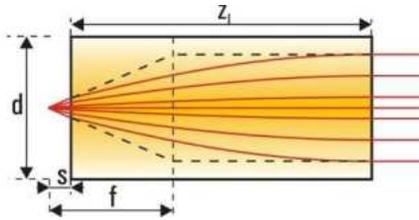


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GRIN Rod Lenses – Numerical Aperture 0.5



Gradient index lenses for fiber coupling and beam shaping of laser diodes

Diameter (mm)	Pitch P	Working distance s (mm)	Lens length z _l (mm)	Focal length f (mm)	Gradient constant g (mm ⁻¹)	Refractive index at the center of the profile n ₀	Wavelength λ (nm)	Product code
0.50	0.25	0	1.10	0.43	1.427	1.629	670	GT-LFRL-050-025-50-NC (670)
	0.25	0	1.11	0.44	1.418	1.624	810	GT-LFRL-050-025-50-NC (810)
	0.25	0	1.12	0.44	1.406	1.616	1550	GT-LFRL-050-025-50-NC (1550)
	0.23	0.06	1.00	0.44	1.427 - 1.406*	1.629 - 1.616*	670-1550	GT-LFRL-050-023-50-NC
1.00	0.25	0	2.26	0.89	0.695	1.629	670	GT-LFRL-100-025-50-NC (670)
	0.25	0	2.27	0.89	0.691	1.624	810	GT-LFRL-100-025-50-NC (810)
	0.25	0	2.29	0.91	0.685	1.616	1550	GT-LFRL-100-025-50-NC (1550)
	0.23	0.12 - 0.11*	2.07	0.90	0.695 - 0.685*	1.629 - 1.616*	670 - 1550	GT-LFRL-100-023-50-NC
1.80	0.25	0	4.34	1.70	0.362	1.629	670	GT-LFRL-180-025-50-NC (670)*
	0.25	0	4.36	1.72	0.360	1.624	810	GT-LFRL-180-025-50-NC (810)
	0.25	0	4.40	1.74	0.357	1.616	1550	GT-LFRL-180-025-50-NC (1550)
	0.23	0.25 - 0.21*	3.98	1.74	0.362 - 0.357*	1.629 - 1.616*	670 - 1550	GT-LFRL-180-023-50-NC
2.00	0.25	0	4.92	1.93	0.319	1.629	670	GT-LFRL-200-025-50-NC (670)*
	0.25	0	4.95	1.94	0.317	1.624	810	GT-LFRL-200-025-50-NC (810)
	0.25	0	4.99	1.97	0.314	1.616	1550	GT-LFRL-200-025-50-NC (1550)
	0.23	0.27 - 0.23*	4.53	1.96	0.319 - 0.314*	1.629 - 1.616*	670 - 1550	GT-LFRL-200-023-50-NC

*: depending on wavelength

- Working distance, design wavelength and lens length deviating from these standards are available on request
- 8° angled facet / other diameters (0.25 mm, 0.35 mm, 0.60 mm and 0.85 mm) are available on request
- ZEMAX files can be [DOWNLOADED](#) from our website
- For tolerances, handling and storage see page 26

GRIN rod lenses are offered without antireflection coatings as standard.

Antireflection coatings (for incidence angles of 0 ... 30° corresponding to measurements on a reference substrate) can be offered:

Coating Code: NC: no coating (reflection loss approx. 12 %) - standard
 C1: λ = 400 ... 700 nm, R < 1.0 %
 C2: λ = 800 ... 1000 nm, R < 0.5 %
 C5: λ = 1310 ... 1550 nm, R < 0.5 %

One - sided coatings are available on request.

Order example:

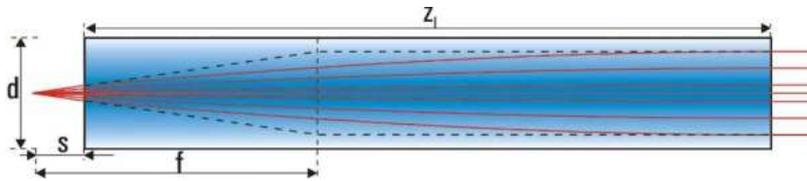
GT - LFRL - 100 - 025 - 50 - NC - (670)	
GT	GRINTECH
LFRL	Focusing Rod Lens
100	Diameter: 0.5, 1.0, 1.8 or 2.0 mm
025	Pitch: 0.25 or 0.23
50	NA: 0.50
NC	Coating Code: NC, C1, C2 or C5
(670)	Design Wavelength

Variations due to modifications of the production process are possible. It is the user 's responsibility to determine suitability for the user 's purpose.

*** not available for following applications :**

Please note our partnership with Inscopix as our exclusive distributor for the field of non-confocal, single photon epi-fluorescence imaging for neuroscience applications in non-humans (see page 8).

GRIN Rod Lenses – Numerical Aperture 0.2



Gradient index lenses for fiber coupling and beam shaping of laser diodes

Diameter (mm)	Pitch P	Working distance s (mm)	Numerical Aperture NA	Lens length z_l (mm)	Focal length f (mm)	Gradient constant g (mm ⁻¹)	Refractive index at the center of the profile n_0	Wavelength λ (nm)	Product code
0.50	0.25	0	0.20	3.05	1.28	0.515	1.524	670	GT-LFRL-050-025-20-NC (670)
	0.25	0	0.20	3.06	1.28	0.513	1.521	810	GT-LFRL-050-025-20-NC (810)
	0.25	0	0.19	3.16	1.32	0.497	1.515	1550	GT-LFRL-050-025-20-NC (1550)
	0.24	0.09 - 0.07*	0.19	3.06	1.33	0.515 - 0.497*	1.524 - 1.515*	670 - 1550	GT-LFRL-050-024-20-NC
1.00	0.25	0	0.20	6.12	2.56	0.260	1.524	670	GT-LFRL-100-025-20-NC (670)
	0.25	0	0.20	6.13	2.57	0.259	1.521	810	GT-LFRL-100-025-20-NC (810)
	0.25	0	0.19	6.32	2.65	0.248	1.515	1550	GT-LFRL-100-025-20-NC (1550)
	0.24	0.18 - 0.16*	0.19	6,08	2.68	0.260 - 0.248*	1.524 - 1.515*	670 - 1550	GT-LFRL-100-024-20-NC
1.80	0.25	0	0.20	11.15	4.66	0.141	1.524	670	GT-LFRL-180-025-20-NC (670)
	0.25	0	0.20	11.17	4.68	0.140	1.521	810	GT-LFRL-180-025-20-NC (810)
	0.25	0	0.19	11.38	4.78	0.138	1.515	1550	GT-LFRL-180-025-20-NC (1550)
	0.24	0.31 - 0.26*	0.19	10.99	4.79	0.141 - 0.138*	1.524 - 1.515*	670 - 1550	GT-LFRL-180-024-20-NC

*: depending on wavelength

- Working distance, design wavelength and lens length deviating from these standards are available on request
- other diameters (0.25 mm and 0.35 mm) are available on request
- ZEMAX files can be [DOWNLOADED](#) from our website
- For tolerances, handling and storage see page 26

GRIN rod lenses are offered without antireflection coatings as standard. Antireflection coatings (for incidence angles of 0 ... 10° corresponding to measurements on a reference substrate) can be offered:

Coating Code: NC: no coating (reflection loss approx. 12 %) - standard
 C1: $\lambda = 400 \dots 700$ nm, R < 1.0 %
 C2: $\lambda = 800 \dots 1000$ nm, R < 0.5 %
 C5: $\lambda = 1310 \dots 1550$ nm, R < 0.5 %

One - sided coatings are available on request.

Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

Order example:

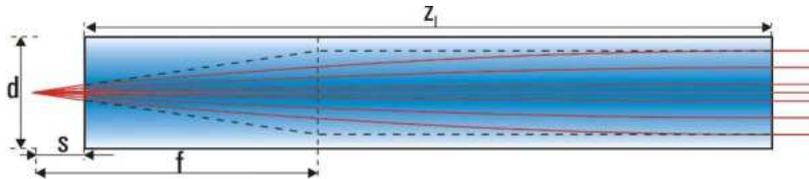
GT - LFRL - 100 - 025 - 20 - NC - (670)
GT GRINTECH
LFRL Focusing Rod Lens
100 Diameter: 0.5, 1.0, 1.8 mm
025 Pitch: 0.25 or 0.24
20 NA: 0.20
NC Coating Code: NC, C1, C2 or C5
(670) Design Wavelength

*** not available for following applications :**

Please note our partnership with Inscopix as our exclusive distributor for the field of non-confocal, single photon epi-fluorescence imaging for neuroscience applications in non-humans (see page 8).

GRIN Rod Lenses – Numerical Aperture 0.2 – for high-performance collimation

with optimized gradient index profile for compensation of higher-order spherical aberrations and better beam quality



Gradient index lenses for fiber coupling and beam shaping of laser diodes

Diameter (mm)	Pitch P	Working distance s (mm)	Numerical Aperture NA	Lens length z _l (mm)	Focal length f (mm)	Gradient constant g (mm ⁻¹)	Refractive index at the center of the profile n ₀	Wavelength λ (nm)	Product code
1.00	0.25	0	0.20	6.04	2.52	0.260	1.524	670	GT-CFRL-100-025-20-NC (670)
	0.25	0	0.20	6.05	2.53	0.259	1.521	810	GT-CFRL-100-025-20-NC (810)
	0.25	0	0.19	6.32	2.65	0.248	1.515	1550	GT-CFRL-100-025-20-NC (1550)
	0.24	0.18 - 0.16*	0.19	6.08	2.66	0.260 - 0.258*	1.524 - 1.515*	670 - 1550	GT-CFRL-100-024-20-NC (1550)
1.80	0.25	0	0.19	11.06	4.62	0.141	1.524	670	GT-CFRL-180-025-20-NC (670)
	0.25	0	0.19	11.08	4.64	0.140	1.521	810	GT-CFRL-180-025-20-NC (810)
	0.25	0	0.19	11.38	4.78	0.138	1.515	1550	GT-CFRL-180-025-20-NC (1550)
	0.24	0.31 - 0.26*	0.19	10.99	4.79	0.141 - 0.138*	1.524 - 1.515*	670 - 1550	GT-CFRL-180-024-20-NC (1550)

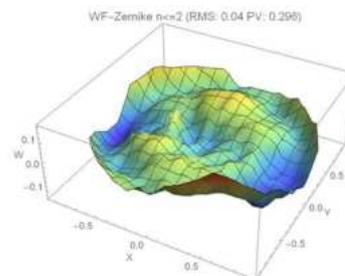
*: depending on wavelength

- Working distance, design wavelength and lens length deviating from these standards are available on request
- ZEMAX files can be [DOWNLOADED](#) from our website
- For tolerances, handling and storage see page 26

optimized

- Wavefront RMS @ 635 nm < 0.07
- diffraction limited properties
- higher order spherical aberrations are corrected
- for high-performance applications (e.g. collimators with M² < 1.1)

measured wavefront error: 0.055λ RMS



GRIN rod lenses are offered without antireflection coatings as standard.

Antireflection coatings (for incidence angles of 0 ... 10° corresponding to measurements on a reference substrate) can be offered:

Coating Code: NC: no coating (reflection loss approx. 12 %) - standard
 C1: λ = 400 ... 700 nm, R < 1.0 %
 C2: λ = 800 ... 1000 nm, R < 0.5 %
 C5: λ = 1310 ... 1550 nm, R < 0.5 %

One - sided coatings are available on request.

Variations due to modifications of the production process are possible. It is the user 's responsibility to determine suitability for the user 's purpose.

*** not available for following applications :**

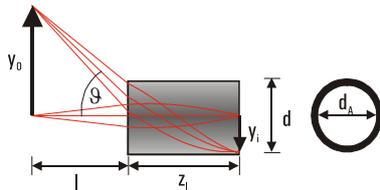
Please note our partnership with Inscopix as our exclusive distributor for the field of non-confocal, single photon epi-fluorescence imaging for neuroscience applications in non-humans (see page 8).

Order example:

GT - CFRL - 100 - 025 - 20 - NC - (670)	
GT	GRINTECH
CFRL	Focusing Rod Lens for high-performance collimation
100	Diameter: 1.0, 1.8 mm
025	Pitch: 0.25 or 0.24
20	NA: 0.20
NC	Coating Code: NC, C1, C2 or C5
(670)	Design Wavelength

GRIN Objective Lenses for Endoscopy

- Gradient index lenses for endoscopic imaging optics
- Non-toxic silver-based glass material
- view angle $\vartheta = \pm 30^\circ$
- Plane surfaces, low chromatic aberration
- Combination with prisms and beam splitter cubes on request
- Aperture and field stops (black chromium coating ring on lens surface generated by photolithography) are available on request
- Certification: Biological safety – toxicology (EN ISO 10993-1)
- Design wavelength: 570 nm



Diameter d (mm)	Working distance l (mm)	Lens length ¹ z _i (mm)	Parax. Magnification M = y _o /y _i	Refractive index at the center of the profile n _o	Product code
2.0*	Infinity	4.86	--	1.635	GT-IFRL-200-inf-50-NC*
2.0	20	5.14	-10.56	1.635	GT-IFRL-200-020-50-NC
	10	5.42	-5.35	1.635	GT-IFRL-200-010-50-NC
	5	5.94	-2.81	1.635	GT-IFRL-200-005-50-NC
1.8*	Infinity	4.29	--	1.635	GT-IFRL-180-inf-50-NC*
1.8	20	4.51	-11.94	1.635	GT-IFRL-180-020-50-NC
	10	4.72	-6.04	1.635	GT-IFRL-180-010-50-NC
	5	5.14	-3.14	1.635	GT-IFRL-180-005-50-NC
1.0	Infinity	2.23	--	1.635	GT-IFRL-100-inf-50-NC
	20	2.29	-22.85	1.635	GT-IFRL-100-020-50-NC
	10	2.35	-11.46	1.635	GT-IFRL-100-010-50-NC
	5	2.47	-5.80	1.635	GT-IFRL-100-005-50-NC
0.85	Infinity	1.89	--	1.635	GT-IFRL-085-inf-50-NC
	10	1.96	-13.61	1.635	GT-IFRL-085-010-50-NC
	5	2.05	-6.86	1.635	GT-IFRL-085-005-50-NC
0.6	Infinity	1.31	--	1.635	GT-IFRL-060-inf-50-NC
	10	1.35	-19.47	1.635	GT-IFRL-060-010-50-NC
	5	1.39	-9.77	1.635	GT-IFRL-060-005-50-NC
0.5	Infinity	1.09	--	1.635	GT-IFRL-050-inf-50-NC
	10	1.12	-23.47	1.635	GT-IFRL-050-010-50-NC
	5	1.14	-11.77	1.635	GT-IFRL-050-005-50-NC
0.35	5	0.80	-16.67	1.635	GT-IFRL-035-005-50-NC
0.25	5	0.56	-23.16	1.635	GT-IFRL-025-005-50-NC

- Working distance and lens length deviating from these standards are available on request
- ZEMAX files can be [DOWNLOADED](#) from our website
- For tolerances, handling and storage see page 26

GRIN rod lenses are offered without antireflection coatings as standard. Antireflection coatings (R < 1.0 % for the design wavelength and incidence angles of 0 ... 30° corresponding to measurements on a reference substrate) can be offered:

Coating Code: NC: no coating (reflection loss approx. 12 %) - standard
C1: $\lambda = 400 \dots 700 \text{ nm}$, R < 1.0 %

One - sided coatings are available on request.

Order example:

GT - IFRL - 100 - 010 - 50 - NC	
GT	GRINTECH
IFRL	Imaging Focusing Rod Lens
100	Diameter: 0.25, 0.35, 0.5, 0.6, 0.85, 1.0, 1.8 or 2.0 mm
010	Working distance: 5, 10, 20 mm or infinity
50	NA: 0.50
NC	Coating Code: NC or C1

Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

Note: GRINTECH objective lenses can be combined with GRIN relay lenses to complete endoscopic imaging systems by gluing the optical surfaces directly together. Prisms to change the direction of view can also be glued directly on the front surface of the objective lens.

We are happy to advise you.

*** not available for following applications :**

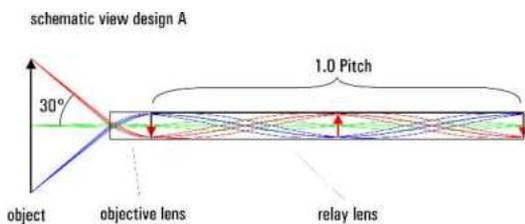
Please note our partnership with Inscopix as our exclusive distributor for the field of non-confocal, single photon epi-fluorescence imaging for neuroscience applications in non-humans (see page 8).

GRIN Endoscopic Rod Lens Systems

GRIN endoscopic systems, which combine a GRIN objective lens, a GRIN relay lens and a GRIN eyepiece. Combining the system with a prism enables the change of the direction of view. Standard diameters are 0.35, 0.5, 1.0 and 2.0 mm. We offer the systems in two different principle design options:

Design A:

The objective lens creates a reduced intermediate image at the exit surface of the objective lens, which will be imaged by the relay lens 1:1 (if the lens length of the relay lens is a multiple of the period) or - 1:1 (if the lens length of the relay lens is an odd multiple of the half period) to the exit surface of the relay lens.



possible working distances (please specify):

0.35 mm diameter: 5 mm,

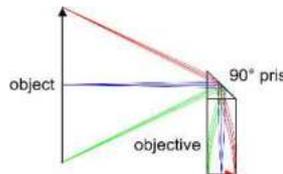
0.5 to 2.0 mm diameter: 5 mm, 10 mm and infinity

other working distances on request

possible pitch lengths:

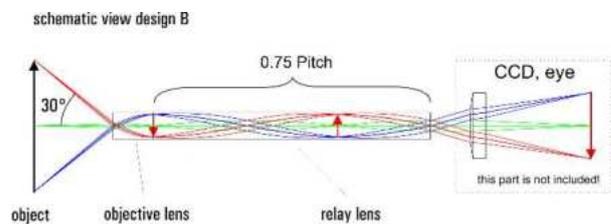
diameter	Relay pitch	System length [mm]	Image orientation
0.35	0.5	approx. 8.2	inverted to like design A
	1.0	approx. 15.7	like design A
	1.5	approx. 23.1	inverted to like design A
0.50	0.5	approx. 16.3	inverted to like design A
	1.0	approx. 31.4	like design A
	1.5	approx. 46.5	inverted to like design A
1.00	0.5	approx. 24.7	inverted to like design A
	1.0	approx. 47.0	like design A
	1.5	approx. 69.4	inverted to like design A
2.00	0.5	approx. 55.5	inverted to like design A
	1.0	approx. 105.8	like design A
	1.5	approx. 156.0	inverted to like design A

Both versions are available with a 90° change of view by attaching a prism to the objective.



Design B:

The objective lens creates a reduced intermediate image at the exit surface of the objective lens, which will be imaged by the relay lens at infinity. Such a lens system is a complete endoscopic imaging system. It allows the direct observation with the human eye or the use of a conventional camera system (including camera lens): camera and camera lens are not included!



possible working distances (please specify):

0.35 mm diameter: 5 mm,

0.5 to 2.0 mm diameter: 5 mm, 10 mm and infinity

other working distances on request

possible pitch lengths:

diameter	Relay pitch	System length [mm]	Image orientation
0.35	0.75	approx. 12.0	like design B
	1.25	approx. 19.4	inverted to like design B
	1.75	approx. 26.9	like design B
0.5	0.75	approx. 23.8	like design B
	1.25	approx. 38.9	inverted to like design B
	1.75	approx. 54.0	like design B
1.00	0.75	approx. 35.9	like design B
	1.25	approx. 58.2	inverted to like design B
	1.75	approx. 80.6	like design B
2.00	0.75	approx. 80.7	like design B
	1.25	approx. 130.9	inverted to like design

Order example:

GT - ERLS - d - wd - p	
GT	GRINTECH
ERLS	Endoscopic Rod Lens System
d	Diameter: 0.35, 0.50, 1.00 or 2.00 mm
wd	Working distance: 5, 10 mm or infinity
p	Relay pitch: 0.50, 0.75, 1.00, 1.25, 1.50 or 1.75

For tolerances, handling and storage see page 28

We are happy to advise you. Please contact us.

Extension of Partnership

Brain Imaging – one of the most enabling applications of GRINTECH micro optics

Endomicroscopy using GRINTECH lenses and assemblies allows an *in-vivo* imaging access to deep tissue regions in the brain, especially in non-humans. It helps to understand disease formation and progression on a cellular level of the tissue.

We are pleased to inform that GRINTECH GmbH has expanded its strategic partnership with Inscopix Inc. beyond one-photon imaging to include exclusively serving customers on behalf of GRINTECH in two-photon imaging and across all non-human neuroscience research applications.

Inscopix offers innovative products and scientific consulting services for advancing neuroscience research and we are excited to be able to partner with Inscopix to serve a broader research community. Inscopix commits to continuing to support legacy GRINTECH customers with their microendoscope imaging needs across all neuroscience preclinical imaging applications. Inscopix Field Scientific Consultants and Inscopix's Support team will now be available to all legacy GRINTECH customers and to any customer interested in leveraging microendoscope imaging for their brain research, irrespective of whether the user or lab is a customer of Inscopix instrumentation. The expanded partnership aims to benefit GRINTECH customers and the broader Neuroscience research community with a dedicated neuroscience partner, enhanced scientific support and customer service, and volume-based pricing discounts.

Going forward, Inscopix will be your primary contact for ordering GRIN lenses for non-human Neuroscience research applications. If you have a one-time, custom GRIN lens order, Inscopix will work with GRINTECH to ensure that if Inscopix is unable to fulfill the order, GRINTECH will do so.

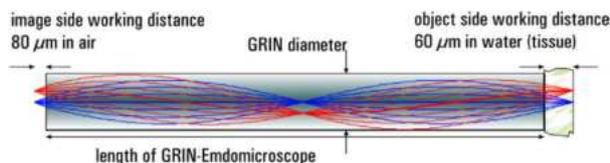
www.inscopix.com

For more information, please contact info@grintech.de

GRIN Needle Endomicroscopes for Fluorescence Microscopy

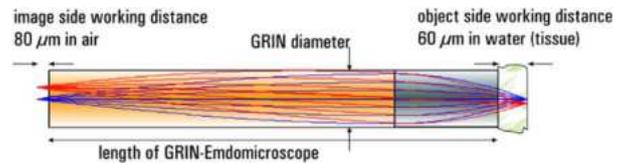
GRIN Needle Endomicroscopes are used for deep tissue imaging. They relay the micron-scale resolved image of the tissue over a longer length to a plane outside of the tissue at the other end of the needlescope. They are used with epi - fluorescence imaging (Design Wavelength 520 nm). The Endomicroscopes are fabricated as GRIN-singlets with NA = 0.50 on both sides or as GRIN-doublets with an object NA of 0.5 and an image NA of 0.19. Working distances on object side are specified in water or tissue, on image side in air. They are offered in different lengths resulting from adding 0.5 GRIN-pitches (periods) to the GRIN. Optional, they can be offered as side viewing needlescope by adding a 90° prism on object side.

