

Aspheric solutions  
from a single source.

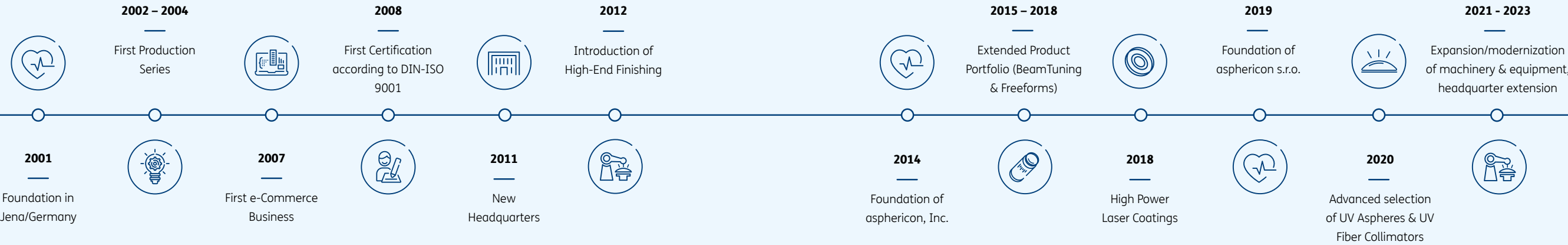
# Visionen leben

## EXCEEDING EXPECTATIONS IN EVERY WAY

Visionen leben – Bringing visions to life. With this mission, asphericon is continuously pushing the boundaries of what is possible and establishing new milestones in the world of photonics. Our passion for revolutionizing the manufacturing of aspheric systems with new technologies is changing the degree of precision and quality that is possible. By combining a worldwide unique CNC control technology with high-end manufacturing processes, we routinely achieve unique levels of dimensional precision for optical components, assemblies and systems.



