PRECISION IN A NEW DIMENSION

I KUGLER I LASER OPTICS AND COMPONENTS

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PRECISION IN A NEW DIMENSION

KUGLER Laser Optics –
Ultra Precision Technologies for the 21st Century

KUGLER Laser Optics – more than 25 years of experience in precision engineering and metal optics manufacturing! When talking about reflective optics and optical systems for laser industries, machine builders, and laser users, KUGLER is first choice: not only for manufacturing state-of-the-art laser products, but also for consulting, development, and training. From simple laser mirrors to highly aspheric adaptive optics, from standard bending units to complex multi-axis NC focusing heads – we provide state-of-the-art products and most competent customer care.

TÜV SÜD ISO 9001

KUGLER has been certified according to DIN EN ISO 9001: 2000
Certificate Register Number: 12 100 26419 TMS
KUGLER works in conformity with RoHS (Restriction of Hazardous Substances)

KUGLER®
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The managing directors:
Lothar Kugler with his sons
Joerg and Till Kugler

KUGLER has manufactured *metal optics* and *components for laser systems* since its foundation in 1983. Starting as an application lab for air-bearing machine tool manufacturing, the metal optics shop turned out to be the strongest growing field of the young company: KUGLER became OEM supplier for almost every CO_2 laser manufacturer. As a consequence, the company launched its laser component business as a new department within the company in 1990, accompanied by the introduction of the laser focusing head KUGLER LK2 at the Hanover trade fair, a revolutionary design at that time.

In this catalog, we show the line-up of our *metal optics and laser components* – featuring not only the products themselves, but also the innovative technologies behind them. Get fascinated by the possibilities of modern metal machining: highly reflective mirror surfaces, precise optical components, manufactured by the ultra-precision specialist KUGLER.

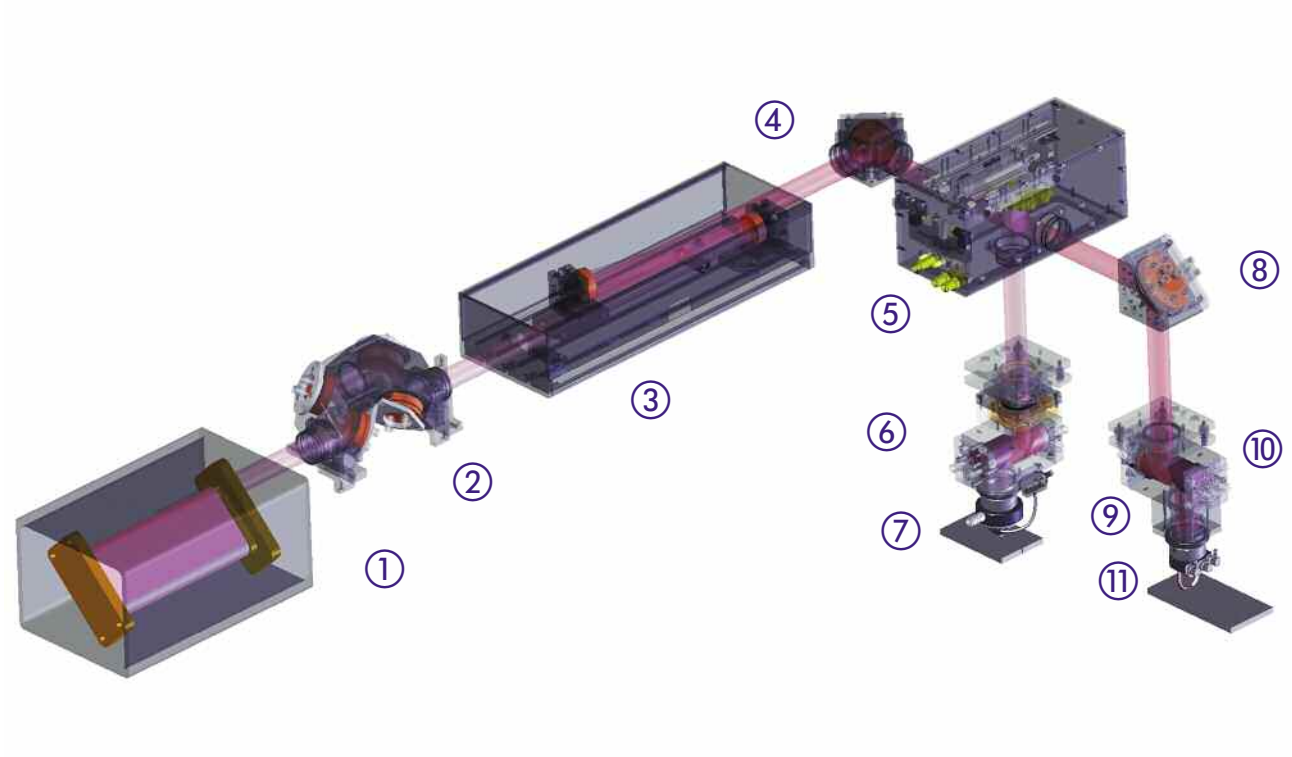
Content overview

Detailed product information and data sheets for the products shown in this catalog are available on our internet site, refer to *www.kugler-precision.com/optics*.

Laser source (resonator), beam delivery system (beam line), positioning axes, focusing head – similar components are found in almost every laser tool for cutting, welding, or hardening. Laser power, wavelength, the stroke of the positioning axes, and the laser focusing head determine the field of application of a laser machine. Simple marking lasers as well as precision lasers for micromanufacturing, welding robots for automotive industries, and largest welding systems in ship yards or for pipeline construction, all of them may contain components manufactured by KUGLER. Innovative and reliable, made from metal, developed and designed with the experience of the optics manufacturer from Salem, located near the Lake of Constance, Germany.

The KUGLER manufacturing program *Laser Optics and Laser System Components* features mirrors and essential components of the beam delivery system of a laser tool. As a metal optics manufacturer, KUGLER specializes in supplying components for CO_2, fiber, and NdYAG lasers with a power range from 100 Watts up to highest powers of e.g. 60 Kilowatts. Many of the components shown in this catalog can also be used for shorter wavelengths (e.g. in the visible range), or are suitable for other applications (e.g. measuring systems).

We are committed to find the best economical solutions for our customers. Therefore KUGLER is engaged in R&D to continuously optimize the quality of its existing laser products and to design new innovative optics and systems. Feel free to ask us for advice. Our laser optics and laser system component specialists, in cooperation with their colleagues from the air-bearing tool group or the micromachining department, will all contribute to finding the optimum solution for you.



KUGLER Components for a Modern Laser Machine Tool

1 Resonator Mirror Page 14
Best surface quality, highest reflectivity. Top of the line in metal mirror manufacturing.

2 Back Reflection Suppressor System BRS Page 20
For stable laser operation even in case of back scattering of laser radiation from a highly reflective workpiece.

3 Beam Expander / Telescope KST-NT Page 21
Z-fold expanding optics for good performance with long travel axes.

4 Bending Unit UE with Circular Polarizer Mirror PR Page 19
For stable results independent of the machining direction.

5 Beam Switch SW Page 19
Multiple focusing heads operated with one laser beam source.

6 Laser Cutting Head LK190C, LK390C Page 23
Mirror focusing suitable for highest laser powers. Easy maintenance.

7 Non-Contact Height Sensor Page 23
The “auto focus” sensor of a laser cutting machine.

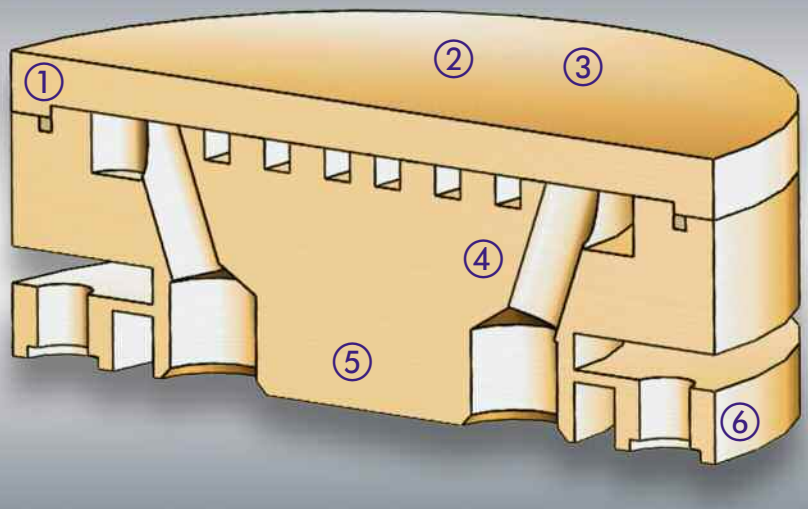
8 Bending Unit with Adaptive Mirror AO Page 20
Focus shifting in combination with a focusing head.

9 Laser Welding Head LK190W, LK390W Page 23
Dynamic mirror focusing. Compact design, rugged, versatile.

10 Rooftop Mirror Page 11
To generate a twin focus with laser heads LK. Efficient welding.

11 Cross Jet Nozzle Page 23
Supersonic air jet to protect the focusing mirror.

All KUGLER components feature highly economical manufacturing with air-bearing ultra-precision machine tools. Not only the precision mirror surfaces, but also functional mechanical surfaces of the beam delivery components (e.g. for alignment) are produced using this technology. On the following pages, you will find typical details of KUGLER Laser Optics and Laser System Components.



Laser Optics

A laser mirror can be a simple piece of metal or glass. Modern mirrors however, feature a number of important technical details found in a typical KUGLER mirror, based on many years of experience in the development and manufacturing of optics.

1 Base material of the mirror is oxygen free copper (OFHC) (OFE) or an aluminum alloy, selected for high reflectivity and low scattering. Our well-proven heat treatment increases the long-term stability of the mirror.

2 The mirror surface is direct-cut on KUGLER air-bearing ultra-precision machine tools (page 8). Sub-micrometer geometrical accuracies and nanometer roughness guarantee the outstanding optical performance of the mirror.

3 For a higher reflectivity and/or better scratch resistance, the metal mirror surface can be vacuum coated (page 16). Highest reflectivity coatings: HRC for CO_2 lasers and EGY for fiber lasers.

4 Innovative water cooling structures (e.g. spiral cooling) transport heat away from the surface in multi-kilowatt laser applications. Mirror top and mirror base are fixed together in an in-house soldering process. Mirrors feature self-closing water connectors for “drip-free” maintenance.