Singlets:



- object side working distance in water: 60 μm
- image side working distance in air: 0 μm / 80 μm
- design wavelength: 520 nm
- NA Object / image side: 0.50 / 0.50
- Magnification: 1:1 / 1:-1 (depending on pitch length)

Doublets:

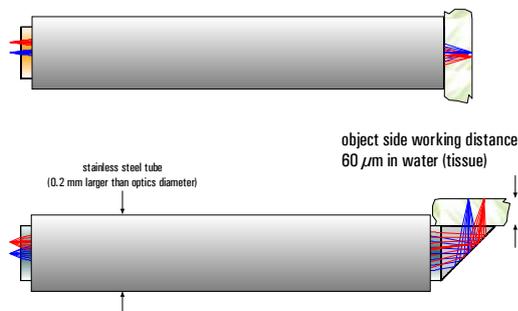


- object side working distance in water: 60 μm
- image side working distance in air: 80 μm
- design wavelength: 520 nm
- NA Object / image side: 0.50 / 0.19
- Magnification: 1:2.6 / 1:-2.6 (depending on pitch length)

Available lengths:

Diameter (mm)	Product Code	Image side working distance (μm)	Length (mm)
0.50	NEM-050-06-00-520-S-0.5p	0	2.22
	NEM-050-06-08-520-S-0.5p	80	2.08
	NEM-050-06-08-520-S-1.0p	80	4.38
	NEM-050-06-08-520-S-1.5p	80	6.67
	NEM-050-06-08-520-S-2.0p	80	8.96
1.00	NEM-100-06-00-520-S-0.5p	0	4.67
	NEM-100-06-08-520-S-0.5p	80	4.54
	NEM-100-06-08-520-S-1.0p	80	9.28
	NEM-100-06-08-520-S-1.5p	80	14.02

- Other diameters (0.35 mm, 0.60 mm, 0.85 mm, 1.80 mm or 2.00 mm), other working distances or other design wavelength are available on request



Available lengths:

Diameter (mm)	Product Code	Length (mm)
0.50	NEM-050-06-08-520-DS	3.98
	NEM-050-06-08-520-DM	10.08
	NEM-050-06-08-520-DL	16.19
1.00	NEM-100-06-08-520-DS	8.28
	NEM-100-06-08-520-DM	20.50

- Other diameters (0.35 mm, 1.8 mm), other working distances or other design wavelength are available on request

Notes:

- Diameters are sole GRIN-optics diameters
- Optional the Endomicroscopes can be delivered in medical-grade stainless steel tubes (1.4301), with outer diameters of 0.70 mm for 0.5 mm optics and 1.2 mm for 1.0 mm optics. The tubes are mounted flush on the object side (tissue, high NA) for the side viewing version the prism is not protected by the tube.. On the image side, the optics sticks out of the tube by 50 – 500 μm. Please add –ST to the product code if desired.
- The lengths can have a tolerance of +/- 5 %.
- The lenses are non-coated. For customized projects, the lenses can be AR-coated.
- A side-viewing scope using microprisms may be also possible on a customized basis (see left).
- Please ask for combination with imaging fiber bundles (Fujikura) as customized solution.
- For tolerances, handling and storage see page 28

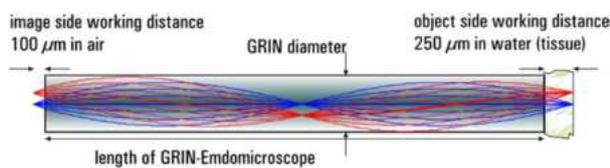
*** not available for following applications :**

Please note our partnership with Inscopix as our exclusive distributor for the field of non-confocal, single photon epi-fluorescence imaging for neuroscience applications in non-humans (see page 8)

GRIN Needle Endomicroscopes for 2-Photon Microscopy

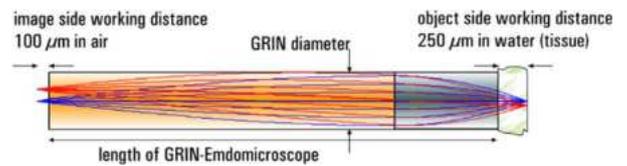
GRIN Needle Endomicroscopes are used for deep tissue imaging. They relay the micron-scale resolved image of the tissue over a longer length to a plane outside of the tissue at the other end of the needlescope. They are used with multi-photon fluorescence imaging (Design Wavelength 860 nm). The Endomicroscopes are fabricated as GRIN-singlets with NA = 0.50 on both sides or as GRIN-doublets with an object NA of 0.5 and an image NA of 0.19. Working distances on object side are specified in water or tissue, on image side in air. They are offered in different lengths resulting from adding 0.5 GRIN-pitches (periods) to the GRIN. Optional, they can be offered as side viewing needlescope by adding a 90° prism on object side.

Singlets:



- object side working distance in water: 250 μm
- image side working distance in air: 100 μm
- design wavelength: 860 nm
- NA object / image side: 0.50 / 0.50
- Magnification: 1:1 / 1:-1 (depending on pitch length)

Doublets:



- object side working distance in water: 250 μm
- image side working distance in air: 100 μm
- design wavelength: 860 nm
- NA object / image side: 0.50 / 0.19
- Magnification: 1:2.6 / 1:-2.6 (depending on pitch length)

Available lengths:

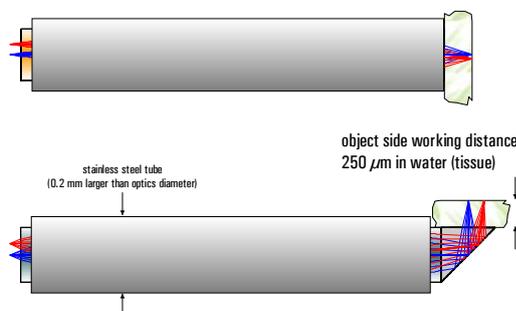
Diameter (mm)	Product Code	Length (mm)
0.50	NEM-050-25-10-860-S-0.5p	1.87
	NEM-050-25-10-860-S-1.0p	4.20
	NEM-050-25-10-860-S-1.5p	6.52
	NEM-050-25-10-860-S-2.0p	8.85
1.00	NEM-100-25-10-860-S-0.5p	4.38
	NEM-100-25-10-860-S-1.0p	9.22
	NEM-100-25-10-860-S-1.5p	14.07

- Other diameters (0.35 mm, 0.60 mm, 0.85 mm, 1.80 mm or 2.00 mm), other working distances or other design wavelength are available on request

Available lengths:

Diameter (mm)	Product Code	Length (mm)
0.50	NEM-050-25-10-860-DS	3.79
	NEM-050-25-10-860-DM	9.89
	NEM-050-25-10-860-DL	16.00
1.00	NEM-100-25-10-860-DS	8.09
	NEM-100-25-10-860-DM	20.09

- Other diameters (0.35 mm, 1.80 mm), other working distances or other design wavelength are available on request



Notes:

- Diameters are sole GRIN-optics diameters
- Optional the Endomicroscopes can be delivered in medical-grade stainless steel tubes (1.4301), with outer diameters of 0.70 mm for 0.5 mm optics and 1.2 mm for 1.0 mm optics. The tubes are mounted flush on the object side (tissue, high NA) for the side viewing version the prism is not protected by the tube.. On the image side, the optics sticks out of the tube by 50 – 500 μm . Please add -ST to the product code if desired.
- The lengths can have a tolerance of +/- 5 %.
- The lenses are non-coated. For customized projects, the lenses can be AR-coated.
- A side-viewing scope using microprisms may be also possible on a customized basis (see left).
- Please ask for combination with imaging fiber bundles (Fujikura) as customized solution.
- For tolerances, handling and storage see page 28

* not available for following applications :

Please note our partnership with Inscopix as our exclusive distributor for the field of non-confocal, single photon epi-fluorescence imaging for neuroscience applications in non-humans (see page 8).

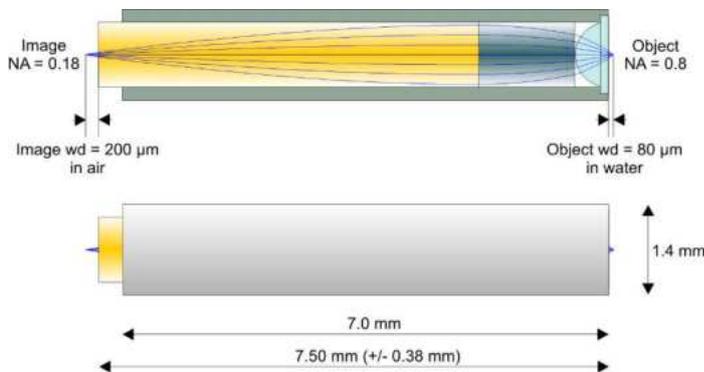
High-NA Endomicroscopic Imaging Objective for Fluorescence Microscopy

GRINTECH's high-NA Endomicroscopic Imaging Objectives cascade the optical power of a plano-convex lens and a GRIN lens with aberration compensation to achieve an object NA of 0.8.

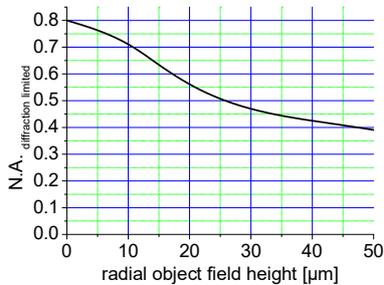
Applications: In vivo endomicroscopy, fluorescence microscopy, tissue imaging, flexible fluorescence microscopy, NA conversion

Product Code: GT-MO-080-018-488

- Features:**
- Object NA = 0.80
 - Object working distance 80 μm (water)
 - Image NA = 0.18
 - Magnification 4.65 x
 - Recommended Excitation 488 nm
 - Mounted in stainless steel holder

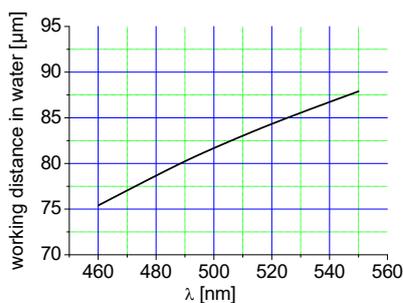


Diffraction limited NA versus Field



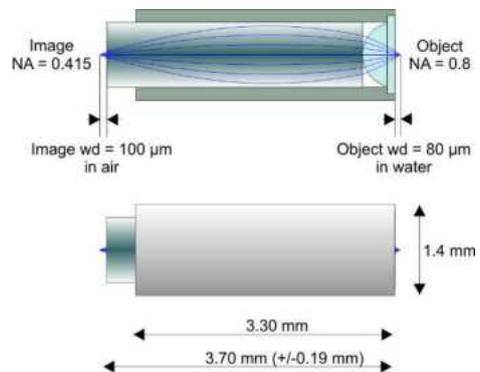
(from optical design simulation according to Marechal criterion @ 488 nm, wavefront RMS $\leq 0.07 \lambda$)

Chromatic Aberration in Object Space

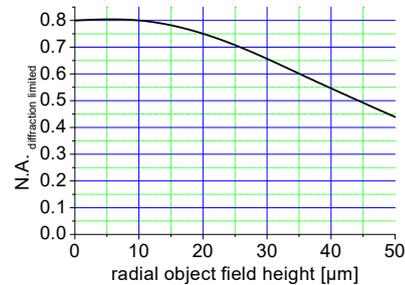


Product Code: GT-MO-080-0415-488

- Features:**
- Object NA = 0.80
 - Object working distance 80 μm (water)
 - Image NA = 0.415
 - Magnification 1.92 x
 - Recommended Excitation 488 nm
 - Mounted in stainless steel holder

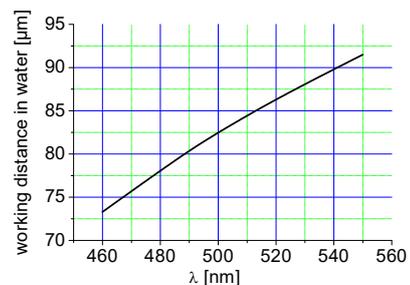


Diffraction limited NA versus Field



(from optical design simulation according to Marechal criterion @ 488 nm, wavefront RMS $\leq 0.07 \lambda$)

Chromatic Aberration in Object Space



Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.
For tolerances, handling and storage see page 28
Pat. US 7,511,891

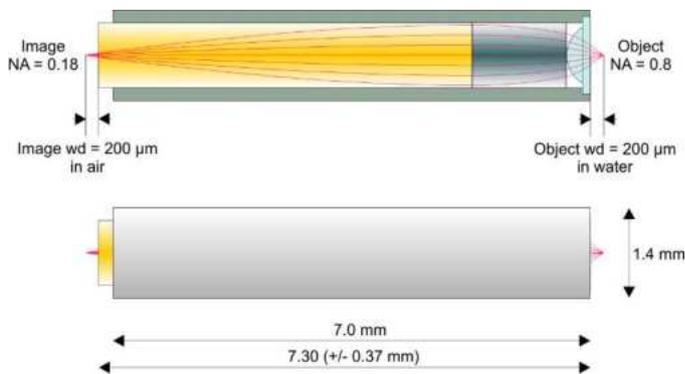
High-NA Endoscopic Imaging Objective for 2-Photon Microscopy

GRINTECH's high-NA Endoscopic Imaging Objectives cascade the optical power of a plano-convex lens and a GRIN lens with aberration compensation to achieve an object NA of 0.8.

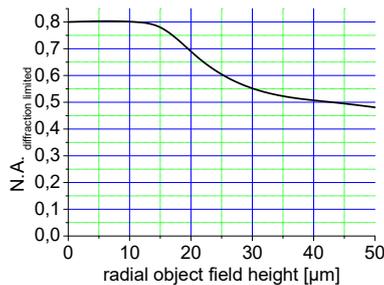
Applications: In vivo endomicroscopy, 2-photon microscopy, deep brain and tissue imaging, flexible fluorescence microscopy, NA conversion

Product Code: GT-MO-080-018-810

- Features:**
- Object NA = 0.80
 - Object working distance 200 μm (water)
 - Image NA = 0.18
 - Magnification 4.8 x
 - Recommended Excitation 800 – 900 nm
 - Mounted in stainless steel holder

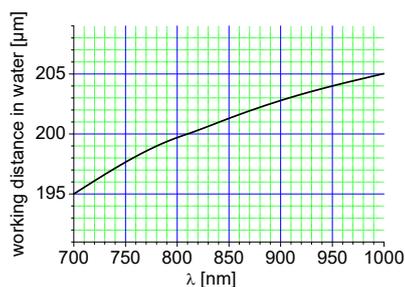


Diffraction limited NA versus Field



(from optical design simulation according to Marechal criterion @ 810 nm, wavefront RMS $\leq 0.07 \lambda$)

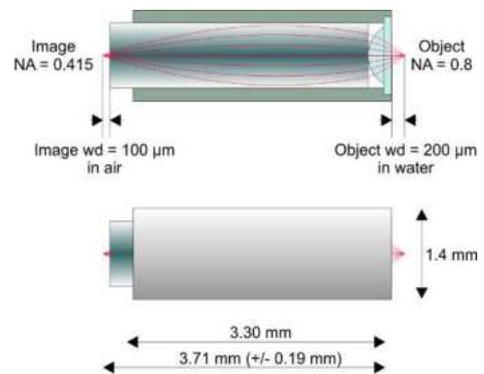
Chromatic Aberration in Object Space



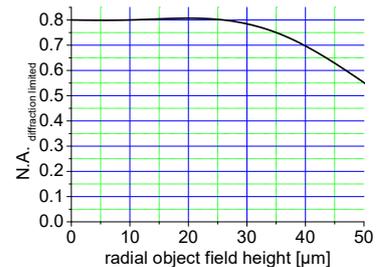
Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose. For tolerances, handling and storage see page 28

Product Code: GT-MO-080-0415-810

- Features:**
- Object NA = 0.80
 - Object working distance 200 μm (water)
 - Image NA = 0.415
 - Magnification 1.92 x
 - Recommended Excitation 800 – 900 nm
 - Mounted in stainless steel holder

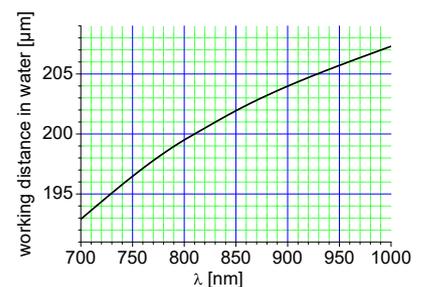


Diffraction limited NA versus Field



(from optical design simulation according to Marechal criterion @ 810 nm, wavefront RMS $\leq 0.07 \lambda$)

Chromatic Aberration in Object Space



High-NA chromatic and field corrected Endoscopic Imaging Objectives (MO-ACR)

GRINTECH's high-NA Endoscopic Imaging Objectives with object Numerical Apertures of 0.75 are offered in a broad achromatic and field corrected version to significantly increase the usable field of view. A GRIN-refractive multilens hybrid design allows a broader chromatic and off-axis correction resulting also in a higher confocal sensitivity (confocal signal throughput) compared to the previous versions with diffractive correcting elements.

Applications:

In vivo endomicroscopy, single photon fluorescence microscopy, nonlinear optical imaging modalities (SHG, TPF), tissue imaging, flexible fluorescence microscopy, NA conversion

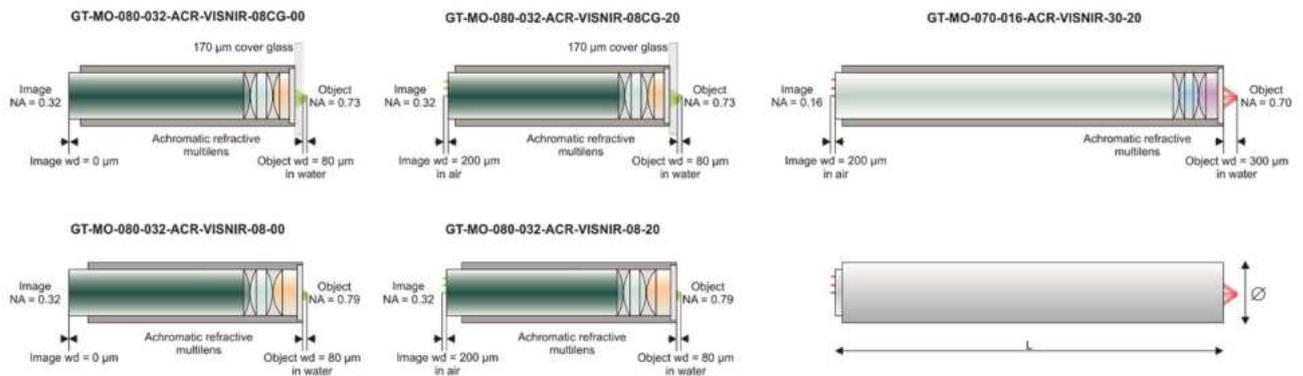
GT-MO-080-032-ACR-VISNIR-xx-xx series represents high resolution field and color corrected objectives with a magnification of 2.3. The image side NA of 0.32 matches to imaging fiber bundles. Color correction is from 450 nm to 900 nm with an optimal performance from 488 nm to 520 nm. The objectives are assembled in stainless steel mounts.

GT-MO-070-016-ACR-VISNIR-30-20 is optimized for wavelengths of 450 nm and 900 nm to achieve an ideal performance in SHG and TPF applications within a large field of view.

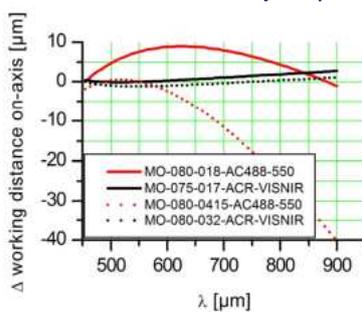
Four combinations of proximal and distal working distances are offered as listed below:

GT-MO-080-032-ACR-VISNIR-...	...08CG-00	...08CG-20	...08-00	...08-20
Object NA	0.73	0.73	0.79	0.79
Object WD in water [μm]	80	80	80	80
Designed for cover glass [μm]	170	170	none	none
Image NA	0.32	0.32	0.32	0.32
Image WD in air [μm]	0	200	0	200
Magnification	2.2	2.2	2.4	2.4
Dimensions Ø / L [mm]	1.3 / 4.89	1.3 / 4.57	1.3 / 5.02	1.3 / 4.7

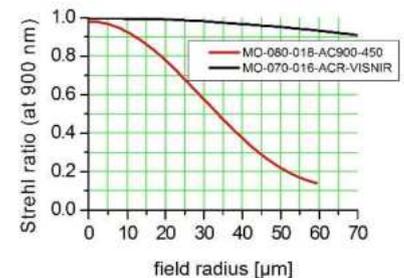
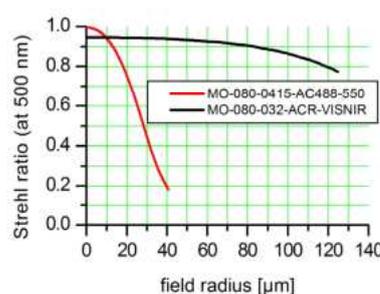
GT-MO-070-016-ACR-VISNIR-30-20
0.7
300
none
0.16
200
4.4
1.3 / 8.36



Chromatic Aberration in Object Space



Field Dependent Strehl Ratio in Object Space (From Optical Design)



Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose. For tolerances, handling and storage see page 26

Application Note – High NA chromatic and field corrected Endomicroscopic Imaging Objectives

The generation of GRINTECH's color and field corrected high-NA **MO-ACR** objectives resolve cellular details in micron resolution from center to the margin of the aperture

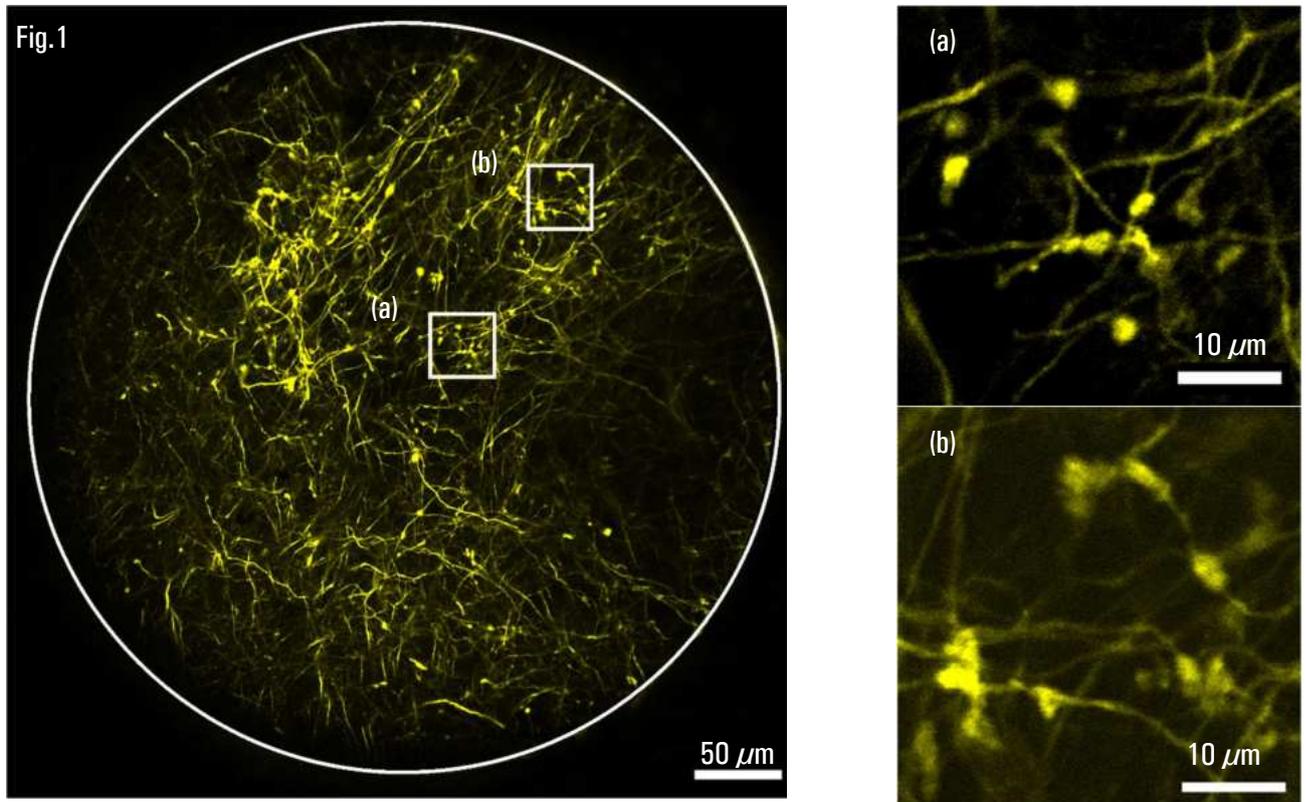


Fig.1: Mouse brain section, PFA fixation, cover glass 170 μm confocally imaged in fluorescence (exc. 488nm) with **GT-MO-080-032-ACR-VISNIR-08CG-00** coupled to Olympus FV1000 with MO 10x; NA = 0.4 with XYZ-Stage. White circle shows backside aperture of 1 mm corresponding to full object FOV of 450 μm , with optimal imaging quality in FOV of 360 μm . (a) and (b): 40 μm x 40 μm sections of the center and edge of object FOV.