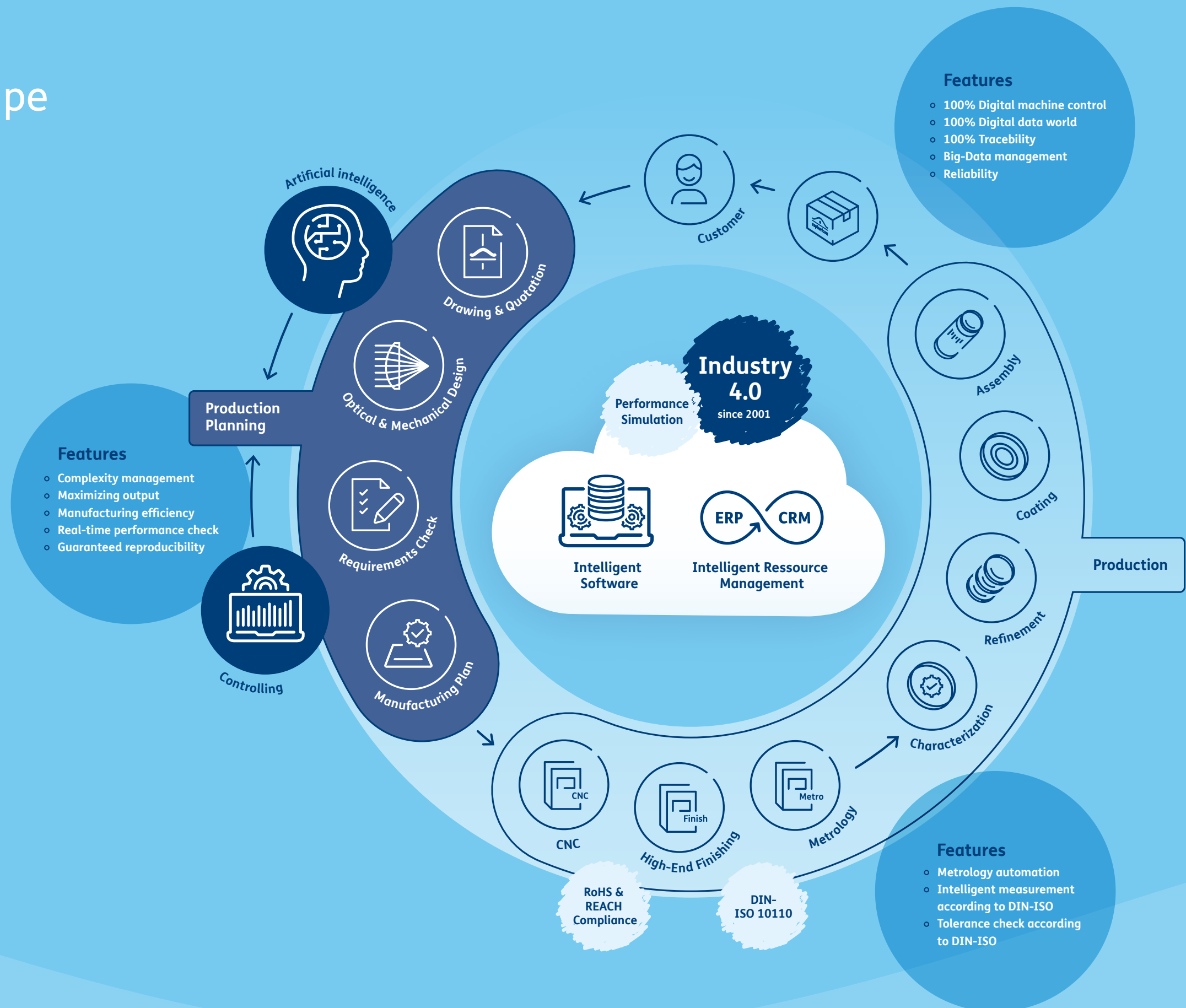
## ASPHERICON MILESTONES



# Fully digitized process landscape

## INTEGRATED MANUFACTURING FOR HIGH-QUALITY AND EFFICIENT RESULTS

Software architecture as the central success factor for reliable, effective and efficient manufacturing of photonic components and systems. We at asphericon have been using and defining Industry 4.0 for more than 20 years. The principle behind this: We digitize your requirements and transfer them directly into the manufacturing process. No manual processing, everything is managed digitally: starting with all specifications, through the entire production process to the final documentation. This results in extremely flexible manufacturing processes for prototypes, single pieces or large series. asphericon reduces complexity, uses big data for optimizations, manufactures and documents according to DIN-ISO standards. Projects can be easily reproduced: Trust the technology leader!

