benefits:
- 4-magnetron assembly
- Highest reflection and coating durability
- Movable cathode inclination for perfect adaptation to substrate curvature and excellent layer uniformity
- Coating of curved substrates up to Ø 4.5 m / 15 ft.
- Protected and enhanced Al or Ag mirrors
- Pre-cleaning of chamber and substrate via MF or DC glow discharge
- Lower chamber-half on rails for easy substrate exchange

Technical data

General design features		Components	
Loading capacity	Up to 8 tons weight	Cathodes (4 pcs.)	LEYBOLD OPTICS
Max. substrate Ø	4.5 m / 15 ft.	Sputter target	Al, Ag, Nb, Si
Rate monitoring	4 x quartz-crystal head	Sputter power supply	DC and DC pulsed
Remote access	LAN/WLAN/air card	Uniformity	< ± 5 %

Deimos 5500





STARpro. **Versatile coating system for small-batch optical filter production.**

1 Separate load-lock

2 Adjustable sputter distance

3 Ergonomic graphical user-interface (GUI)

4 Integrated cooling water system

5 Three gas cylinders can be incorporated

Small, fast and precise
Bühler Leybold Optics’ STARpro is a reactive single magnetron-sputtering system that covers a wide range of applications through the use of Si_3N_4 and SiO_2 multi-layers. The system is very easy to install and operate. Moreover, the STAR achieves spot-on accuracy and high reproducibility throughout the entire target lifetime via the implementation of the premium optical monitoring system LEYBOLD OPTICS OMS 5100.

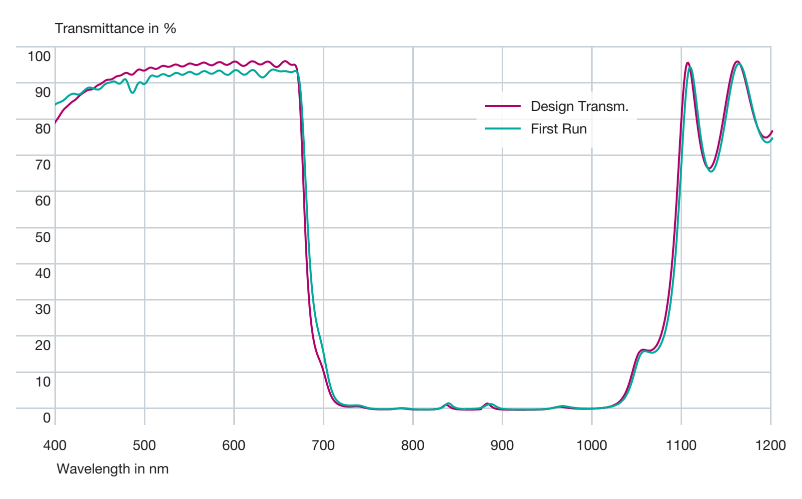
Applications:
- Anti-reflection (AR) coatings
- Bandpass filters
- Edge filters
- Dielectric mirrors
- Dichroics

Key benefits:
- Separate load-lock chamber for:
  - higher process stability
  - low particle contamination
- Adjustable sputter distance
- Planetary system for high uniformity
- High deposition rates of up to 2 nm/s
- Plug-and-play:
  Extremely easy to install and operate
- Very compact footprint (~1 m^2/11 sq. ft.)
- All components in one base frame

Technical data

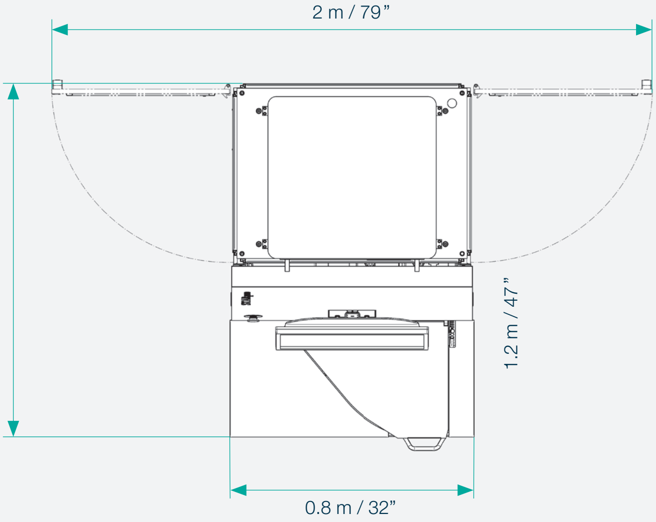
General features		**Components**	
Loading capacity	4 substrates	Cathode	LEYBOLD OPTICS PK150
Max. substrate Ø	80 mm / 3.51"	Sputter target	Silicon (Si)
Process gas N_2. O_2. Ar	Incorporated	Sputter power supply	DC pulsed
Optical monitoring	LEYBOLD OPTICS OMS 5100	Sputter rate SiO_2	1.2 – 2.0 nm/s
Remote access	LAN / WLAN / air card	Sputter rate Si_3N_4	0.7 –1.2 nm/s

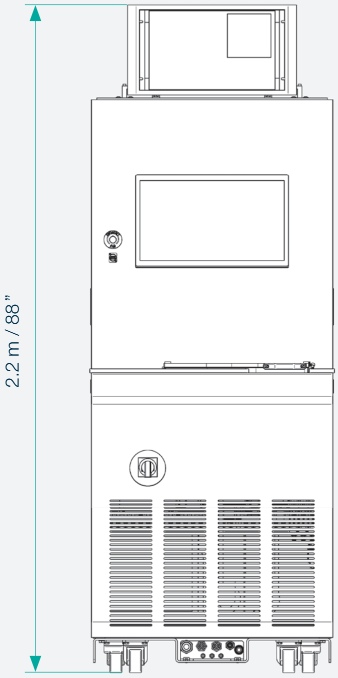
IR-cut filter



Excellent performance with the first run due to LEYBOLD OPTICS OMS 5100 in-situ optical monitoring system.

STARpro





LEYBOLD OPTICS DLC.
The reference high-precision PECVD system.

