Sill OPTICS

NEWS

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CURRENT RESEARCH ACTIVITIES

PROJECT TOMOSphere (No. 13N12069)
Tomographic monitoring of 3D cell cultures from pluripotent stem cells.

PROJECT ADALAM (No. 637045)
Sensor based adaptive laser micromachining using ultrashort pulse lasers for zero-failure manufacturing.

PROJECT MAShES (No. 637081)
Multimodal spectral control of laser processing with cognitive abilities.

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Telecentric f-theta lens with short focal length

About 5 years ago, Sill Optics introduced the fused silica f-theta lens series S4LFT4010. The scan lenses have focal lengths of 100 mm, support beam diameters of 10 mm and achieve 35 mm x 35 mm fields. There are versions for 355 nm, 515 nm – 545 nm, 808 nm – 980 nm and 1030 nm – 1090 nm available.

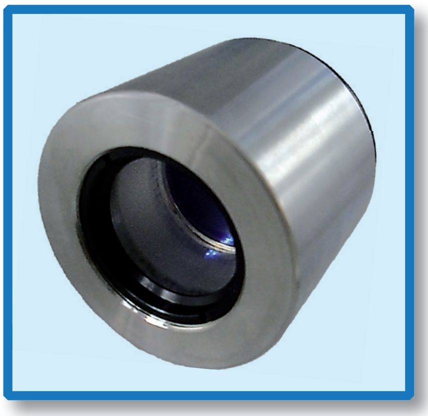
Ghosts are focused back reflections from lens surfaces and have high potential to destroy coatings and bulk material. Even though the lens elements are coated with anti-reflective coatings, which transitions the light from the index of refraction of the air to the refractive index of the bulk material of the lens, less than 0.2% reflection still remains from each surface, even using the special Sill Optics low absorption coating. In a pulsed pico or femtosecond laser the peak power of a focused ghost spot can exceed the damage threshold of the coating or the bulk material. So it is critical to avoid any internal ghosts within the lens or focused spots on the galvo mirrors.

The S4LFT4010/328, designed for 1064 nm provides spot sizes of around 20 µm. The new scan lens S4LFT4065/328 with a focal length of 65 mm is capable to accept a 10 mm beam, generating a diffraction limited spot of around 10 µm on a 15 mm x 15 mm field. The S4LFT4065/328 incorporates fused silica lenses and our industry proven low absorption coating. Of course, there are not internal ghosts in lens elements or on scan mirrors.

	part number	focal length [mm]	scan angle ± [°]	scan length [mm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	length [mm]	max. outside-Ø [mm]	mounting thread	working distance [mm]	protective window
	S4LFT4010/328	100.3	14.4	49.5	35 x 35	10.0	32.0	78.7	106.0	M85x1	129.8	S4LPG2250
NEW	S4LFT4065/328	65.1	9.4	21.2	15 x 15	15.0	24.0	76.5	94.0	M85x1	83.1	S4LPG0394

Compensation of the thermal shift by passive components

Thermal shift occurs when some of the energy from a high power laser is absorbed by the bulk material of the f-theta lens elements. The energy heats the glass at the point where the beam passes through the lens changing the index of refraction, which defocuses the lens. The amount of defocus varies depending on power level, the number of lens elements in the lens and the thickness of the irradiated glass.



Sill Optics conducted a research project (TFOS, no. KF-3015201DF2) to design a compensating optical system to reduce the thermal shift in high power systems. Sill Optics has designed a compensating optics, which is based on a material, which provides a negative temperature coefficient in the material refractive index. This optical element is placed in front of the focusing optics or in the collimated input beam ahead of the galvanometer. In case of using an f-theta lens, the amount of thermal focus shift also depends on the scan pattern and the scan speed.

If a standard compensating lens is used, the thermal shift can be reduced by a factor of 2-3. However, if the compensating lens is matched to the f-theta lens, the reduction in thermal shift can be increased up to 10 times.