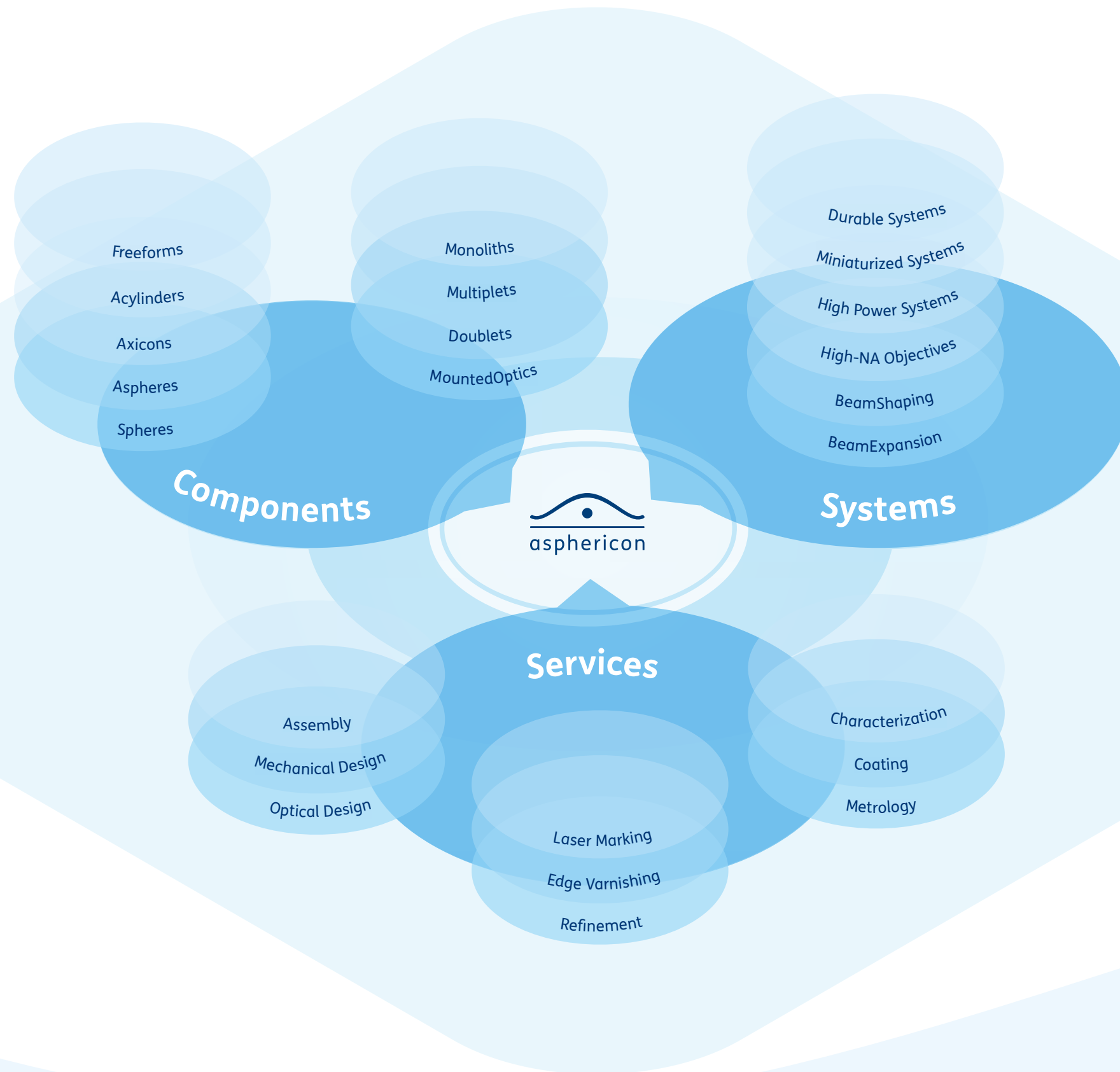




# Everything from a single source

## FROM COMPONENTS TO SYSTEMS AND SERVICES

asphericon combines a researcher's pioneering spirit with the practical ability to implement customer-oriented, economical solutions. Latest manufacturing technologies, continually evolving proprietary control software, world class metrology equipment, and highly qualified employees ensure that we can provide more than 750 customers worldwide with innovative solutions. We will assist you from the initial optical design, through manufacturing and coating, precision metrology, optical characterization to the assembly of optical modules to complete ready-made systems – everything at a space-approved quality level.



### REFERENCE #1

#### ASPHERES FOR OUTER SPACE: SENTINEL-4 SATELLITE



- = Developing and manufacturing lenses to withstand extreme conditions in space
- = Processing and handling demanding materials (e.g. CaF<sub>2</sub>)
- = Aspheres with diameters of 50 to 80 mm and a spectral resolution of 0.12 to 0.5 nm
- = Surface roughness Rq of 5 Å („Ångstrom polish“)

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### REFERENCE #2

#### FREEFORM OPTICS FOR RADIO ASTRONOMY



- = Manufacturing of two freeforms with high-resolution optical surfaces (material: Zerodur)
- = Development of a sub-aperture polishing technique and combination of high-resolution 2D measuring technology with automated correction algorithm

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# Solutions for various industries