1 In-situ optical monitoring system

2 Flat-rotatable substrate holder

3 Process chamber stainless steel Ø 550 mm

4 Substrates up to Ø 465 mm

5 RF generator with 13.56 MHz matchbox

LEYBOLD OPTICS DLC 600 –
the diamond-like carbon coating system
The LEYBOLD OPTICS DLC 600 coater operates under high-vacuum conditions and uses plasma-enhanced chemical-vapor deposition (PECVD) technology. These machines are used by industry leaders for precision optics applications to produce mainly optical and thermal imaging systems. The Bühler Leybold Optics R&D and process team is your partner for customized processes.

Key benefits:
- Benchmark uniformity across entire coating area
- Excellent reproducibility via optical monitoring
- Wide variety of substrate sizes
- Suitable for flat and curved substrates
- Highest end-product quality

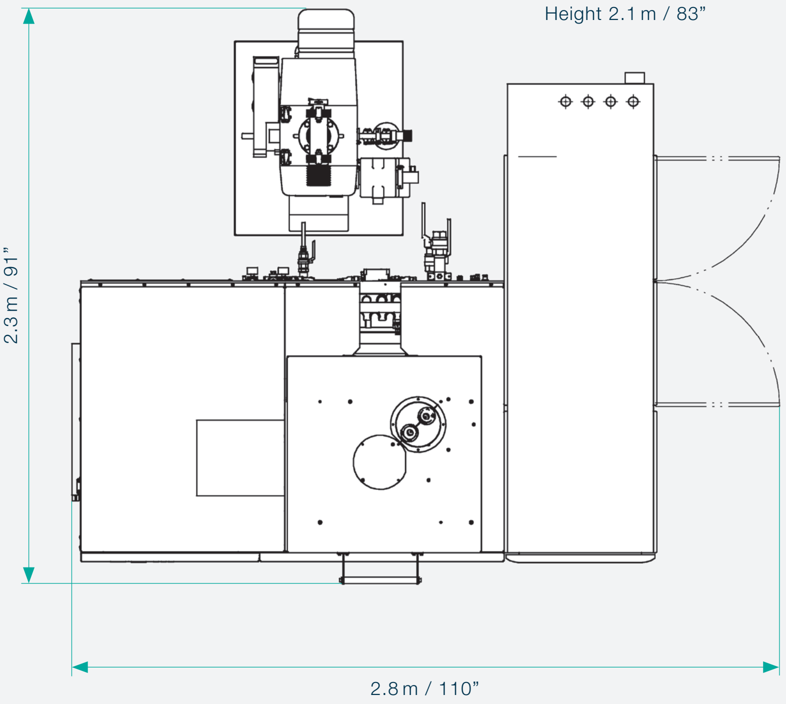
Applications:
- Diamond-like carbon (DLC) layers
- Anti-reflective coatings
- Substrates: Ge, Si and others
- Optical imaging
- Thermal imaging
- Night-vision equipment
- Distance control

Technical data

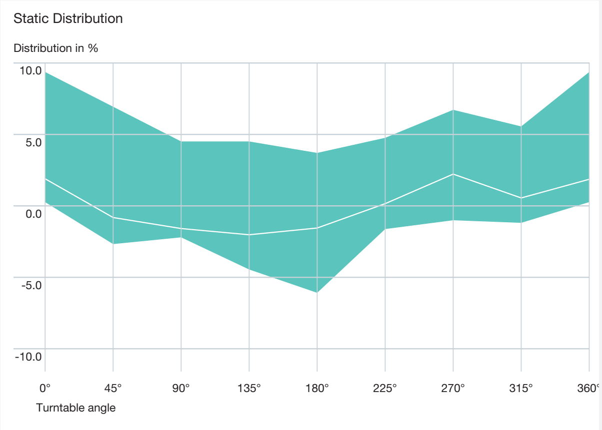
Coating technology	PECVD coating system (Plasma-enhanced chemical-vapor deposition)
Coating layer	Diamond-like carbon (DLC)
Capacity	Turntable with Ø 465 mm / 18.3”
Power supply (MF)	13.56 MHz
Standard anti-reflection (AR) processes*	
On Ge	Tav @ 8.0 – 11.5 µm
On Ge	Tav @ 3.5 – 5.0 µm
On Si	Tav @ 3.5 – 5.0 µm
Durability performance	Standard environmental tests (MIL-…)
Layer monitoring	
Time control	Yes
Optical monitoring	LEYBOLD OPTICS OMS 5100
Site requirements	
Footprint	4.4 m x 3.3 m / 173” x 128”
Electric power	23 kVA
Line voltage	400 VAC, 3-phase, 50/60 Hz
System weight	1500 kg

(*) Other processes on request

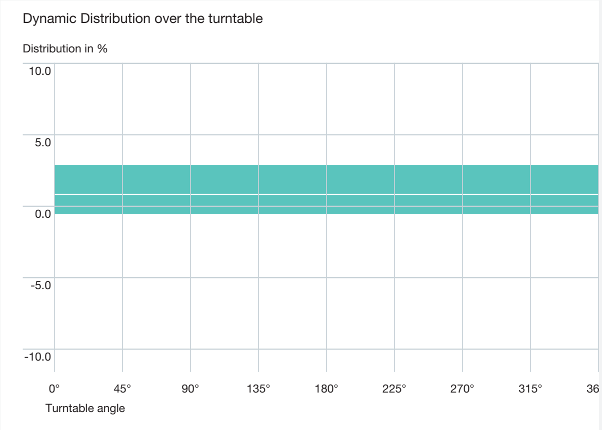
LEYBOLD OPTICS DLC 600



Uniformity characteristics



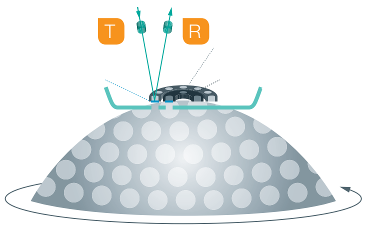
Measured optical properties across different sub-strate positions without rotation.