Sill Optics offers the following elements which are available in two different thicknesses depending on which scan lens is used. The element is built up as a plano parallel lens and fits into any collimated beam. The device is available for 1030 nm - 1090 nm lasers.

part number	thickness [mm]	for example for lens number	reduction of thermal shift by
S4SET9301/050	50.0	S4LFT1420/328	> 50%
S4SET9301/075	75.0	S4LFT3162/328	> 50%

Microstructuring on larger fields with scan lenses

Laser processing of large surface areas with a small diameter laser spot using a galvanometer based system requires either moving the object and stitching together small size scan fields or moving the scan head over the work surface. This approach dramatically increases cost and complexity of the system.

Sill Optics has designed two new large field f-theta lenses, which provide a large scan field and small spot diameter by utilizing large diameter input laser input beams.

The S4LFT3480/126 (1064 nm, glass lens, focal length 480 mm) provides a scan field of 320 mm x 320 mm and provides an average spot diameter over this field of 34 µm using a 30 mm 1/e² diameter input beam.

The S4LFT3430/121 (532 nm, glass lens, focal length 430 mm) provides a scan field of 310 mm x 310 mm and provides an average spot diameter over this scan field of 22 µm using a 20 mm 1/e² input beam.

part number	focal length [mm]	scan angle ± [°]	scan length [mm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	length [mm]	max. outside-Ø [mm]	mounting thread	working distance [mm]	protective window
S4LFT3480/126	479.8	26.3	226.3	320 x 320	30.0	63.7	183.2	260.0	M150x1	443.7	S4LPG0220/081
S4LFT3430/121	430.0	28.4	438.4	310 x 310	20.0	53.3	149.0	240.0	M130x1	409.1	S4LPG1118/121

Diode laser lenses now available in fused silica with low absorption coating from 900 nm to 1070 nm

Diode laser power increases and makes higher demands on the optics. Additionally, the typical wavelength of the diode lasers of 808 nm – 980 nm shifted to longer wavelengths based on higher achievable efficiency. Sill Optics reacts and enlarges the f-Theta series for diode lasers by launching pure fused silica lenses as already used for USP and high power applications in solid-state lasers at various wavelengths with success.

These high-power lenses are equipped with the new coating /449. It offers a transmission of at least 99.75 % over the entire wavelength range from 900 nm to 1.070 nm and shows the identical low absorption values like the coating for 1.030 nm – 1.090 nm. Fused silica lenses are optimized for one wavelength and show dispersion effects. For same scan angle, spot location is shifted with different wavelengths, for example. Due to high fiber diameter and large spot sizes on the scan area the overlap of foci is still sufficient. Because of that, fused silica lenses can be combined with high power laser diodes without difficulty.

Regarding large input beam diameter and high laser power, Sill Optics offers high-end fused silica aspheres as collimating elements and focusing elements at non-scanning applications. Aspheres with focal length of 20 mm to 200 mm are available with the new wideband low absorption coating /449.

part number	focal length [mm]	scan angle ± [°]	scan length [mm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	length [mm]	max. outside-Ø [mm]	mounting thread	working distance [mm]	protective window
S4LFT0082/449	81.7	10.0	28.3	20 x 20	15.0	33.0	103.1	93.8	M85x1	84.1	S4LPG0082/449
S4LFT3162/449	163.0	23.0	127.3	90 x 90	15.0	27.7	102.0	130.0	M85x1	200.9	S4LPG4160/449
S4LFT2175/449	162.8	28.3	152.2	94 x 94	20.0	30.5	110.2	159.0	M85x1	204.7	S4LPG2175/449
S4LFT3260/449	276.1	21.0	200.8	142 x 142	15.0	31.0	61.0	105.0	M85x1	345.0	S4LPG2250/449
S4LFT1330/449	338.5	24.3	304.1	215 x 215	20.0	38.5	174.6	163.0	M85x1	202.0	S4LPG2175/449
S4LFT0435/449	401.7	20.1	282.8	200 x 200	20.0	34.0	63.0	206.0	M85x1	471.4	S4LPG2250/449
S4LFT1420/449	418.5	27.1	396.0	280 x 280	14.0	28.3	67.7	122.0	M85x1	497.5	S4LPG4160/449
S4LFT1500/449	498.4	26.8	480.8	340 x 340	20.0	30.5	68.0	148.0	M85x1	568.7	S4LPG2175/449