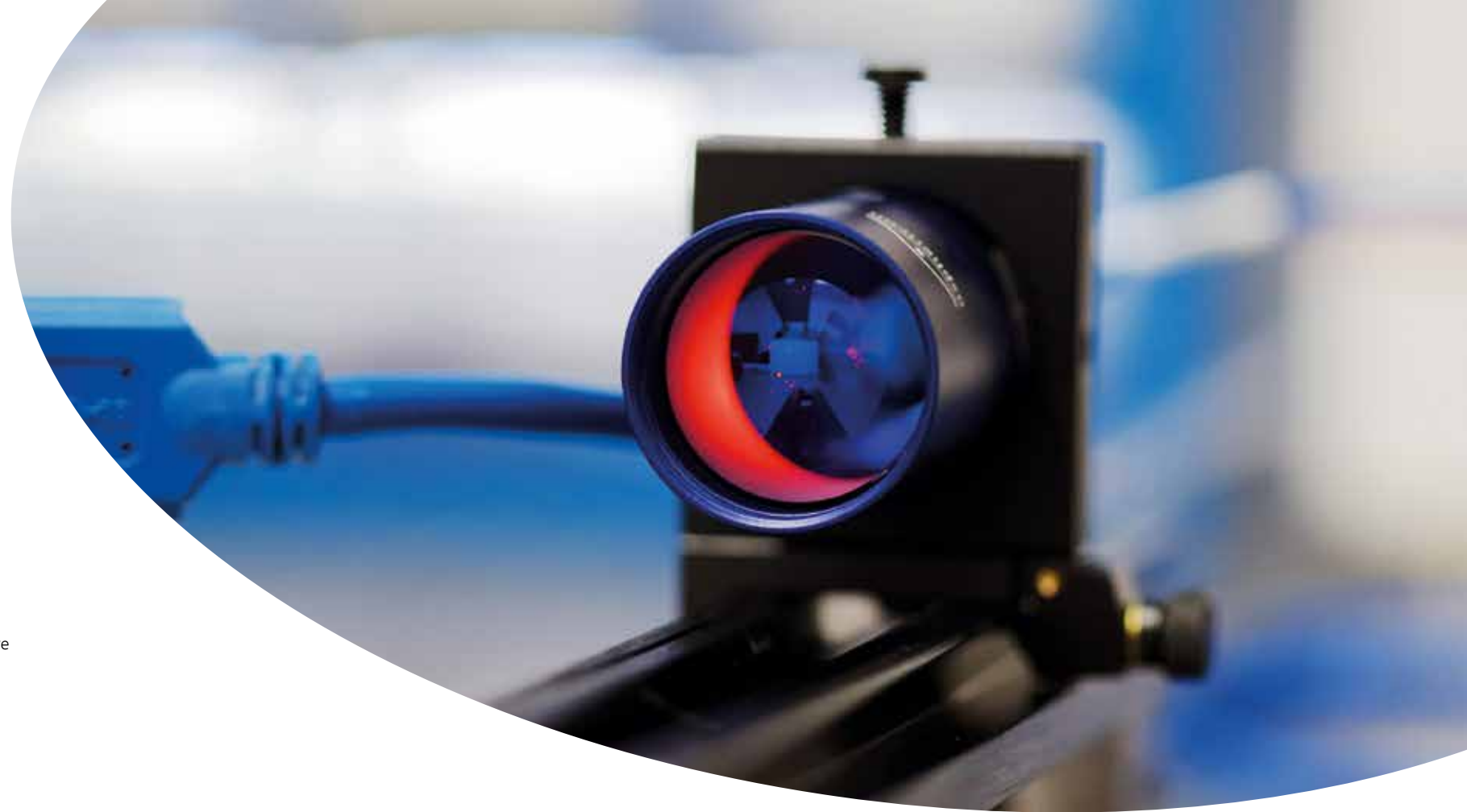
## LIFE SCIENCE & MEDICAL

- = Optics with perfect imaging qualities
- = BeamTuning/BeamShaping for optimized illumination (e.g. in fluorescence microscopy)
- = High-precision antireflection, dielectric and filter coatings for separation of wavelengths
- = Diffraction-limited optical systems
- = Compact designs with best imaging results



## LASER TECHNOLOGY

- = Optics, mirrors and powerful systems for maximum laser power
- = High-End Finishings for ultra-precise optical surfaces
- = High-precision Gauss to Top-Hat beam shapers
- = Coatings providing desired spectral properties to improve the durability of high energy lasers
- = Optics/coatings resistant to harsh environments
- = Objective lenses for laser material processing



## INDUSTRIAL & MECHANICAL ENGINEERING

- = Lenses with lowest roughness values for perfectly focused lines & minimal scattering
- = Mirrors and reflectors with high reflectivity and excellent long-term stability
- = Temperature resistant coatings
- = High-performance freeform systems with miniaturized designs & perfect image quality
- = UV, VIS, IR optics with best imaging properties



## IMAGING & DISPLAY

- = High-end aspheres for perfect imaging qualities and high-resolution images
- = Customer-specific mirrors
- = Compact freeforms for image processing systems of reduced size
- = Anti-reflective coatings or wavelength-specific filter layers
- = High-End Finishing for min. roughness values, better imaging and focusing of incident rays



## SOLUTIONS FOR SAFETY & SECURITY

- = Optical designs reducing the complete system to min. size and weight
- = Robust and durable optics resistant to harsh environments (e.g. high temperature differences, humidity or contamination)
- = Ultra-hard, sputtered coatings up to 5.1  $\mu\text{m}$
- = (Anti-reflection) coatings to improve the quality of your optical elements
- = IR optics to transmit infrared rays
- = Optics for thermographic cameras with high precision



## AUTOMOTIVE & AEROSPACE INDUSTRY

- = Temperature-resistant and durable optics with best imaging results
- = High-End Finishings for lowest roughness
- = Mirrors of highest quality for perfect images, clearest view and lowest glare
- = Freeform systems for effective transmission of radiation with reduced production size
- = Optical components for challenging LIDAR solutions
- = Compact and effective optical designs

### REFERENCE #3

#### BEAM SHAPER FOR FLAT-FIELD ILLUMINATION



- = Solution for even illumination in laser-based microscopy, e.g. fluorescence microscopy
- = Beam shaper for transforming Gaussian beams into flat Top-Hat profiles
- = Homogeneity of illumination: > 95 %

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### REFERENCE #4

#### SPHERES AND ASPHERES FOR STAR TRACKER



- = Ultra-compact optical system using aspheric and spherical components
- = Radiation-resistant glasses, surface form tolerances  $\leq 0.5 \text{ fr}$  and roughness  $\leq 0.2 \text{ nm}$
- = Super wideband AR-coating (ARSBB 480–850 nm) to support thermal stability

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# Single components for the highest demands

## SETTING THE STANDARD OF TOMORROW

Our comprehensive product range offers the perfect solution for your application. Discover a large number of user-specific elements as well as off-the-shelf optics – from high-quality aspheres, axicons and aspheric cylinders through mirrors and reflectors to ultra-precise mounted optics, freeforms and doublets. With the latest technologies we manufacture optical components in various shapes for all wavelengths, using a wide range of materials from more than 100 optical glasses, crystals, polymers and ceramics to semiconductors and metals.

### Wave-lengths

UV, VIS, NIR, MIR

### Materials

All optical Glasses and Fused Silica, Optical Crystals like  $\text{CaF}_2$ , Sapphire, IR materials (Infrared Glasses, Silicon, Germanium), Polymers, Metals

### Shapes

Aspheres, Axicons, Acylinders, Spheres, Mirrors, Doublets/ Multiplets, Freeforms





## ASPHERES

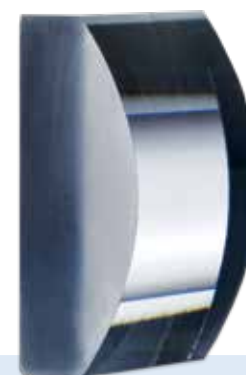
Aspheres have excellent imaging properties due to their optimized shape. The main advantage is the ability to correct spherical aberrations. By using an asphere, the total number of elements in an optical system can be reduced. The result is a much more compact and powerful design than a comparable system based on spherical lenses.