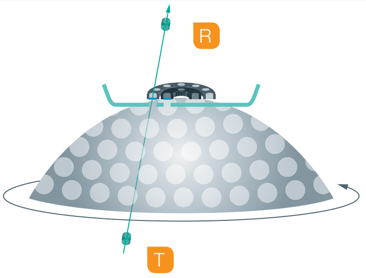
The operation in dynamic mode with rotating turntable shows perfect uniformity.

Leybold Optics – precision monitoring.
Total process control – perfect product quality.

Stationary optical monitoring set-ups



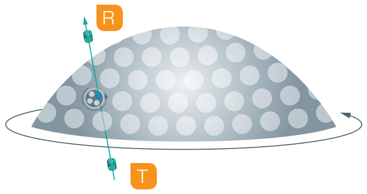
- Optical monitoring in reflection mode
- Test-glass exchanger in the center



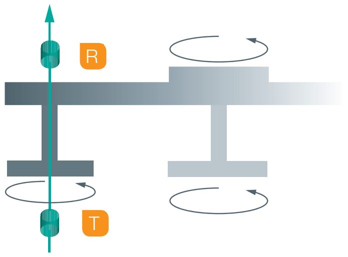
- Optical monitoring in transmission mode
- Test-glass exchanger in the center

T	Transmitter
R	Receiver

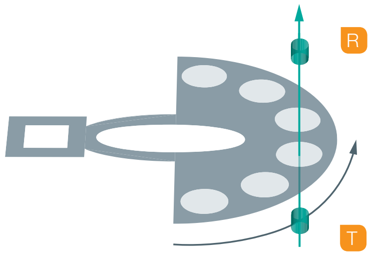
Intermittent optical monitoring set-ups



- Optical monitoring directly on moving substrates
- Test-glass exchanger on calottes



- Optical monitoring directly on moving substrates
- Substrates moving on planetary carriers

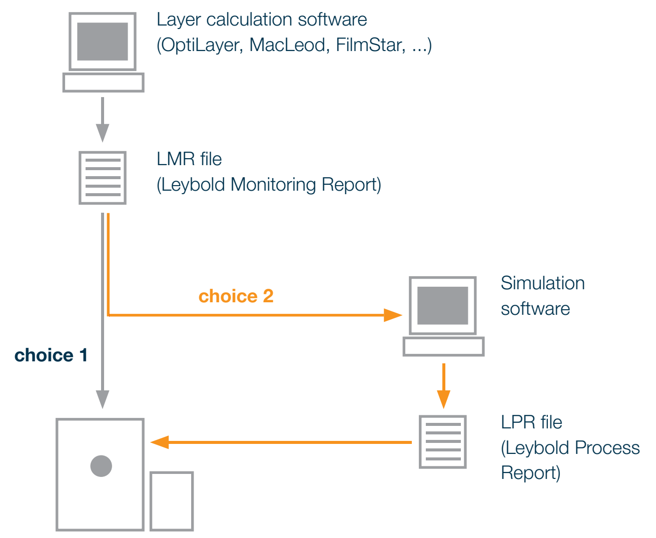


- Optical monitoring directly on moving substrates
- Substrates rotating on HELIOS turntable at high-speed

Bühler Leybold Optics has been setting setting benchmarks in optical monitoring for decades. Direct intermittent measurement – the breakthrough in optical monitoring – was introduced first by Leybold Optics and is used in the SYRUSpro and HELIOS series.

Film design and monitor run-sheet data are interfaced with the coating equipment using LMR or LPR files. Both file formats were invented by Leybold Optics, whereas LMR files are usually generated by most commonly used thin-film design software programs available on the market.

The systems are supported by simulation and pre-production analyzing tools, thus virtually eliminating the need for test- or calibration-runs.



Technical data

	LEYBOLD OPTICS OMS 5100	LEYBOLD OPTICS WB-OMS	LEYBOLD OPTICS BBM
Detector type	Single (PMT, Si, InGaAs, PbS)	Diode array 1024 pixel	CCD array 2048 pixel
Dispersive element	Grating monochromator	Polychromator	Polychromator
Dynamic range	26 bit	16 bit	16 bit
Detector noise rms @ 400 nm	0.0025 %	0.03 %	0.4 %
Detector noise rms @ 1000 nm	0.001 %	0.05 %	0.4 %
rms detector noise best case	0.001 %	0.01 %	0.3 %
Continuous measurement for stationary measurement	Optional: light chopper up to 80 Hz	--	--
Intermittent measurement	Triggered by incremental sensor	Triggered by incremental sensor	Triggered by incremental sensor
Min. data aquisition time	0.8 ms	1.1 ms	2 ms
Time jitter for measurement	< 0.05 ms	< 0.1 ms	< 2 ms
Optical resolution (FWHM)	0.5 nm – 8.8 nm controllable	3.5 nm	1 nm Optional: NIR 5 nm
Useful wavelength range with halogen lamp	330 nm – 2500 nm	400 nm – 1000 nm	380 nm - 1050 nm Optional: NIR 380 nm – 1700 nm
Useful wavelength range with deuterium lamp	200 nm – 360 nm	--	250 nm - 380 nm

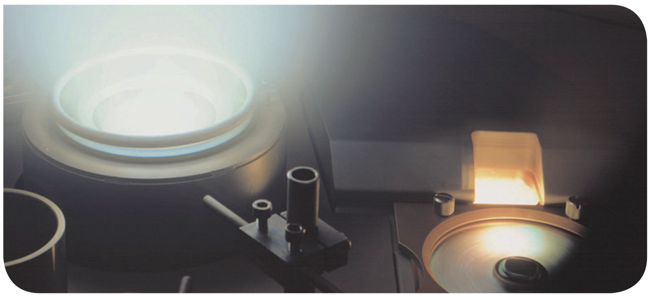
Data evaluation and software features

	LEYBOLD OPTICS OMS 5100	LEYBOLD OPTICS WB-OMS	LEYBOLD OPTICS BBM
In-situ monitor	Intensity vs. time @ single wavelength	Intensity vs. time @ single wavelength plus Transmittance vs. wavelength	Transmittance vs. wavelength
Thickness control	End-point control by monochromatic strategies (Turning-point, online corrected trigger-point)	End-point control by monochromatic strategies (Turning-point, online corrected trigger-point).	End-point control by calculated thickness
Re-engineering of thickness errors	Offline based on slow spectral scan between the layers	Offline	Online
Re-optimization of remaining layers	Offline based on slow spectral scan between the layers	Offline based on saved spectra	Offline based on saved spectra Optional: online available

Key benefits of the systems

LEYBOLD OPTICS OMS 5100	LEYBOLD OPTICS WB-OMS	LEYBOLD OPTICS BBM
Highest stability and accuracy	Monochromatic and broadband monitor in one system	Easy-to-use. No monitor run sheet required
Premum product with unique reproducibilty	High flexibility of end-point control	High light-sensitivity
High degree of error compensation for many layer systems	Re-engineering capability	Re-engineering capability
High tolerance to systematic errors (Calibration, dispersion n,k)	Powerful and easy-to-use graphical user-interface (GUI)	Re-optimization capability

Leybold Optics APSpro – plasma sources.
Most powerful device in the market.



