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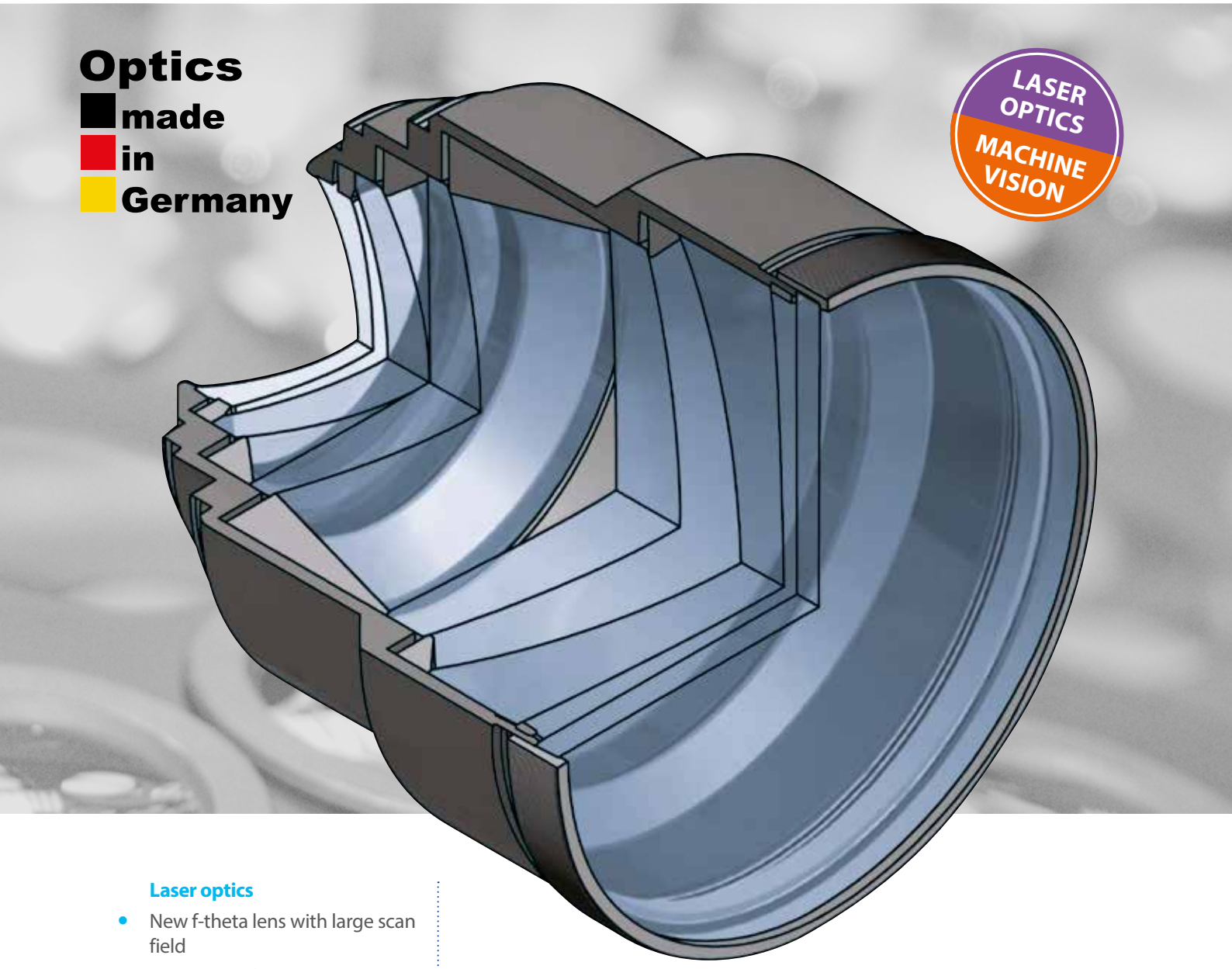
SILL OPTICS

SILL OPTICS NEWS



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Telecentric lenses with focus tunable lens and coaxial illumination

The main developments of the previous year fuse to one: The combination of our focus tunable telecentric lenses with our advanced coaxial light coupling telecentric lenses. This is obvious, since a telecentric bright field front lighting has significant advantages for object detection with focus tunable liquid lens.