5 The body of the laser mirror is designed in a way, that mounting forces are not transferred to the optical surface (no deformations). Furthermore, operation of the mirror is not affected in case of short-time failures of the water cooling, even at highest laser powers.

6 The rear side of the mirror is precision-machined to micrometer tolerances, in order to allow reproducible screw-mounting of the mirror.

Laser System Components

State-of-the-art precision mechanical components for industrial applications, even under rough environmental conditions.

1 Made from aluminum or steel: Precision machined housings of the KUGLER Laser System Components. Tight tolerances enable a highly reproducible exchange of components, minimizing the need for alignment, and thus allowing for an easy integration into laser machine tools. Housing surfaces are hard-anodized to reduce the potential dangers of scattered laser radiation and the risk of corrosion, and to increase scratch resistance in rough applications.

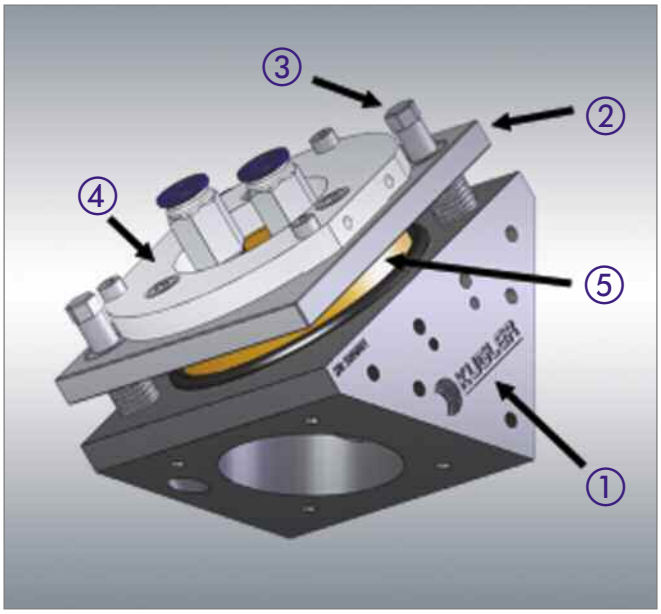
2 Alignment surfaces, alignment plates: Every part requiring a long-term stability after first-time set up and during operation is made from optimized materials. The alignment plates of the bending units are made from stainless steel, featuring high stiffness, suitable for axis accelerations of several “g”, and resulting in excellent temperature stability.

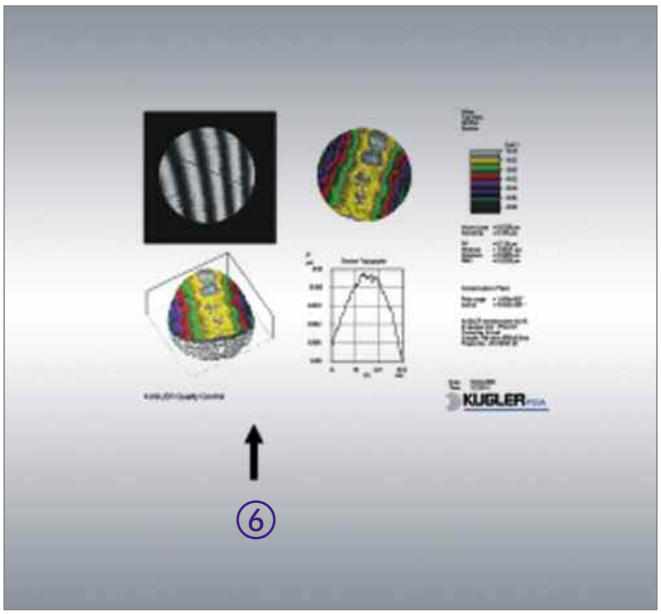
3 KUGLER Laser System Components aligned by means of sturdy, easy to use adjustment elements: Instead of fragile micrometer screws, steel fine thread screws are used featuring a resolution of approx. 100 microrads. Simple disk springs or “sophisticated” spring elements (e.g. made by wire erosion) used to preload the adjustment elements result in a high stiffness and a large stroke for stable optical alignment.

4 KUGLER Metal Mirrors for the laser system components are mounted on precision diamond machined supporting plates or rings: This guarantees life-time reproducible exchange of the mirror unit without having to readjust the alignment elements of the housing, e.g. during maintenance.

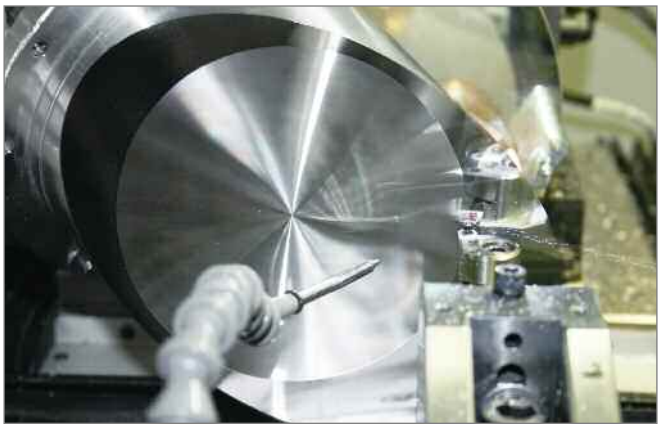
5 Laser System Components equipped with ultra-precision diamond-machined KUGLER metal mirrors: Featuring optimum surface accuracies and a non-surpassed surface roughness, for an excellent price.

6 In-house production of all essential machining steps and in-house assembly are standard for all KUGLER Laser System Components. Quality checks are performed using modern interferometry test equipment – 100% for each component.



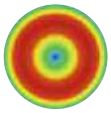


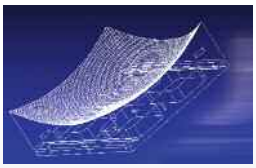
KUGLER laser mirrors are ultra-precision diamond-machined on air-bearing tools – tools developed, designed, and constructed by KUGLER. A solid granite machine base and an air-bearing table featuring vibration-free axis motion are essential for optics manufacturing. The table supports the workpiece, which is moved beneath a large fly-cutter disk mounted to an air-bearing spindle. This disk supports the dedicated single crystalline natural diamond tool bit, producing the mirror surface on the workpiece by cutting parallel milling traces with a spacing of only few micrometers, producing sub-micrometer chips. Our machine tools feature interferometers mounted parallel to the spindle for immediate quality checks of optical surfaces – surfaces produced directly to final quality, without the need for an additional polishing process.



For the manufacturing of focusing mirrors, KUGLER utilizes special precision diamond turning lathes. In contrast to standard lathes, where the tool bit motion is independent of the main spindle, most of our lathes feature a slow-tool capability, where the motion of the linear stages is fully synchronized with the spindle rotation angle. This allows to produce optical parts which are not rotational symmetric (like biconic mirrors), or parts with a large off-axis value (like large focal length parabolic mirrors, e. g. with more than 1000 mm focal length).

We still have it: Our lathe with only one air-bearing axis! Realized by a rotary table and a laser controlled piezo actuator moving absolutely vibration-free, this lathe yields a superior surface gloss at a higher machining speed.





Flat Mirrors

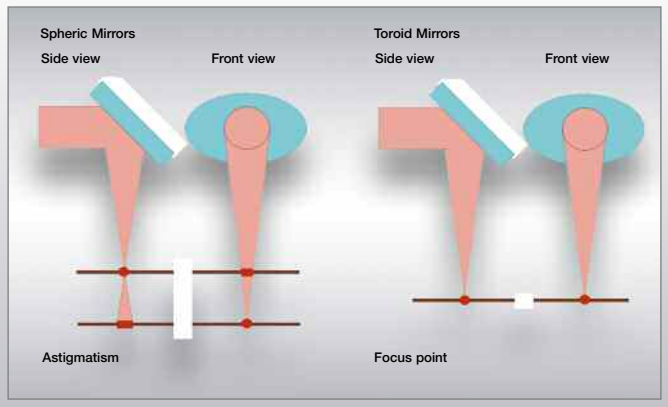
Flat mirrors are essential for every beam line and also important for many beam sources. Not made from glass, but from copper: easy, economical manufacturing with fly-cutter tools, high infrared reflectivity, best thermal and mechanical stability at highest laser powers. Coatings to improve the optical properties and to protect the surface from scratches and machining debris in industrial use. For laser powers from 100 W to more than 40 kW, not only for CO_2, but for all infrared wavelengths and visible light.

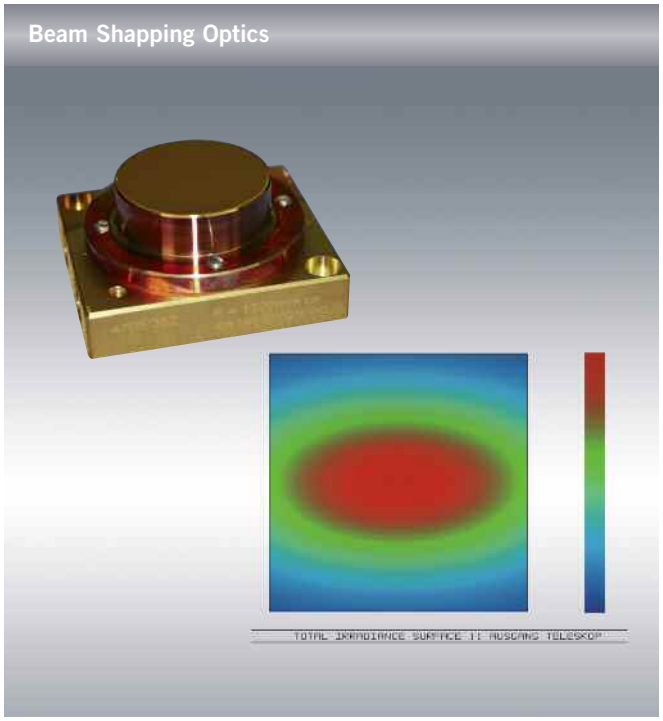
KUGLER manufactures flat copper mirrors in many sizes as standard and customized components (up to more than 300 mm diameter). As single mirrors or mirror units mounted to supporting plates, e.g. for KUGLER focusing heads or bending units. With or without direct water cooling. Flatness typically better than 0.25 µm, roughness (Ra) better than 3 nm. Metal coatings (gold, molybdenum) or dielectric multilayer coatings (circular polarizers, enhanced reflectivities for 10.6 µm, 1064 nm, or 632 nm).