LEYBOLD OPTICS APSpro

Bühler Leybold Optics' proprietary technology APS (Advanced Plasma Source) was introduced in 1992 and delivers maximum performance and productivity paired with its unique ability to produce shift-free optical coatings. In contrast to other sources in the market, low- and high-index materials can be applied with sufficient densification but without additional heating – even for SiO_2. While the main applications of the plasma-ion-assisted deposition (PIAD) process lie in coating materials such as metal oxides and nitrides, it can, however, also be used in coating pure metals and non-metal oxides.

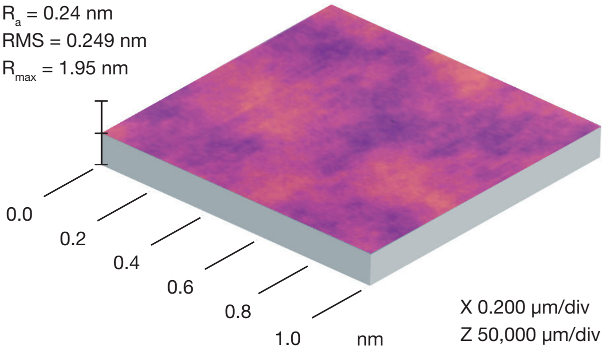
Key benefits:

- Perfect, shift-free spectral performance
- Dense and extremely smooth films
- High deposition rates
- High refractive-index layers
- Wide-angle characteristics
- Enormous library of established processes

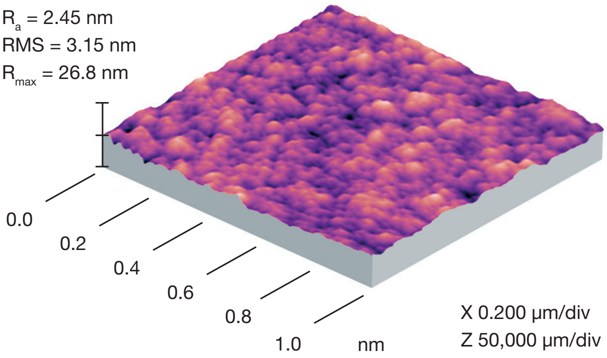
Technical data APSpro

Discharge current	Typical 65 A (max. 100 A)
Discharge voltage	≤ 200 V
Discharge power	≤ 15 kW
Bias voltage	55 - 200 V
Heater power	1.8 kW
Process gas	O_2 / Ar flow controller
Ion current density	1300 µA/cm² @ 450 mm
Ion energy	20 – 250 eV

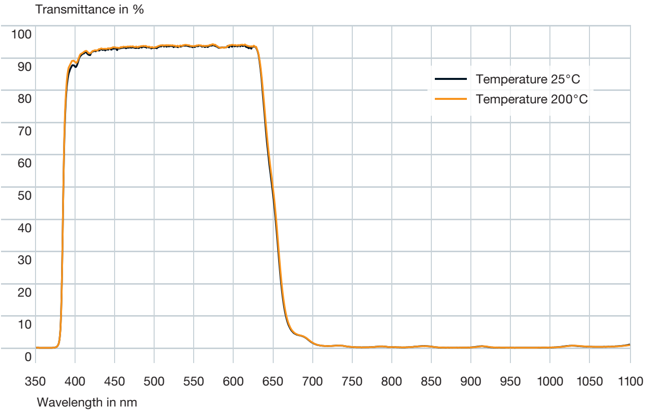
Strikingly better layer smoothness with LEYBOLD OPTICS APSpro



Standard surface roughness with conventional coating

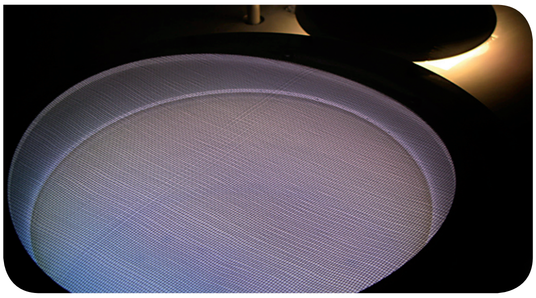


Perfect shift-free characteristics



Optical filter created with APSpro at different temperatures.

Leybold Optics Lion – RF plasma sources. **Ideal for high-performance coatings.**



LEYBOLD OPTICS LION

The LEYBOLD OPTICS LION RF source is based on the electron cyclotron wave resonance principle (ECWR). It is completely integrated in our control systems and dedicated for use in large coating systems like the SYRUSpro 1350 and SYRUSpro 1500. These ion sources combine optimum process operation with ease-of-use and low production cost. Moreover, a single grid (mesh) allows for easy and quick maintenance.