For a measurement system with backlight illumination, a telecentric lens with tunable working distance has no benefit as the whole object depth has to be imaged with a certain resolution at one single shot. A bright or dark field illumination in a defined angle of incidence (e.g. ring light) is limited, since the best homogeneity will be realized only for one working distance and not for all focusing planes. The appropriate solution would be a special illumination setup for different focal positions or a coaxial bright field illumination. Since more than 10 years, Sill Optics offers telecentric lenses with coaxial collimated illumination successfully. Their main applications are high precision measurement tasks of surfaces. Last year, we presented a modular system for lenses with field of view larger than Ø60mm, whereby the beam splitter can be changed by the customer himself and a retardation plate can be inserted into the lens easily. For magnifying lenses, the retardation plate is available as an add-on at the front lens. Thus, the customer has the possibility to fit the lens to different illumination conditions.

For many of our telecentric lenses with focus tunable liquid lens, a coaxial coupling through the lens is combinable. Thus, you can prevent shading at the detection plane and a very good edge detection is possible because of the collimated illumination beam path. The illumination beam path is not affected while tuning the liquid lens.

part number	magnification	working distance [mm]	Ø clear aperture [mm]	max. sensor size [mm]	wave-length [nm]	NA	max. distortion [%]	length [mm]	mount	LED [mA]	LED [V]
S5VPL6060/LED	0.29	137.5-205.9	86.0	17.6 (1.1")	623 (+/- 11)	0.0015	0.47	294.2	C-mount	350	2.5
S5VPL2660/LED	0.374	113.4-172.9	48.0	11.0 (2.3")	623 (+/- 11)	0.0015	0.63	213.8	C-mount	350	2.5
S5VPL2898/LED	0.579	81.7-98.2	61.0	16.0 (1")	623 (+/- 11)	0.03	0.47	172.6	C-mount	350	2.5
S5VPL0625/LED	1.0	179.1-196.5	29.0	16.0 (1")	623 (+/- 11)	0.03	0.73	142.3	C-mount	350	2.5
S5VPL0422/LED	2.0	100.5-109.7	26.0	28.6	623 (+/- 11)	0.04	0.35	155.8	M42x1	350	2.5

Camera-based observation in laser material processing

Observing laser manufacturing while processing enables a quick analyzation and thus an immediate reaction. One possibility is the camera-based process observation, whereby several methods are practicable for different systems:

In coaxial observation setups, light from the processed object passes the scan lens, the scan system and a beam splitter to be imaged with a telephoto lens on a sensor. Thus, a small field of view is moved simultaneously with the laser beam. Thereby, the resolution is limited by the aperture of the scanner. Aberrations that are caused by the scanning system and by the wavelength difference between laser and observation wavelength, can only be decreased, but not eliminated, by using multispectral f-theta lenses and a time-consuming calibration.

Another possibility for observing a laser process is the installation of a lens with oblique orientation to the processing field. Caused by the oblique view, a difference in optical path occurs that depends on the tilt angle, working distance and field of view. The resulting blur at the field edges can be solved by using a lens that considers the Scheimpflug principle. It describes that the blur on an image caused by a tilted object plane can be compensated by tilting the sensor plane by a defined angle too. To realize this, Sill Optics offers a custom specific adaptor that is sensor-sided integrated into the lens. Distortion that is caused by the tilted view can be improved significantly by telecentric or bi-telecentric lenses.

For transparent workpieces there is also the opportunity of observing the working process through the material from below. Beside the observation wavelength the laser wavelength passes the imaging too. Because of that, the lens design has to fulfil additional criteria e.g. prevention of absorption peaks and design for the laser energy.

We are pleased to support you regarding the appropriate method for process observation of your system.

The first telecentric SWIR lens

Affordable InGaAs sensors with a spectral sensitivity between 900 and 1700 nm and increasing resolution establish growing application fields (e.g. food and pharmaceutical industries) and became an additional leading force in machine vision industries.

As a specialist in telecentric optics for machine vision Sill Optics offers the first bi-telecentric lens for SWIR waveband. According to market demands, the lens is suitable for hyperspectral imaging with a wide wavelength range as well as for application with bandpass filter.