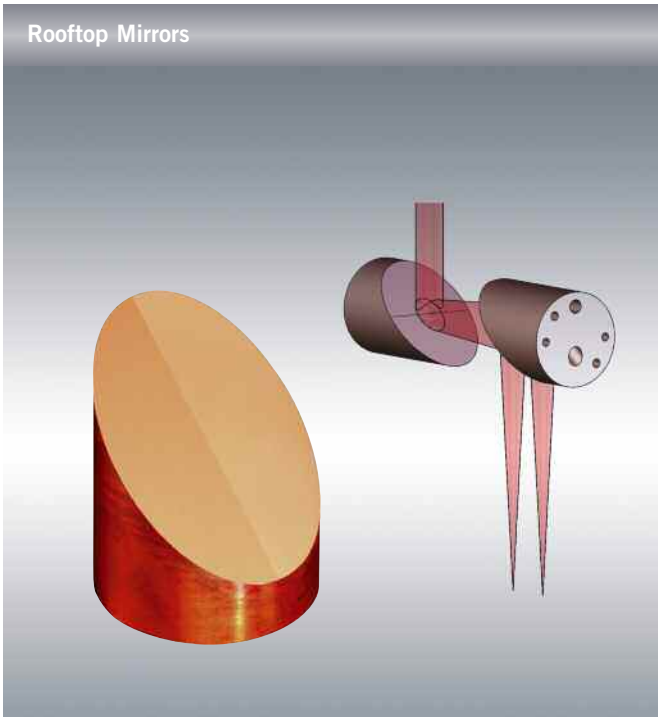
Mirrors for Beam Expanders or for Simple Focusing Tasks

Spheric mirrors in a laser beam path are used to change the beam diameter or the beam waist position in order to illuminate the laser focusing head in an optimum way. They are also used in expanding telescopes with small bend angles (z-fold optics). For larger bend angles (> 15° – 20°), with toroid mirrors featuring two different surface radii, a complete compensation of the astigmatism found with simple spheric mirrors is achieved. Spheric and toroid mirrors can also be part of simple focusing assemblies (especially with large focal lengths). An extreme version of a toroid mirror is a cylindrical mirror producing a focus line, often used for laser hardening.

KUGLER spheric and toroid mirrors are diamond fly-cut in a highly economical production process. Radius accuracies of better than 1 % or 2 %, surface figures of better than 0.25 µm (spheric mirrors), roughness values (Ra) of better than 3 nm. Smaller radii are diamond turned to a high accuracy (radius accuracy better than 0.02 mm). Water cooling, vacuum coatings, carrier plates are available as standard.





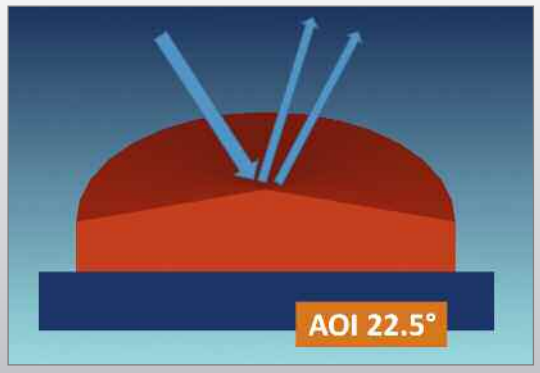


Beam Shapping Optics

Elliptical mirrors, convex parabolics, biconic mirrors, or just cylindrical mirrors – all what might be needed for beam shaping in a CO_2, fiber, or NdYAG laser system can be delivered by KUGLER. New machining systems allow the production of non-rotationally symmetric mirrors at very moderate costs.

Design your beam path and choose mirrors with the best geometries – we will manufacture them for you! Or rely on our beam path calculation service – refer to the second part of this catalogue (page 22).

Beam shaping "extreme": An axicon mirror is an example for an optical component with a significant influence on a laser beam. The mirror is not smooth, but features a distinct tip. It transforms a Gaussian beam into a beam with a donut-like energy distribution, an intensity profile with a "hole" in its center. This can be used for coaxial coupling of a secondary beam with a different wavelength. This type of a cone-like mirror can be diamond turned quite easily for an on-axis system. But, an on-axis design usually requires transparent optics, which is not such a good idea for high power lasers!



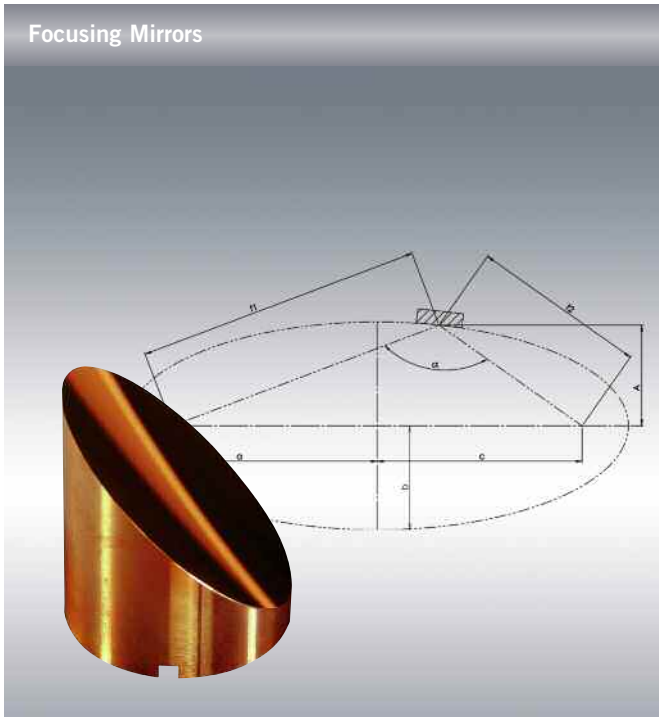
With KUGLER's turning lathes featuring slow-tool technology now it is possible to manufacture off-axis axicon mirrors: direct water-cooled mirrors transform the laser beam like a standard axicon, but at the same time deflect the beam at e.g. 45° or 90°. See an application on page 22!

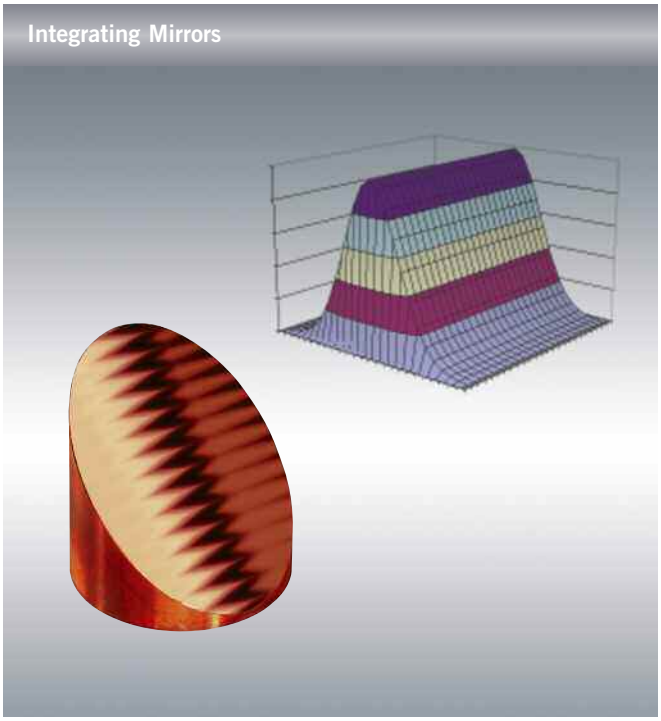
Rooftop Mirrors

In case one focus point is not enough: Rooftop mirrors split the light into two parts in a way, that a twin focus spot is produced by the focusing mirror of a laser machine. Two spots with equal intensity, separated by a few tenths of a millimeter, can significantly improve welding, especially of aluminum.

If you need some more spots, three or four-fold mirrors are also possible, with laser energy ratios which you can select.

KUGLER manufactures rooftop mirrors with the same dimensions as the flat mirror units for laser heads LK, or as single mirrors for all laser systems.





Focusing Mirrors

Focusing with mirrors instead of lenses: Geometrically perfect due to the genuine parabolic shape (no lens aberrations), practically non-destructible by heat (laser power) and pressure (process gases) due to solid metal. Aspheric mirrors, such as parabolic mirrors, are highly cost-effective optic components, responsible for finally transferring all of the laser power to the workpiece. These mirrors represent the outstanding machining technology and the accumulated experience of the KUGLER staff.

Standard focusing mirrors, bend angle 90°, with diameters up to 75 mm, focal lengths up to more than 400 mm, e.g. 1200 mm for remote welding.

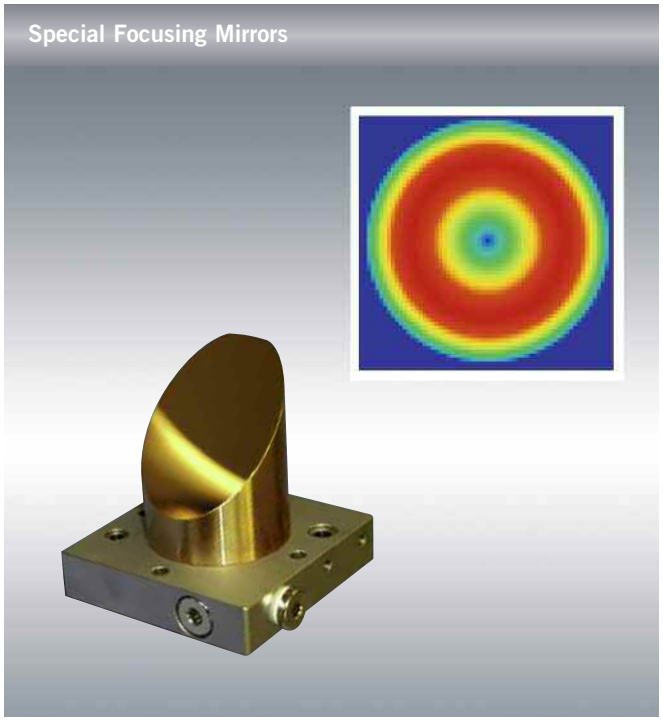
Mirrors with an elliptical surface geometry for fiber lasers – eliminating the need for a separate fiber collimator.