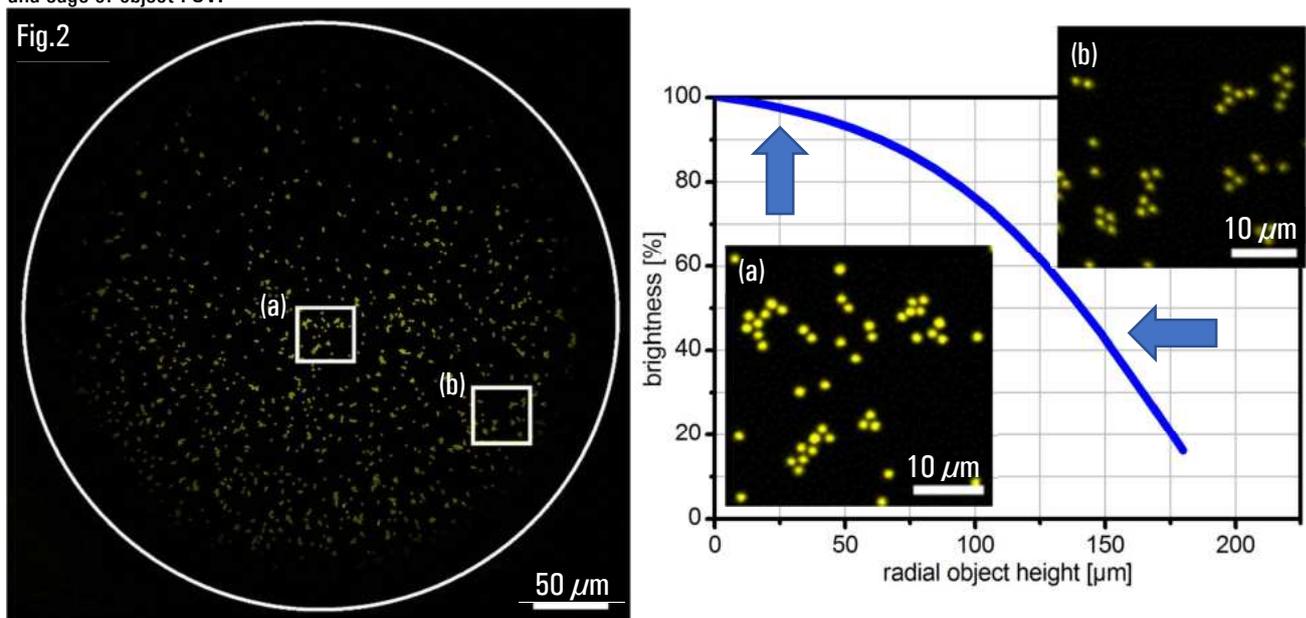


Fig.2: fluorescence beads with $\varnothing = 2\mu\text{m}$ yellow/green acquired with **GT-MO-080-032-ACR-VISNIR-08-00**. Right: bead brightness depending on the radial object height. (a) and (b) 40 μm x 40 μm sections from the center and edge of object FOV.

The usable field of view is increased to 300 % in diameter compared to previous MO-080 objectives

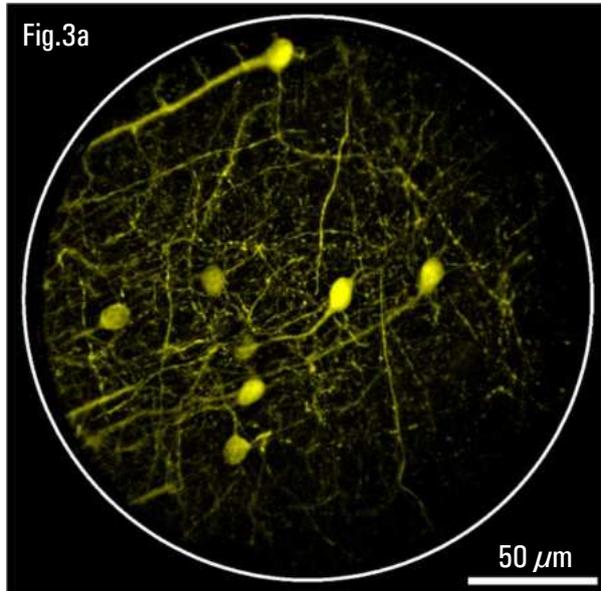


Fig.3a: GT-MO-070-016-ACR-VISNIR-30-20
with full object FOV of 200 μm (optimal imaging in 150 μm)
compared to Fig.3b.

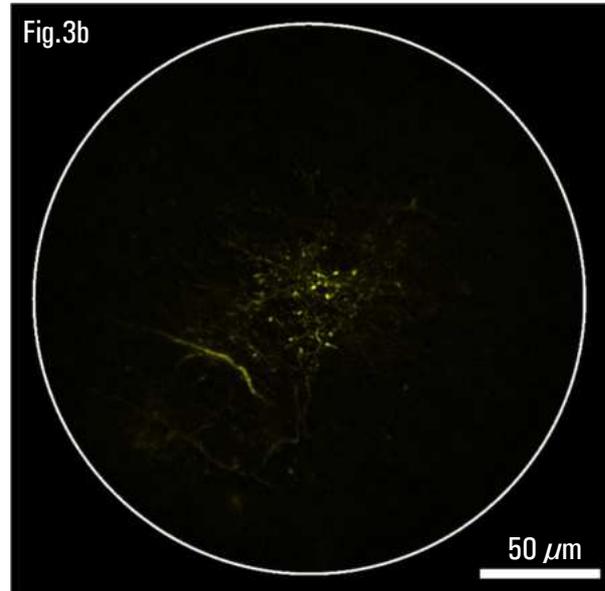


Fig.3b: GT-MO-080-018-AC900-450 with FOV of 65 μm

Now available also in 1.3 mm outer diameter instead of 1.4 mm

For more details, please contact GRINTECH.

NEW High-NA chromatic and field corrected Endomicroscopic Imaging Objectives with reduced curvature (MO-ACR-REDUCURV)

GRINTECH's new variant of high-NA Endomicroscopic Imaging Objectives with object Numerical Apertures of 0.7 are offered in a broad achromatic and field corrected version to significantly increase the usable field of view. A combination of four micro lenses achieves the same chromatic and off-axis performance as our MO-ACR-series with reduced field curvature which allows for acquisition of smaller image stacks and addressing more applications.

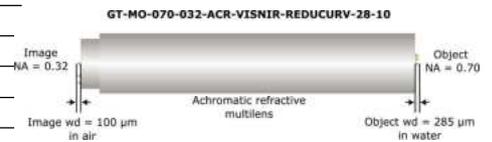
Applications:

In vivo endomicroscopy, single photon fluorescence microscopy, nonlinear optical imaging modalities (SHG, TPF), tissue imaging, flexible fluorescence microscopy, NA conversion, especially all applications that require less curvature

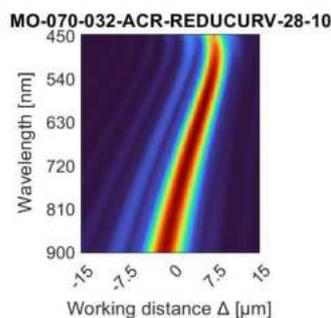
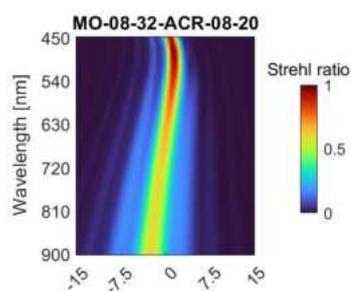
GT-MO-070-032-ACR-VISNIR-REDUCURV-xx-xx represents high resolution field and color corrected objectives with a magnification of 2.2. The image side NA of 0.32 matches to imaging fiber bundles. Color correction is achieved from 450 nm to 900 nm with an optimal performance from 488 nm to 900 nm. The objectives are assembled in stainless steel mounts.

The new micro objective type with reduced field curvature is offered so far as a version for usage without cover glass. Here you can compare with our MO-ACR series. Please note also the different mechanical dimensions.

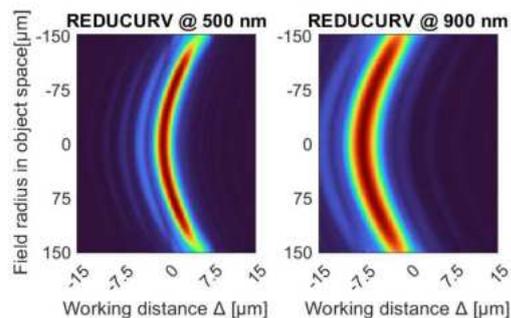
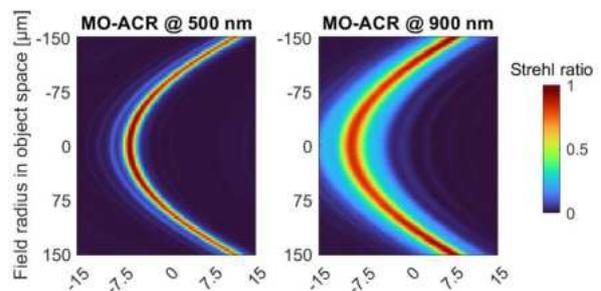
	GT-MO-070-032-ACR-VISNIR-REDUCURV-28-10	GT-MO-080-032-ACR-VISNIR-08-20
Object NA	0.70	0.79
Object WD in water [μm]	285	80
Designed for cover glass [μm]	none	none
Image NA	0.32	0.32
Image WD in air [μm]	100	200
Magnification	2.2	2.3
Field curvature radius [mm]	2	0.55
Dimensions Ø / L [mm]	2.2 / 13	1.3 / 4.7



Chromatic Aberration in Object Space



Field Dependent Strehl Ratio in Object Space



Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

For tolerances, handling and storage see page 28

More information can be found here: Stark, S. L., et al. (2023). "Field curvature reduction in miniaturized high numerical aperture and large field-of-view objective lenses with sub 1 μm lateral resolution." *Biomedical Optics Express* 14(12).

NEW High-NA chromatic and field corrected Endoscopic Imaging Objectives with reduced field curvature (MO-ACR-REDUCURV)

GRINTECH's new variant of high-NA Endoscopic Imaging Objectives with object Numerical Apertures of 0.5 are offered in a broad achromatic and field corrected version to significantly increase the usable field of view. A combination of four micro lenses achieves the same chromatic and off-axis performance as our MO-ACR-series with reduced field curvature which allows for acquisition of smaller image stacks and addressing more applications.

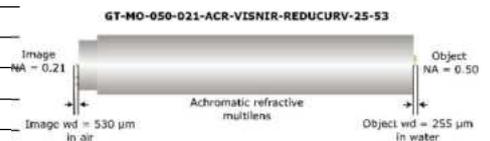
Applications:

In vivo endomicroscopy, single photon fluorescence microscopy, nonlinear optical imaging modalities (SHG, TPF), tissue imaging, flexible fluorescence microscopy, NA conversion, especially all applications that require less curvature

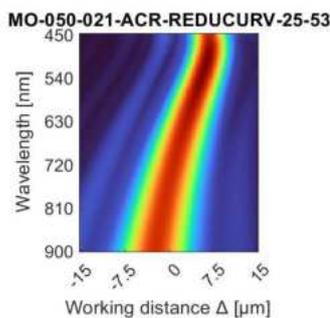
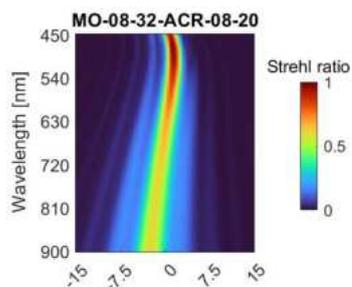
GT-MO-050-021-ACR-VISNIR-REDUCURV-xx-xx represents high resolution field and color corrected objectives with a magnification of 2.3. The image side NA is in this case 0.21. Color correction is achieved from 450 nm to 900 nm with an optimal performance from 488 nm to 900 nm. The objectives are assembled in stainless steel mounts.

The new micro objective type with reduced field curvature is offered so far as a version for usage without cover glass. Here you can compare with our MO-ACR series.

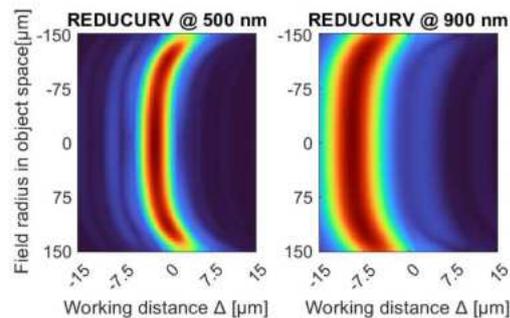
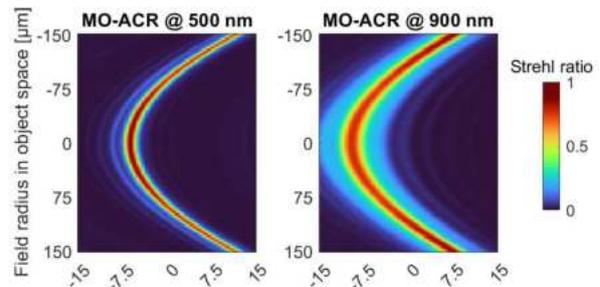
	GT-MO-050-021-ACR-VISNIR-REDUCURV-25-53	GT-MO-080-032-ACR-VISNIR-08-20
Object NA	0.50	0.79
Object WD in water [μm]	255	80
Designed for cover glass [μm]	none	none
Image NA	0.21	0.32
Image WD in air [μm]	530	200
Magnification	2.3	2.3
Field curvature radius [mm]	2	0.55
Dimensions Ø / L [mm]	1.2 / 5.0	1.3 / 4.7



Chromatic Aberration in Object Space



Field Dependent Strehl Ratio in Object Space



Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose. For tolerances, handling and storage see page 28

High-NA chromatically and field corrected Endomicroscope Tube for CARS and non-linear imaging

GRINTECH's high-NA Endomicroscope tube with object Numerical Aperture of 0.50 features sub-micron resolution imaging with a field of view of 300 μm for CARS/2-Photon-Fluorescence/SHG modalities. It has a diameter of 3.0 or 2.2 mm and a rigid length of 178 mm. A GRIN-refractive multilens hybrid design allows chromatic and off-axis correction between 795 nm and 1029 nm.

Applications:

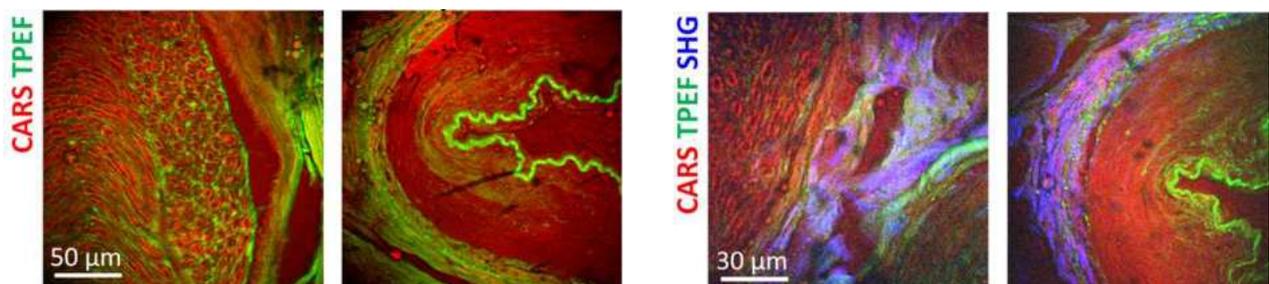
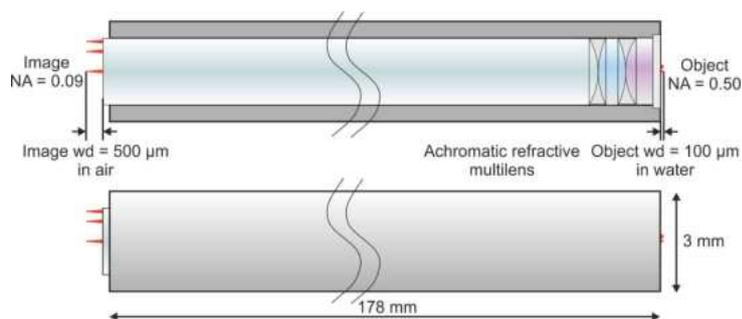
In vivo endomicroscopy, nonlinear optical endoscopy (CARS, SHG, TPF), tissue imaging, proximal scanning, NA conversion

GT-MO-050-009-ACR795/1029-10-50 represents a high resolution field- and NIR-chromatically corrected objective with a magnification of 5.6. The image side NA of 0.09 matches to low NA telecentric spot scanning. Chromatic correction is realized between 795 nm to 1029 nm together with an optimal performance.

The optics is assembled in a stainless steel tube of 3.0 or 2.2 mm diameter (optional).

Specifications:

GT-MO-050-009-ACR795/1029-10-50	
Object NA	0.50
Object WD in water [μm]	100
Image NA	0.09
Image WD in air [μm]	Approx. 500
Magnification	5.6
Dimensions \varnothing / L [mm]	3.0 or 2.2 / 178



Images:

Human nervus suralis – cryosection, images recorded through Endomicroscopic tube + Plan-Apo 5x/0.16 + Zeiss CARS LSM (Courtesy by TU Dresden)

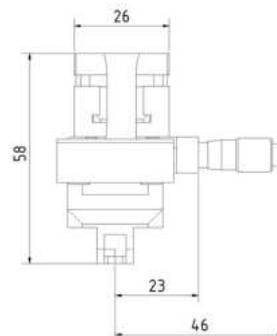
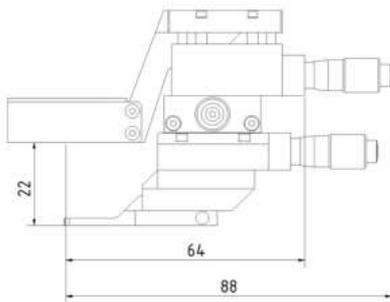
Reference: Zirak, P., et al. (2018). "Invited Article: A rigid coherent anti-Stokes Raman scattering endoscope with high resolution and a large field of view." *APL Photonics* 3(9): 092409.

Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose. For tolerances, handling and storage see page 28

PosUnit 3x for GRIN-Needle Endomicroscopes and High NA Objectives

XYZ Stage and objective mounting to connect and align to microscope objectives

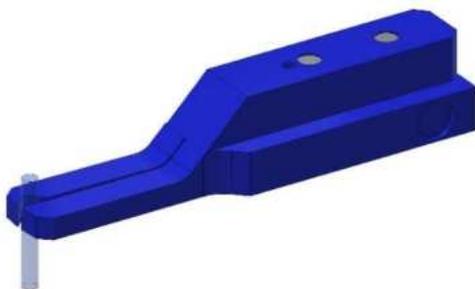
PosUnit 3X



Applications and properties

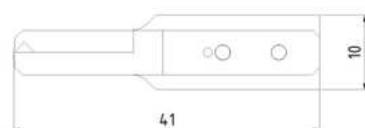
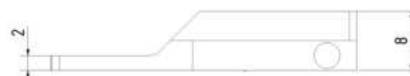
- holding, handling and three-axis-positioning of GRIN-microsystem relative to microscope objectives
- mounting for microscope objective diameter 35mm (standard)
- smaller microscope objective diameters are possible with assistance of an adapter ring
- stable and reliable construction of the XYZ-stage
- adjustment travel: X - 5 mm, Y - 5 mm, Z - 5 mm with scale reading in all axis, bar distance 10 μ m.
- easy pick and drop of GRIN Lenses with a resiliently mounted snap system
- Jaw seat fits exactly to the jaws of the previous model
- durable anodized aluminum surface
- clamping unit not included

Clamping unit



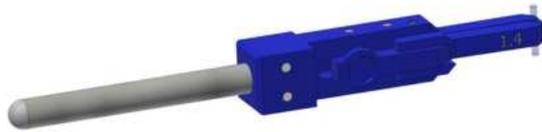
Applications and properties

- Holding device for grin lenses to be accommodated within the Pos Unit 3X
- different prism groove sizes available for diameter: **0.5 / 0.7 / 1.0 / 1.2 / 1.3 mm**
- resiliently mounted snap system for easy pick and drop and handle of GRIN Lenses, now guided by precise axis
- magnetic holder for PosUnit 3X
- durable anodized aluminum surface



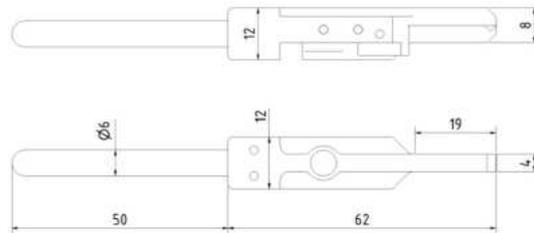
GRIN Lens Gripper for GRIN-Lenses, Needle Endomicroscopes and High NA Objectives

GRIN Lens Gripper

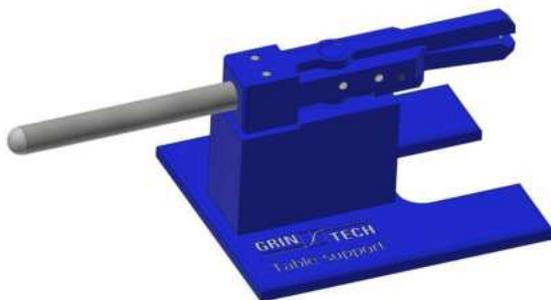


Applications and properties

- Basic Unit - GRIN Lens Gripper
- Holding device for grin lenses
- different prism groove sizes available for diameter: **0.5 / 0.7 / 1.0 / 1.2 / 1.3 mm**
- springy-loaded snap system for easy pick up and handle micro-optics
- durable anodized aluminum surface

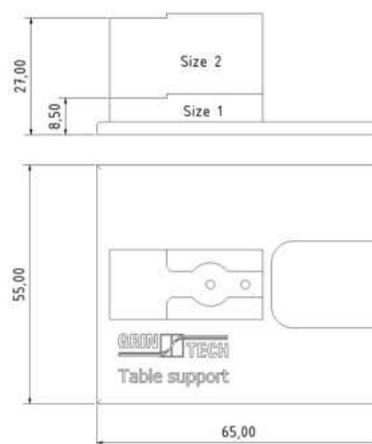


Tool - Table support



Applications and properties

- Table support for GRIN Lens Gripper
- for cleaning and inspection on table
- horizontal and vertical storage of the lens axis possible
- Shelf heights available in 8.5mm and 27mm from the table surface
- magnetic holder
- durable anodized aluminum surface

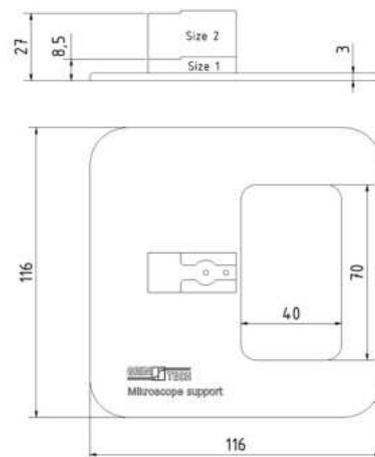


Tool - Microscope support

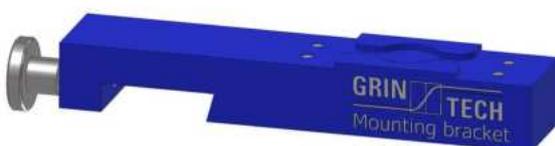


Applications and properties

- Microscope support for GRIN Lens Gripper
- for cleaning and inspection on Microscope
- horizontal and vertical storage of the lens axis possible
- Shelf heights available in 8.5mm and 27mm from the Support surface
- magnetic holder
- durable anodized aluminum surface

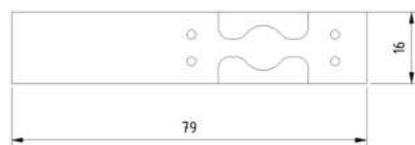


Tool Mounting Bracket



Applications and properties

- for mounting GRIN Lens Gripper on Newport ULTRAalign™ system
- measuring and inspection on Newport ULTRAalign™ system
- magnetic holder
- durable anodized aluminum surface



Small Size Laser-Optic Line Generator

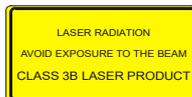
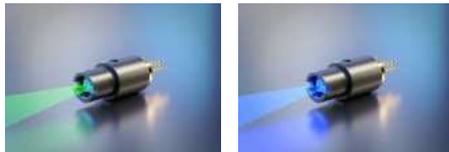
GRINTECH's Gradient-Index Micro-Optic Components with plane optical surfaces generate a homogeneous laser line from a Gaussian beam of a single-mode laser diode. The extraordinary small module size of $\varnothing 6.43 \text{ mm} \times 10.5 \text{ mm}$ and a weight of only 1.5 g are combined with a line uniformity of approx. $\pm 8\%$ and a diffraction-limited focus size.