UV beam expanders now available with new low absorption coating for 343 nm to 355 nm

Sill Optics has been offering low absorption coatings from 515 nm - 545 nm and 1030 nm - 1090 nm for several years. Sill Optics now offers these same high performance coatings for the UV range of 343 nm - 355 nm. Low absorption coatings are approximately a 10x improvement over the previous coating. The low absorption coating allows for higher power lasers, reduces thermal shift from reduced energy absorption at the coating and increases the life and durability of the expander.

All of the following standard beam expanders offered by Sill Optics will now incorporate this new low absorption coating.

part number	magnification	max. entrance aperture [mm]	max. exit aperture [mm]	max. outside-Ø [mm]	length [mm]
S6EXPxxxx/574	1.5x..20x	8.0	30.0	46.0	85.0
S6EXKxxxx/574	0.8x.. 4x	12.0	26.0	46.0	44.7
S6EXZ5075/574	1-8x Zoom	10.0	30.0	58.0	162.0
S6EXZ5310/574	1-3x Zoom	10.0	20.0	47.0	85.2
S6EXZ5311/574	1-3x Zoom	10.0	20.0	47.0	85.2

Lenses for femtosecond lasers

The pace in the development of short pulse and ultrashort pulse lasers has been amazingly rapid. Laser systems utilizing picosecond lasers are efficient tools in many industrial and scientific applications. Besides “cold ablation”, another key feature of short pulse lasers are nonlinear effects like multi photon absorption and self-focusing in transparent materials. In glass cutting applications, these effects are utilized for modifying the index of refraction and to distribute the laser energy along the beam axis, i. e. maintaining a near-constant beam radius over many Rayleigh lengths, thus providing a very large depth of field.

These effects are well suited in contour cutting (filament cutting) of uncured, chemically hardened glass (cover glasses of smart phones) and sapphire, resulting is very high quality edges and very little material removal. The glass is cut by plasma dissociation leading to cutting kerfs smaller than 1 µm. This results in a kerf which is much smaller than the diffraction limited laser spot focus diameter. Sill Optics now offers a range of specially designed lens for these short pulse lasers.

For pulse lengths shorter than 1 ps, the laser creates a noticeable spectral bandwidth, which can have an impact on the spot performance. Thus, an 800 fs Gaussian shaped pulse has a spectral width of approx. 2 nm and a 250 fs pulse a width of almost 7 nm. Usually, laser lenses are corrected for monochromatic light. The spectral bandwidth of short pulse lasers results in so-called color errors both in and transverse to the propagation direction. The resulting spot will be distorted and blurred, as the laser pulse intensity is spread onto a larger area inhibiting multi photon processes.

Sill Optics has introduced a telecentric f-Theta lens with a focal length of 100 mm and a maximum field size of 35 mm x 35 mm. The unique feature of this lens is the color correction from 1.0 µm to 1.1 µm, i.e. for a 100 nm wide spectrum. For a 10 mm beam the lens is diffraction limited. This f-Theta lens is available for purchase under part number S4LFT7010/450. A version for 1.500 nm – 1.600 nm will follow soon.

part number	focal length [mm]	wave length [nm]	scan angle ± [°]	scan length [mm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture-stop [mm]	length [mm]	max. outside-Ø [mm]	mounting thread	working distance [mm]	protective window
S4LFT7010/450	100.2	1000 - 1100	14.4	49.5	35 x 35	10.0	32.0	98.8	94.0	M85x1	115.0	S4LPG0005/450
S4LFT7010/008	100.0	1500 - 1600	14.4	49.5	35 x 35	10.0	32.0	98.8	94.0	M85x1	113.6	S4LPG0005/008