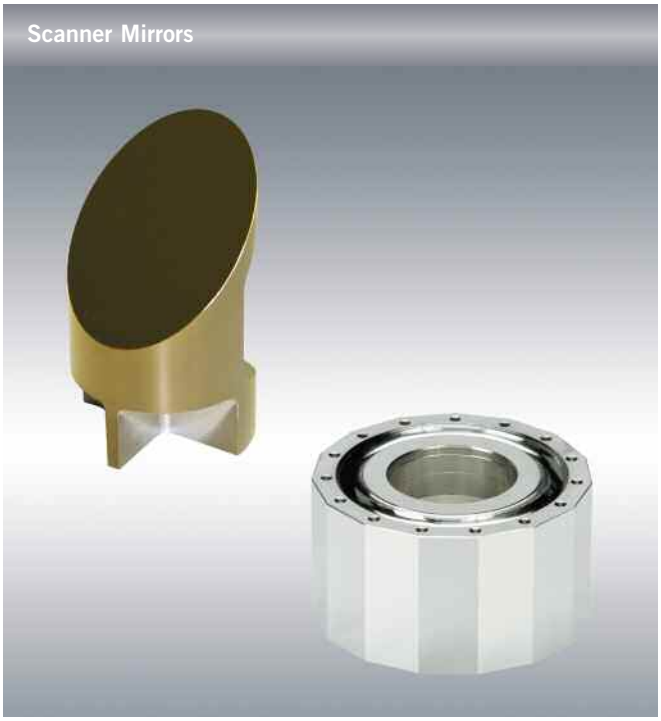
Larger diameters, smaller angles (also with larger focal lengths) on request. Standard surface figure 0.3 µm to 1 µm, roughness (Ra) approx. 5 nm. With or without direct water cooling. Versions with thread patterns practically for all focusing heads. Mounted to supporting plates (mirror units) for KUGLER LK190 / LK390 focusing heads. Molybdenum coating for CO_2 laser welding tasks, or high-reflectivity coatings, EGY (for fiber lasers) or HRC (for CO_2 lasers) optional.

Integrating Mirrors

Homogenization of the focus intensity at the workpiece – a task always needed for the surface treatment of metals. Whereas true two-dimensional intensity integration requires most complex mirrors, a one-dimensional line integration (see graph), as is sufficient for line-by-line scanning of a workpiece, is economically achieved by a KIS-mirror according to a KUGLER patent.

KIS Integrating Mirrors replace the focusing mirror (same sizes, same versions) and are produced for spot sizes from a few millimeters (length and width) up to several inches. Please note, due to interference and diffraction effects, a varying focus quality is achieved with different lasers. The best homogenization effect is achieved with instable-resonator CO_2 lasers, with diode lasers, or with high power fiber lasers.





Special Focusing Mirrors

Sometimes a round spot or a square spot is not good enough – often elliptical focus spots, or even focus lines do a far better job! Using controlled astigmatism is a very popular way to produce an elliptical spot especially for laser welding (e.g. gap bridging) – KUGLER has produced mirrors featuring this optical effect for more than 25 years now.

For surface treatment applications (e.g. laser hardening), copper mirrors with parabolic cylinder geometries and a length of more than half a meter produce a very narrow line focus, which can be swept over a workpiece using galvo or polygon scanners!

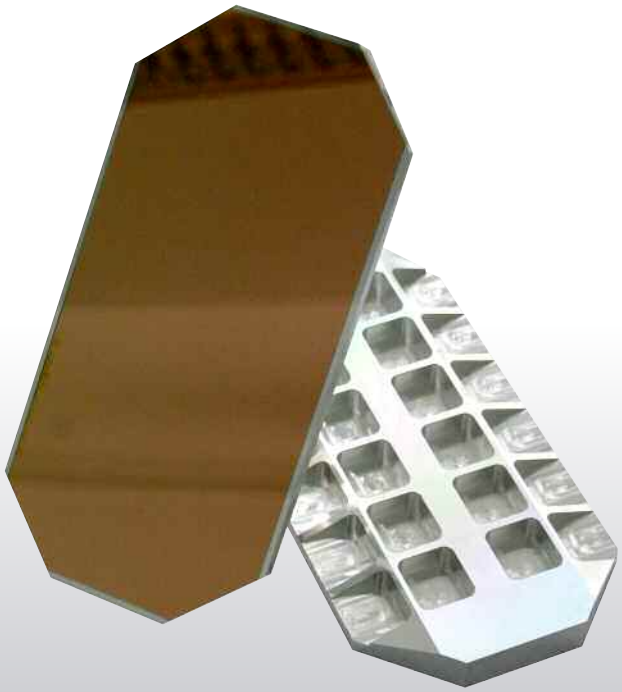
KUGLER offers focusing mirrors producing a small ring focus. Typical ring diameters are of the order of a few tenth of a millimeter, similar to the spacing of twin spot systems in welding applications. A donut-like intensity distribution in the focus spot can be achieved just by exchanging either the flat bending mirror or the off-axis parabolic mirror in a focusing head.

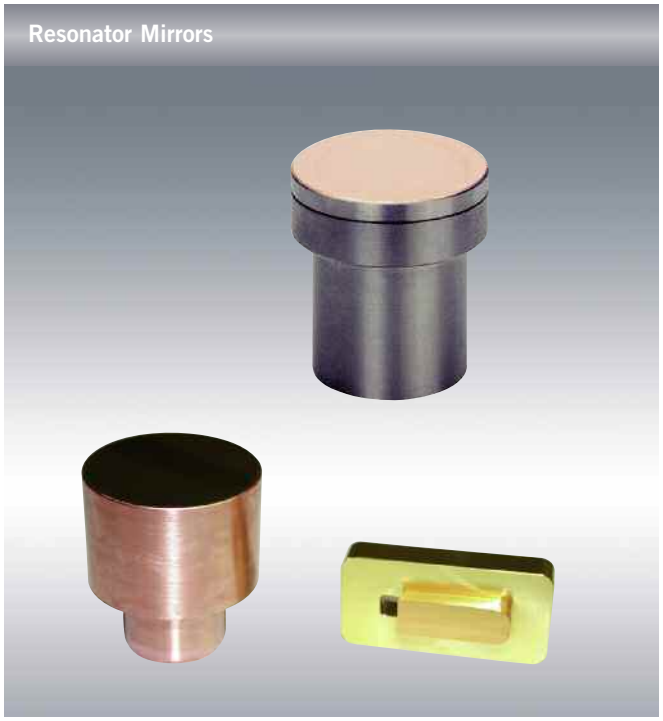
Scanner Mirrors

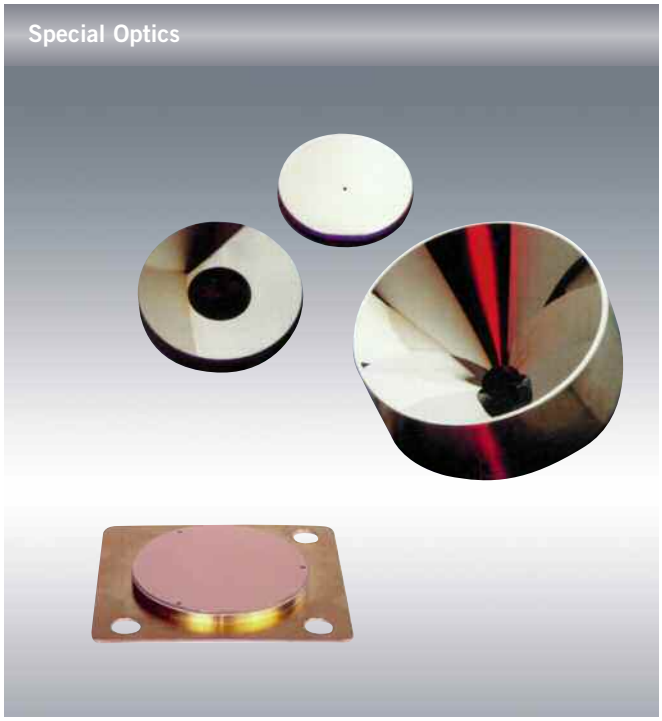
Remote welding, dynamic motion of the focus spot at high speeds, or just simply mirrors for a scanning head – all this requires optical components that are not only designed for best optical performance, but also feature properties like low mass, balanced moments of inertia, and durability at high accelerations.

KUGLER manufactures polygon scanner wheels (up to diameters of nearly 700 mm!), water-cooled flat mirrors for remote welding, or scanner mirrors for high-speed galvos. In order to reduce weight, often an aluminum mirror body is chosen – covered with high-quality galvanic copper plating for the reflecting mirror surface.

Our scanner mirrors are in use in industrial bar code readers, in medical systems for eye surgery, in dicing machines for the production of electro steel, or even in spacecrafts and satellites as optics for distance sensors!







Resonator Mirrors

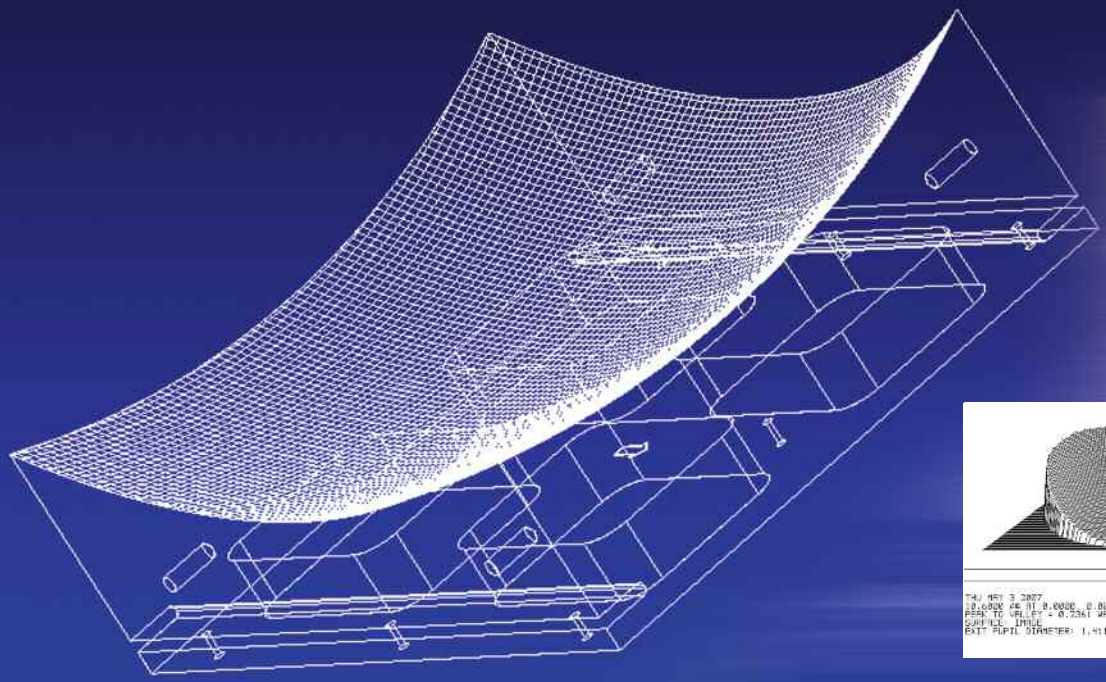
Surface figures of better than 100 nanometers, highest reflectivity, practically no residual scattering, corrosion-protected mirror bodies, integrated water cooling, integrated output windows: Mirrors for operation inside the resonator of a laser beam source are most demanding, not only concerning technology, but also considering logistics and quality management. We have the experience, the appropriate machine tools, and the measuring equipment needed for the economical realization of such complex tasks. KUGLER, the specialist for resonator mirrors, produces small and large quantities.