Applications:

- 3D contour mapping
- Optical alignment
- Machine vision
- Biomedical

Standard Options:

- Line divergence (Fan angle): $\pm 10^\circ, \pm 15^\circ, \pm 20^\circ$ (see ordering information below)
- Line focus position can be specified between 80 mm and infinity (collimation) when ordering. Please see remarks below for focus size and depth of focus.
- Red laser diode: QDLaser – QLF063A-AA, $\lambda = 660 \text{ nm}$, $P_{LD} = 50 \text{ mW}$, TO-18 ($\varnothing 5.6 \text{ mm}$) package (driver on request)
520 nm and 450 nm wavelength – available on request
- Input laser beam specification for laser diodes TO-18:
Slow axis divergence: 9 deg. (+ 1.5 / - 0.5 deg.) @ FWHM

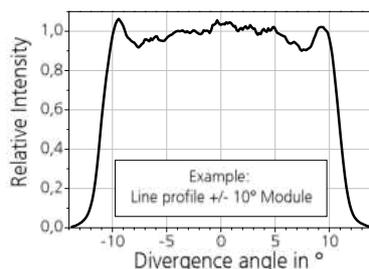


Environmental Specifications:

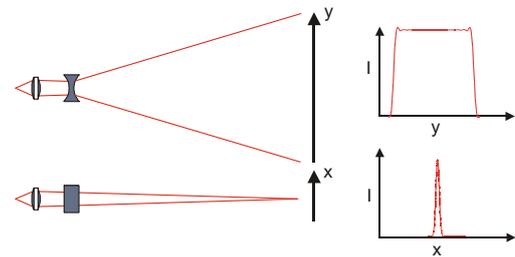
- Operating temperature: 0 ... 50°C
- Storage temperature: -20°C ... +70°C
- Resistance to vibrations: 2 g / 20 ... 500 Hz (acc. IEC68-2-6)
- Resistance to mechanical shock: 15 g / 6 ms (acc. IEC68-2-29)
- Laser safety class: depending on application and additional optics up to class 3B

Optical Specifications:

- Fan divergence angles : $\pm 10^\circ, \pm 15^\circ, \pm 20^\circ$
- Focus distance: 80 mm – infinity, Gaussian shape
- Line width in focus: FWHM/Distance = $0.60 \mu\text{m}/\text{mm}$,
Example: approx. 120 μm line width (FWHM) in 200 mm distance
- Far field divergence depending on line widths, approx. according to Gaussian beam laws
 - Squint angle: $\leq 2^\circ$
 - Transmission efficiency: $P_{out} / P_{LD} = 90 - 95\%$



Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

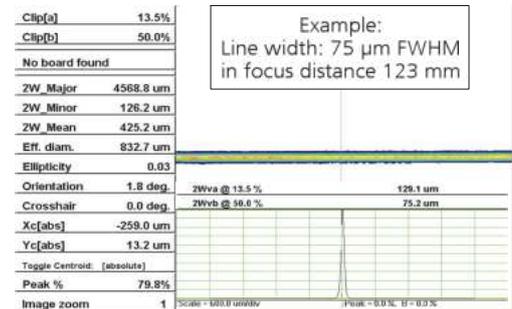
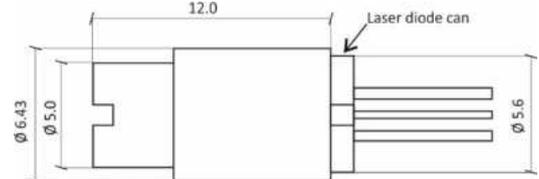


Mechanical Specifications:

- Weight: 1.5 g
- Dimensions version 1: $\varnothing 6.43 \text{ mm} \times 12.0 \text{ mm}$
- Dimensions version 2: $\varnothing 8.00 \text{ mm} \times 12.0 \text{ mm}$
- Package material: anodised aluminium



Dimensions Version 1:



Order example:

GT – LLGM – 643 – DA – FD	
GT	GRINTECH
LLGM	Laser Line Generator Modul
643	Diameter: 6.43 mm
DA	Divergence Angle: 10 for $\pm 10^\circ$ 15 for $\pm 15^\circ$ 20 for $\pm 20^\circ$
FD	Focus distance in mm (between 80mm and infinity)

Customization - GRIN Cylindrical Lenses

Applications:

- Fast Axis Collimation of High Power Laser Diode Bars
- High Brightness Diodes
- Beam Shaping Purposes

In addition to our standard products, GRINTECH offers GRIN cylindrical lenses according to customer specifications. Please ask us and let us know your requirements as detailed as possible (the closer we know your specifications the better we can advise you).

Working Distance (s): _____

Design wavelength: _____

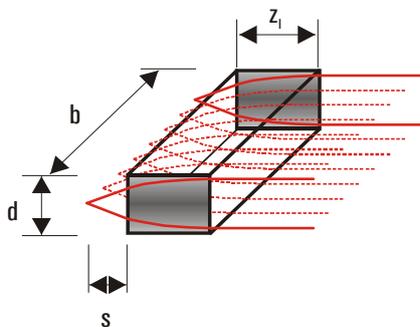
Lens length (z): _____

Width (b): _____

Coating: _____

Quantity: _____

Quantity: _____



Customization - GRIN Fiber Assemblies

Applications:

- Focussing Probes
- Collimators
- Fiber Coupling
- Fiber optical sensors

In addition to our standard products, GRINTECH offers fiber optic probes and assemblies according to customer specifications. Please ask us and let us know your requirements as detailed as possible (the closer we know your specifications the better we can advise you).

For the optical and mechanical design and the quotation we need at least the following information:

Fiber type:

for example: single mode, polarization maintaining, multimode, or special fiber
please specify operating wavelength (for SM, PM), core size (for MM)

Fiber length:

Connector:

FC/PC, FC/APC or other (please specify)

Design wavelength:

Diameter of the optical components:

0.5, 1.0 or 1.8 mm

Housing of the optical part:

none or stainless steel tube (please specify outer diameter and length of tubing)

Focusing probe:

please specify working distance / Spot size (diameter @1/e²)

Collimating probe:

please specify beam diameter (@1/e²)

Others:

For example: prism for side firing, 8° angled facet for reducing back reflections, AR coating, ...

Quantity:

Typical configurations:



GRIN-Lens Ø 1.80 mm
Stainless Steel Tube Ø 2.00 mm
Fiber



GRIN-Lens Ø 1.00 mm / Prism 1.00 mm
Stainless Steel Tube Ø 1.20 mm
Fiber



GRIN-Lens Ø 1.00 mm / Prism 1.00 mm
Stainless Steel Tube Front Ø 1.20 mm
Stainless Steel Tube Back
Fiber

Customization - GRIN Biophotonic Probes – Imaging Probes

Applications:

- Imaging Probes

In addition to our standard products, GRINTECH offers imaging fiber bundle assemblies with imaging micro-optics according to customer specifications.

Please ask us and let us know your requirements as detailed as possible (the closer we know your specifications the better we can advise you).

For the optical and mechanical design and the quotation we need at least the following information:

For Imaging Probes

Fiber bundle type (Fujikura):

FIGH-10-350S, FIGH-10-500N, FIGH-30-850N, **other**

Fiber bundle Length:

Connector:
none or FC/PC

Working distance:

Diameter of the optical components:

0.5 or 1.0 mm

Others:

For example: prism for side firing, ...

Quantity:

Typical configurations:



GRIN-Lens
Stainless Steel Tube
Imaging Fiber Bundle



GRIN-Lens
Prism
Stainless Steel Tube
Imaging Fiber Bundle

Customization - GRIN Biophotonic Probes – OCT/Focussing Probes

Applications:

- OCT / Focussing Probes

In addition to our standard products, GRINTECH offers fiber optic assemblies according to customer specifications. Please ask us and let us know your requirements as detailed as possible (the closer we know your specifications the better we can advise you).

For the optical and mechanical design and the quotation we need at least the following information:

For OCT / Focussing Probes

Fiber type:

single mode, polarization maintaining, or special fiber
please specify operating wavelength (for SM, PM)

Fiber length:

Connector:

FC/PC, FC/APC or other (please specify)

Design wavelength:

Diameter of the optical components:

0.5, 1.0 or 1.8 mm

Working distance / Spot size:

For spot size please specify diameter @1/e²

Housing of the optical part:

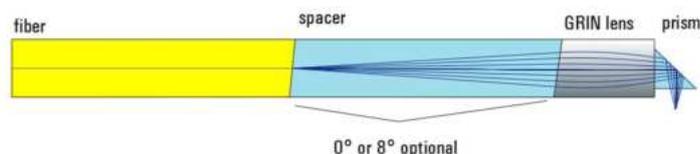
none or stainless steel tube (please specify outer diameter and length of tubing)

Others:

For example: prism for side firing, 8° angled facet for reducing back reflections, AR coating, ...

Quantity:

Typical configuration:



Development of Customized GRIN Systems

In addition to our standard products and customized systems, GRINTECH offers more sophisticated solutions as customized developments.

Please ask us and let us know your requirements as detailed as possible. The closer we know your specifications the better we can advise you.

Our development services include

- Zemax design studies
- Adaption of the refractive index profile (NA, higher order correction)
- Coatings (special AR coatings, beam splitting coatings, reflectivity coatings, ...)
- Stops (aperture and field stops)
- Chromatic corrections
- ...

The following examples show some customer inspired systems and may illustrate the possibilities.

Example configurations:



lens diameter: 1.0 mm / 2.0 mm,
with beam splitting cube



lens diameter: 2.0 mm,
with beam splitting cube and prism

Tolerances / Handling Instructions

Tolerances:

For of our single lenses we have the following fabrication tolerances and quality criteria:

Tolerances:	Surface quality:
lens length z_l : $\pm 5\%$ due to variations of the gradient constant	5 / 3 x 0.025; L 3 x 0.005; E 0
working distance s : ± 0.02 mm (only LFRL- and CFRL lens series)	(defined by DIN ISO 10110-7:2000-02).
diameter d : + 0 / -0.01 mm	The surface quality is defined within 90 % of the lens diameter.
- tighter diameter tolerances on request	Outside of this area defects are allowed.

Storage and Handling of Lenses

Storage

GRIN lenses and lens systems should be stored in a dry environment. For short term storage, the plastic box or foam packing in which the lenses are shipped will provide adequate storage.

Recommended storage temperature: -20°C - 80°C.

Storage boxes should ensure that the lenses do not touch each other to prevent chipping and scratches. Best is to use the original box.

Handling

Lenses should be carefully handled with plastic tweezers, preferably those with a tapered end. Lenses should be picked up out of their individual compartments by firmly holding each on its side cylinder surface (not the polished ends). Especially small sized lenses may stick to the lens box material and can be lost during removal.

Cleaning

If it is necessary to clean the lens surfaces due some dust or other contaminant which may impair the optical performance. GRINTECH generally recommends the use of ethyl alcohol as a cleaning solvent, maybe combined with some smooth lintfree lens cleaning tissue.

Acetone may also be used, but it should be pure enough, otherwise it might leave some residue on the lens surface.

Gradient Index (GRIN) Lenses

- GRIN rod lenses for fiber coupling
- GRIN cylindrical lenses for beam shaping of high power laser diode bars and high brightness diodes
- easy to assemble due to the plane surfaces
- good off- and on-axis performance
- non-toxic silver and lithium ion exchange

Gradient Index Optics

GRIN lenses represent an interesting alternative to conventional spherical lenses since the lens performance depends on a continuous change of the refractive index within the lens material. Instead of curved shaped surfaces only plane optical surfaces are used. The light rays are continuously bent within the lens until finally they are focussed on a spot.



Fig. 1 GRIN lens

Conventional spherical lens

The GRIN lenses are produced by silver ion exchange in a special glass. The composition of the glass is protected by a patent. In contrast to the conventionally used technology this is a non-toxic process and bears no health and environmental risks for both the producer as well as the user of these products. This process is performed in rods and slabs resulting in rod lenses and cylindrical lenses with plane optical surfaces.

A radial refractive index profile of nearly parabolic shape

$$n(r) = n_0 \operatorname{sech}(gr)$$

realizes a continuous cosine ray trace within a GRIN focussing lens, the period length z_{1-p} of the lens is given by

$$z_{1-p} = \frac{2\pi}{g}$$

and does not depend on the entrance height and the entrance angle of the light ray (see Fig 2). n_0 represents the refractive index at the center of the profile, r the radius and g the gradient constant.

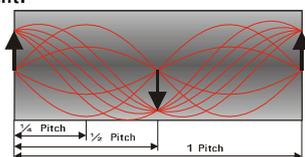


Fig. 2. Ray traces within a GRIN focussing lens of different pitch lengths

The geometrical length of the particular lens z_1 is calculated from the characteristic pitch of the lens P ,

$$z_1 = \frac{2\pi}{g} P$$

Various imaging designs can be realized using the same index profile by choosing different lens lengths:

A 1- (2, 3, or more, respectively)-pitch lens reproduces an object placed in the entrance surface of the lens identically into the exit surface.

A half-pitch lens images an object on the entrance surface inverted to the exit surface of the lens.

A quarter-pitch lens images a point source on the entrance surface of the lens into infinity or collimates it, respectively. This configuration is usually applied to the collimation of single-mode and multi-mode optical fibers and laser diodes.

A 0.23-pitch lens images a point source placed in the working distance s into infinity or collimates it (see Fig. 3).

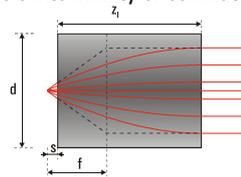


Fig. 3. GRIN rod lens

The geometrical gradient constant g and the lens length z_1 determines the focal length f and the working distance s of the lens,

$$f = \frac{1}{n_0 g \sin(gz_1)}, \quad s = \frac{1}{n_0 g \tan(gz_1)}$$

Various imaging problems can be solved by choosing different lens lengths z_1 (see Fig.4).

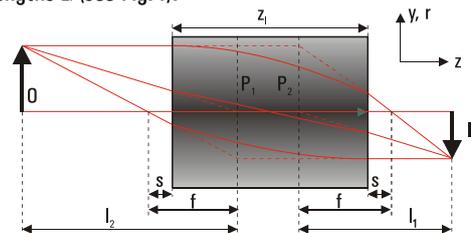


Fig. 4. Image formation by a GRIN focusing lens

The maximum acceptance angle of a GRIN collimating lens Θ is determined by the numerical aperture NA. As in fiber optics, it is derived from the maximum index change of the GRIN profile,

$$\sin(\Theta) = NA = \sqrt{n_0^2 - n_R^2} = n_0 \sqrt{1 - \operatorname{sech}^2(gd/2)}$$

n_R is the refractive index at the margin of the profile, and d is the lens diameter or the lens thickness, respectively.

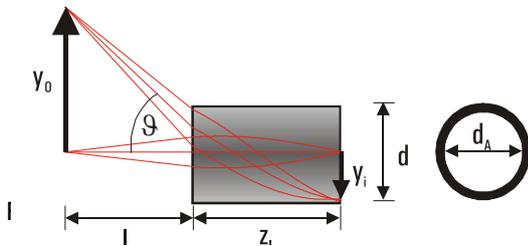
GRIN lenses with a high numerical aperture ($NA \approx 0.5$) are produced by silver ion exchange in a special glass which avoids any coloration in the visible spectral range. The absorption edge of the silver containing glass occurs at a wavelength of $\lambda_{0.5} = 370$ nm. GRIN lenses with low numerical aperture ($NA \leq 0.2$) are fabricated via lithium ion exchange. The absorption edge of the glass being used is at a wavelength of $\lambda_{0.5} = 235$ nm.

Gradient Index Imaging Optics

- GRIN rod lenses and systems
- endoscopic and other miniaturized imaging applications
- easy to assemble due to the plane surfaces
- good off- and on-axis performance
- AR-coating on both sides possible
- non-toxic silver and lithium ion exchange
- low chromatic aberration

GRIN Objective Design

GRINTECH objective lenses are produced by non-toxic silver ion exchange in glass and are suited for medical applications. The large view angle of 60 degrees ($\pm 30^\circ$) is obtained by a strong index change within the glass material. The objective lenses image the object plane in a working distance l (see Fig. 1) into the end surface of the lens on a reduced scale.

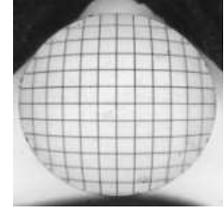
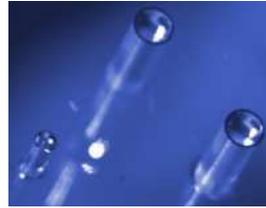


The lenses are specified by the rod diameter d and the working distance l (see the respective data sheet). The corresponding magnification M and the necessary lens length z_l are calculated by

$$M = \sqrt{\frac{1}{n_0^2 g^2 l^2 + 1}} ; z_l = \frac{\arctan(-n_0 l g) + \pi}{g},$$

where n_0 is the center index of the lens, and g is the gradient constant of the lens. For each diameter, g can be calculated by using the lens length of the respective lens type with infinite working distance,

$$g = \frac{\pi}{2z_l^{\text{inf}}}.$$



Beside standard working distances, customized lens designs can be provided on request.

The dispersion of the index gradient causes a relative change of the focal length as function of the wavelength. In the visible range, the focal length of lenses with NA of 0.5 increases by approx. 0.017 % per nm with rising wavelength. For objective lenses of 1.0 mm diameter, the image plane of the blue light part (440 nm) is located approx. 18 μm inside the lens. The image plane of the red light part (650 nm) is located approx. 18 μm outside the lens exit plane. For lenses of 0.5 mm diameter for example, half of these image shift values is valid.

GRINTECH objective lenses are characterized by a small field curvature. The image field is slightly bent inwards. For lenses of 1.0 mm diameter the field curvature is $-40 \mu\text{m}$ maximum at 90 % of the aperture, for 0.5 mm diameter $-20 \mu\text{m}$ maximum.

The barrel shaped distortion of the image increases up to approx. 14 % of the image height at the lens margin (see CCD-image above).

The resolution limit of the objective lenses is on-axis approx. 400 lines per mm in white light.

GRIN Imaging Systems

Complete imaging systems for endoscopes and other applications are fabricated by combining GRINTECH objective lenses, GRIN relay lenses of customized pitch lengths, and prisms. Please contact GRINTECH for customized solutions.

GRINTECH

Gradient Index Optics

GRIN Rod Lenses



Precision for every application

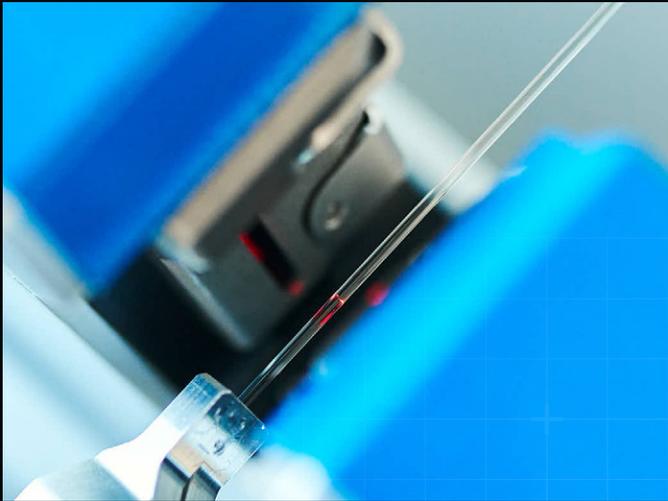
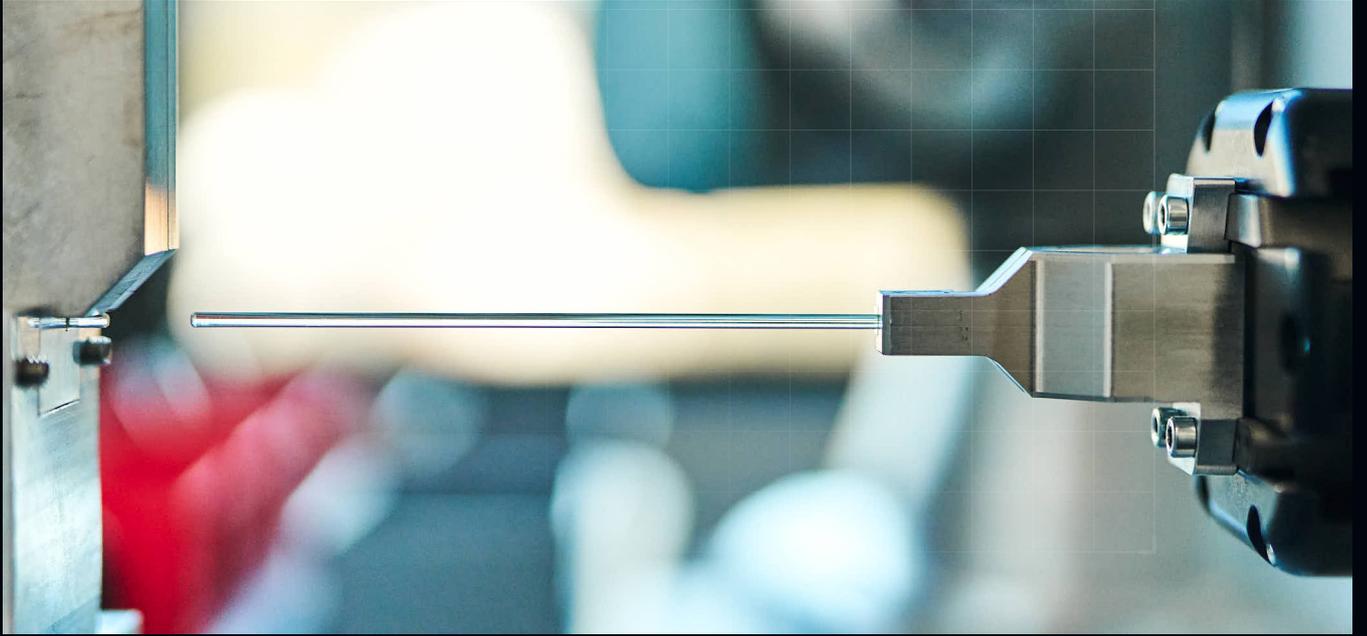
GRIN rod lenses are made of non-toxic glass material (biocompatibility according to EN ISO 10993-1). With standard diameters between 0.25 mm and 2.0 mm, they have plane surfaces and numerical apertures of 0.2 and 0.5. GRIN lenses with a numerical aperture (NA) of 0.5 are preferably used for fiber coupling and laser diode beam shaping. GRIN lenses with an NA of 0.2 have longer focal lengths and lens lengths. Optionally, we also offer these with better correction of spherical aberration (high performance).

