LT ULTRA

Constant focal-diameter and -position over the entire working area

For laser applications with continously changing beam path lengths

LT ULTRA

ADOPTIC

Control of the laser beam quality over the entire working area

- flexible control of the laser beam diameter in focus
- flexible control of the focal length
- increase of the processing speed
- enhancement of the application range

Perfectly suitable for controlling CO_2-lasers for 2D- and 3D-material processing applications up to 3 kW

Improved competition advantages for laser-source and -machine manufacturer

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Controllable beam quality over the entire working area

- flexible control of the laser beam diameter in focus
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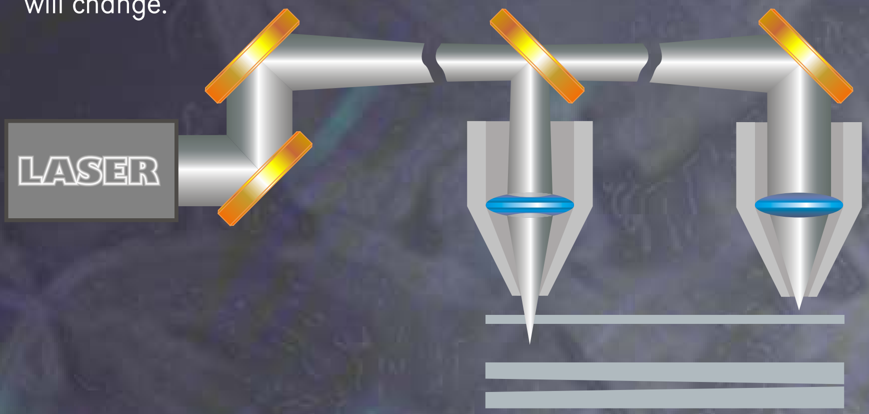
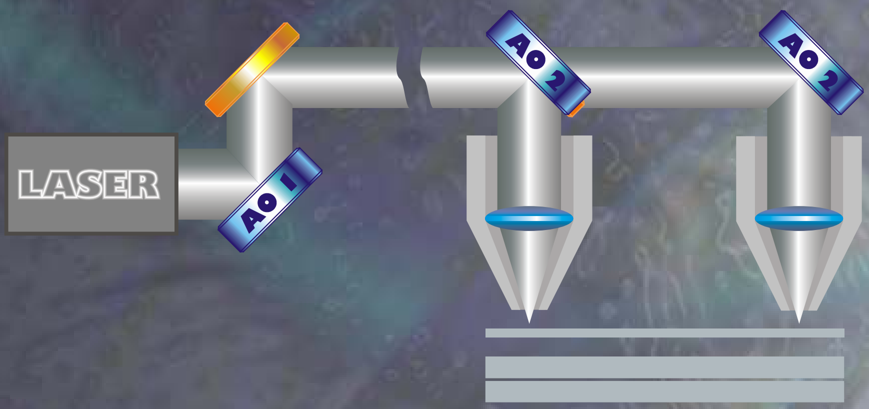
In case of laser machines with changing beam path lengths (i.e. flying optics arrangements) the laser beam diameter and the phase front radius are changing continuously along the beam path. Consequently the beam spot diameter in focus will become smaller with larger raw beam diameters and vice versa. Phase front changes lead to corresponding changes of the effective focal length of the system so that the optimal working distance will change.





The adaptive optics can compensate both above mentioned uncontrolled sources of processing problems, thus it represents an optimal technical solution. For controlling both influence factors two adaptive mirrors are necessary. The first adaptive mirror is usually inserted next to the laser output into the beam path and is controlled in such a way that the raw beam diameter onto the focusing optics remain constant the entire working beam path. This generates a constant working spot diameter within the entire working area. This first adaptive mirror is an attractive alternative to the widely used motorized lens also because of its capability to handle higher power levels then the lens. Without any further compensation the focal length still changes with the phase front radius variations. A second adaptive mirror inserted preferably just in front of the focusing optics into the beam path can be controlled in such a way that all systematic or accidental phase front radius changes are entirely compensated, thus the focal length remains constant within the entire working area.
Only the active compensation of both sources of changes assures a really constant processing quality within the entire working area.