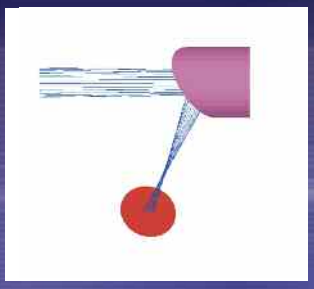
KUGLER develops and optimizes processes in close cooperation with laser beam source builders, e.g. for new, innovative geometries for CO_2 slab mirrors, but also manufactures precisely according to well established designs.

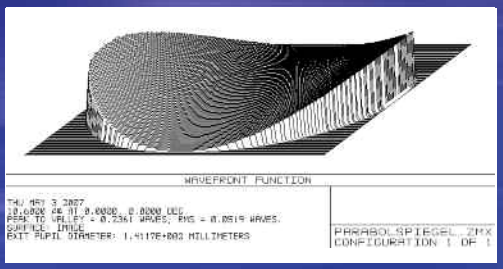
Special Optics

Lightweight mirrors, e.g. for welding robots, large aperture elliptical mirrors for the imaging of fiber ends, multi-facetted hardening mirrors, or just simply hard-to-get replacement optics for older lasers: KUGLER always has the “metal optics solution”, using its modern machine tools, relying on its highly motivated and experienced staff.

Special mirrors with surface sizes from a few square millimeters up to a few square feet. Mirrors with a length of more than one meter and with diameters of up to 700 mm can be machined at KUGLER, Salem. The ultra-precision manufacturing department features 15 air-bearing fly-cutter tools and turning lathes for aspherics, and special air-bearing machine tool arrangements. Furthermore, the micro-production group uses turning lathes for drum structuring, as well as a 5-axis high-speed milling center, both suitable for production of optical surfaces. All these precision machine tools have been developed, designed, and constructed by KUGLER and are continuously kept up-to-date.







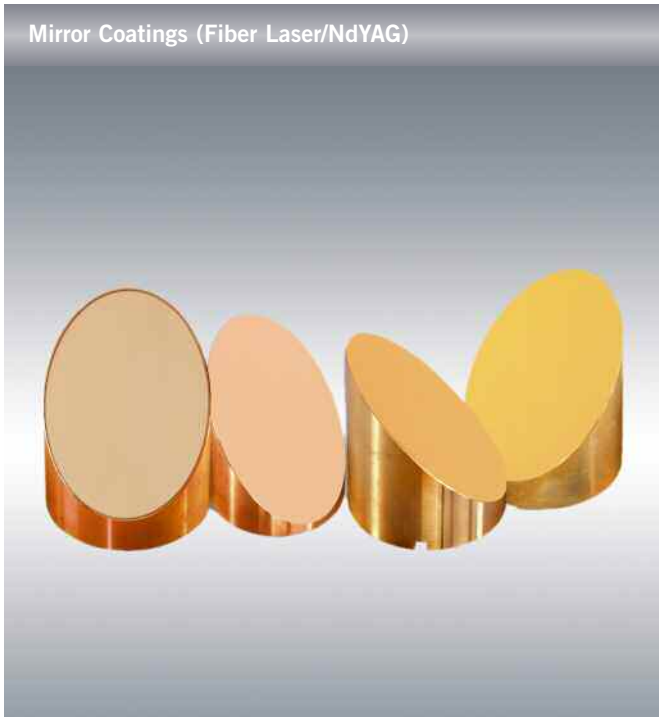
Optics Calculations

We calculate, we simulate, we optimize, we measure, and we qualify. KUGLER employs graduated physicists with expertise in metal optics design and manufacturing as well as in interferometrical testing. This enables us not only to manufacture a mirror geometry, but also allows us to predict its performance in a laser system.

We use modern ray tracing software as well as dedicated physical optics propagation software, e. g. taking into account the real M^2 of a laser source. Just define what a laser mirror should do – and we assist you in finding a cost-effective solution!

Fixturing tools guarantee deformation-free manufacturing of mirrors with our diamond turning or milling machines. The machines are programmed with data gained from the optics calculations. After the optional coating of the mirrors, final inspection measurements verify the customer´s specifications.

	Specialized Design		Conventional Machining	Ultra Precision Technologies		
optical specifications	optical design (ZEMAX)	CAM system (Diffsys)				
mechanical specifications	fixture design (Solid Works)		fixture production	diamond machining	coating	quality inspection
	mechanical design	mirror 3D model	blank production			



Mirror Coatings (CO_2)

The natural reflectivity of copper makes it excellent for use as optics material in many laser systems. Due to this, diamond-machined metal optics are often used without any further surface treatment. In an industrial environment however, mechanical protection of the soft copper surfaces is often needed. For this purpose, gold and molybdenum are deposited on the mirrors in vacuum coating chambers. Dielectric coatings are applied for reflectivity enhancement. For resonator mirrors power losses can be reduced to below 0.1%. Polarizing coatings as used in many CO_2 laser tools are also available.

KUGLER offers coatings for many wavelengths in cooperation with well-known national and international partners. Coatings for CO_2 laser mirrors are listed in a separate data sheet, available for download from our internet site. In addition to optical coatings, we also deliver protective and functional coatings for the non-optical surfaces of laser components (hard anodizing, black anodizing, gold plating).

Name	Type	Reflectivity (%) @ 1064 nm			Refl. (%) @ 633 nm
		0°	45°	45°p	
Al	Aluminium, no coating	92.0	94.0	89.0	90.0
OFHC	Copper, no coating	97.0	97.7	96.3	90.0
PG	Protected Gold, gold + dielectric	96.0	96.7	95.3	90.0
HG	Hard Gold (plasma gold) pure metallic	96.8	97.3	96.2	90.0
EGY	Enhanced Gold-YAG dielectric multi layer	99.5	99.6	99.5	90.0

Mirror Coatings (Fiber Laser/NdYAG)

Latest developments in laser machining in the near infrared range (NdYAG laser, disk laser, fiber laser) require optic components capable of handling highest powers.

By selecting appropriate diamond cutting techniques, KUGLER mirrors for NIR applications feature comparatively low losses due to scattering. In order to further enhance the performance of the mirrors, KUGLER offers the metal mirrors with dedicated coatings for the NIR wavelength range!

Especially the high reflectivity coating EGY reduces losses of high power fiber lasers significantly. Thermal effects like focus shifts are minimized, they are lower than for typical transmissive elements.

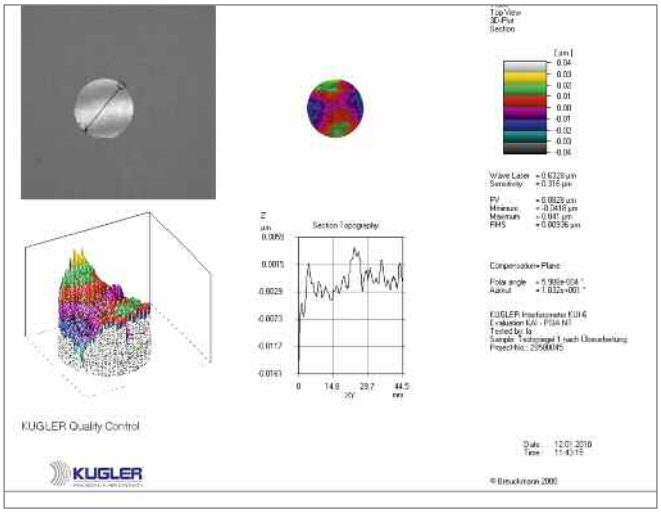
Name	Type	Reflectivity (%) @ 10.6 µm			Refl. (%) @ 633 nm	Phase Retardation
		0°	45°	45°p		
R-HRC	Resonator coating	99.9	99.9	99.7	–	< 2°
HRC	Dielectric / beam line high reflectivity	99.8	99.8	99.4	> 80	< 2°
HG	Hard Gold / beam line general purpose	98.9	98.8	97.6	> 90	< 2°
OFHC	Uncoated / beam line / low cost / high power	99.2	99.4	99.0	> 90	< 1°
MO	Molybdenum / heavy duty	98.8	98.6	97.4	> 55	< 1°
PR	Phase Retarder coating / circular polarizer	–	98.8	98.5	> 80	90°±2°
BRS	Absorption coating reflection suppression	–	99	< 5	> 80	–

Without obligation. For latest information please refer to www.kugler-precision.com/coatings.

Quality Control

Quality control from order to delivery. Quality assurance is one of the most delicate points in metal optics manufacturing: Specifications are close to what can be manufactured, and manufacturing is close to what can be measured. Everything is sub-micron. KUGLER is used to these accuracies: As a long-year manufacturer of worldwide renowned interferometers for surface inspection we know how to measure the Nanometers!

And where interferometers are not practical, our latest measuring tool will do the job: KUGLER employs a large coordinate measuring machine with a 3D-accuracy of about 1/3 micrometer, one of the most accurate systems available on the market. Now we can measure aspheres and freeform surfaces up to 700 x 700 mm!

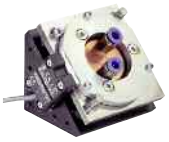


Mirror Cleaning and Packaging

A clean room for final mirror cleaning, inspection, and packing the mirrors into safe transport boxes: This is what KUGLER provides for its customers in order to guarantee a perfect product, ready for direct use or for storage.

KUGLER metal mirrors are shipped in metal cans or covered with plastic lids, with desiccant, depending on the model. All mirrors are laser marked for identification. OEM mirrors can be delivered with customer specific marking in customers' shipping boxes. Therefore many of our mirrors do not show a KUGLER logo on it.

The KUGLER Cleaning Set – for the in-field maintenance of metal optics! Carefully selected items needed for safe and efficient cleaning of different kinds of metal mirrors.