GRIN objective lenses with viewing angles of $\pm 30^\circ$ are mainly used for endoscopic applications, e.g. in conjunction with image guide bundles or GRIN relay lenses.

Customizable at the customer's request

On request, the following are possible:

- Working distance and lens length changes
- Change of design wavelength
- Anti-reflective coatings
- 8° facet polishing
- Other diameters, e.g. 0.25, 0.35, 0.6 and 0.85 mm

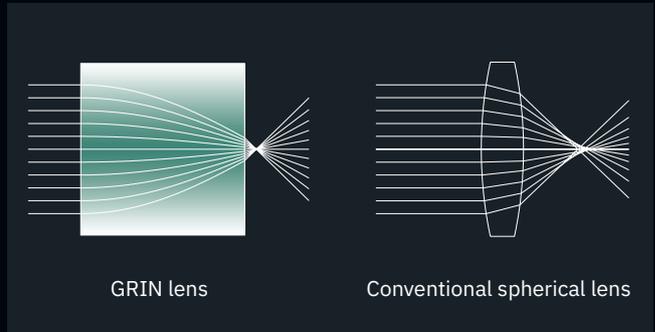


Gradient Index (GRIN) Lenses – An Introduction

GRIN lenses represent an interesting alternative to conventional spherical lenses since the lens performance depends on a continuous change of the refractive index within the lens material. Instead of curved shaped surfaces only plane optical surfaces are used. The light rays are continuously bent within the lens until finally they are focussed on a spot.

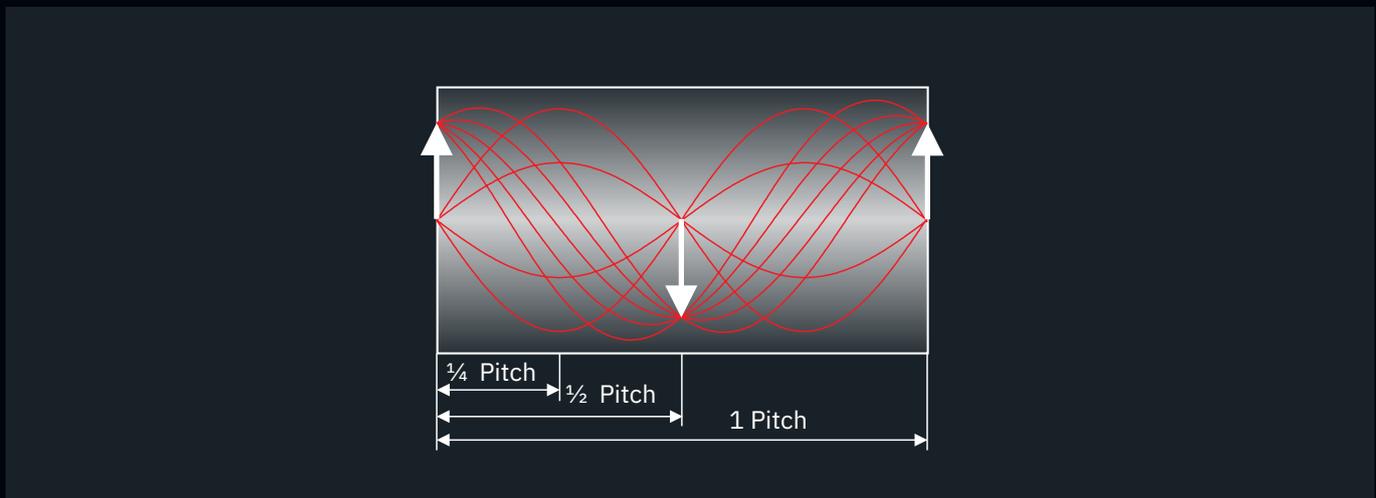
Types and Properties

- GRIN rod lenses for fiber coupling
- Easy to assemble due to the plane surfaces
- Good off- and on-axis performance
- Non-toxic silver and lithium ion exchange



The GRIN lenses are produced by silver ion exchange in a special glass. In contrast to the conventionally used technology this is a non-toxic process and bears no health and environmental risks for both the producer as well as the user of these products. This process is performed in rods (and can also be offered in slabs) resulting in rod lenses and optionally in cylindrical lenses with plane optical surfaces.

A radial refractive index profile of nearly parabolic shape $n(r) = n_0 \operatorname{sech}(gr)$ realizes a continuous cosine ray trace within a GRIN focussing lens, the period length z_{1-p} of the lens is given by $z_{1-p} = 2\pi/g$ and does not depend on the entrance height and the entrance angle of the light ray. n_0 represents the refractive index at the center of the profile, r the radius and g the gradient constant.



Ray traces within a GRIN focussing lens of different pitch lengths

The geometrical length of the particular lens z_l is calculated from the characteristic pitch of the lens P ,

$$z_l = \frac{2\pi}{g} P$$

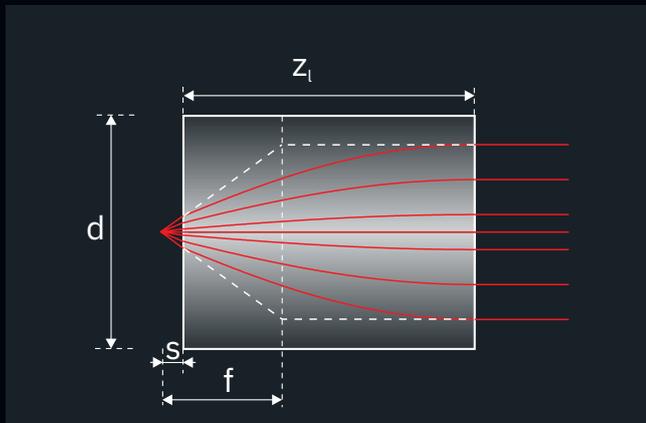
Various imaging designs can be realized using the same index profile by choosing different lens lengths:

A 1- (2, 3, or more, respectively)-pitch lens reproduces an object placed in the entrance surface of the lens identically into the exit surface.

A half-pitch lens images an object on the entrance surface inverted to the exit surface of the lens.

A quarter-pitch lens images a point source on the entrance surface into infinity or collimates it, respectively. This configuration is usually applied to the collimation of single-mode and multi-mode optical fibers and laser diodes.

A 0.23-pitch lens images a point source placed in the working distance s into infinity or collimates it.



GRIN rod lens

The geometrical gradient constant g and the lens length z_l determine the focal length f and the working distance s of the lens,

$$f = \frac{1}{n_0 g \sin(gz_l)} \quad , \quad s = \frac{1}{n_0 g \tan(gz_l)}$$

Various imaging problems can be solved by choosing different lens lengths z_l .

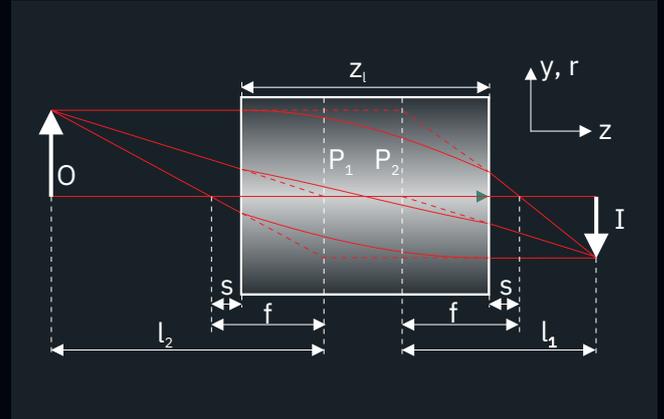


Image formation by a GRIN focusing lens

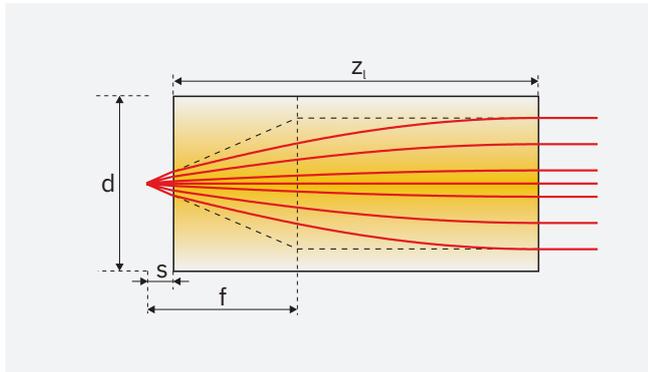
The maximum acceptance angle of a GRIN collimating lens ϑ is determined by the numerical aperture NA. As in fiber optics, it is derived from the maximum index change of the GRIN profile,

$$\sin(\vartheta) = NA = \sqrt{n_0^2 - n_R^2} = n_0 \sqrt{1 - \operatorname{sech}^2(gd/2)} \quad .$$

n_R is the refractive index at the margin of the profile, and d is the lens diameter or the lens thickness, respectively.

GRIN lenses with a high numerical aperture ($NA \approx 0.5$) are produced by silver ion exchange in a special glass which avoids any coloration in the visible spectral range. The absorption edge of the silver containing glass occurs at a wavelength of $\lambda_{0.5} = 370$ nm. GRIN lenses with low numerical aperture ($NA \leq 0.2$) are fabricated via lithium ion exchange. The absorption edge of the glass being used is at a wavelength of $\lambda_{0.5} = 235$ nm.

GRIN Rod Lenses – Numerical Aperture 0.5



Gradient index lenses for fiber coupling and beam shaping of laser diodes

- Working distance, design wavelength and lens length deviating from these standards are available on request
- 8° angled facet/ other diameters (0.25 mm, 0.35 mm, 0.60 mm and 0.85 mm) are available on request
- ZEMAX files can be downloaded from our website

Diameter d (mm)	Pitch P	Working distance s (mm)	Lens length z _l (mm)	Focal length f (mm)	Gradient constant g (mm ⁻¹)	Refractive index at the center of the profile n ₀	Wavelength λ (nm)	Product code
0.50	0.25	0	1.10	0.43	1.427	1.629	670	GT-LFRL-050-025-50-NC (670)
	0.25	0	1.11	0.44	1.418	1.624	810	GT-LFRL-050-025-50-NC (810)
	0.25	0	1.12	0.44	1.406	1.616	1550	GT-LFRL-050-025-50-NC (1550)
	0.23	0.06	1.00	0.44	1.427–1.406*	1.629–1.616*	670–1550	GT-LFRL-050-023-50-NC
1.00	0.25	0	2.26	0.89	0.695	1.629	670	GT-LFRL-100-025-50-NC (670)
	0.25	0	2.27	0.89	0.691	1.624	810	GT-LFRL-100-025-50-NC (810)
	0.25	0	2.29	0.91	0.685	1.616	1550	GT-LFRL-100-025-50-NC (1550)
	0.23	0.12–0.11*	2.07	0.90	0.695–0.685*	1.629–1.616*	670–1550	GT-LFRL-100-023-50-NC
1.80	0.25	0	4.34	1.70	0.362	1.629	670	GT-LFRL-180-025-50-NC (670)
	0.25	0	4.36	1.72	0.360	1.624	810	GT-LFRL-180-025-50-NC (810)
	0.25	0	4.40	1.74	0.357	1.616	1550	GT-LFRL-180-025-50-NC (1550)
	0.23	0.25–0.21*	3.98	1.74	0.362–0.357*	1.629–1.616*	670–1550	GT-LFRL-180-023-50-NC
2.00	0.25	0	4.92	1.93	0.319	1.629	670	GT-LFRL-200-025-50-NC (670)
	0.25	0	4.95	1.94	0.317	1.624	810	GT-LFRL-200-025-50-NC (810)
	0.25	0	4.99	1.97	0.314	1.616	1550	GT-LFRL-200-025-50-NC (1550)
	0.23	0.27–0.23*	4.53	1.96	0.319–0.314*	1.629–1.616*	670–1550	GT-LFRL-200-023-50-NC

* depending on wavelength

As standard, GRIN rod lenses are provided without antireflection (AR) coatings. However, AR coatings can be offered as described at the end of this brochure. Please find here also further important information on tolerances, handling, and cleaning.

GRIN Rod Lenses – Numerical Aperture 0.2

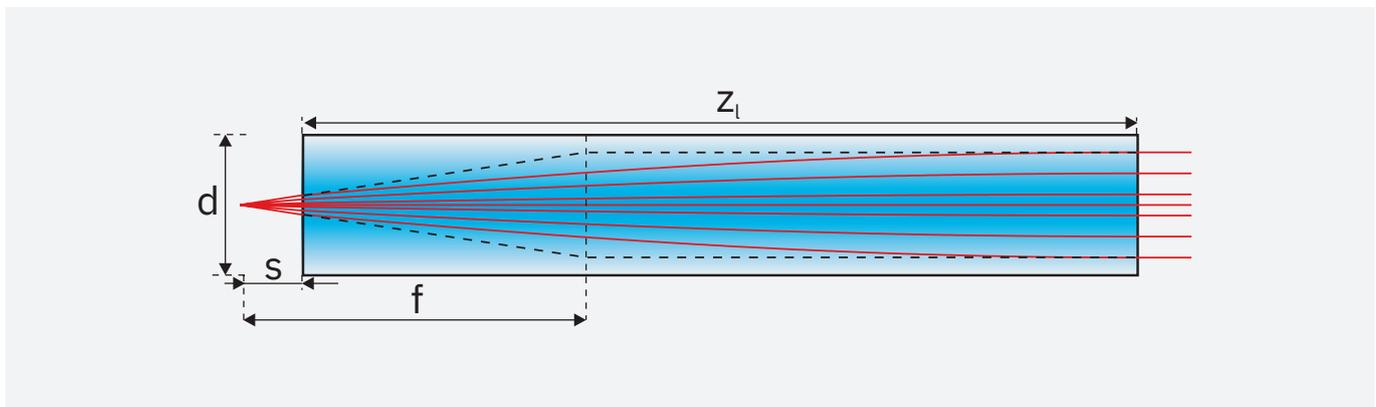
Gradient index lenses for fiber coupling and beam shaping of laser diodes with 0.2 NA. Two types of these lenses are offered: The **Standard LFRL**-type with first-order correction of spherical aberration is recommended for multimode beam applications. The **High-performance CFRL**-type with higher-order correction of spherical aberration is recommended for singlemode Gaussian beam applications ($M^2 \leq 1.1$).

- Working distance, design wavelength and lens length deviating from these standards are available on request
- Other diameters (0.25 mm and 0.35 mm) are available on request
- ZEMAX files can be downloaded from our website

Standard LFRL lenses – recommended for multimode applications

Diameter d (mm)	Pitch P	Working distance s (mm)	Numerical Aperture NA	Lens length z_l (mm)	Focal length f (mm)	Gradient constant g (mm ⁻¹)	Refractive index at the center of the profile n_0	Wave-length λ (nm)	Product code
0.50	0.25	0	0.20	3.05	1.28	0.515	1.524	670	GT-LFRL-050-025-20-NC (670)
	0.25	0	0.20	3.06	1.28	0.513	1.521	810	GT-LFRL-050-025-20-NC (810)
	0.25	0	0.19	3.16	1.32	0.497	1.515	1550	GT-LFRL-050-025-20-NC (1550)
	0.24	0.09–0.07*	0.19	3.06	1.33	0.515–0.497*	1.524–1.515*	670–1550	GT-LFRL-050-024-20-NC
1.00	0.25	0	0.20	6.12	2.56	0.260	1.524	670	GT-LFRL-100-025-20-NC (670)
	0.25	0	0.20	6.13	2.57	0.259	1.521	810	GT-LFRL-100-025-20-NC (810)
	0.25	0	0.19	6.32	2.65	0.248	1.515	1550	GT-LFRL-100-025-20-NC (1550)
	0.24	0.18–0.16*	0.19	6.08	2.68	0.260–0.248*	1.524–1.515*	670–1550	GT-LFRL-100-024-20-NC
1.80	0.25	0	0.20	11.15	4.66	0.141	1.524	670	GT-LFRL-180-025-20-NC (670)
	0.25	0	0.20	11.17	4.68	0.140	1.521	810	GT-LFRL-180-025-20-NC (810)
	0.25	0	0.19	11.38	4.78	0.138	1.515	1550	GT-LFRL-180-025-20-NC (1550)
	0.24	0.31–0.26*	0.19	10.99	4.79	0.141–0.138*	1.524–1.515*	670–1550	GT-LFRL-180-024-20-NC

* depending on wavelength



First order parameters of a GRIN lens with 0.2 NA: diameter, working distance, focal length, lens length.

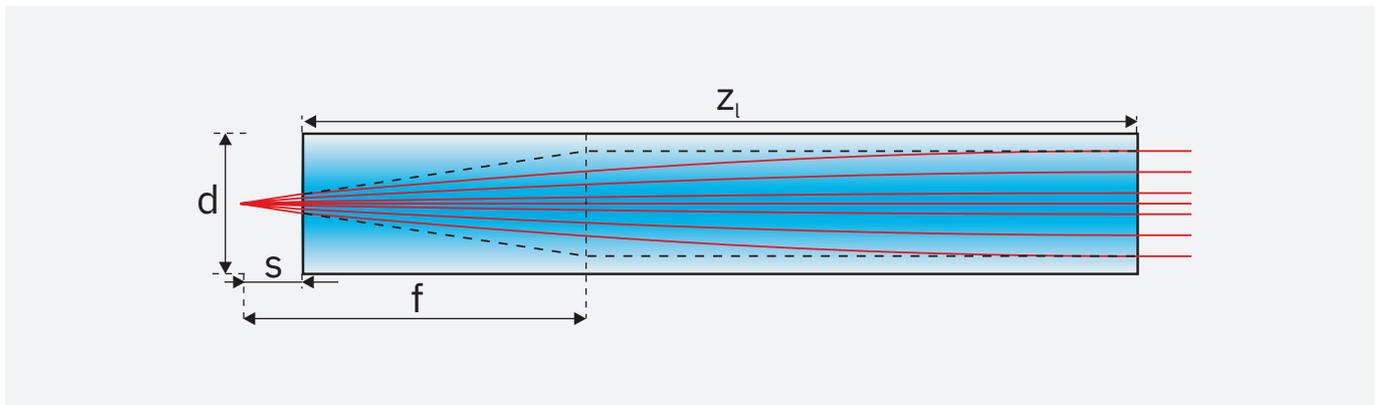
GRIN Rod lenses – Numerical Aperture 0.2

High-performance CFRL lenses – recommended for singlemode applications

Diameter d (mm)	Pitch P	Working distance s (mm)	Numerical Aperture NA	Lens length z_l (mm)	Focal length f (mm)	Gradient constant g (mm ⁻²)	Refractive index at the center of the profile n_0	Wave-length λ (nm)	Product code
1.00	0.25	0	0.20	6.04	2.52	0.260	1.524	670	GT-CFRL-100-025-20-NC (670)
	0.25	0	0.20	6.05	2.53	0.259	1.521	810	GT-CFRL-100-025-20-NC (810)
	0.25	0	0.19	6.32	2.65	0.248	1.515	1550	GT-CFRL-100-025-20-NC (1550)
	0.24	0.18–0.16*	0.19	6.08	2.66	0.260–0.258*	1.524–1.515*	670–1550	GT-CFRL-100-024-20-NC (1550)
1.80	0.25	0	0.19	11.06	4.62	0.141	1.524	670	GT-CFRL-180-025-20-NC (670)
	0.25	0	0.19	11.08	4.64	0.140	1.521	810	GT-CFRL-180-025-20-NC (810)
	0.25	0	0.19	11.38	4.78	0.138	1.515	1550	GT-CFRL-180-025-20-NC (1550)
	0.24	0.31–0.26*	0.19	10.99	4.79	0.141–0.138*	1.524–1.515*	670–1550	GT-CFRL-180-024-20-NC (1550)

* depending on wavelength

As standard, GRIN rod lenses are provided without antireflection (AR) coatings. However, AR coatings can be offered as described at the end of this brochure. Please find here also further important information on tolerances, handling, and cleaning.

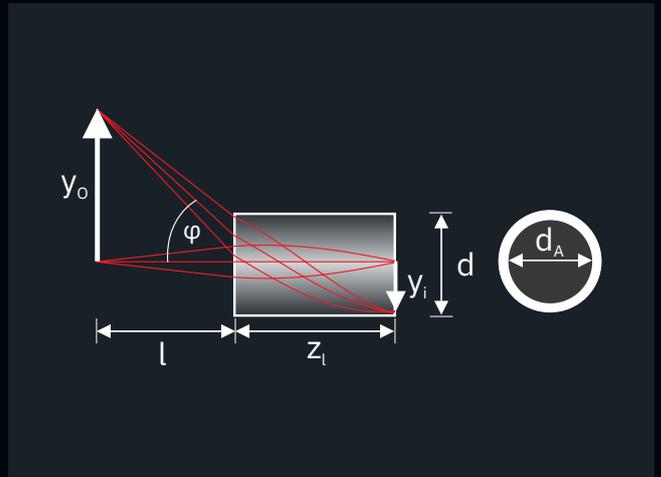


First order parameters of a GRIN lens with 0.2 NA: diameter, working distance, focal length, lens length.

Gradient Index Imaging Optics – An Introduction

Types and Properties

- GRIN rod lenses and systems
- Endoscopic and other miniaturized imaging applications
- Easy to assemble due to the plane surfaces
- Good off- and on-axis performance
- AR-coating on both sides possible
- Non-toxic silver and lithium ion exchange
- Low chromatic aberration



GRIN Objective Design

GRINTECH objective lenses are produced by non-toxic silver ion exchange in glass and are suited for medical applications. The large view angle of 60 degrees ($\pm 30^\circ$) is obtained by a strong index change within the glass material. The objective lenses image the object plane in a working distance l into the end surface of the lens on a reduced scale.

The lenses are specified by the rod diameter d and the working distance l (see the respective data sheet). The corresponding magnification M and the necessary lens length z_l are calculated by

$$M = \sqrt{\frac{1}{n_0^2 g^2 l^2 + 1}} ; z_l = \frac{\arctan(-n_0 l g) + \pi}{g} ,$$

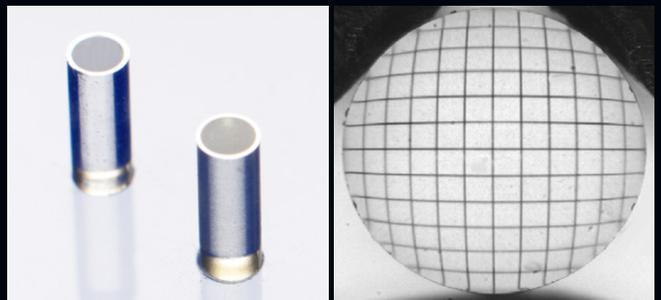
where n_0 is the center index of the lens, and g is the gradient constant of the lens. For each diameter, g can be calculated by using the lens length of the respective lens type with infinite working distance,

$$g = \frac{1}{2z_l^{inf}} .$$

Beside standard working distances, customized lens designs can be provided on request.

The dispersion of the index gradient causes a relative change of the focal length as function of the wavelength. In the visible range, the focal length of lenses with NA of 0.5 increases by approx. 0.017 % per nm with rising wavelength. For objective lenses of 1.0 mm diameter, the image plane of the blue light part (440 nm) is located approx. 18 μm inside the lens. The image plane of the red light part (650 nm) is located approx. 18 μm outside the lens exit plane. For lenses of 0.5 mm diameter for example, half of this image shift values is valid.

GRINTECH objective lenses are characterized by a small field curvature. The image field is slightly bent inwards. For lenses of 1.0 mm diameter the field curvature is – 40 μm maximum at 90% of the aperture, for 0.5 mm diameter – 20 μm maximum.



The barrel shaped distortion of the image increases up to approx. 14% of the image height at the lens margin (see CCD-image above).