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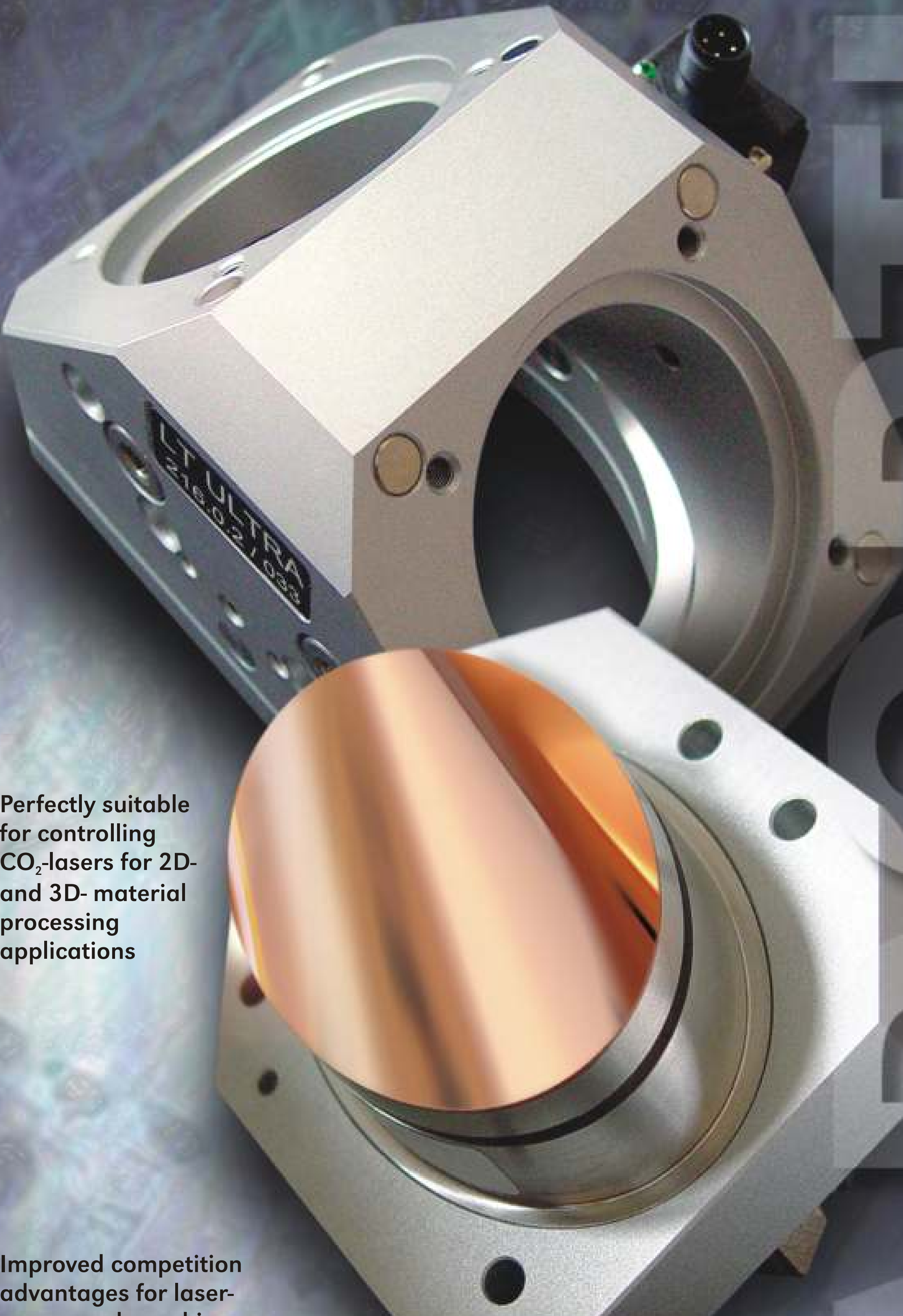
ADOPTIC



Perfectly suitable for controlling CO_2-lasers for 2D- and 3D- material processing applications