### CUSTOM ASPHERES

- = Materials: almost every type of glass, silica, germanium, silicon, IR lenses, zerodur
- = Diffraction-limited quality (Strehl up to 0.99)
- = Roughness values as low as 5 Å
- = High-end optical coatings

### STOCKOPTICS ASPHERES

- = Materials: S-LAH64, N-BK7, fused silica
- = Diameter: 10 to 100 mm
- = Up to 7 standard coatings
- = Quality: up to  $\text{RMSi} \leq 0.02 \mu\text{m}$
- = Also available: mounted aspheres



## ACYLINDERS

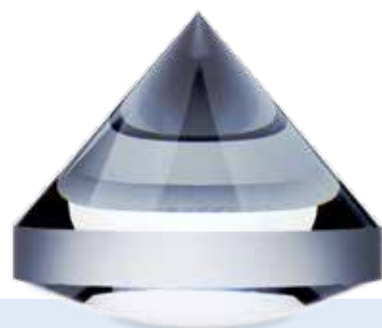
Aspheric cylinders can be realized in plano-convex, plano-concave, bi-concave or bi-convex shapes. We offer specific lenses with a cylinder surface and both spherical and aspheric rear surfaces.

### CUSTOM ACYLINDERS

- = Materials: almost every type of glass, silica, germanium, silicon, IR lenses, zerodur
- = Outstanding quality (roughness values  $\leq 5 \text{ Å}$ )
- = High-end optical coatings

### STOCKOPTICS ACYLINDERS

- = Material: S-LAH64
- = Size:  $10 \times 10$  to  $50 \times 50 \text{ mm}$
- = 3 standard coatings
- = Quality:  $\text{RMSi} \leq 0.5 \mu\text{m}$
- = Obtainable with high-precision mountings



## AXICONS

In contrast to aspheric lenses, the shape of an axicon resembles a cone. The conical shape of the axicon generates ring-shaped beam profiles, which can be used in a variety of applications.

### CUSTOM AXICONS

- = Materials: almost every type of glass, silica, germanium, silicon, IR lenses, zerodur
- = Excellent quality (roughness values  $\leq 5 \text{ Å}$ )
- = High-end optical coatings

### STOCKOPTICS AXICONS

- = Material: fused silica
- = Diameter: 25.4 – 50.8 mm
- = 4 standard coatings
- = Quality:  $\text{RMSi} < 0.07 \mu\text{m}$
- = Available as mounted axicons



## SPHERES

asphericon's product range includes plano-convex/ plano-concave, bi-convex/bi-concave lenses as well as achromatic singlets, doublets and triplets in a wide variety of geometries and materials.

### CUSTOM SPHERES

- = Materials: almost every type of glass, crystals, germanium, silicon, metals, PMMA, IR materials
- = High quality customized coatings (spectral range from 190 nm to  $5.1 \mu\text{m}$ )

- = Short delivery times
- = RoHS conformity

## DATA SHEETS



On our website, we provide essential information on all our products as quick and easy downloads. If you need additional materials, please contact us.

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## OPTICAL DESIGN FILES



For seamless planning of your experimental set-up, we offer a selection of optical design files (Code V, Zemax, etc.) for free download on our website.

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## MIRRORS

Aspheric mirrors, including paraboloids, hyperboloids and ellipsoids, as well as mirrors with a customer specific aspheric surface, are among the specialties of asphericon.

### CUSTOM MIRRORS

- = Materials: almost all types of glass, e.g. fused silica, as well as germanium, silicon, zerodur, infrared glass and  $\text{CaF}_2$
- = Accuracies of up to 50 nm global form deviation (irregularity) or 25 nm RMSi
- = Achievable roughnesses, depending on the material and shape, up to 0.5 nm Rq



## FREEFORMS

Freeformed surfaces have no rotational symmetry and therefore allow the implementation of completely new concepts for optical systems. The use of freeforms reduces the number of elements in an optical set-up, allowing smaller, lighter and more efficient systems.

### CUSTOM FREEFORMS

- = Unconventional shapes in all materials (also ceramics)
- = Lenses, mirrors, monolithic elements with diameters up to 300 mm
- = Excellent surface quality (up to at least RMSi 50 nm)
- = CGH-free measurement including all position tolerances (complete component)
- = Individual coating and mounting concepts



## DOUBLETS/MULTIPLETS

Our latest manufacturing technologies also enable the production of robust aspheric and bi-aspheric doublets and multiplets from relevant optical materials. The resistance of the cemented lenses to extreme environmental conditions is verified by asphericon within the scope of in-house tests according to DIN and/or MIL standards.

### CUSTOM DOUBLETS/MULTIPLETS

- = Shapes: any edge geometries, also steps
- = Outer surfaces can be cylindrical or freeform
- = Diameter: up to 250 mm
- =  $< 10 \mu\text{m}$  ETV
- = Individual coatings
- = Optional: combinable with environmental tests



## MONOLITHS

Monolithic optical systems are characterized by the possibilities of a high degree of integration, small pack sizes and robustness against environmental influences. Due to the necessary folding of the optical beam paths, freeform optical surfaces must inevitably be used in order to sufficiently correct aberrations in the system.