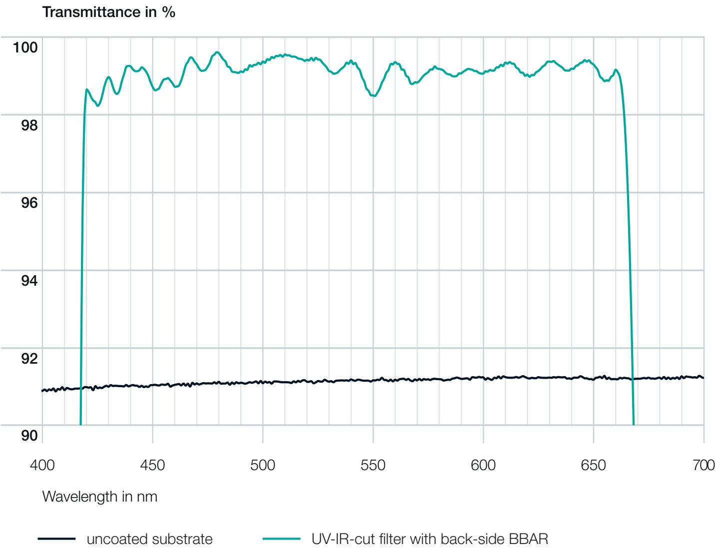
Key benefits:

- Ideal for large chambers
- High power to cover large areas
- High deposition rates
- Layers with very low losses
- Low absorption and scattering
- Easy maintenance
- Low running cost

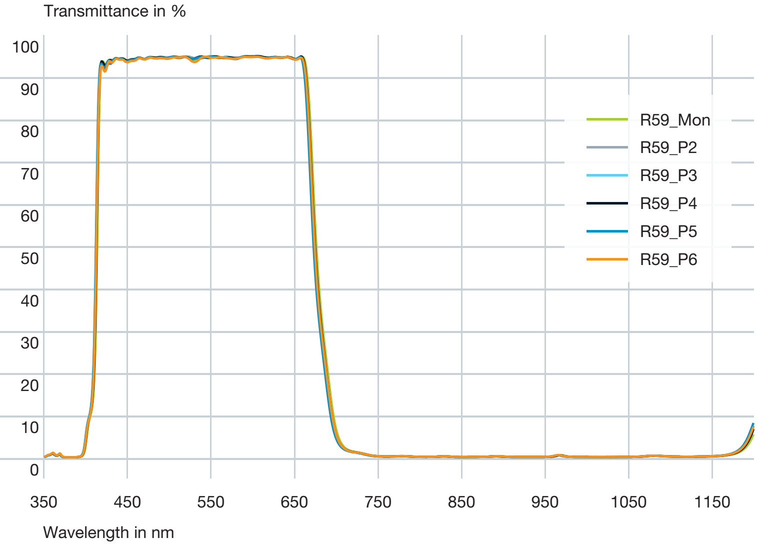
Technical data LION

Free grid-diameter (aperture)	300 mm
RF power	≤ 6.5 kW
Total ion current	≤ 3A
Ion energy	90 – 900 eV
Typical gasses	O2 / Ar / N_2
Matching network	Computerized auto-matching
Ion extraction	Single grid (mesh)

IR-cut-filter



Uniformity



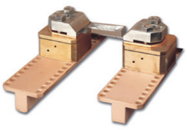
Excellent uniformity over Ø 1400 mm dome (< ± 0.5 %)

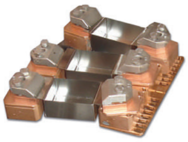
Leybold Optics – evaporator units.
High-performance components.

Thermal-resistance evaporators

Bühler Leybold Optics offers a wide variety of models featuring different numbers as well as volumes of boats. As a result, maximum flexibility combined with optimum equipment configuration can be realized for every application in machines of the SYRUSpro and ARES series.

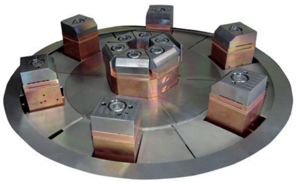

Low-power thermal-resistance source, (e.g. for hydrophobic top layers)


High-power, highly-flexible single-boat thermal evaporator

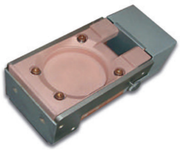

High-volume triple-boat evaporator (optional: twin-boat model)

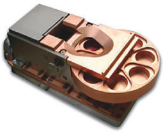
Overview LEYBOLD OPTICS thermal evaporators

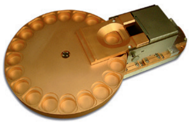
System	Operation power	Evaporator boats
Lower-power thermal-resistance source		
Single-source	7 V / 600 A	1
High-power thermal-resistance source		
Single-source	3.5 V / 1200 A	1
Twin-source	3.5 V / 1200 A	2
Triple-source	3.5 V / 1200 A	3
High-volume thermal-resistance source		
Hexagon source	3.5 V / 1200 A	6



High-volume system
Hexagon source with six large-volume boats. A revolver mechanism places the active source always in the same position – thus ensuring optimum uniformity. The very large volume makes the hexagon source especially well-suited for infrared applications.


Low-volume electron-beam gun, featuring a precisely controlled energy source.


High-power LEYBOLD OPTICS HPE 12/10 with a variety of porringer sizes and forms.


High-volume LEYBOLD OPTICS HPE 12 with up to 20 pockets and a large ring groove.

Electron-beam guns – LEYBOLD OPTICS HPE series

Based on decades of experience in thin-film technology the LEYBOLD OPTICS HPE series is well known for the reliable evaporation of a large range of coating materials such as oxides, fluorides, metals and sulfides. As such, it is the ideal choice for ophthalmic and precision optics, electronics and optoelectronics applications.

Technical data LEYBOLD OPTICS HPE series

System	HPE 6	HPE 12/10	HPE 12
Beam power (max. output)	10 kW	10 kW	10 kW
Acceleration voltage (typical)	8 kV	8 kV	8 kV
Main deflection angle	270°	270°	270°
Operating vacuum (typical)	$< 5 \times 10^{-4}$	$< 5 \times 10^{-4}$	$< 5 \times 10^{-4}$
Filament voltage/current	10 V / 32 A	10 V / 32 A	10 V / 32 A
Cooling water			
Consumption rate	10 l/min	10 l/min	10 l/min
Inlet temperature (max.)	25 °C	25 °C	25 °C
Inlet pressure	5 – 6 bar	5 – 6 bar	5 – 6 bar
Return pressure (max.)	0.5 bar	0.5 bar	0.5 bar
Dimension (overall)			
Width	126 mm	176 mm	320 mm
Length	380 mm	394 mm	569 mm
Height	144 mm	144 mm	144 mm

Key benefits of LEYBOLD OPTICS evaporator units:

- Large variety of evaporation materials
- Wide deflection angle of 270°
- Programmable range of evaporation patterns
- Crucible types: ring groove, single- or multi-pocket
- Indirect, direct or intensive cooling capabilities
- Quick exchange of cathode and crucible
- Long lifetimes of cathodes and filaments
- Service connections to atmosphere

LEYBOLD OPTICS IBF series.
Beyond measurable precision with IBF.