Bending Units Page 19

Beam bending at an angle of 90° or just at 5°, sensitive alignment and highest pointing stability. For flat, spheric and toroid mirrors. Apertures 35 mm, 50 mm, 70 mm.

Beam Switches Page 19

Fast beam switching, highest number of switching cycles: Pneumatically actuated, rugged switching units SW50 and SW70 for industrial lasers.

BRS Back Scattering Suppression Page 20

Suppression of dangerous reflections from the workpiece back into the laser source in welding applications, with polarizing mirrors.

Adaptive Mirrors Page 20

Dynamical beam diameter modification and focus shifting for laser cutting and welding.

Laser Beam Expander KST Page 21

Laser telescopes KST-NT featuring astigmatism compensation, optional with adaptive mirrors.

Beam Path Calculations and System Layout Page 22

Divergence, M^2, diffraction limit, wave front distortion – we know how to calculate a beam path.

Laser Welding Heads Page 23

From a simple holder for a focusing mirror to a complex, motorized focusing head with cross jet mirror protection: Always sturdy, always reliable, for all industrial welding tasks.

Laser Cutting Heads Page 23

Laser cutting with reflective optics – for flat bed systems and for 3D-laser machines. Non-contact height gauging.

NEW!

Fiber Laser Focusing Head / Fiber Collimator Page 24

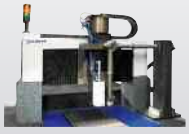
All-mirror collimating and focusing for high power fiber lasers: Cutting and welding without transmissive optics for higher reliability.

Hybrid Welding Head Page 25

A special laser system component made from standard parts: The high performance welding head LK390H with integrated welding torch. Hybrid technologies, e.g. for pipeline construction.

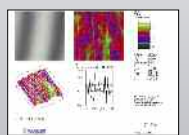
Scanner Systems Page 25

Medium and large size polygon scanners for medical and industrial machining applications.



Special Designs Page 26

Numerically controlled motorized laser focusing heads or other customized beam delivery components: 25 years of the KUGLER laser component group leave their mark.



Laser Micro Machining Page 26

With a laser focus spot size of less than 10 micrometers we enter the field of laser micro machining.

Quality Assurance / Training – Service – Development Page 27

Nanometer roughness, sub-micrometer surface figures, arc-second angular precision – the KUGLER quality assurance takes care of laser mirrors and laser system components.

Bending Units

KUGLER Bending Units UE – and the laser beam hits, where it should hit – at the focusing head. Every beam path requires adjustable mirrors for laser light bending and alignment. The most compact, yet rugged bending units UE feature aperture diameters of 35 mm, 50 mm, and 70 mm, and are precisely adjustable with a high pointing stability in the arc-second range, even in an industrial environment. Water cooled mirrors, mounted onto precision machined supporting rings, are easily exchanged for cleaning and maintenance, and are reinserted into the UE housing with a high reproducibility.

KUGLER supplies different versions of bending units, UE35, UE50, and UE70, for 90°-bending, or for small angles in z-fold beam paths. Besides flat mirrors, the UE units can be equipped with spheric or toroid mirrors or even with adaptive mirrors. Different vacuum coatings for the mirrors (for CO_2 or fiber lasers) are offered. Tube flanges optional, larger sizes (e.g. aperture diameter 100 mm) on request.

Beam Switches

Beam switches distribute the radiation of one laser source to different machining stations or to different focusing heads of one laser tool. This enables a highly economical production with reduced idle times and with short cycle times. Often built on steel plates, the pneumatically actuated beam switches feature short switching times of 100 – 200 milliseconds and are designed for failure free operation with several million switching cycles, even when mounted to motion axes accelerated with several “g”.

KUGLER Beam Switches SW are offered in different sizes (aperture diameters 50 mm, 70 mm) and configurations (e.g. as 3-fold switch). Versions with one- or two-fold mirrors, different coatings for CO_2 and NdYAG lasers. Detailed product information is available from our internet site.

BRS Systems

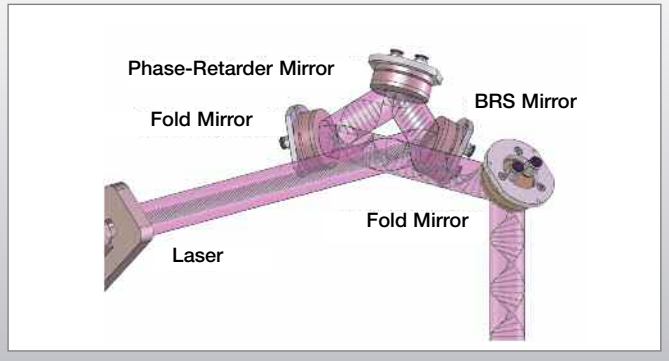
The laser beam hits the workpiece, which acts as a mirror! Especially during the laser machining of highly reflective materials, reflections from the workpiece back into the laser can cause mode jumping and power instabilities of the CO_2 beam source. In this case, there is a need for an “optical isolation”. This is achieved by separating the reflected light by means of polarizing effects: A phase retarder mirror (PR) in the beam path between laser and workpiece finally rotates the polarization of the reflections hitting towards the beam source by 90°. A mirror with an absorbing BRS coating (Back Reflection Suppressor System) eliminates this polarization rotated light. Polarizing effects of mirrors essentially depend on the angle of incidence and on the polarization angles. These are different for the PR and the BRS mirror, leading to a complex, three-dimensional arrangement of the optics. Here using a KUGLER BRS housing significantly simplifies the laser beam path.

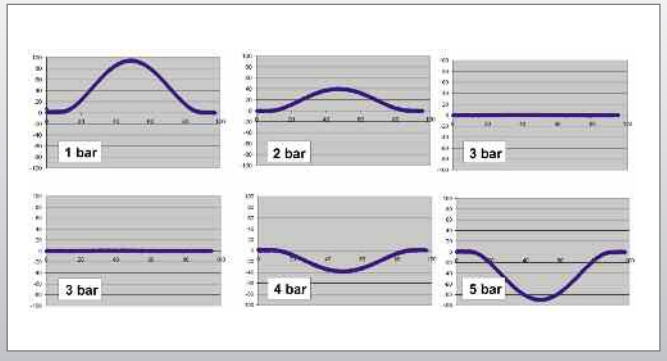
BRS “compact”, comprising a BRS and a PR mirror in one housing. Interfaces compatible to bending unit UE50. BRS “linear” mainly for back reflection suppression in lasers with a circular polarizer.

Adaptive Mirrors

Optical components with a focal length that can be changed from “focusing” to “defocusing” within a wide range. Especially in laser tools with long stroke axes, adaptive mirrors are used to relocate the beam waist, or to dynamically change the focus of the focusing head. Focusing and defocusing is achieved by a controlled aspheric deformation of the mirror surface by pressurized air. KUGLER manufactures easy-to-integrate adaptive mirrors for small bend angles (z-folding) and for 90° bending, with dedicated bending units UE.

Adaptive mirrors AO90/70 and AO5/70, bend angles 90° and 5° to 15°, effective focus range -4 m to +4 m (+/- 0.25 diopters), aperture diameter up to 30 mm. The delivery scope includes a pressure control valve (0-10 V control voltage). See *www.kugler-precision.com* for details. Gold coated or uncoated KUGLER Adaptive Mirrors are compatible with fiber lasers. For CO_2 lasers a special high reflectivity coating has been tested successfully!



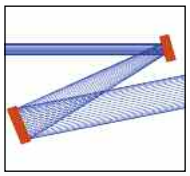
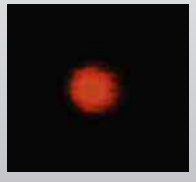


Laser Beam Expander

KUGLER KST – A series of beam expanders featuring direct water-cooled copper mirrors for highest laser powers. Even with the first laser telescopes delivered by KUGLER 25 years ago, astigmatism compensation has already been one of the main issues assuring diffraction limited performance. In the days of purely spherical mirrors, this had been accomplished by selecting appropriate bending angles for the mirrors, which often resulted in an output beam non-parallel to the input beam leading to the telescope.

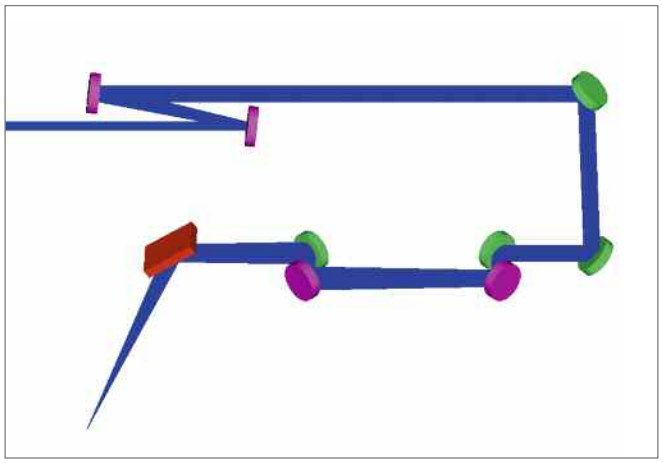
Today input and output beam are always in parallel, as compensation is done by aspherical mirrors inside the KUGLER Telescope KST. Especially our latest models KST-NT can be equipped with special mirrors to achieve virtually any beam shape desired. Of course, standard versions just enlarge a “round” beam and relocate the beam waist or control the beam diameter at the position of the focusing head.

Three nominal apertures of 35 mm, 50 mm and 70 mm can conveniently be selected for the beam expander input and output. As an example: The model KST35/50NT1.4x expands a beam 1.4 times, with an input aperture of 35 millimeters, and an output of 50 millimeters. The KST can also be equipped with mirrors for NdYAG, disk, and fiber lasers.