### CUSTOM MONOLITHIC SYSTEMS

- = Unconventional shapes in many materials (also ceramics)
- = Monolithic systems with diameters up to 100 mm
- = Excellent surface quality (up to at least RMSi 50 nm)
- = CGH-free measurement including all position tolerances (complete component)
- = Individual coating and mounting concepts

## HIGH-END FINISHING



For maximum precision and unrivalled high surface quality asphericon offers various High-End Finishing processes. The asphericon Ångström-Polishing, for example, enables roughness values of 5 Å (Rq according to ISO 10110) on all aspheric surfaces.

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## EXPERT FOR FREEFORM OPTICS



asphericon has been working on the (batch) production of freeforms for many years. Together with powerful partners, the development and marketing of innovative freeform optical systems were decisively advanced.

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# Next generation of optical systems

## CUSTOM SYSTEMS

asphericon designs, develops and manufactures complete assemblies and optical systems suitable for your applications. Our team will support you from the first feasibility study, through prototype construction, to precise system integration. Benefit from in-house manufactured high-precision mounts, assembly in ISO 5 and ISO 7 certified cleanroom systems and standardized testing and documentation processes. Everything from a single source.



1 MINIATURIZED DESIGNS, E.G. MONOLITHIC (FREEFORM) SYSTEMS

2 HIGH-QUALITY OPTICAL SURFACES

3 INTELLIGENT ASSEMBLY CONCEPTS

4 HIGH-QUALITY (LOW LOSS) COATINGS WITH LONG-TERM STABILITY

5 EXACT ADJUSTMENT WITH HIGH STABILITY

6 SENSITIVE MATERIALS LIKE  $\text{CaF}_2$



### WIDE RANGE OF CUSTOMIZED OPTICAL SYSTEMS

In order to find the optimum solution for every application, we offer a wide range of options for customer-specific optical systems. The spectrum ranges from **high-NA lenses** and **high power systems** to **miniaturized solutions** and **durable optical systems**. Of course, this is never an either-or-decision, rather different focal points can

be set and combined, resulting in highly efficient system solutions. The reverse case, a reduction to the essentials with simultaneously optimized performance, for example for selected series systems, can also be flexibly implemented. Due to the 100% traceability of all system components, the individual data from manufacturing and quality control are available for all parts and can be employed for an analysis of their performance at any time.

### BEAMTUNING SYSTEM

Beam expansion and beam shaping beyond the diffraction limit – BeamTuning by asphericon. The entire system comprises of beam expanders, fiber collimators, beam shapers as well as intra- and cross-system adapters for a wide wavelength

range (355 nm, 500 – 1600 nm). An intelligent mounting concept ensures easy and timesaving handling, no adjustments needed. Discover plug & play in perfection.

- = Easy to connect (free beam or fiber coupled)
- = Flexible choice of input and output beam diameters
- = Short overall length (three times shorter than average)
- = Optimized to all wavelengths [355 nm, 500 – 1600 nm]



### BEAMTUNING IN ACTION



Join our experts in the lab and get to know the world of BeamTuning. The video series shows the main working principles and various options for beam expansion and beam shaping. Live plug & play.

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# Customized services

## EVERYTHING FROM A SINGLE SOURCE

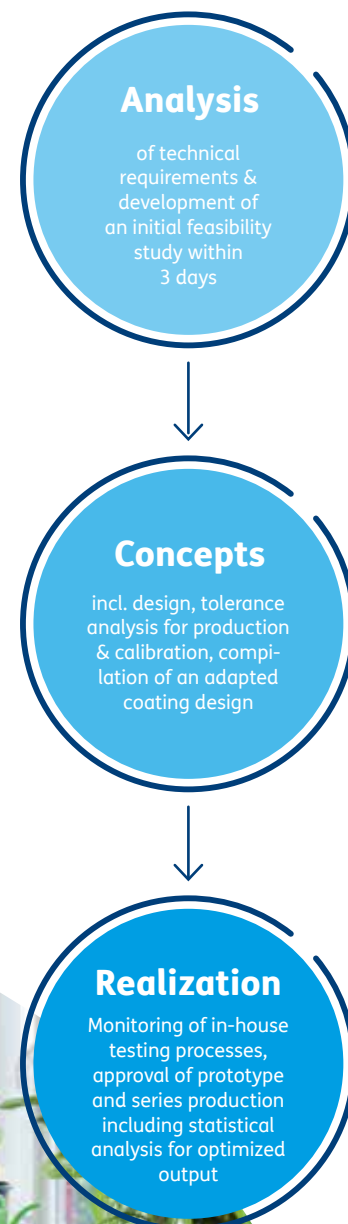
asphericon brings together its technological leadership in a comprehensive product range – the perfect basis for your optical application at the highest level. Benefit from customer-oriented and economical solutions. We accompany you from the first optical system design through manufacturing and coating, the precise measurement and documentation up to the assembly of complete modules and systems as well as their optical characterization and refinement.