1 Fully automated process and control

2 6-axis direct drive system

3 Grid HF ion beam source

4 Aperture changer

5 Probe holder according to customer requirements

6 Innovative locking system

7 Advanced vacuum and cooling system

Ultra-precision as standard

The LEYBOLD OPTICS IBF series with ion beam figuring (IBF) technology is the ideal solution for the production of surfaces with an extreme high precision of a few nanometers and a local resolutions in the submillimeter range.

It is a dry error correcting and polishing process under vacuum where accelerated argon atoms ablate nano-scaled particles from the surface of the workpiece.

Nearly all geometries and materials can be processed which makes it perfectly for a broad field of applications – from space, nanotechnology and reflector telescopes to semiconductors, photonics, research industry.

These IBF machines of type IBF are the excellent final processing step, which can be followed by further coating processes with the Bühler Leybold Optics coating machines.

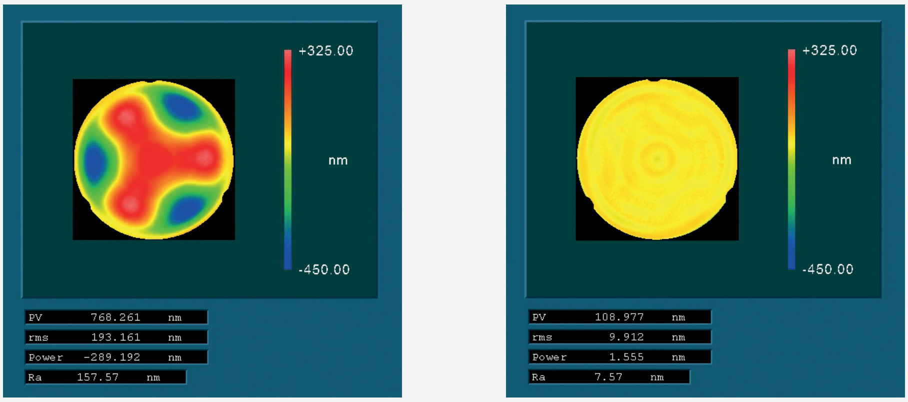
Key benefits:

- Surface qualities of $\lambda/200$ and greater
- Processing across the entire substrate surface up to and beyond the edge
- 6-axis direct drive system
- Integrated diaphragm changer
- Integrated load lock for faster workpiece changeover
- High reproducibility

Applications:

- Lithography optics
- Telescope mirrors
- Deep and extreme UV (DUV/EUV)
- Laser crystals and optics
- Sharp-edged optics
- Precision asphere and freeform manufacturing

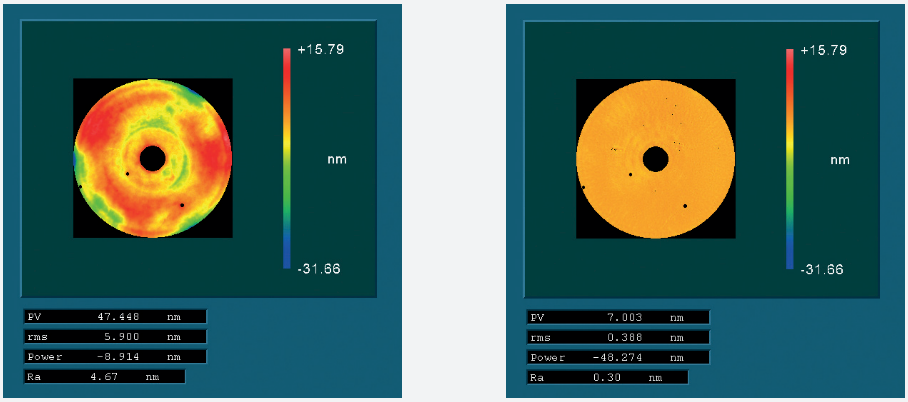
IBF results on various materials



PV 768.261 nm
rms 193.161 nm
Power -289.192 nm
Ra 157.57 nm

PV 108.977 nm
rms 9.912 nm
Power 1.555 nm
Ra 7.57 nm

Material BK7: Before IBF (left) and final figure (right). Workpiece properties: flat, Ø 70 mm. 7 x better PV / 19.5 x better rms.



PV 47.448 nm
rms 5.900 nm
Power -8.914 nm
Ra 4.67 nm

PV 7.003 nm
rms 0.388 nm
Power -48.274 nm
Ra 0.30 nm

Material SiO_2: Before IBF (left) and final figure (right). Workpiece properties: concave, Ø 200 mm, radius of curvature 339.28 mm. 6.8 x better PV / 15 x better rms.

Further advantages of IBF-technology:

- Easy to use and full deterministic processing
- Processing materials with difficult properties (e.g. extremely soft and porous)
- No force and pressure exerted to the sample (e.g. very thin and sensitive substrates)
- Production of complex optical geometry like aspherical and freeform is almost impossible by manual work
- Up to the edge processing with constant quality (increasing free aperture, ideal for segmented optics)
- Increased throughput / batch processing by full automation
- Predictable processing and lead times
- Treatment of single lens arrays in one batch (e.g. small lenses)
- In-situ etch rate measurement
- No human monitoring required
- Low operating costs and low maintenance requirements