The resolution limit of the objective lenses is on-axis approx. 400 lines per mm in white light.

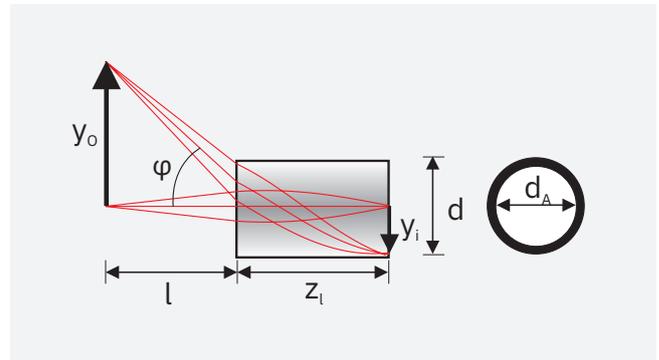
GRIN Imaging Systems

Complete imaging systems for endoscopes and other applications are fabricated by combining GRINTECH objective lenses, GRIN relay lenses of customized pitch lengths, and prisms. Please contact GRINTECH for customized solutions.

GRIN Objective Lenses for Endoscopy

Gradient index lenses for endoscopic imaging optics

- Non-toxic silver-based glass material
- View angle φ +/- 30° (numerical aperture 0.5)
- Plane surfaces, low chromatic aberration
- Combination with prisms and beam splitter cubes on request
- Aperture and field stops (black chromium coating ring on lens surface generated by photolithography) are available on request
- Certification: Biological safety – toxicology (EN ISO 10993-1)
- Design wavelength: 570 nm



Diameter d (mm)	Working distance s (mm)	Lens length z_l (mm)	Parax. Magnification $M = y_o/y_i$	Refractive index at the center of the profile n_0	Product code
2.0	Infinity	4.86	—	1.635	GT-IFRL-200-inf-50-NC
	20	5.14	-10.56	1.635	GT-IFRL-200-020-50-NC
	10	5.42	-5.35	1.635	GT-IFRL-200-010-50-NC
	5	5.94	-2.81	1.635	GT-IFRL-200-005-50-NC
1.8	Infinity	4.29	—	1.635	GT-IFRL-180-inf-50-NC
	20	4.51	-11.94	1.635	GT-IFRL-180-020-50-NC
	10	4.72	-6.04	1.635	GT-IFRL-180-010-50-NC
	5	5.14	-3.14	1.635	GT-IFRL-180-005-50-NC
1.0	Infinity	2.23	—	1.635	GT-IFRL-100-inf-50-NC
	20	2.29	-22.85	1.635	GT-IFRL-100-020-50-NC
	10	2.35	-11.46	1.635	GT-IFRL-100-010-50-NC
	5	2.47	-5.80	1.635	GT-IFRL-100-005-50-NC
0.85	Infinity	1.89	—	1.635	GT-IFRL-085-inf-50-NC
	10	1.96	-13.61	1.635	GT-IFRL-085-010-50-NC
	5	2.05	-6.86	1.635	GT-IFRL-085-005-50-NC
0.6	Infinity	1.31	—	1.635	GT-IFRL-060-inf-50-NC
	10	1.35	-19.47	1.635	GT-IFRL-060-010-50-NC
	5	1.39	-9.77	1.635	GT-IFRL-060-005-50-NC
0.5	Infinity	1.09	—	1.635	GT-IFRL-050-inf-50-NC
	10	1.12	-23.47	1.635	GT-IFRL-050-010-50-NC
	5	1.14	-11.77	1.635	GT-IFRL-050-005-50-NC
0.35	5	0.80	-16.67	1.635	GT-IFRL-035-005-50-NC
0.25	5	0.56	-23.16	1.635	GT-IFRL-025-005-50-NC

General Information & Customization

- Working distance and lens length deviating from these standards are available on request
- ZEMAX files can be downloaded from our website
- As standard, GRIN rod lenses are provided without antireflection (AR) coatings. However, AR coatings can be offered as described at the end of this brochure. Please find here also further important information on tolerances, handling, and cleaning.

Coating Options

GRIN rod lenses are produced without antireflection coatings as standard. Antireflection coatings (for incidence angles of 0°–30° corresponding to measurements on a reference substrate) can be offered:

Coating Code:

NC: no coating (reflection loss approx. 12%) – standard

C1: $\lambda = 400 \dots 700 \text{ nm}$, $R < 1.0\%$

C2: $\lambda = 800 \dots 1000 \text{ nm}$, $R < 0.5\%$

C5: $\lambda = 1310 \dots 1550 \text{ nm}$, $R < 0.5\%$

One - sided coatings are available on request. Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

If AR coating is needed, please replace in the product code NC by C1, C2 or C5.

Please note our partnership with Inscopix as our exclusive distributor for the field of neuroscience applications in non-humans. If you wish to order GRIN lenses of this brochure for these applications, please visit www.inscopix.com or contact order.inscopix@bruker.com.

Tolerances and Handling Instructions

For our single lenses we have the following fabrication tolerances and quality criteria:

Tolerances

- Lens length z : $\pm 5\%$ due to variations of the gradient constant
- Working distance s : $\pm 0.02 \text{ mm}$ (only LFRL- and CFRL lens series)
- Diameter d : $+0 / -0.01 \text{ mm}$
- Tighter diameter tolerances on request

Surface quality

- $5/3 \times 0.025$; $L 3 \times 0.005$; $E 0$ (defined by DIN ISO 10110-7:2000-02).
- The surface quality is defined within 90% of the lens diameter. Outside of this area defects are allowed.

Storage

GRIN lenses and lens systems should be stored in a dry environment. For short term storage, the plastic box or foam packing in which the lenses are shipped will provide adequate storage. Recommended storage temperature: $-20^\circ\text{C} - 80^\circ\text{C}$.

Storage boxes should ensure that the lenses do not touch each other to prevent chipping and scratches. Best is to use the original box.

Handling

Lenses should be carefully handled with plastic tweezers, preferably those with a tapered end. Lenses should be picked up out of their individual compartments by firmly holding each on its side cylinder surface (not the polished ends). Especially small sized lenses may stick to the lens box material and can be lost during removal.

Cleaning

If it is necessary to clean the lens surfaces due some dust or other contaminant which may impair the optical performance. GRINTECH generally recommends the use of ethyl alcohol as a cleaning solvent, maybe combined with some smooth lintfree lens cleaning tissue.

Acetone may also be used, but it should be pure enough, otherwise it might leave some residue on the lens surface.

GRINTECH

Gradient Index Optics

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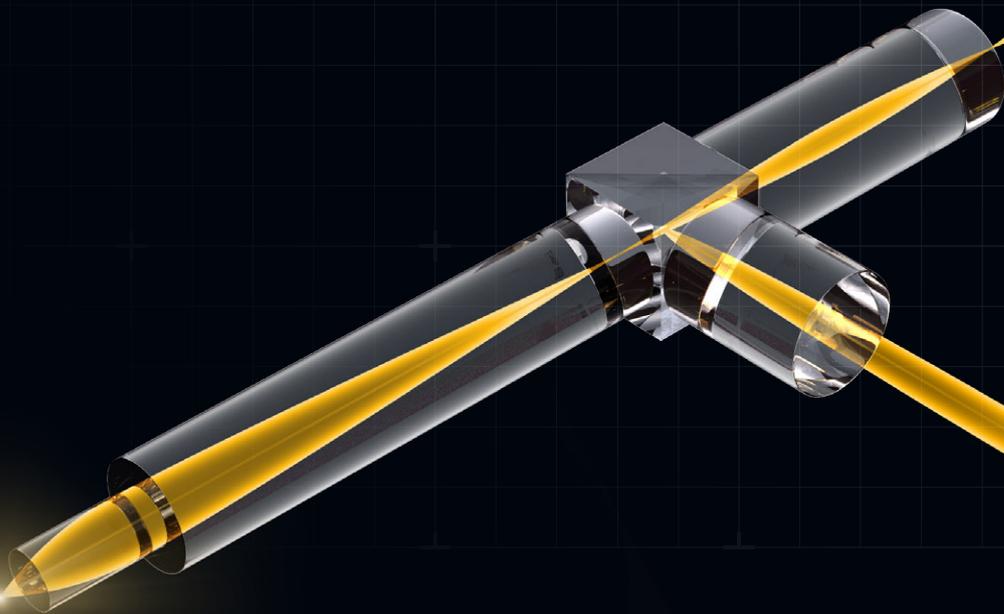
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GRINTECH

Gradient Index Optics

GRIN Assemblies for Imaging



Precision for every application

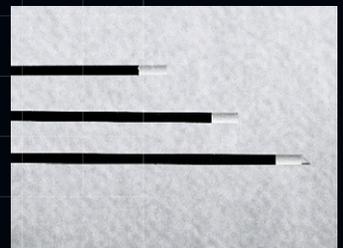
Endoscopic assemblies often consist of biocompatible GRIN objective lenses and other micro-optical components such as GRIN relay lenses, image-guiding fiber bundles, prisms and beam splitters.

- GRIN objective lenses are made of non-toxic glass material (biocompatibility according to EN ISO 10993-1). With standard diameters between 0.25 and 2.0 mm, they have plane optical end faces. GRIN objective lenses with viewing angles of +/- 30° are mainly used for endoscopic applications
- In endoscopic assemblies, GRIN objective lenses produce a reduced intermediate image in the size of the lens diameter, which is transmitted over longer distances with relay lenses. Optical design files (ZEMAX) are available on request.
- We offer customer-specific assemblies made of GRIN lenses with image-guiding fiber bundles

Customizable at the customer's request

On request, the following are possible:

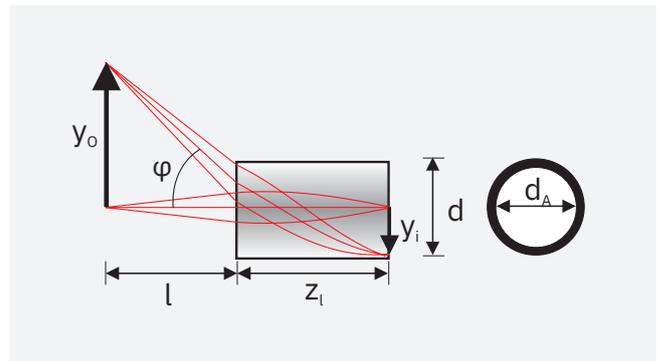
- Working distance and lens length changes
- Design wavelength change
- Photolithographically generated apertures on GRIN end faces



GRIN Objective Lenses for Endoscopy

Gradient index lenses for endoscopic imaging optics

- Non-toxic silver-based glass material
- View angle φ +/- 30° (numerical aperture 0.5)
- Plane surfaces, low chromatic aberration
- Combination with prisms and beam splitter cubes on request
- Aperture and field stops (black chromium coating ring on lens surface generated by photolithography) are available on request
- Certification: Biological safety – toxicology (EN ISO 10993-1)
- Design wavelength: 570 nm



Diameter d (mm)	Working distance s (mm)	Lens length z_l (mm)	Parax. Magnification $M = y_o/y_i$	Refractive index at the center of the profile n_o	Product code
2.0	Infinity	4.86	—	1.635	GT-IFRL-200-inf-50-NC
	20	5.14	-10.56	1.635	GT-IFRL-200-020-50-NC
	10	5.42	-5.35	1.635	GT-IFRL-200-010-50-NC
	5	5.94	-2.81	1.635	GT-IFRL-200-005-50-NC
1.8	Infinity	4.29	—	1.635	GT-IFRL-180-inf-50-NC
	20	4.51	-11.94	1.635	GT-IFRL-180-020-50-NC
	10	4.72	-6.04	1.635	GT-IFRL-180-010-50-NC
	5	5.14	-3.14	1.635	GT-IFRL-180-005-50-NC
1.0	Infinity	2.23	—	1.635	GT-IFRL-100-inf-50-NC
	20	2.29	-22.85	1.635	GT-IFRL-100-020-50-NC
	10	2.35	-11.46	1.635	GT-IFRL-100-010-50-NC
	5	2.47	-5.80	1.635	GT-IFRL-100-005-50-NC
0.85	Infinity	1.89	—	1.635	GT-IFRL-085-inf-50-NC
	10	1.96	-13.61	1.635	GT-IFRL-085-010-50-NC
	5	2.05	-6.86	1.635	GT-IFRL-085-005-50-NC
0.6	Infinity	1.31	—	1.635	GT-IFRL-060-inf-50-NC
	10	1.35	-19.47	1.635	GT-IFRL-060-010-50-NC
	5	1.39	-9.77	1.635	GT-IFRL-060-005-50-NC
0.5	Infinity	1.09	—	1.635	GT-IFRL-050-inf-50-NC
	10	1.12	-23.47	1.635	GT-IFRL-050-010-50-NC
	5	1.14	-11.77	1.635	GT-IFRL-050-005-50-NC
0.35	5	0.80	-16.67	1.635	GT-IFRL-035-005-50-NC
0.25	5	0.56	-23.16	1.635	GT-IFRL-025-005-50-NC

General Information & Customization

- Working distance and lens length deviating from these standards are available on request
- ZEMAX files can be downloaded from our website
- As standard, GRIN rod lenses are provided without antireflection (AR) coatings. However, AR coatings can be offered as described at the end of this brochure. Please find here also further important information on tolerances, handling, and cleaning.

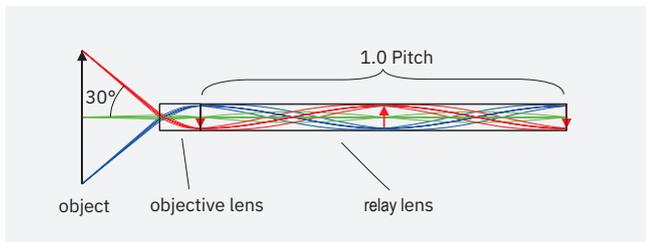
GRIN Endoscopic Rod Lens Systems

GRIN endoscopic systems consist of a GRIN objective lens, a GRIN relay lens and a GRIN eyepiece. Combining the system with a prism enables the change of the direction of view. Standard diameters are 0.35, 0.5, 1.0 und 2.0 mm. We offer the systems in two different principle design options.

Design A

The objective lens creates a reduced intermediate image at the exit surface of the objective lens, which will be imaged by the relay lens 1:1 (if the lens length of the relay lens is a multiple of the period) or -1:1 (if the lens length of the relay lens is an odd multiple of the half period) to the exit surface of the relay lens.

- possible standard working distances: for 0.35 mm diameter: 5 mm, for 0.5 to 2.0 mm diameter: 5 mm, 10 mm and infinity. Other working distances on request.



Schematic view design A

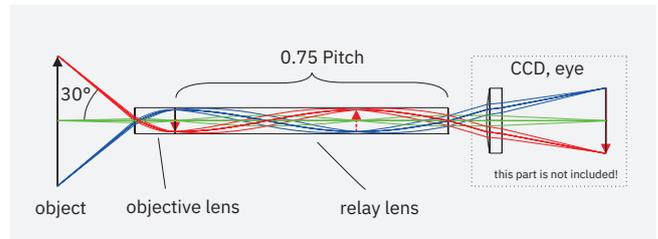
Possible Pitch Lengths:

Diameter d (mm)	Relay pitch	System length (mm)	Image orientation
0.35	0.5	approx. 8.2	inverted to design A
	1.0	approx. 15.7	like design A
	1.5	approx. 23.1	inverted to design A
0.50	0.5	approx. 16.3	inverted to design A
	1.0	approx. 31.4	like design A
	1.5	approx. 46.5	inverted to design A
1.00	0.5	approx. 24.7	inverted to design A
	1.0	approx. 47.0	like design A
	1.5	approx. 69.4	inverted to design A
2.00	0.5	approx. 55.5	inverted to design A
	1.0	approx. 105.8	like design A
	1.5	approx. 156.0	inverted to design A

Design B

The objective lens creates a reduced intermediate image at the exit surface of the objective lens, which will be imaged by the relay lens at infinity. Such a lens system is a complete endoscopic imaging system. It allows the direct observation with the human eye or the use of a conventional camera system (including camera lens): camera and camera lens are not provided by GRINTECH.

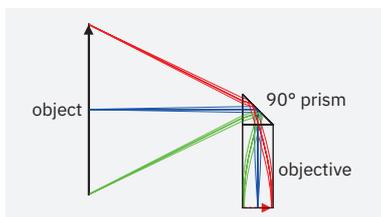
- possible standard working distances: for 0.35 mm diameter: 5 mm, for 0.5 to 2.0 mm diameter: 5 mm, 10 mm and infinity. Other working distances on request.



Schematic view design B

Possible Pitch Lengths:

Diameter d (mm)	Relay pitch	System length (mm)	Image orientation
0.35	0.75	approx. 12.0	like design B
	1.25	approx. 19.4	inverted to design B
	1.75	approx. 26.9	like design B
0.50	0.75	approx. 23.8	like design B
	1.25	approx. 38.9	inverted to design B
	1.75	approx. 54.0	like design B
1.00	0.75	approx. 35.9	like design B
	1.25	approx. 58.2	inverted to design B
	1.75	approx. 80.6	like design B
2.00	0.75	approx. 80.7	like design B
	1.25	approx. 130.9	inverted to design B



90° Change of view

Both versions are available with a 90° change of view by attaching a prism to the objective.

Customization – GRIN Biophotonic Probes – Imaging Probes

In addition to our standard products, GRINTECH offers imaging fiber bundle assemblies with imaging micro-optics according to customer specifications. Please ask us and let us know your requirements as detailed as possible (the closer we know your specifications the better we can advise you).

Applications

- Imaging Probes
- Confocal endoscopy
- Microscopic endoscopy
- Endoscopy
- Multimodal endomicroscopy

For the optical and mechanical design and the quotation we need at least the following information:

- Fiber bundle type (Fujikura): FIGH-10-350S, FIGH-10-500N, FIGH-30-850N, other
- Fiber bundle length
- Connector: none or FC/PC
- Working distance
- Diameter of the optical components: 0.5 or 1.0 mm
- Further information or specification: For example: prism for side firing, or other.
- Quantity

Typical Configurations:



GRIN-lens assembly in stainless steel tube with imaging fiber bundle



GRIN-lens prism assembly in stainless steel tube with imaging fiber bundle

Development of Customized GRIN Systems

In addition to our standard products and customized systems, GRINTECH offers more sophisticated solutions as customized developments.

Please ask us and let us know your requirements as detailed as possible. The closer we know your specifications the better we can advise you.

The following examples show some customer inspired systems and may illustrate the possibilities.

Our development services include:

- Zemax design studies
- Adaption of the refractive index profile: NA, higher order correction
- Coatings: special AR coatings, beam splitting coatings, reflectivity coatings, etc.
- Stops: aperture and field stops
- Chromatic corrections

Example Configurations:



GRIN lens assemblies with beam splitter cubes, GRIN diameters: 1.0, 1.8 and 2.0 mm in these examples.

Coating Options

GRIN rod lenses are produced without antireflection coatings as standard. Antireflection coatings (for incidence angles of 0°–30° corresponding to measurements on a reference substrate) can be offered for several GRIN lens geometries, except on GRIN relay lenses

Coating Code:

NC: no coating (reflection loss approx. 12%) – standard

C1: $\lambda = 400 \dots 700 \text{ nm}$, $R < 1.0\%$

C2: $\lambda = 800 \dots 1000 \text{ nm}$, $R < 0.5\%$

C5: $\lambda = 1310 \dots 1550 \text{ nm}$, $R < 0.5\%$

One-sided coatings are available on request. Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

Please note our partnership with Inscopix as our exclusive distributor for the field of neuroscience applications in non-humans. If you wish to order GRIN lenses of this brochure for these applications, please visit www.inscopix.com or contact order.inscopix@bruker.com.

Tolerances and Handling Instructions

For our singlet lenses we have the following fabrication tolerances and quality criteria:

Tolerances

- Lens length z_L : $\pm 5\%$ due to variations of the gradient constant
- Working distance s : $\pm 0.02 \text{ mm}$ (only LFRL- and CFRL lens series)
- Diameter d : $+0/-0.01 \text{ mm}$
- Tighter diameter tolerances on request

Surface quality

- $5/3 \times 0.025$; $L 3 \times 0.005$; $E 0$ (defined by DIN ISO 10110-7:2000-02).
- The surface quality is defined within 90% of the lens diameter. Outside of this area defects are allowed.

Storage

GRIN lenses and lens systems should be stored in a dry environment. For short term storage, the plastic box or foam packing in which the lenses are shipped will provide adequate storage. Recommended storage temperature: $-20^\circ\text{C} - 80^\circ\text{C}$.

Storage boxes should ensure that the lenses do not touch each other to prevent chipping and scratches. Best is to use the original box.

Handling

Lenses should be carefully handled with plastic tweezers, preferably those with a tapered end. Lenses should be picked up out of their individual compartments by firmly holding each on its side cylinder surface (not the polished ends). Especially small sized lenses may stick to the lens box material and can be lost during removal.

Cleaning

If it is necessary to clean the lens surfaces due some dust or other contaminant which may impair the optical performance. GRINTECH generally recommends the use of ethyl alcohol as a cleaning solvent, maybe combined with some smooth lintfree lens cleaning tissue.

Acetone may also be used, but it should be pure enough, otherwise it might leave some residue on the lens surface.

GRINTECH

Gradient Index Optics

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Daejeon 34071 Republic of Korea

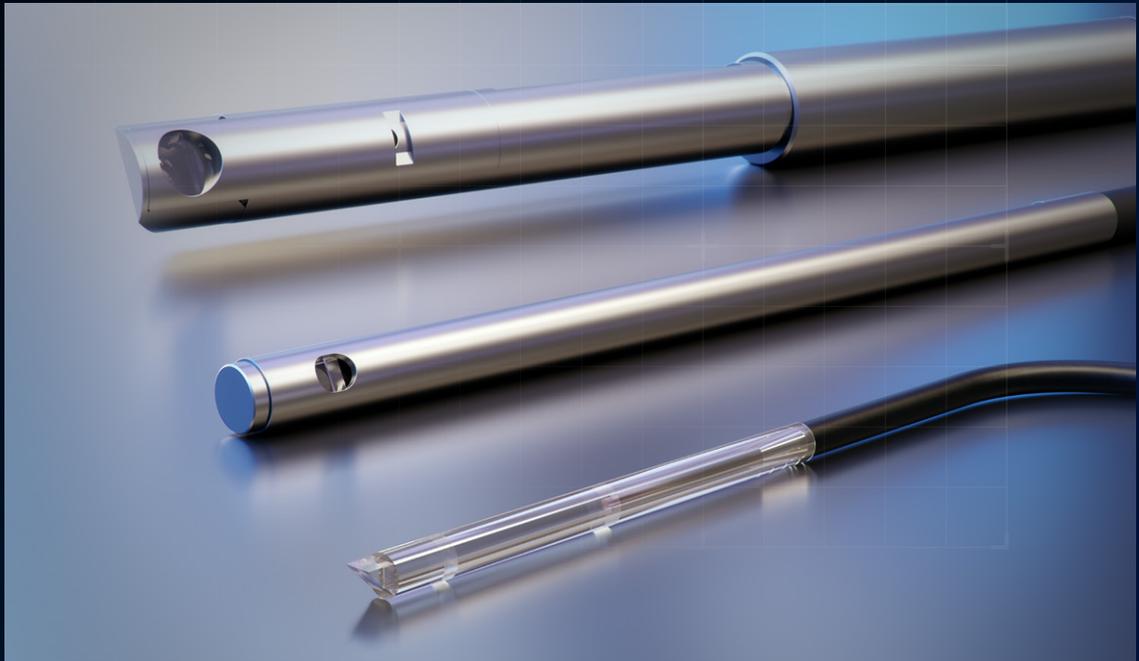
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GRINTECH

Gradient Index Optics

Fiber-Optic Modules



Precision for every application

Due to their **plano-optical end-faces**, GRIN lenses are often combined with other plano-optical components, such as prisms, optical fibers and beam splitters, to form fiber-optic modules for **optical non-contact sensor technology** and **biophotonics**.