### OPTICAL DESIGN

In addition to the optical design of refractive, diffractive and reflective elements, our expertise includes system design optimized to meet the requirements of ultrashort laser pulses. When realizing individual design solutions, we are focused on development, production times and outstanding quality, while always keeping an eye on economic efficiency.

### MECHANICAL DESIGN

Mechanical design from asphericon comprises the development and production of frames, holders and mounts up to a diameter of 300 mm as well as high-precision in-house machining of metal.



### ASSEMBLY

asphericon supports you in the development and production of mounts as well as the assembly of complete lenses and (sub-)systems. Specific requirements including environmental conditions, the choice of materials, resilience, and quality levels are converted into cost-efficient mechanical designs. We are also able to meet demanding cleanliness levels. Depending on your requirements, we implement individual production steps in clean room classes 5 and 7.

### METROLOGY

A wide range of tactile and interferometric measuring instruments is used to achieve accurate and reproducible results. asphericon's metrology spectrum includes:

- = Tactile measurement up to diameters of 260 mm
- = Full-surface non-contact measurement up to 420 mm
- = Non-contact center thickness measurement
- = Roughness measurement  $R_a < 0.5$  nm RMS, measuring field up to 1 x 1 mm
- = Measurement of freeforms: form and positional tolerances, roughness
- = Measurement/position check of mounts, mounted optics and complete systems
- = Confocal 3D defect characterization



### CHARACTERIZATION

Characterizations can be optionally performed for lenses and optical systems. The high quality of our products is guaranteed by a high-resolution wavefront measurement and a certificate.

#### Optical characterization at asphericon includes:

- = Wavefront measurement (wavelength range 400–1064 nm, other on request)
- = Measurement of MTF, PSF and Strehl ratio

**EQUIPMENT:** Phasics™ SID4 HR

### LEADING METROLOGY KNOW-HOW

asphericon combines a unique measuring equipment with 100% digitized processes. This guarantees complete automation of the entire measuring process, ensures reproducibility and efficiency. Get to know our in-house metrology know-how.



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COATINGS

High-end coatings for your challenging products in outstanding quality and with reasonable delivery times. Equipped with state-of-the-art manufacturing and metrology technologies, our experienced team of technicians turns coating ideas into reality.

- = Coating: dielectric mirrors, anti-reflective coatings, filter coatings, metallic mirrors, beam splitters
- = Substrate sizes: up to a diameter of 300 mm
- = Spectral range: 190–5100 nm
- = Coatings with low scattering and high reflection
- = Ultra-hard layers with high climatic and mechanical stability
- = Fast-Lane coating (24/48h delivery)

Magnetron Sputtering (MS)  
technology

Ion Assisted Deposition (IAD)  
technology

Electron Beam Evaporation (EBE)  
technology

ADDITIONAL TEST METHODS

- = Realization and documentation of environmental tests according DIN, MIL-C-675C, MIL-C-48497A, MIL-PRF-13830, DO-160G, etc.
- = In-house tests for temperature, humidity, salt spray/solubility and water
- = Laser induced deflection (LID)
- = Cavity ring down method (CRD)

REFINEMENT

EDGE VARNISHING

To extinguish stray light, for aperture diaphragms or cosmetic aspects, asphericon also offers edge varnishing for optical components. Our selection of different varnish types enables a homogeneous, rich black, as well as arbitrarily ground and polished component contours due to the preceding, optimized surface treatment.

- = Materials: all types of glass, crystals and ceramics
- = Solvent resistant
- = Special lacquer possible on request (e.g. conductive paintwork)

LASER MARKING

Laser marking allows the clear identification and traceability of individual lenses up to complex systems. Thanks to defect-free markings by optimized pulse regimes, azimuths, side markings or scales can be used as assembly aids, use character strings or logos to complete your product.

- = Free selectable font sizes and types
- = Materials: all types of glass, plastics, metals, ceramics, crystals and semiconductors
- = Marking size: 1 - 80 mm
- = Positioning accuracy: < 0.1 mm
- = Cylindrical edges/plane front surfaces (vertical and horizontal) 360° circumferential possible
- = Optional: discreet lettering (counterfeit protection)

HIGH-PERFORMANCE OPTICAL COATINGS



Learn more about selected optical coatings with their fields of application as well as modern coating technologies in a two-part blog article series.

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ULTRA-HARD SPUTTERING LAYERS



Ultra-hard, climatically and mechanically stable coatings in the spectral range from VIS to MIR thanks to Magnetron Sputtering technology. asphericon coats customer-specific optics made of glass, quartz or crystals. Also as a 24/48h Fast-Lane service. Learn more online.