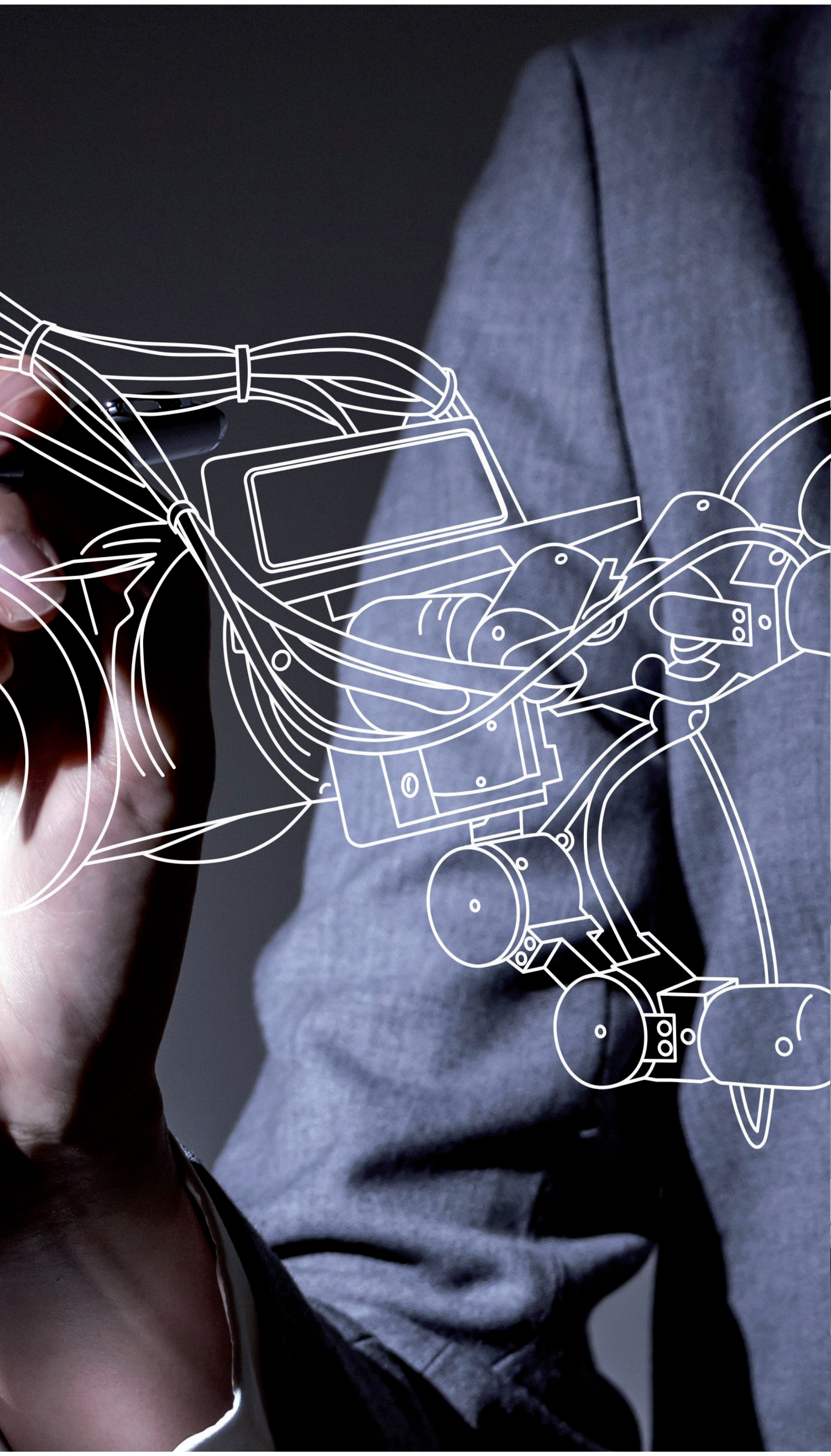
Machine Portfolio

Model	IBF 200	IBF 450	IBF 600	IBF 800	IBF 1200
Max. diameter of flat samples	200 mm	450 mm	600 mm	800 mm	1200 mm
Max. weight of samples	35 kg	35 kg	100 kg	100 kg	200 kg

Options: Fully automated processing via robot handling and workpiece magazines – enables automatic loading and unloading of multiple workpieces for uninterrupted processing.

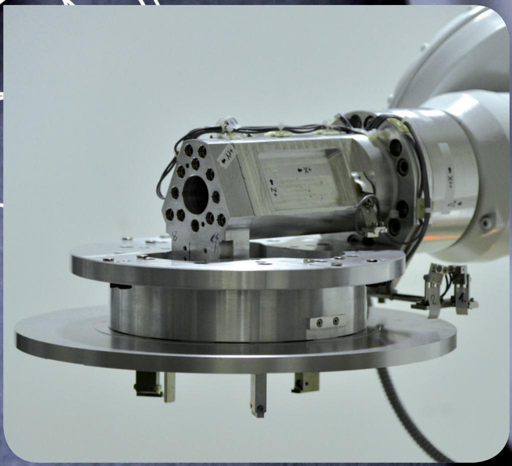
Bringing your company a step ahead.
Automation solutions made by Bühler.

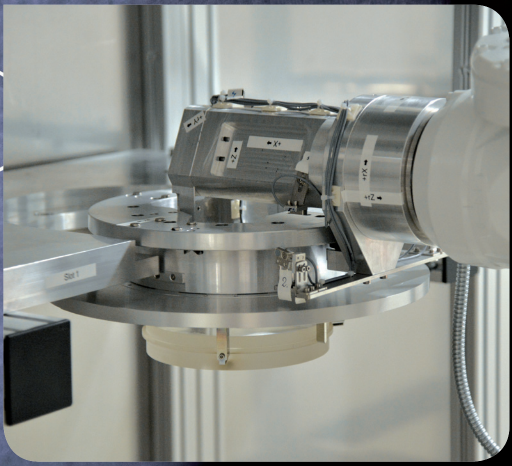
Depending on the specific customer's requirements our engineers will find the individual solution that perfectly matches to your requirements. This does not only count for the purely mechanical part for picking and placing, gripping or the selection of the required robot. Our goal is to serve our customers with a sustainable solution that covers all aspects to run your production and preferably without operator intervention.