The bi-telecentric lens (part. nr. S5LPJ6835) has a magnification of 0.33 for a maxi-mum field of view of Ø48mm. The lens design is optimized for NA 0.03, that equals a F# of 5.5. With reservations regarding vignetting and maximum resolution, imaging with F# 2.0 is possible for applications with high demand in light intensity. The remaining object-sided telecentric error is less than 0.5°, the distortion is less than 0.5%.

Equivalently, we offer an entocentric SWIR lens with a focal length of 50mm (part no. S5LPJ6805). This lens has been developed for a maximum sensor size of 17.6mm (1.1'' sensor) and a minimum F# of 1.8. It is available with C-Mount or M42 thread. The working distance can be adjusted between 400mm and infinity. Stop size and focus are mechanically adjustable and can be fixed by a locking screw. The distortion varies between <0.5% (infinite working distance) and <1.5% (working distance 400mm).

The sensor-sided telecentricity of both lenses enables the combination with spectrometers or with prism based multi-sensor cameras.

A telecentric lens with magnification 0.5 and an entocentric lens with focal length 75mm will be available soon. Both lenses are sensor-sided telecentric and specified for a sensor diagonal of 24mm.

part number	focal length [mm]	max. F/#	max. field angle [°]	max. image diagonal [mm]	wave-length [nm]	min. working distance [mm]	max. distortion [%]	length [mm]	mount
S5LPJ6805/216	50.0	1.8	9.1	17.6 (1.1")	900-1700	400.0	1.2	71.8	C-mount
S5LPJ6805/M42	50.0	1.8	9.1	17.6 (1.1")	900-1700	400.0	1.2	71.8	M42x1

part number	magnification	NA	Ø clear aperture [mm]	max. sensor size [mm]	wave-length [nm]	working distance [mm]	max. distortion [%]	length [mm]	mount
S5LPJ6835	0.333	0.03	62.0	16.0 (1")	900-1700	147.0	0.26	195.5	C-mount

Beam expanders

Beam expanders are optical systems used to increase or decrease the beam diameter. The product of beam diameter and divergence of the laser beam is a constant and therefore remains unchanged, i.e. increasing the beam diameter means reducing the divergence of the beam to the same degree. This is true for the expanders with fixed expansion factor as well as for the zoom expanders, where the magnification is variable. Each type of our beam expanders offers a manual or motorized divergence adjustability.

All optical elements of beam expanders consist of fused silica and provide stable and reliable performance even with high average power or laser with high peak power. Because of the high power density (especially at the entrance lens element) we advise our low absorption coating always be used.

Further information can be found in our laser product catalog.

Telecentric fused silica scan lenses for short pulse laser

Beam focusing has an important role to play in many spheres of technical optics.

A single lens with a suitable focal length is the simplest solution. For even machining surfaces, a single lens is not sufficient, because the curved image plane requires repositioning of the focus. To circumvent complex movements, so called f-theta lenses are designed to compensate this position shift and provide an even image area.

Additionally they feature a consistent spot size over the whole scanning plane. Telecentricity is an option which provides a perpendicular incidence on the working plane. Furthermore, it is desirable to enable large scan areas, as they allow treatment of larger work pieces without moving the optical unit or target.

Since several years, Sill offers series S4LFT4010 with 100 mm focal length. This group of f-theta lenses for different wavelength regions from UV to IR offer comparably small spot sizes for increased fluence. The S4LFT4125/075 is an enhanced version for lasers with ultraviolet radiation and consists of fused silica equally. The scan area has been improved from 35 mm x 35 mm to 50 mm x 50 mm. Despite the higher focal length, a focal diameter of 8 µm ($1/e^2$) can be reached inside the whole scan area with a 10 mm input beam diameter. S4LFT4126/292 (515 nm – 545 nm) and S4LFT4127/328 (1030 nm – 1090 nm) are two further options for scan lenses with a focal length of 125mm but designed for different wavelength regions.

Furthermore Sill introduced a series with 65 mm focal length for UV (S4LFT4067/075), green (S4LFT4066/292) and IR (S4LFT4065/328) providing field sizes of 15 mm x 15 mm to reach spot sizes in the range of 3 µm (UV) to 10 µm (IR).