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# Production capabilities

## STOCKOPTICS ASPHERES

Specifications	α High-NA (S-LAH64)	α Low-NA (N-BK7)	α UV-grade fused silica
Diameter	10 – 50 mm	12.5 – 100 mm	12.5 – 50 mm
Diameter Tolerance	± 0.05 mm	+0/-0.05 mm	+0/-0.05 mm
NA	0.49 – 0.61	0.23 – 0.61	0.11 – 0.64
f/d	0.71 – 0.90	0.8 – 2.0	0.7 – 4.0
λ <sub>Design</sub>	780 nm	780 nm	285 nm, 355 nm
RMS Irregularities (RMSi)	≤ 0.5 μm	≤ 0.5 μm	Up to ≤ 0.02 μm
EFL Tolerance	≤ 0.1%	≤ 0.1%	≤ 0.1%
Surface Imperfections (Scratch/Dig)	60 – 40	60 – 40	20 – 20
Center Thickness Tolerance	± 0.05 mm	± 0.05 mm	± 0.05 mm
Clear Aperture	≥ 90 %	≥ 90 %	≥ 90 %
Coating	3 Standard coatings	3 Standard coatings	7 Standard coatings

## CUSTOM ASPHERES

Specifications	Standard-Quality	Precision-Quality	High-End Finishing	Diamond-Turning
Diameter	8 – 300 mm	4 – 300 mm	6 – 300 mm	1 – 420 mm
Diameter Tolerance	± 0.10 mm	± 0.01 mm	± 0.01 mm	
Center Thickness	2 – 60 mm	2 – 60 mm	< 60 mm	From 0.5 mm
Center Thickness Tolerance	± 0.10 mm	± 0.05 mm	± 0.05 mm	
Irregularity (PV)	10 – 4 fr (2.7 – 1.1 μm)	1 fr (0.3 μm)	0.3 fr (0.08 μm)	
RMS Irregularities (RMSi)	0.75 – 0.3 μm	0.09 μm	< 0.015 μm	0.02 μm
Surface Imperfections (Scratch/Dig)	60 – 40	40 – 20	10 – 5 for Ø < 2“; 20 – 10 for Ø > 2“	
Surface Roughness (Rq)	3 nm	1.5 nm	0.5 nm	1 nm
Full-surface Interferometric Measurement	Optional	Optional	Guaranteed	Guaranteed
Coating	Customer-specific			

## SPHERES

Specifications	Standard-Quality	Precision-Quality	High-End Finishing
Diameter	8 – 300 mm	8 – 300 mm	8 – 300 mm
Diameter Tolerance	± 0.1 mm	± 0.1 mm	± 0.01 mm
Center Thickness	2 > CT < 100 mm	2 > CT < 100 mm	2 > CT < 100 mm
Center Thickness Tolerance	± 0.1 mm	± 0.03 mm	± 0.01 mm
Tolerance of Radius	± 0.1%	± 0.01%	± 0.01%
Tilt	300“	30“	15“
Surface Irregularity	0.8 fr	0.3 fr	0.3 fr
Surface Imperfections (Scratch/Dig)	60 – 40	40 – 20	20 – 10
Surface Roughness (Rq)	2 nm	1.5 nm	0.5 nm
Coating	Customer-specific		

## AXICONS

Specifications	Custom Axicons	StockOptics Axicons
Diameter	1 – 420 mm	25.4 / 50.8 mm
Diameter Tolerance	± 0.03 mm	± 0.1 mm
RMS Irregularities (RMSi)	40 nm	≤ 70 nm
Surface Imperfections (Scratch/Dig)	20 – 10	40 – 20
Coating	Customer-specific	4 Standard coatings
Laser Damage Threshold	Customer-specific	12 J/cm², 100 Hz, 6 ns, 532 nm
Full-surface Interferometric Measurement	Optional	Optional

## ACYLINDER

Specifications	Custom Acylinder	StockOptics Acylinder
Diameter	Up to 200 × 96 mm	10 × 10 – 50 × 50 mm
RMS Irregularities (RMSi)	20 nm	≤ 500 nm
Surface Imperfections (Scratch/Dig)	20 – 10	60 – 40
Coating	Customer-specific	3 Standard coatings
Laser DamageThreshold	Customer-specific	12 J/cm², 100 Hz, 6 ns, 532 nm
Full-surface Interferometric Measurement	Optional	Optional

## MIRRORS

Specifications	Custom Mirrors
Diameter	1 – 420 mm
Diameter Tolerance	< 0.015 μm
RMS Irregularities (RMSi)	25 nm
Surface Imperfections (Scratch/Dig)	20 – 10
Coating	Customer-specific
Full-surface Interferometric Measurement	Optional

All products are also available as reflective mirror elements.

## FREEFORMS

Specifications	Standard-Quality	Precision-Quality	Diamond-Turning
Diameter	8 – 300 mm	4 – 300 mm	1 – 150 mm
Diameter Tolerance	± 0.10 mm	± 0.01 mm	
Center Thickness	2 – 60 mm	2 – 60 mm	From 0.5 mm
Center Thickness Tolerance	± 0.10 mm	± 0.05 mm	
RMS Irregularities (RMSi)	0.75 – 0.3 μm	< 0.05 μm	0.1 μm
Surface Roughness (Rq)	2.0 – 3.0 nm	1.5 – 2.0 nm	Up to 1 nm
Full-surface Interferometric Measurement	Optional	Optional	Optional

# asphericon worldwide

## THE INTERNATIONAL SALES NETWORK OF ASPHERICON



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