- **Measurement principles** include **white light interferometry, OCT, or the confocal chromatic concept** (exclusive to Micro-Epsilon Messtechnik) and various **spectroscopy methods**
- In accordance with the customer's specifications, we develop optical and mechanical designs that are perfectly adapted to the application
- Spot sizes, working distances, numerical apertures, as well as specifically scaled chromatic aberration are typical parameters that we design according to your specifications.
- In addition to GRIN lenses, optical concepts also include refractive spherical and aspherical as well as diffractive elements.
- Our services include optical design including tolerance analysis, mechanical design, optics and mechanical production, assembly, qualification of the modules, as well as application and climate tests

We invite you to send us your needs to info@grintech.de. Please see a selection of questions on following pages which typically arise to develop a project.



Coating Options

GRIN rod lenses are produced without antireflection coatings as standard. Antireflection coatings (for incidence angles of 0°–30° corresponding to measurements on a reference substrate) can be offered for several GRIN lens geometries, except on GRIN relay lenses

Coating Code:

NC: no coating (reflection loss approx. 12%) – standard

C1: $\lambda = 400 \dots 700 \text{ nm}$, $R < 1.0\%$

C2: $\lambda = 800 \dots 1000 \text{ nm}$, $R < 0.5\%$

C5: $\lambda = 1310 \dots 1550 \text{ nm}$, $R < 0.5\%$

One-sided coatings are available on request, as well as custom beam splitter coatings (special reflectivity, dichroic or polarizing). Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

Please note our partnership with Inscopix as our exclusive distributor for the field of neuroscience applications in non-humans. If you wish to order GRIN lenses of this brochure for these applications, please visit www.inscopix.com or contact order.inscopix@bruker.com.

Tolerances and Handling Instructions

For our single lenses we have the following fabrication tolerances and quality criteria:

Tolerances

- Lens length z : $\pm 5\%$ due to variations of the gradient constant
- Working distance s : $\pm 0.02 \text{ mm}$ (only LFRL- and CFRL lens series)
- Diameter d : $+0/-0.01 \text{ mm}$
- Tighter diameter tolerances on request

Surface quality

- $5/3 \times 0.025$; $L 3 \times 0.005$; $E 0$ (defined by DIN ISO 10110-7:2000-02).
- The surface quality is defined within 90% of the lens diameter. Outside of this area defects are allowed.

Storage

GRIN lenses and lens systems should be stored in a dry environment. For short term storage, the plastic box or foam packing in which the lenses are shipped will provide adequate storage. Recommended storage temperature: $-20^\circ\text{C} - 80^\circ\text{C}$.

Storage boxes should ensure that the lenses do not touch each other to prevent chipping and scratches. Best is to use the original box.

Handling

Lenses should be carefully handled with plastic tweezers, preferably those with a tapered end. Lenses should be picked up out of their individual compartments by firmly holding each on its side cylinder surface (not the polished ends). Especially small sized lenses may stick to the lens box material and can be lost during removal.

Cleaning

If it is necessary to clean the lens surfaces due some dust or other contaminant which may impair the optical performance. GRINTECH generally recommends the use of ethyl alcohol as a cleaning solvent, maybe combined with some smooth lintfree lens cleaning tissue.

Acetone may also be used, but it should be pure enough, otherwise it might leave some residue on the lens surface.

Customization – GRIN Fiber Optic Modules

In addition to our standard products, GRINTECH offers fiber optic probes and assemblies according to customer specifications. Please ask us and let us know your requirements as detailed as possible (the closer we know your specifications the better we can advise you).

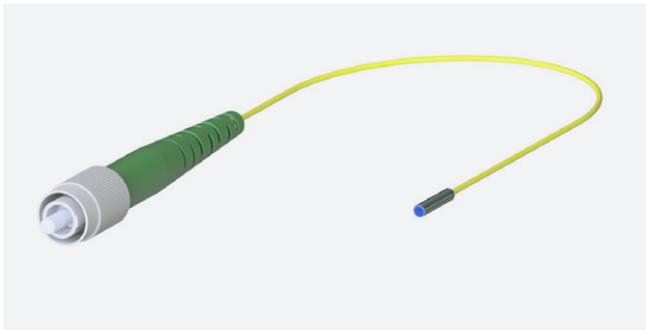
Applications

- Focusing Probes
- Collimators
- Fiber Coupling
- Fiber optical sensors

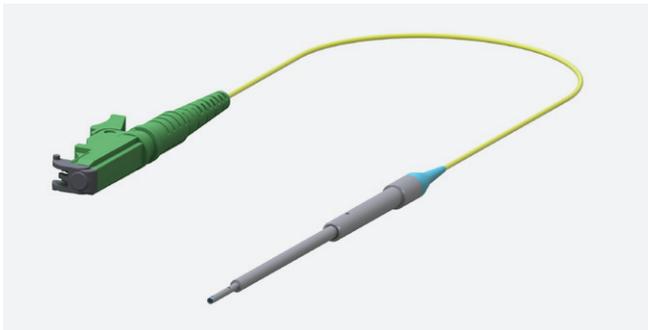
For the optical and mechanical design and the quotation we need at least the following information:

- Fiber type: single mode (SM), polarization maintaining (PM), multimode (MM), or special fiber. Please specify operating wavelength (for SM, PM), core size and numerical aperture (for MM)
- Fiber Length
- Connector: FC/PC, FC/APC , E2000, F3000, ST, SMA or other (please specify)
- Design wavelength
- Diameter of the optical components: 0.5, 1.0 or 1.8 mm
- Housing of the optical part: none or stainless steel tube (please specify outer diameter and length of tubing)
- Focusing probe: please specify working distance / Spot size (diameter @ $1/e^2$)
- Collimating probe: please specify beam diameter (@ $1/e^2$)
- Further information or specification: For example: prism for side firing, 8° angled facet for reducing back reflections, AR coating, etc.
- Quantity

Examples of typical configurations



GRIN-Lens Ø 1.80 mm connected to optical fiber in a stainless steel tube of 2 mm diameter, with FC/APC connector



Fiber-optic probe with 1.2 mm stainless steel tip, with E2000 connector



Fiber-optic assembly of 1.0 mm GRIN-lens with 90° prism, mounted in 1.2 mm stainless steel tube, fiber in 0.9 mm tubing with FC-connector

Customization – GRIN Biophotonic Probes – OCT/ Focussing Probes

In addition to our standard products, GRINTECH offers fiber optic assemblies according to customer specifications. Please ask us and let us know your requirements as detailed as possible (the closer we know your specifications the better we can advise you).

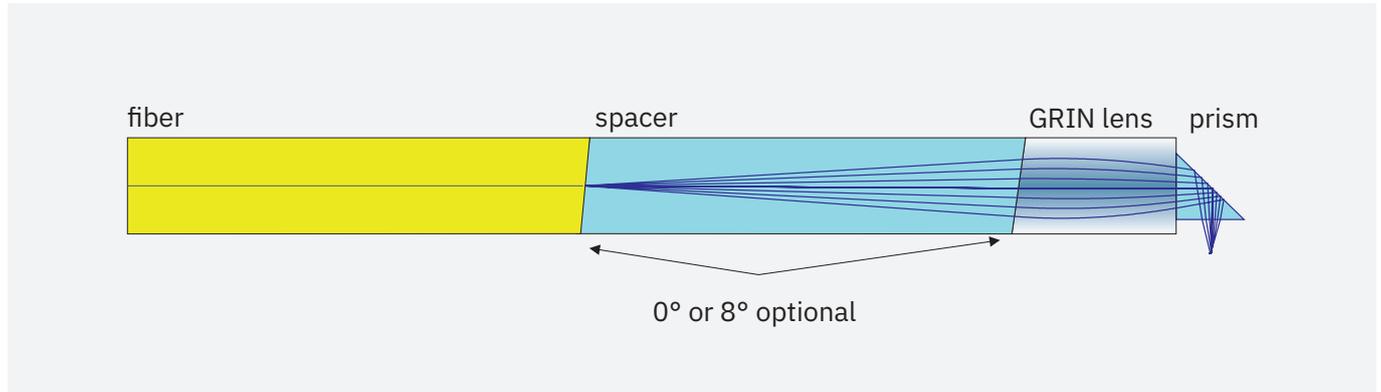
Applications

- OCT/ Focusing Probes

For the optical and mechanical design and the quotation we need at least the following information:

- Fiber type: single mode, polarization maintaining, or special fiber. Please specify operating wavelength (for SM, PM)
- Fiber Length
- Connector: FC/PC, FC/APC or other (please specify)
- Design wavelength
- Diameter of the optical components: 0.5, 1.0 or 1.8 mm
- Working distance/ Spot size: For spot size please specify diameter @ $1/e^2$
- Housing of the optical part: none or stainless steel tube (please specify outer diameter and length of tubing)
- Collimating probe: please specify beam diameter @ $1/e^2$
- Further information or specification or example: prism for side firing, 8° angled facet for reducing back reflections, AR coating
- Quantity

Typical Configurations:



Example of a typical GRIN fiber optic assembly with 90° deflection.

GRINTECH

Gradient Index Optics

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GRINTECH

Gradient Index Optics

GRIN Needle Endomicroscopes

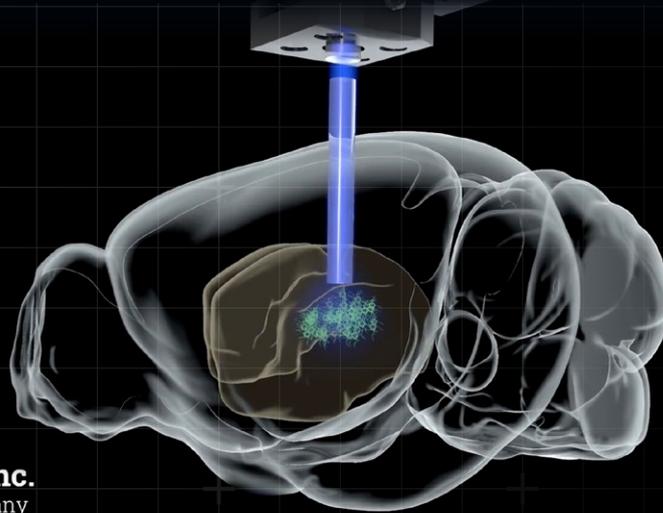


Precision Instruments for Cellular Tissue Research

GRIN needle endomicroscopes allow imaging access to deeper tissue areas.

- in active, living brains, especially for **neurobiological research**. The technology helps to understand the cause and the development of diseases at a cellular level of the tissue.
- **Cancer and rheumatism research** also uses GRIN needle optics to study, for example, metabolic processes, cell dynamics and communication in organs or organ interfaces.
- **Standard Diameters of 0.5 and 1.0 mm**
- GRIN **singlets** with **NA = 0.5** have lengths between **2.2 and 14 mm**
- Magnifying GRIN **doublets** with **NA = 0.5/0.2** have lengths between **4.0 and 20.5 mm**
- Typical modalities include Epi-fluorescence and 2-photon-fluorescence or SHG microscopy
- Please note also our GRIN lens gripper and handling tools, as well as our micro-positioning stage PosUnit 3x

Neuronal imaging is one of the most successful and unique applications of GRINTECH microoptics. In the field of non-human neuroscience, GRINTECH has an exclusive partnership with Inscopix Inc.



Inscopix, Inc.
A Bruker Company

Customizable at the customer's request

On request, the following are possible:

- Working distances, design wavelengths and other parameters can be customized
- Optics are available in additional diameters to customer specifications, e.g. 350 μm , 600 μm , 850 μm , 1800 μm and 2000 μm
- Side-viewing optics with 90° microprisms are available on a customer-specific basis

Brain Imaging – one of the most enabling applications of GRINTECH micro optics

Endomicroscopy using GRINTECH lenses and assemblies allows an in-vivo imaging access to deep tissue regions in the brain, especially in non-humans. It helps to understand disease formation and progression on a cellular level of the tissue.

We are pleased to inform that GRINTECH GmbH has expanded its strategic partnership with Inscopix Inc. beyond one-photon imaging to include exclusively serving customers on behalf of GRINTECH in two-photon imaging and across all non-human neuroscience research applications.

Inscopix offers innovative products and scientific consulting services for advancing neuroscience research and we are excited to be able to partner with Inscopix to serve a broader research community. Inscopix commits to continuing to support legacy GRINTECH customers with their microendoscope imaging needs across all neuroscience preclinical imaging applications. Inscopix Field Scientific Consultants and Inscopix's Support team will now be available to all legacy GRINTECH customers and to any customer interested in leveraging microendoscope imaging for their brain research, irrespective of whether the user or lab is a customer of Inscopix instrumentation. The expanded partnership aims to benefit GRINTECH customers and the broader Neuroscience research community with a dedicated neuroscience partner, enhanced scientific support and customer service, and volume-based pricing discounts.

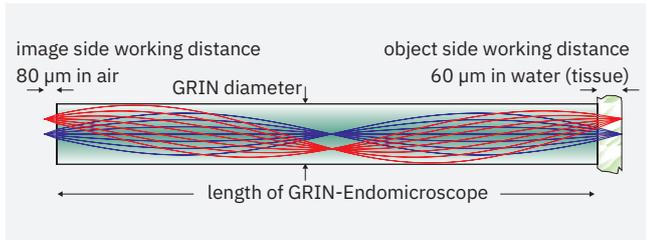
Going forward, Inscopix will be your primary contact for ordering GRIN lenses for non-human Neuroscience research applications. If you have a one-time, custom GRIN lens order, Inscopix will work with GRINTECH to ensure that if Inscopix is unable to fulfill the order, GRINTECH will do so.

If you wish to order GRIN lenses of this brochure, please visit www.inscopix.com or contact order.inscopix@bruker.com.

GRIN Needle Endoscopes for Fluorescence Microscopy

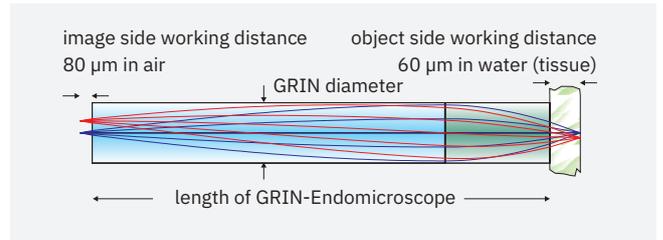
GRIN Needle Endoscopes are used for deep tissue imaging. They relay the micron-scale resolved image of the tissue over a longer length to a plane outside of the tissue at the other end of the needlescope. They are used with epi-fluorescence imaging (Design Wavelength 520 nm). The Endoscopes are fabricated as GRIN-singlets with NA = 0.50 on both sides or as GRIN-doublets with an object NA of 0.5 and an image NA of 0.19. Working distances on object side are specified in water or tissue, on image side in air. They are offered in different lengths resulting from adding 0.5 GRIN-pitches (periods) to the GRIN. Optionally, they can be offered as side viewing needlescope by adding a 90° prism on object side.

Singlets



- Object side working distance in water: 60 μm
- Image side working distance in air: 0 μm / 80 μm
- Design wavelength: 520 nm
- NA Object / image side: 0.50 / 0.50
- Magnification: 1:1 / 1:-1 (depending on pitch length)

Doublets



- Object side working distance in water: 60 μm
- Image side working distance in air: 80 μm
- Design wavelength: 520 nm
- NA Object / image side: 0.50 / 0.19
- Magnification: 1:2.6 / 1:-2.6 (depending on pitch length)

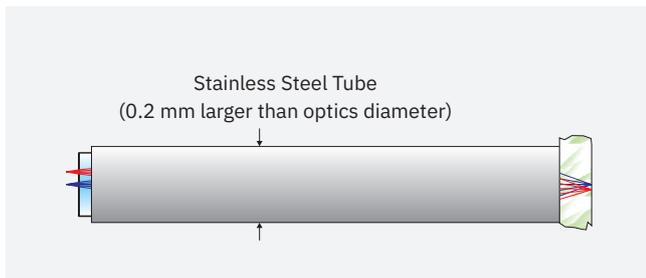
Available lengths

Diameter (mm)	Product Code	Image side working distance (μm)	Length (mm)
0.50	NEM-050-06-00-520-S-0.5p	0	2.22
	NEM-050-06-08-520-S-0.5p	80	2.08
	NEM-050-06-08-520-S-1.0p	80	4.38
	NEM-050-06-08-520-S-1.5p	80	6.67
	NEM-050-06-08-520-S-2.0p	80	8.96
1.00	NEM-100-06-00-520-S-0.5p	0	4.67
	NEM-100-06-08-520-S-0.5p	80	4.54
	NEM-100-06-08-520-S-1.0p	80	9.28
	NEM-100-06-08-520-S-1.5p	80	14.02

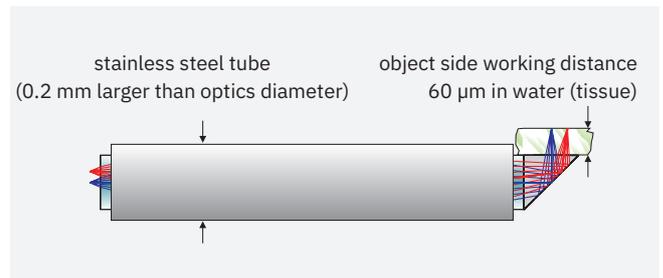
Available lengths

Diameter (mm)	Product Code	Length (mm)
0.50	NEM-050-06-08-520-DS	3.98
	NEM-050-06-08-520-DM	10.08
	NEM-050-06-08-520-DL	16.19
1.00	NEM-100-06-08-520-DS	8.28
	NEM-100-06-08-520-DM	20.50

Other diameters (0.35 mm, 0.60 mm, 0.85 mm, 1.80 mm or 2.00 mm), other working distances or design wavelength are available on request.



GRIN needle endomicroscope with optional stainless steel tube



GRIN needle endomicroscope with optional 90° prism and stainless steel tube

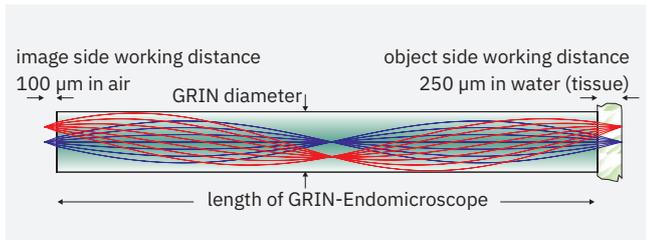
Notes:

- Diameters are sole GRIN-optics diameters
- Optionally the Endomicroscopes can be delivered in medical-grade stainless steel tubes (1.4301), with outer diameters of 0.70 mm for 0.5 mm optics and 1.2 mm for 1.0 mm optics. The tubes are mounted flush on the object side (tissue, high NA) for the side viewing version the prism is not protected by the tube
- On the image side, the optics sticks out of the tube by 50–500 μm. Please add -ST to the product code if desired.
- The lengths can have a tolerance of +/-5%.
- The lenses are non-coated. For customized projects, the lenses can be AR-coated.
- A side-viewing scope using microprisms may be also possible on a customized basis.
- Please ask for combination with imaging fiber bundles (Fujikura) as customized solution.
- For tolerances, handling and storage see the end of this brochure.

GRIN Needle Endoscopes for 2-Photon Microscopy

GRIN Needle Endoscopes are used for deep tissue imaging. They relay the micron-scale resolved image of the tissue over a longer length to a plane outside of the tissue at the other end of the needlescope. They are used with multi-photon fluorescence imaging (Design Wavelength 860 nm). The Endoscopes are fabricated as GRIN-singlets with NA = 0.50 on both sides or as GRIN-doublets with an object NA of 0.5 and an image NA of 0.19. Working distances on object side are specified in water or tissue, on image side in air. They are offered in different lengths resulting from adding 0.5 GRIN-pitches (periods) to the GRIN. Optionally, they can be offered as side viewing needlescope by adding a 90° prism on object side.

Singlets



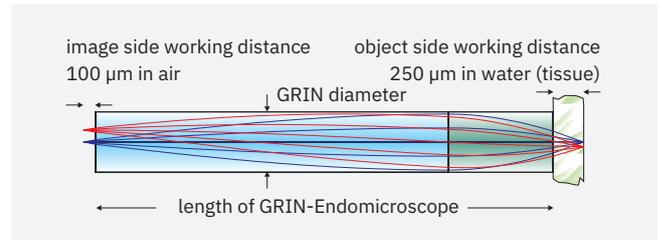
- Object side working distance in water: 250 μm
- Image side working distance in air: 100 μm
- Design wavelength: 860 nm
- NA object / image side: 0.50 / 0.50
- Magnification: 1:1 / 1:-1 (depending on pitch length)

Available lengths

Diameter (mm)	Product Code	Length (mm)
0.50	NEM-050-25-10-860-S-0.5p	1.87
	NEM-050-25-10-860-S-1.0p	4.20
	NEM-050-25-10-860-S-1.5p	6.52
	NEM-050-25-10-860-S-2.0p	8.85
1.00	NEM-100-25-10-860-S-0.5p	4.38
	NEM-100-25-10-860-S-1.0p	9.22
	NEM-100-25-10-860-S-1.5p	14.07

Other diameters (0.35 mm, 0.60 mm, 0.85 mm, 1.80 mm or 2.00 mm), other working distances or other design wavelength are available on request.

Doublets

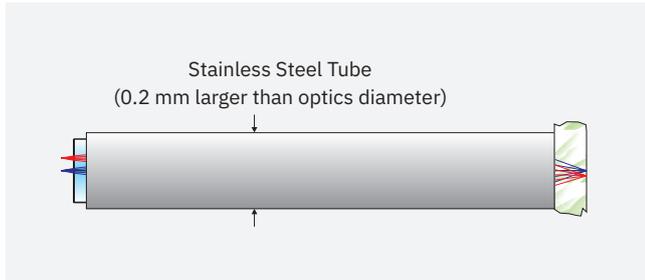


- Object side working distance in water: 250 μm
- Image side working distance in air: 100 μm
- Design wavelength: 860 nm
- NA object / image side: 0.50 / 0.19
- Magnification: 1:2.6 / 1:-2.6 (depending on pitch length)

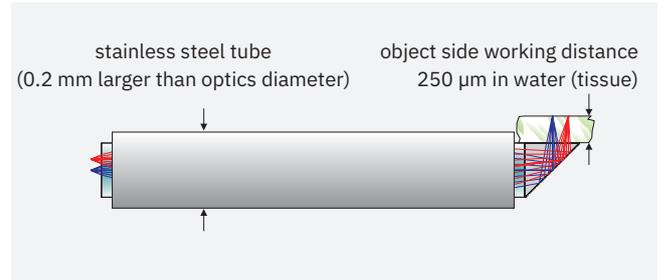
Available lengths

Diameter (mm)	Product Code	Length (mm)
0.50	NEM-050-25-10-860-DS	3.79
	NEM-050-25-10-860-DM	9.89
	NEM-050-25-10-860-DL	16.00
1.00	NEM-100-25-10-860-DS	8.09
	NEM-100-25-10-860-DM	20.09

Other diameters (0.35 mm, 1.80 mm), other working distances or other design wavelength are available on request.



GRIN needle endomicroscope with optional stainless steel tube



GRIN needle endomicroscope with optional 90° prism and stainless steel tube

Notes:

- Diameters are sole GRIN-optics diameters
- Optionally the Endomicroscopes can be delivered in medical-grade stainless steel tubes (1.4301), with outer diameters of 0.70 mm for 0.5 mm optics and 1.2 mm for 1.0 mm optics. The tubes are mounted flush on the object side (tissue, high NA) for the side viewing version the prism is not protected by the tube.
- On the image side, the optics sticks out of the tube by 50–500 μm. Please add -ST to the product code if desired.
- The lengths can have a tolerance of +/- 5%.
- The lenses are non-coated. For customized projects, the lenses can be AR-coated.
- A side-viewing scope using microprisms may be also possible on a customized basis (see left).
- Please ask for combination with imaging fiber bundles (Fujikura) as customized solution.
- For tolerances, handling and storage see below.