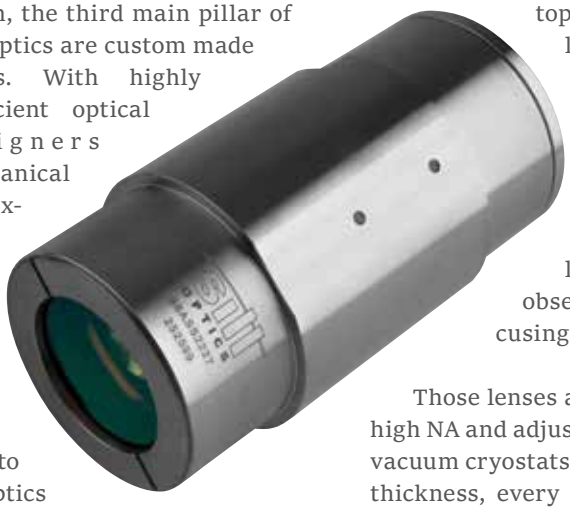
All series incorporate fused silica lenses and our industry proven low absorption coating. Of course, there are not internal ghosts in lens elements or on scan mirrors and therefore compatible with short pulse lasers. The new lens series are diffraction limited for the specified input beam diameter. Furthermore there are no internal and external ghosts and therefore no back reflections nearby the scanner.

part number	focal length [mm]	wavelength range [nm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	working distance [mm]	max. outside-Ø [mm]	length [mm]	mounting thread
S4LFT4065/328	65.1	1030 -1090	15 x 15	10.0	24.0	83.1	94.0	76.5	M85x1
S4LFT4066/292	67.2	515 - 545	15 x 15	10.0	24.0	85.8	94.0	73.3	M85x1
S4LFT4067/075	65.5	355	15 x 15	10.0	24.0	81.7	94.0	79.0	M85x1

Example for custom made optics: observation of trapped ions

Optics made in Germany

Beside laser optics and lenses or illuminations for machine vision, the third main pillar of Sill Optics are custom made optics. With highly proficient optical designers and also developers of mechanical housings, our outstanding experience stands for itself. As mechanical workshop and the precision optical production are located in one place in Germany, we are able to provide customers or research institutes with prototypes or small to medium sized batches of optics specifically designed for the application.



A very recent example can be found in the field of trapped ions. Those cold ions are a research topic with increasing interest over the last years because of their possibility to store Qubits and the related use for quantum computers. Of course, it is not only important to use them, but to know their behaviour in detail via various basic experiments. Sill Optics has designed lenses both, for just observation or observation combined with laser focusing for such experiments.

Those lenses are furthermore exceptional for their high NA and adjustment to specific wavelengths. As the vacuum cryostats differ in dimension, e. g. the window thickness, every lens has to be designed specifically for the existing conditions.

New fused silica f-theta lens with large scan field

A hundred years ago the idea of cutting material without touching it seemed to be science fiction. However, Albert Einstein lay the foundation for laser material processing when he described the stimulated emission for the first time in 1916 – 1917. Fifty years later scientists presented the first laser which became a tool soon.

Today laser material processing is an established and often used technique for cutting, drilling and welding materials. The typical setup consists of four different elements – the laser itself, the scanner, focusing lens and beam expander and the working surface where the final cutting process takes place.

The development of lasers has not stopped until today, which results in more powerful devices. That requires a high qualitative beam expander and f-theta lens. The scanner enables a two dimensional beam displacement and with that a fast and precise machining. Therefore no movement of the heavy laser part or of the working plane is necessary. The higher the beam displacement the larger is the scan field and with that the maximum size of the building element. The scan field depends on the f-theta lens and is typically limited by the size of the last lens.

Sill Optics offers fused silica lenses with high scan fields. The S4LFT3250/328 which has a scan field of 160 x 160 mm^2 is one of our new products. A maximum input beam diameter of 15 mm is compatible to the lens, as well as a maximum beam diameter of 20 mm. The 20 mm diameter and the suitable scanner system reduce the scan field to 115 x 115 mm^2. Because of the ghost free design it even works in combination with ultrashort pulsed IR lasers. There are also lenses for other wavelengths in the Sill Optics catalogue with similar scan fields. Custom designs are the specialty of Sill Optics because of their high flexibility and high vertical range of manufacture.

part number	focal length [mm]	wavelength range [nm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	working distance [mm]	max. outside-Ø [mm]	length [mm]	mounting thread
S4LFT3250/328	256.0	1030 -1090	160 x 160	15.0	32.5	321.3	159.0	91.3	M85x1
S4LFT3250/328	256.0	1030 -1090	115 x 115	20.0	32,5	321.3	159.0	91.3	M85x1

Expansion of the mini series in fused silica

Size is a matter of definition. Depending on the industrial sector, some millimeters can be a tolerance or determine the function. But laser material processing is established in very different technical sectors. Large steal constructions as well as components from the micro technology can be fabricated by lasers. Therefore there are scanner systems with different sizes for input beam diameters from 7 mm up to 30 mm.