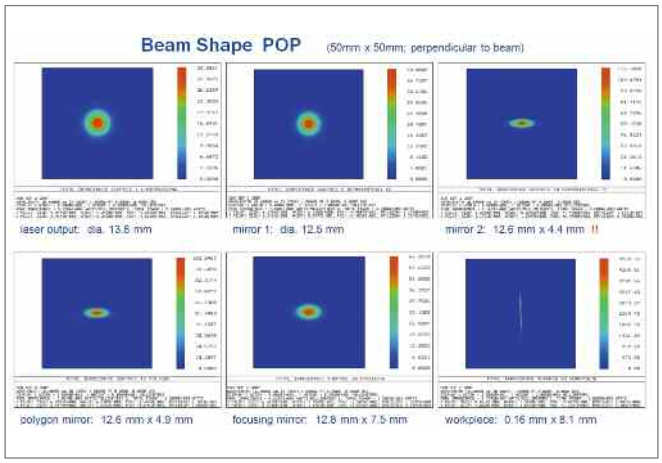
Optical Systems	Advantages	Disadvantages	
Standard Beam Expander • Convex and concave mirrors both spherical • Input beam parallel to output beam	• Mirrors easy to make • Easy to align	• Severe astigmatism • Coma	
Beam expander with tilted beam path • Convex mirror and concave mirror both spherical • Input beam NOT parallel to output beam	• Astigmatism compensated • Mirrors easy to make	• Residual coma • Beam path not parallel, alignment issues	
Beam expander with toroid mirror • Convex mirror OR concave mirror with toroidal shape, second mirror spherical • Input beam parallel to output beam	• Astigmatism compensated • Input and output beams are parallel (easy to align)	• Residual coma	
Fully compensated beam expander • Convex mirror OR concave mirror: toroid, second mirror spherical with x^3 correction term • Input beam parallel to output beam	• Astigmatism compensated • Coma compensated • Input beam parallel to output beam (easy to align)	• None, as mirrors can be made with affordable effort on KUGLER slow-tool diamond turning machines	

Beam Path Calculations and System Layout

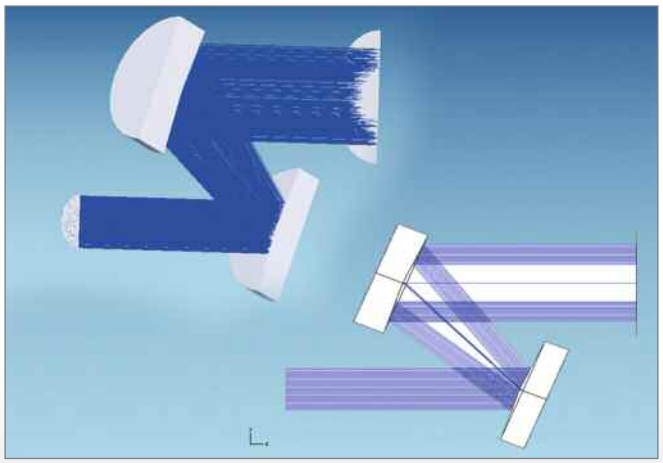
Divergence, M squared (M^2), diffraction limit, wave front distortion – we know how to calculate a beam path. This can be as simple as determining the focus shift introduced by an adaptive mirror, or finding the best expansion ratio of a laser telescope KST, or as complex as designing the beam path of a complete scanner system with variable intensity for hardening purposes.



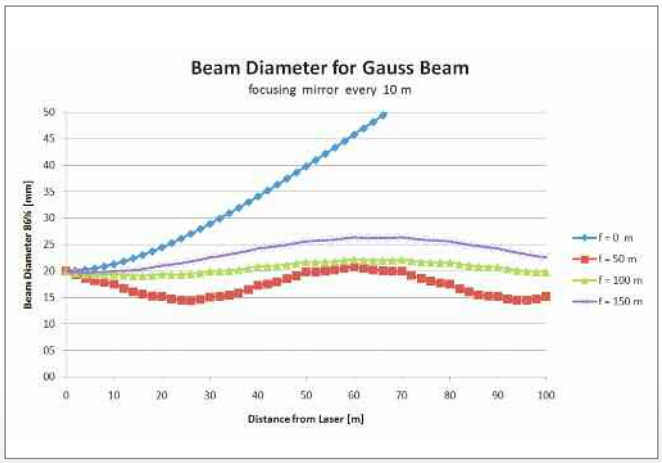
You design the mechanical structure of a laser machine tool, and we take care of the optics! This helps you in setting up new laser systems, or in modifying existing machines. We also assist you in all side aspects of the beam delivery system, from tubing to purge gas delivery.



Beam intensities are calculated using the propagation data of the laser source of the machine. Physical optics algorithms taking into account geometrical optics and diffractive light wave propagation are used to predict heating effects and required mirror sizes. The diagrams show the calculated beam sizes for a long beam path with a polygon scanner, producing a line focus in the end.



Two-mirror off-axis axicon assembly. Calculated and designed by KUGLER. A compact precision machined aluminum housing holds two direct cooled copper mirrors. The unit produces a ring shaped beam with a center clearance of 10 mm from a 40 mm Gaussian input beam.



A 100-meter long relay line for a CO_2 laser: In order to keep the beam safely inside a dia. 50 mm tubing, the influence of refocusing mirrors with a long focal length (from 50 m to 150 m) could be simulated. Without the refocusing mirrors, the beam diverges too much (blue line in the diagram).

Laser Welding Heads

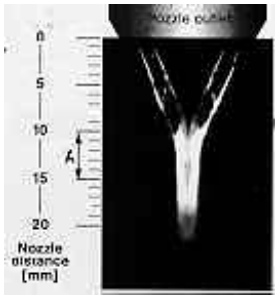
Laser welding heads with reflective optics: No brittle ZnSe-parts, no glass. Rugged, practically non-destructible, even with laser powers of more than 40 kilowatts. KUGLER Focusing Heads LK feature a modular design: the aluminum based modules can be combined with motorized or manually operated rotary stages. An effective supersonic cross jet nozzle with height adjustment (see picture) protects the molybdenum coated, water-cooled focusing mirror. Focal lengths from 150 mm to 600 mm or more, mirrors mounted to precision-machined support plates for reproducible mirror exchange.

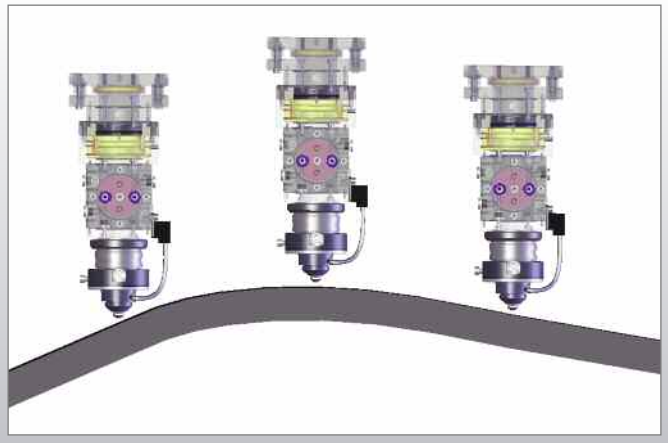
Standard welding heads are available as LK190W (aperture 35 mm) and LK390W (aperture 50 mm), larger sizes on request. Optional rooftop mirrors for twin focus welding, optional integrating mirrors KIS for hardening. With an adaptive mirror AO90/70 mounted above the LK head, dynamical variation of the effective focal length is achieved.

Laser Cutting Heads

Laser cutting – in this field of laser applications, our focusing mirrors show their outstanding optical qualities: No lens aberrations, no damage at highest laser powers. In the cutting heads, the ZnSe-window, required to separate the pressurized head (process gases) from the beam line, is located at the entrance aperture of the laser head, in a safe distance from the cutting nozzle. The LK cutting heads are equipped with an industry-proven, reliable non-contact height gauging system, essential for keeping the laser head in a fixed distance above the workpiece. Due to the modular design of the cutting heads, a manual or a motorized rotary stage can be added.

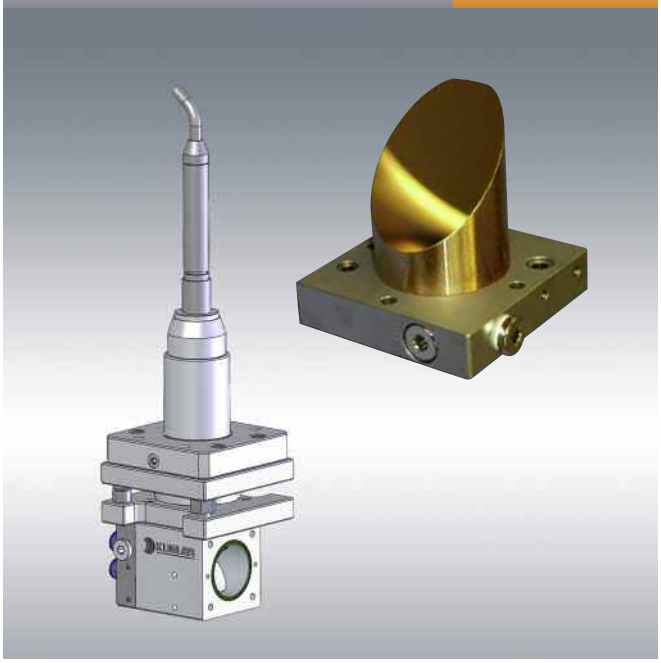
Laser Cutting Heads LK190C (aperture 35 mm) and LK390C (aperture 50 mm), with 3D nozzle adjustment (XYZ-stage). Focal lengths from 150 mm. For special applications, where a ZnSe-window cannot be used (e.g. laser powers above 8 kW), cutting nozzles with off-axis gas feed and a working distance of 10 mm are available (Laval nozzles).





Fiber Laser Focusing Head NEW!

Fiber Laser Collimator NEW!



Fiber Laser Focusing Head

The KUGLER LK190F all-mirror focusing head is first choice: Its direct water cooled aspherical metal mirrors do their job from only a few hundred Watts up to more than 40 kW – diffraction limited and virtually free of aberrations, and with a lower focus shift at high laser powers when compared with typical transmissive focusing heads! The compact 35 mm clear aperture aluminum housing with precision machined mirror mounting surfaces eliminates the need of mirror alignment.

An aspherical 120 mm collimator mirror takes up the laser beam directly from the fiber output without the need for any transmissive optics. A second, exchangeable, aspherical mirror focuses the laser onto the workpiece – with an effective focal length in the range from 150 mm to typically 400 mm, resulting in a magnification range from about 1:1 to 3:1. This range can be extended further by using dedicated combinations of collimator and focusing mirrors.