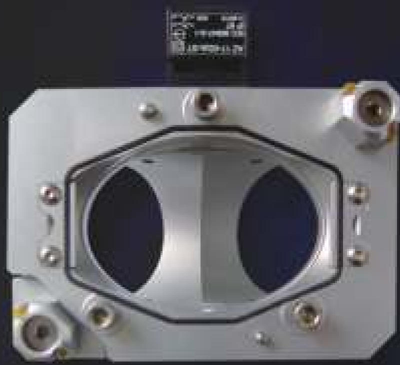
Improved competition advantages for laser-source and -machine manufacturer

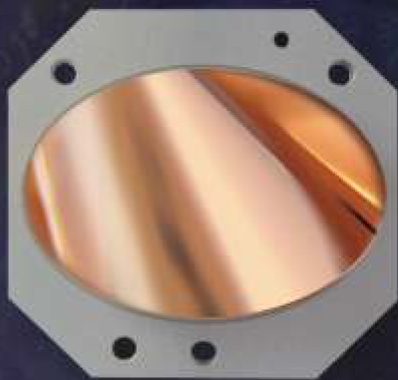
Circular Shape

Most of the first available adaptive mirrors for laser material processing were circular shaped. Due to their symmetrical deformation they can be used for large laser beam corrections, but they cannot be used alone as 90° beam bending units.

Elliptical shape

The deformation of the mirror diaphragm is elliptical under normal observation and almost perfectly spherical under 45°, so that a simple 90° beam bending unit can be implemented.





Independent from the influence of the described physical aspects of the natural beam propagation on the focal position and diameter, which can entirely be compensated with two adaptive mirrors, there is another class of influencing factors which depend on the design of the beam delivery system, many other environmental parameters and the thermal load of the optical components. These influences are mainly time dependent (i.e. thermal deformation of mirrors or the progressively heated gas within the beam delivery system can generate a time dependent "thermal lensing" effect, which usually increases the beam divergence). For their compensation with the adaptive mirrors a time dependent control in addition to the beam path length dependent control is required. A very advantageous alternative to pre-determined control parameters could represent adequate sensors which can enable the use of closed-loop control mechanisms like in case of a plasma sensor capable to control the adaptive mirror in order to track a 3D-welding profile in the range of several 10mm.

FUNCTIONALITY AND DESIGN CHOICE

Controllable adaptive mirrors are based on an elastic, reversible deformation mechanism of a diaphragm shaped mirror (concave or convex deformation), which usually remains flat in the absence of a control signal. The circular adaptive mirrors show mainly a spherical deformation under normal observation. In case of a laser beam deflection under a total angle of more than 20° the wave front will become elliptically deformed, which reduces the beam quality and generates astigmatism. Such a laser beam will have an elliptical focal spot, which will make the laser cutting quality dependent on the respective cutting direction. In order to reduce the influence of this effect, the bending angle of the circular adaptive mirror has to be kept small, so that the usual 90° bending units can only be implemented with the help of an additional standard mirror. Due to economic and technical reasons LT ULTRA offers an alternative elliptical design of the adaptive mirrors. Such mirrors will show mainly an elliptical deformation under normal observation, but this becomes spherical under 45°, so that 90° bending units need only one mirror.

The diaphragm like mirror is in both design models directly water cooled. The cooling water circuit is totally independent from the deformation control. This assures a high linearity of the deformation and a long life time. The cooling water flow rate (typically 5l/min at 5bar water pressure) is constant and independent from the deformation control. Up to 3kW laser power uncoated mirrors can be used. For higher power levels good reflecting coatings are required in order to minimize the thermal induced mirror deformation.

The mirror deformation is pneumatically (or hydraulically) induced and precisely controlled with a proportional valve. The proportional valves are controlled typically with an analog signal 0...+10V or alternatively 4...20mA. Most applications require compressed and filtered dry air or bottle nitrogen.

All adaptive mirrors are passing diverse full load tests during the manufacturing process in order to detect all material failures and functional defects. All delivered adaptive mirrors have passed at least 40000 deformation cycles at full load.

For industrial applications a feedback pressure sensor is optionally available. This allows a continuous monitoring function for the control system of the respective adaptive mirror (tubes, valve, gas pressure, control signal and adaptive mirror body).

LT ULTRA offers the elliptical designed adaptive mirrors for 90°-bending units in two standard sizes. The circular adaptive mirrors (for bending angles of less than 20°) are also offered in two standard sizes.