Key benefits:

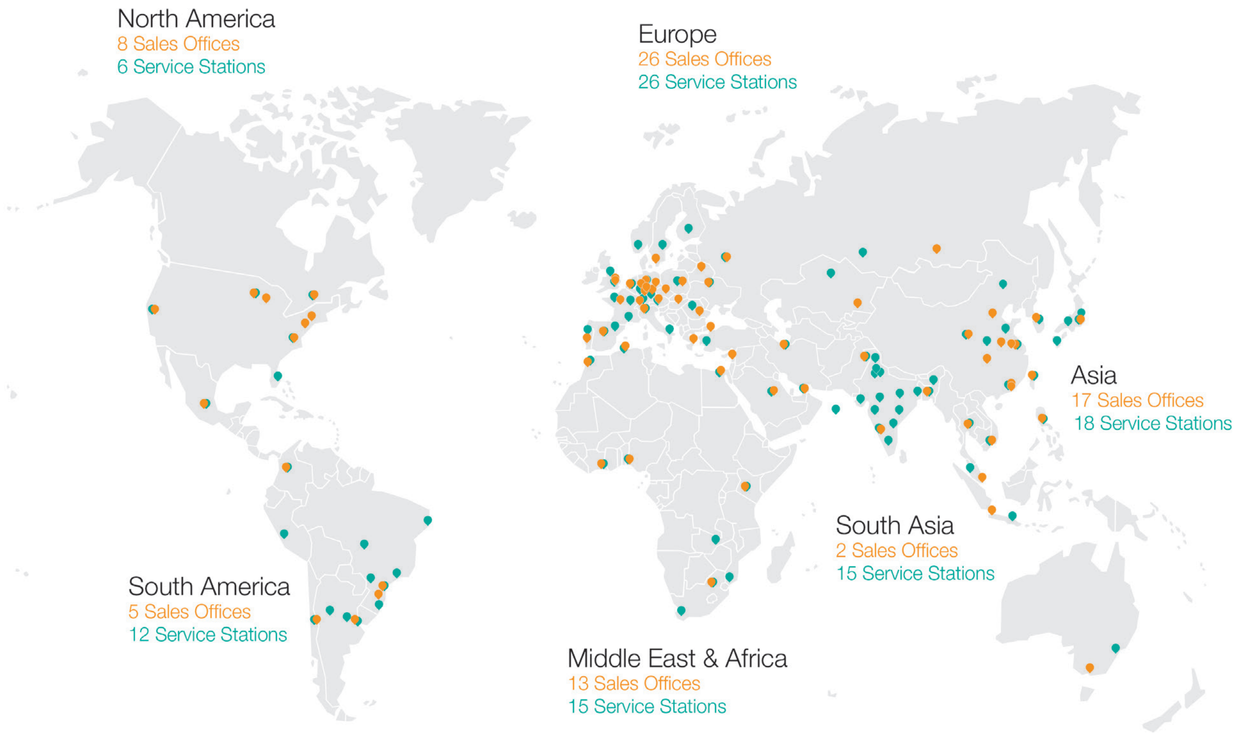
- Automatic loading and unloading of substrates for uninterrupted processing
- Smooth handling of precision parts without operator intervention.
- Enhance production speed, productivity and efficiency





Customer support and services. **CS 4.0 – from customer support/service to customer solutions.**

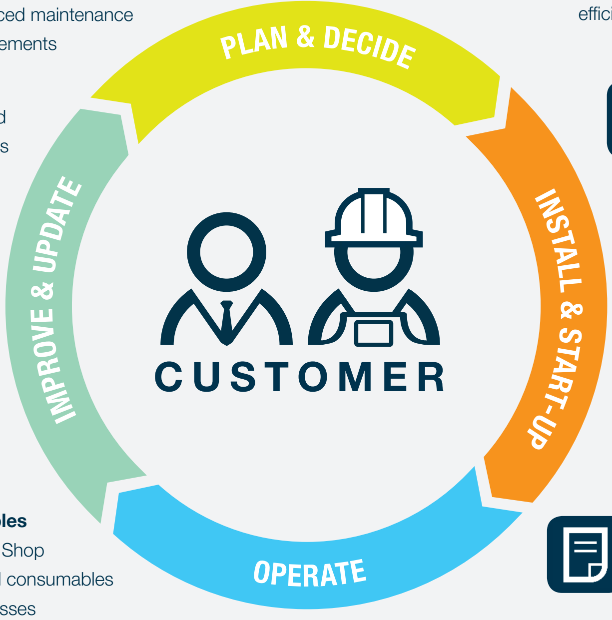
Bühler is where the customer is – connecting machines worldwide to our specialized centers.



Bühler Leybold Optics' relationship with its customer does not end when the machine is delivered, this milestone is the start and continuation of a close partnership. Wherever our customer is, there is Bühler to provide the best services to keep the machine running and meet customer requirements. With a constant roll out of unique and innovative solutions, Bühler helps customers achieve success on the marketplace.

Bühler's commitment to its customers:

- Ensuring right support by running your macine in the most efficient way
- Creating customers experience
- Designing customer solution
- Creating customer success



Retrofits
- Latest technology and efficiency standards
- Lower operating costs
- Reduced maintenance requirements

Consulting
- Process optimization
- Increased productivity
- Greater energy efficiency

Revision
- Overhaul of Bühler and non-Bühler installations
- Latest production technology
- Extended lifecycle

Training
- Education and professional training in training centers around the world

Spare & wear parts
- Longer machine life cycle
- Higher operating safety
- Bühler guarantee

Maintenance
- Minimum downtimes
- Highest reliability and availability
- Scheduled machine service

Consumables
- One Stop Shop
- Dedicated consumables for all processes
- Best quality and short delivery times

Smart Services
- Service packages according to customer needs.

Smart Service Packages
Bühler Leybold Optics has smart packages adapted to your needs.

We offer annual contingency allowance of hours, which can be selected in different packages: bronze, silver and gold or even total care.

Need something different?
We will design the ideal service contract to fit your requirements.

Helpdesk – Follow the sun
Always available during business hours. Contact the Helpdesk of your local service or at headquarters. Problems are analyzed immediately via remote diagnosis.

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IoT – CS 4.0
Anytime and anywhere
Optimize your production by using our IoT solution.

Connecting your machine to our platform can give you the possibility to verify machine status and address problems.

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