The mini series consists of a couple of f-theta lenses which are compatible with very small scanner systems. Because of their small design the products are a cost efficient alternative to commercial f-theta lenses. Our catalogue includes a selection of lenses with different focal lengths and scan fields. The f-theta lenses from the current catalogue consist of optical glass and are suitable for lasers with wavelengths of 1064 nm and 532 nm.

Currently the S4LFT0763/328 expands the series. In spite of the compact design the non telecentric lens enables a scan field of 100 x 100 mm^2 at focal length of 163 mm. Two other lenses with focal lengths of 100 mm and 254 mm are already developed and will widen the product portfolio soon.

The new lenses consist of fused silica, are ghost free and have a low absorbing coating. Therefore the new lenses are ideal for the use of short pulsed lasers or long time processes, where thermal stability is very important (e.g. laser cleaning).

part number	focal length [mm]	wavelength range [nm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	working distance [mm]	max. outside-Ø [mm]	length [mm]	mounting thread
S4LFT0710/328	101.4	1030 -1090	60 x 60	5.0	15.0	120.7	59.2	31.0	M39x1
S4LFT0763/328	163.0	1030 -1090	100 x 100	7.0	15.8	194.1	59.2	31.3	M39x1
S4LFT0725/328	254.3	1030 -1090	140 x 140	8.0	15.5	282.8	59.2	33.3	M39x1

Color corrected f-theta lens for ultrashort pulse lasers

We present the first of its kind fully color corrected f-theta scan lens for ultra-short pulse lasers from Sill Optics GmbH & Co. KG. Lasers with pulses shorter than 1 picosecond create a noticeable spectral bandwidth which will degrade the spot performance via chromatic errors. For example, an 800 femtosecond Gaussian shaped pulse has a spectral width of about 2 nm and a 250 femtosecond pulse has a width of almost 7 nm (1064 nm, FWHM). This will aberrate the spot in an f-theta lens which is designed to focus only one wavelength.

The S4LFT7010/008 covers from 1500 – 160 nm, the S4LFT7010/450 from 1000 – 1100 nm and the S4LFT7012/292 from 510 – 590 nm. All three lenses are designed to have no internal ghosts or back reflections which can damage lens elements within the lens.

Our product range also includes an ultrashort pulse compatible beam expander with fixed magnification factor of three and designed for 1000 – 1100 nm range. The S6ASS4803/450 has a 10 mm ($1/e^2$) maximum input beam diameter and M30 x 1 mounting.

Two new scan lenses from Sill Optics use multiple glass types in its design so all the wavelengths within a pulse are in focus at the work surface. The lenses have focal lengths of 100 mm, are telecentric, have scan areas of 35 mm x 35 mm and will accept a maximum 10 mm $1/e^2$ input beam.

f-theta lenses

part number	focal length [mm]	wavelength range [nm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	working distance [mm]	max. outside-Ø [mm]	length [mm]	mounting thread
S4LFT7010/008	100.0	1500 – 1600	35 x 35	10.0	32.0	115.0	94.0	98.8	M85x1
S4LFT7010/450	100.2	1000 – 1100	35 x 35	10.0	32.0	113.2	94.0	98.8	M85x1
S4LFT7012/292	100.0	510 – 590	35 x 35	10.0	36.1	101.9	94.0	98.8	M85x1

beam expander

part number	magnification	wavelength range [mm]	max. entrance aperture [mm]	max. exit aperture [mm]	max. outside-Ø [mm]	length [mm]
S6ASS4803/450	3.0	1000 – 1100	10.0	31.0	46.0	85.0

OEM optics

Sill Optics has its own optical development department working with latest optical design software “Zemax” and mechanical construction software “Solid Works”. This enables the design of optical and mechanical components optimized for the application of our customers.

We are pleased to answer your questions.

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