Starting with a volume of at least 20 units per year LT ULTRA offers development and production services for customized adaptive mirrors (ADOPTIC).
Due to the symmetrical spherical deformation in case of circular adaptive mirrors, a large range of curvature radii for the uncontrolled mirror (as starting point for the deformation) are available.

For the appropriate choice of an adaptive mirror, please observe the following application and deformation range dependent classification:

A Laser beam collimation (to be placed instead of the first flat 90° beam bending unit after laser output)

- Elliptical, adaptive mirror
- Circular, adaptive mirror as the first part of a Z-folded arrangement

B Focal length correction (to be placed 0.5 – 1.5 m in front of the focusing head within the beam path; i.e. instead of the last flat 90° beam bending unit before the Z-axis)

- Elliptical, adaptive mirror
- Circular, adaptive mirror as the first part of a 90° beam bending unit

Adjusting tools:

For optimal operation of the ADOPTIC adaptive mirrors is important to assure that the laser beam axis corresponds with the center of the mirror. Additionally the specified operation angels of the ADOPTIC surface to the laser beam axis need precisely to be adjusted. For this purpose LT ULTRA offers optionally adequate opto-mechanical adjusting tools.

WORKING PRINCIPLE AND APPLICATIONS

Life time:

The only movable parts of the adaptive mirrors are limited to the mirror diaphragm. In case of a moderate, but for industrial applications typical load the life time is at least 500.000 cycles or one year. Currently LT ULTRA offers for production facilities an exchange re-work service which can be repeated several times. All re-worked units are calibrated and tested.

Documentation:

In case of the order of a complete system, all components of the package are tested together in the ordered configuration before delivery. This includes also the operation test of the control valve and the leak test of all fittings. The operation test consists of more than 1000 cycles per system.

The in house final test of the mirror surface includes three measurements at different control pressure levels and at both ends of the specified operation pressure range as 3D- interferometer measurements (ZYGO). The test documents are stored at LT ULTRA and copies are available upon request.

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The main application of the adaptive optics consists of controlling the propagation of CO_2-laser beams during material processing. This concerns in most cases the 2D-laser cutting processes (flat-bed machines) and some special 3D-applications.

In case of laser machines with changing beam path lengths (i.e. flying optics arrangements) the laser beam diameter and the phase front radius are changing continuously along the beam path. Consequently the beam spot diameter in focus will become smaller with larger raw beam diameters and vice versa. Phase front changes lead to corresponding changes of the effective focal length of the system so that the optimal working distance will change. By inserting a beam expander (telescope) into the beam path close to the laser output a general improvement of the beam quality and stability for the entire working area can be reached. The telescope expands the incoming laser beam and focuses it theoretically at infinite. Usually, out of practical reasons, the telescope generates a beam waist in the middle of the working beam path length. In case of an adequate telescope and a good adjustment, the beam diameter at both ends of the working beam path will be the same. The beam waist diameter is smaller than the raw beam diameter at both ends of the beam path. So the raw beam diameter still changes along the beam path, but within more acceptable limits. This and all other changes of the beam properties will continue to influence the processing results.

The adaptive optics can compensate both above mentioned uncontrolled sources of processing problems, thus it represents an optimal technical solution. For controlling both influence factors two adaptive mirrors are necessary. The first adaptive mirror is usually inserted next to the laser output into the beam path and is controlled in such a way that the raw beam diameter onto the focusing optics remain constant the entire working beam path. This generates a constant working spot diameter within the entire working area. This first adaptive mirror is an attractive alternative to the widely used motorized lens also because of its capability to handle higher power levels then the lens. Without any further compensation the focal length still changes with the phase front radius variations. A second adaptive mirror inserted preferably just in front of the focusing optics into the beam path can be controlled in such a way that all systematic or accidental phase front radius changes are entirely compensated, thus the focal length remains constant within the entire working area.

Only the active compensation of both sources of changes assures a really constant processing quality within the entire working area. In addition the adaptive optics allow the voluntary change of the focal position and diameter in order to compensate process and workpiece dependent parameters (i.e. the reduction of the spot size in order to increase the cutting speed in case of thin sheets). Once optimized the working parameters of a certain process, they can be memorized in the PLC and recalled any time later for continuously constant processing results.