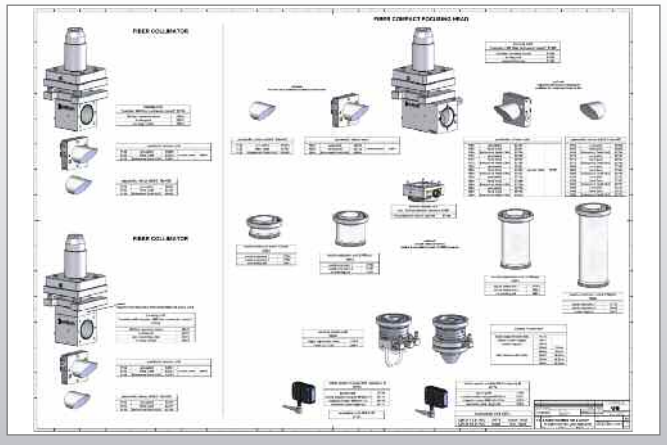
An anti-reflection coated window in a quick-change cassette protects the mirrors and the fiber from debris from the work zone. A cross-jet nozzle adds further protection in a welding environment, a Laval nozzle with a large 10 mm working distance allows for effective laser cutting!

www.kugler-precision.com/fiber

Fiber Collimator

Sometimes it is desired to use a mirror beam delivery system even with a fiber laser. With the KUGLER mirror collimator unit it is possible to upgrade CO_2 Laser tools. It might even not be necessary to exchange the folding and focusing mirrors: The KUGLER HG coating is suitable for both fiber and CO_2 lasers. On the other hand, replacing the mirrors with the high reflectivity EGY coating for fiber lasers guarantees highest efficiencies and lowest thermal effects. And, you save money when choosing a mirror solution instead of a transmissive collimator.

As for all laser components, KUGLER provides system overview sheets showing configurations and options available as standard. Upon request we also provide 3D models and detailed interface drawings. This makes it easy for a system designer to integrate KUGLER components in a new laser machine – from a simple ultra-precision machined metal mirror over an individual collimating or focusing module up to a complete focusing head with welding or cutting nozzles.



Hybrid Welding Head

Scanner Systems

Hybrid Welding Head

A special laser system component made from standard parts: The high performance welding head LK390 with integrated welding torch suitable for wire feeders. Hybrid technologies, e.g. for pipeline construction or for the welding of steel in shipyards, can significantly improve the quality of the weld joint. KUGLER reflective optics and a supersonic cross jet for protection of the molybdenum coated mirrors reduce maintenance requirements in a tough industrial environment, even at highest laser powers.

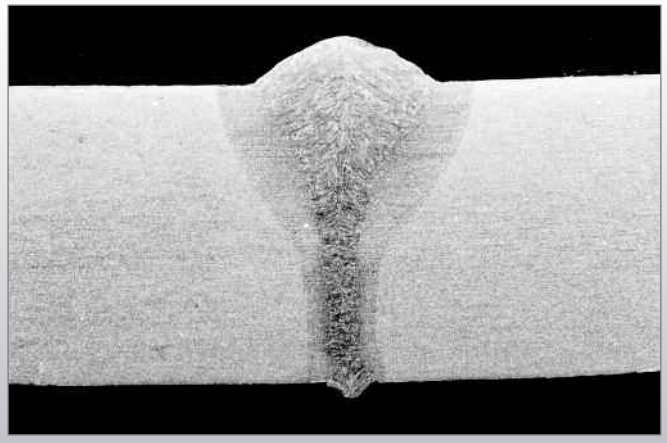
Hybrid welding heads are configured individually for the torch model selected by the customer, and for the torch-to-laser angle and distances as needed for the specific welding task. Regarding the configuration of the Hybrid Heads LK390H (aperture 50 mm), KUGLER cooperates with a university institute renowned for its research activities on welding.

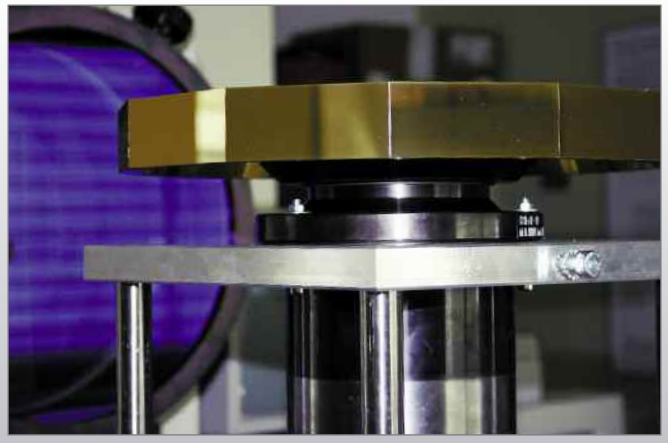
Scanner Systems

KUGLER has a long tradition in developing, designing, and manufacturing polygon scanner units. We use static air bearings for ultra smooth operation, we use selected roller bearings for high-speed applications. Today we focus in building medium and large size scanners for medical and industrial inspection and production applications, with scanner wheel diameters from 80 mm to more than 300 mm, and a speed range from 100 rpm to 40,000 rpm.

Motorization consequently ranges from 100 W to more than 5 kW! Most models (like the HSPP-100) are delivered with a high-resolution incremental encoder and a digital servo controller.

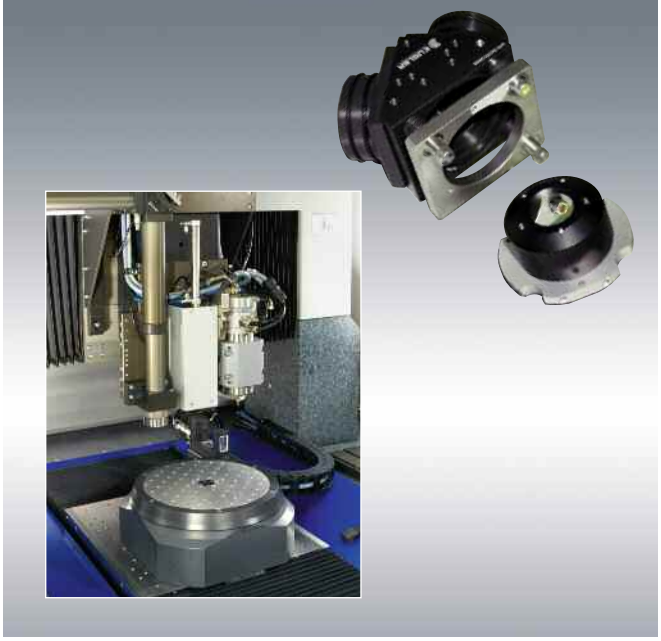
Precision balancing and interferometrical control during the assembly process guarantee best performance and an outstanding life time, which is the key to the success of our scanners.





Special Design

Laser Micro Machining



Special Designs

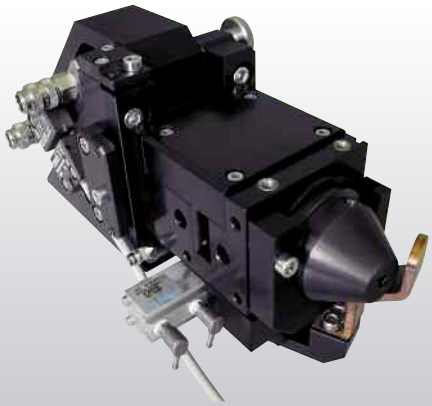
Sometimes you need more than standard: Rotary units with endless rotation, including rotary feeds for process gases, cooling water, electronics, with wire feeders and MGA welding torches: KUGLER designs and builds laser focusing heads according to customers' requirements. Following our long tradition as a laser component supplier, we already might have a solution for your specific needs. Beam delivery components, as expansion telescopes or largest bending units: custom design, higly cost effective and manufactured with the same precision as our standard components.

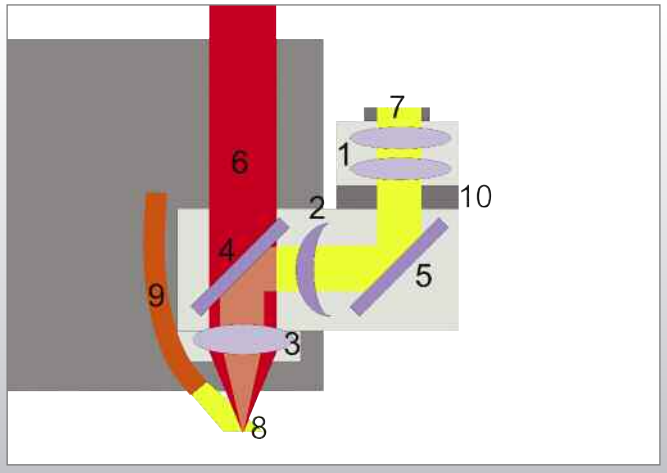
KUGLER is engaged in many national and international research programs, including projects on laser technologies. After developing CO_2-related solutions during the past years, we now focus on research and development for laser micromachining, including femtosecond laser applications.

Laser Micro Machining

With a laser focus spot size of less than 10 micrometers we enter the field of laser micro machining. Due to its experience in ultra-precision positioning, the KUGLER team is strongly engaged in bringing laser micro machining from an R&D level to industry. Main work is the modification and optimization of the KUGLER 5-axis micro milling and laser ablation machine tools MICRO-GANTRY and MICROMASTER.

Some of the new developments might also be useful for users of medium power NIR lasers: e. g. the precision focusing head with integrated laser spot position video observation, or the compact beam bender UE35, which can be delivered with mirrors suitable even for femtosecond laser sources.





Quality Assurance

We can manufacture, what we are able to measure. This simple rule holds for many fields of ultra-precision optics machining. For this reason, one of our main interests has always been the development and implementation of non-contact metrology tools: Fizeau-type interferometers for flatness inspection up to diameters of 300 mm, or Angstrom-resolution interference microscopes for roughness measurement and for the visualization of the crystal structure of mirror surfaces. Made in Salem, Germany. Used directly mounted to ultra-precision fly-cutting machines, or as stand-alone quality inspection tools. The KUGLER metrology tool line-up is completed by autocollimators with sub-arcsecond angular resolution, by 100 nm accuracy optical probe, and by a 0.35 µm accuracy coordinate measuring machine. Standardized inspection procedures help to ensure the high quality level of the laser components and mirrors delivered by KUGLER.

The optical properties for every batch of laser mirrors, for every single laser component are inspected interferometrically. Further tests include mechanical functionality or electrical safety, if appropriate. Quality certificates are shipped with the KUGLER products or can be requested separately.

Training – Service – Development

KUGLER – the people behind the product: Highly motivated young people, experienced senior professionals, skilled workers in manufacturing and assembly, innovative engineers for research and project management. This is the mixture leading to best economical, pragmatic solutions, at highest technical level KUGLER has always been known for.

KUGLER®

PRECISION IN A NEW DIMENSION

KUGLER GMBH

Heiligenberger Str. 100 · 88682 Salem · GERMANY

Tel.: +49 7553 9200-0 · Fax: +49 7553 9200-45

info@kugler-precision.com · www.kugler-precision.com