Tolerances and Handling Instructions

For of our single lenses we have the following fabrication tolerances and quality criteria:

Tolerances

- Lens length z_l : $\pm 5\%$ due to variations of the gradient constant
- Diameter d : $+0/-0.01$ mm
- Tighter diameter tolerances on request

Surface quality

- $5/3 \times 0.025$; $L 3 \times 0.005$; $E 0$ (defined by DIN ISO 10110-7:2000-02).
- The surface quality is defined within 90% of the lens diameter. Outside of this area defects are allowed.

Storage

GRIN lenses and lens systems should be stored in a dry environment. For short term storage, the plastic box or foam packing in which the lenses are shipped will provide adequate storage. Recommended storage temperature: $-20^\circ\text{C} - 80^\circ\text{C}$.

Storage boxes should ensure that the lenses do not touch each other to prevent chipping and scratches. Best is to use the original box.

Handling

Lenses should be carefully handled with plastic tweezers, preferably those with a tapered end. Lenses should be picked up out of their individual compartments by firmly holding each on its side cylinder surface (not the polished ends). Especially small sized lenses may stick to the lens box material and can be lost during removal.

Cleaning

If it is necessary to clean the lens surfaces due some dust or other contaminant which may impair the optical performance. GRINTECH generally recommends the use of ethyl alcohol as a cleaning solvent, maybe combined with some smooth lintfree lens cleaning tissue.

Acetone may also be used, but it should be pure enough, otherwise it might leave some residue on the lens surface.

GRINTECH

Gradient Index Optics

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Germany

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GRINTECH

Gradient Index Optics

Miniature High-NA Objectives



High-performance miniature objectives – *compact and versatile*

GRIN Needle Endomicroscopes (GRIN singlets and doublets) provide a unique and uncomplicated microscopic access with minimal invasiveness to deep tissue regions, especially as consumables. However, if numerical apertures greater than 0.6 ($NA > 0.6$) are required, or the field of view of pure GRIN lenses with high resolution is not sufficient, or chromatic aberration needs to be corrected over a wide spectral range, miniature high-NA objectives with diameters of 1.3 to 2.2 mm provide the solution for your needs.

The different product versions differ in their complexity and thus also in the degree of correction of aberrations.

In 2009, GRINTECH has introduced the **SpheroCor** high-NA objectives with only 1.4 mm diameter, which increase the Numerical Aperture from 0.55 to 0.8 by a combination of GRIN lenses with plano-convex micro-lenses, which correct spherical aberration on-axis and significantly improve the resolution to image, for example, dendritic spines *in vivo* for neuroscientists [Barretto, R., Messerschmidt, B. & Schnitzer, M. *In vivo* fluorescence imaging with high-resolution microlenses. *Nat Methods* 6, 511–512 (2009)]. <https://doi.org/10.1038/nmeth.1339>]. However, chromatic aberration is not corrected and the field of view is limited in these least complex objectives.



Since 2016, GRINTECH offers the **FieldAchromatic** high-NA objectives. With a diameter of only 1.3 mm, they provide a tremendously increased field of view of up to 400 μm in tissue with sub-micron resolution due to the high NA of 0.7 – 0.8. This field correction is combined with a very broad correction of lateral and axial chromatic aberration from 488 to 900 nm, making these objectives the perfect optics for non-linear fiber-scanning endoscopes or coherent fiber bundle based endomicroscopic probe heads. Offering these high NA's, a large field of view and small component diameter results in a stronger field curvature of up to 20–28 μm focus shift at the marginal field of view, which is often accepted when diagnosing volume tissues. A special version of the **FieldAchromatic** Series is the 178 mm long endomicroscopic tube for CARS endomicroscopy providing a chromatic correction from 795 nm to 1029 nm.

In 2023, GRINTECH brought the **ReduCurv** high-NA objectives with diameters of 1.3 and 2.2 mm on the market, the latest generation which offers additionally a significant 70% reduction of field curvature in object space, while keeping high NA, large field of view and sub-micron resolution. Focus shifts from the center to the margin of the field of view are reduced to only 6–7 μm . These objectives are recommended for imaging of planar and very thin samples or where a very flat field of view is required.

We support you with your specific needs:

On request, we advise you for the best solution in your specific application:

- *In vivo* endomicroscopy, single-photon fluorescence microscopy
- Nonlinear Optical Imaging Modalities (SHG, TPF)
- Tissue imaging, flexible fluorescence microscopy
- NA Conversion

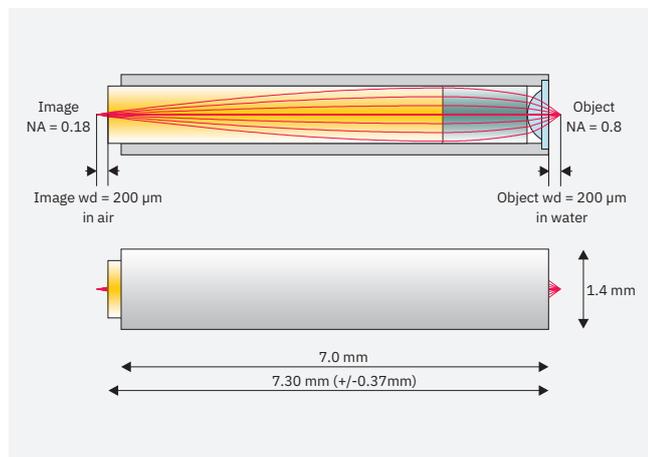
SpheroCor High-NA Endomicroscopic Imaging Objective for 2-Photon Microscopy

GRINTECH's *SpheroCor* high-NA Endomicroscopic Imaging Objectives cascade the optical power of a plano-convex lens and a GRIN lens with spherical aberration compensation to achieve an object NA of 0.8. This first 2009 generation of high NA objectives provides superior resolution of sub-micron details as dendritic spines, for example [Barretto, R., Messerschmidt, B. & Schnitzer, M. *In vivo* fluorescence imaging with high-resolution microlenses. *Nat Methods* 6, 511–512 (2009)].

Product Code: GT-MO-080-018-810

Features:

- Object NA = 0.80
- Object working distance 200 μm (water)
- Image NA = 0.18
- Magnification 4.8 \times
- Recommended Excitation 800–1000 nm
- Mounted in stainless steel holder



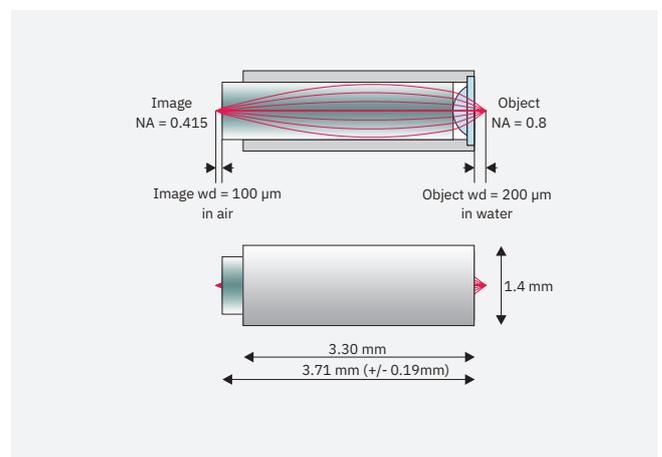
Applications

- *In vivo* endomicroscopy
- 2-photon microscopy
- Deep brain and tissue imaging
- Flexible fluorescence microscopy
- NA conversion

Product Code: GT-MO-080-0415-810

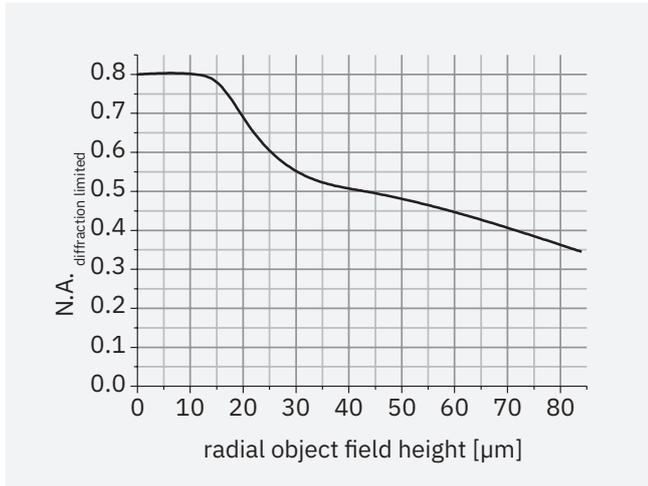
Features:

- Object NA = 0.80
- Object working distance 200 μm (water)
- Image NA = 0.415
- Magnification 1.92 \times
- Recommended Excitation 800–1000 nm
- Mounted in stainless steel holder



Product Code: GT-MO-080-018-810

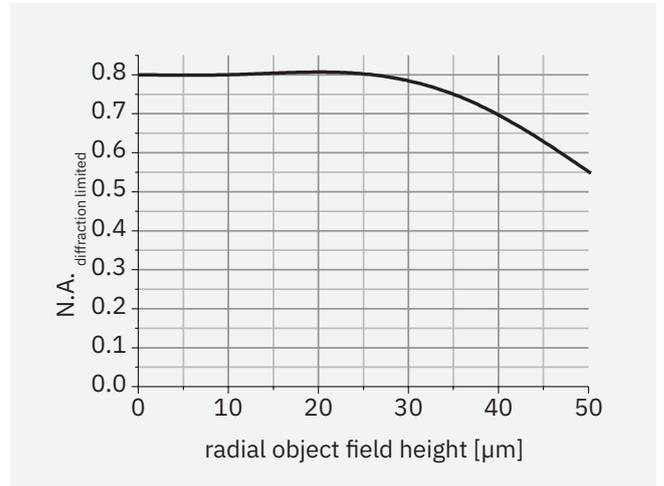
Diffraction limited NA versus Field



From optical design simulation according to Marechal criterion @ 810 nm, wavefront RMS $\leq 0.07 \lambda$

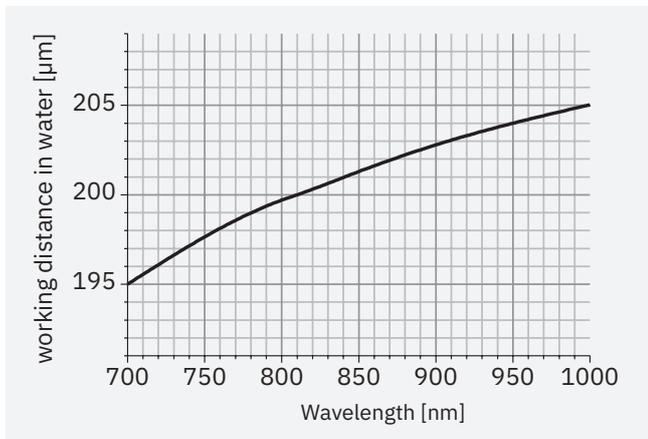
Product Code: GT-MO-080-0415-810

Diffraction limited NA versus Field

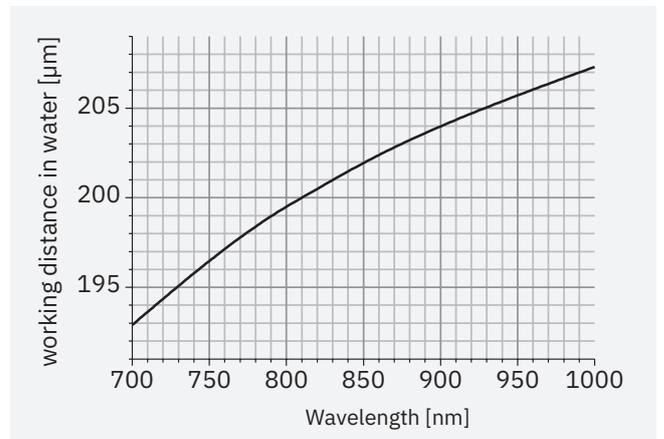


From optical design simulation according to Marechal criterion @ 810 nm, wavefront RMS $\leq 0.07 \lambda$

Chromatic Aberration in Object Space



Chromatic Aberration in Object Space



Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose. For tolerances, handling and storage see the end of this brochure.

SpheroCor High-NA Endomicroscopic Imaging Objective for Fluorescence Microscopy

GRINTECH's *SpheroCor* high-NA Endomicroscopic Imaging Objectives cascade the optical power of a plano-convex lens and a GRIN lens with spherical aberration compensation to achieve an object NA of 0.8.

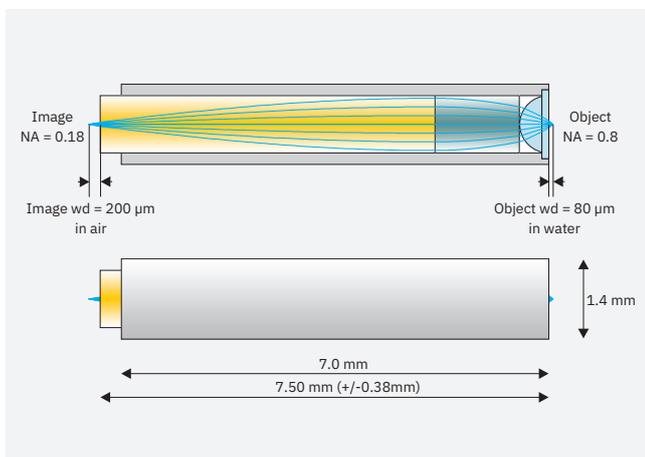
Applications

- *In vivo* endomicroscopy
- Fluorescence microscopy
- Tissue imaging
- Flexible fluorescence microscopy
- NA conversion

Product Code: GT-MO-080-018-488

Features:

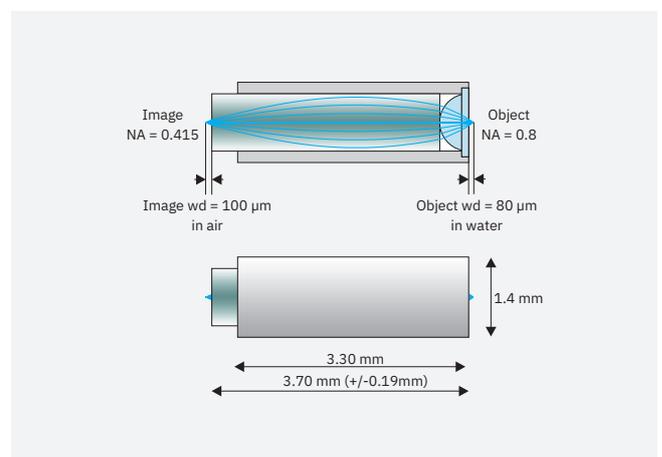
- Object NA = 0.80
- Object working distance 80 μm (water)
- Image NA = 0.18
- Magnification 4.65 \times
- Recommended Excitation 488 nm
- Mounted in stainless steel holder



Product Code: GT-MO-080-0415-488

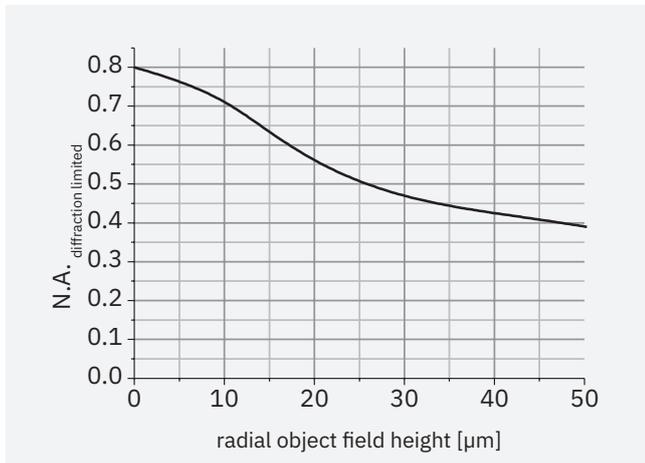
Features:

- Object NA = 0.80
- Object working distance 80 μm (water)
- Image NA = 0.415
- Magnification 1.92 \times
- Recommended Excitation 488 nm
- Mounted in stainless steel holder



Product Code: GT-MO-080-018-488

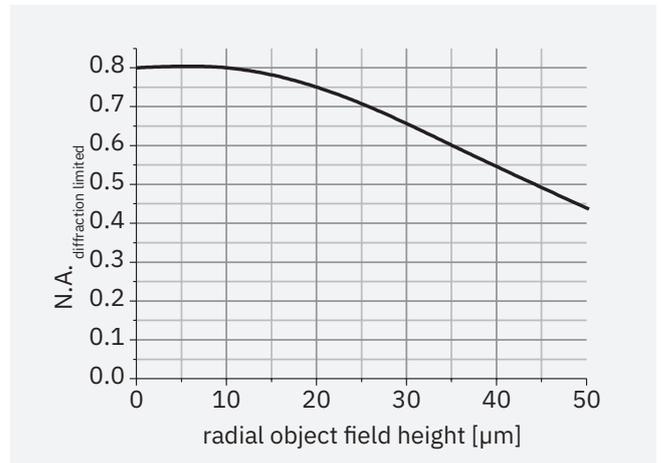
Diffraction limited NA versus Field



From optical design simulation according to Marechal criterion @ 488 nm, wavefront RMS $\leq 0.07 \lambda$

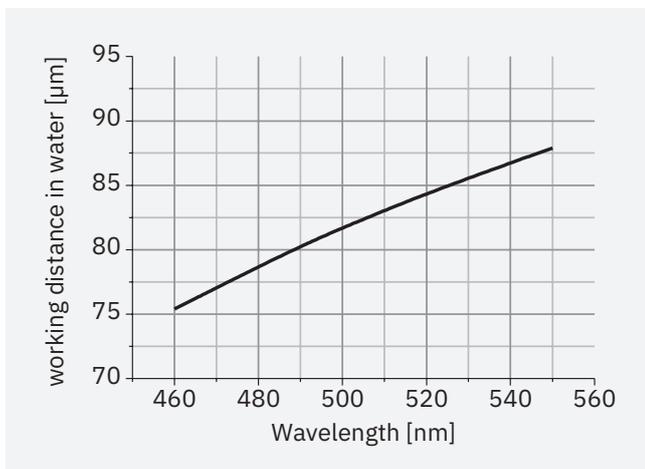
Product Code: GT-MO-080-0415-488

Diffraction limited NA versus Field

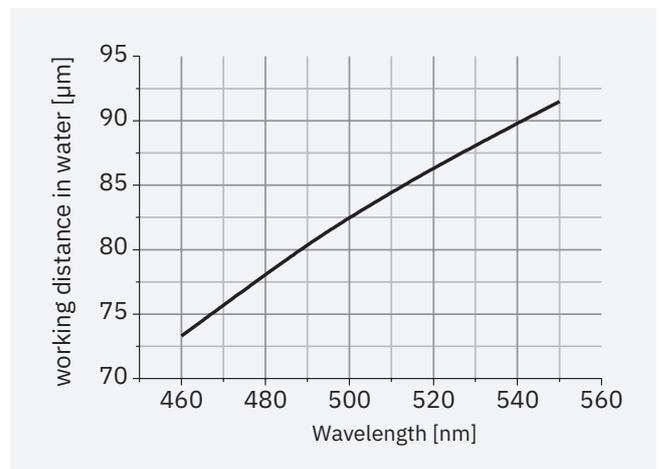


From optical design simulation according to Marechal criterion @ 488 nm, wavefront RMS $\leq 0.07 \lambda$

Chromatic Aberration in Object Space



Chromatic Aberration in Object Space



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FieldAchromatic High-NA chromatic and field corrected Endomicroscopic Imaging Objectives

GRINTECH's *FieldAchromatic* high-NA Endomicroscopic Imaging Objectives with object Numerical Apertures of 0.75 are offered in a broad achromatic and field corrected version to significantly increase the usable field of view.

A GRIN-refractive multilens hybrid design allows a broader chromatic and off-axis correction resulting also in a higher confocal sensitivity (confocal signal throughput) compared to the previous versions with diffractive correcting elements.

Applications

- *In vivo* endomicroscopy
- Single photon fluorescence microscopy
- Nonlinear optical imaging modalities (SHG, TPF)
- Tissue imaging
- Flexible fluorescence microscopy
- NA conversion

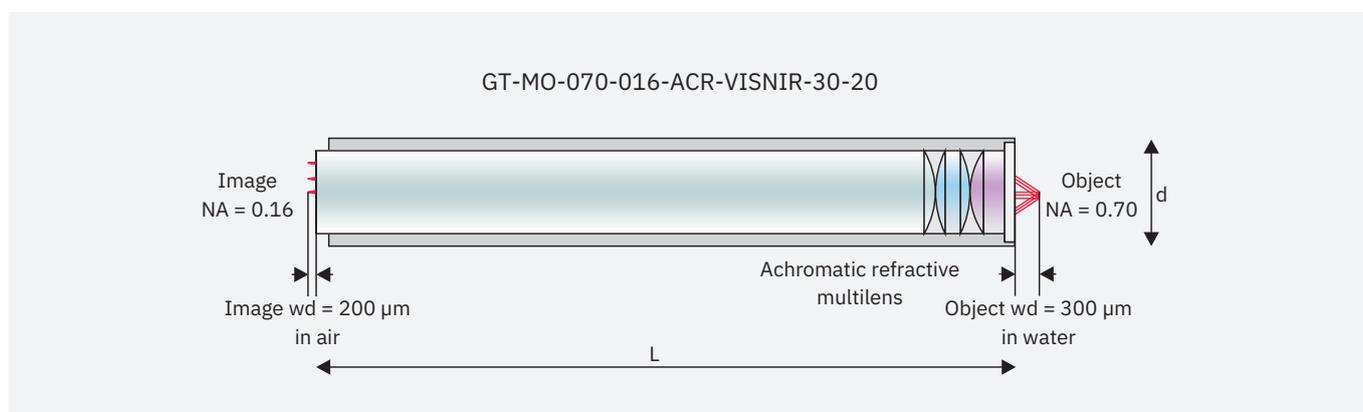
GT-MO-080-032-ACR-VISNIR-xx-xx series represents high resolution field and color corrected objectives with a magnification of 2.3. The image side NA of 0.32 matches to imaging fiber bundles. Color correction is from 450 nm to 900 nm with an optimal performance from 488 nm to 520 nm. The objectives are assembled in stainless steel mounts.

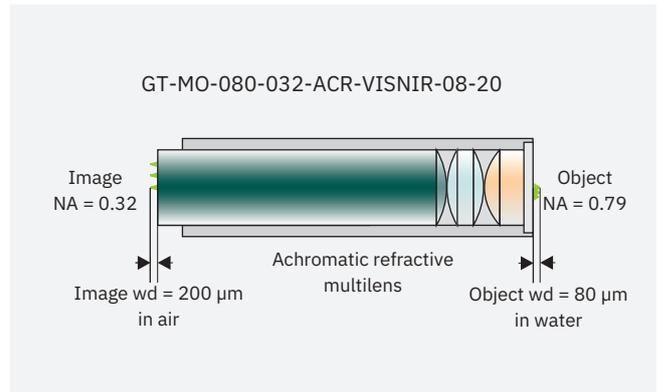
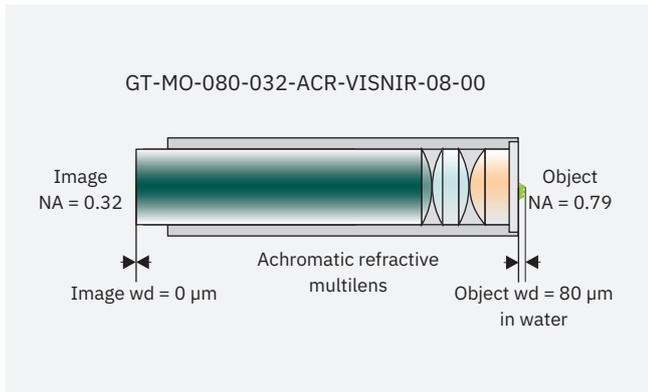
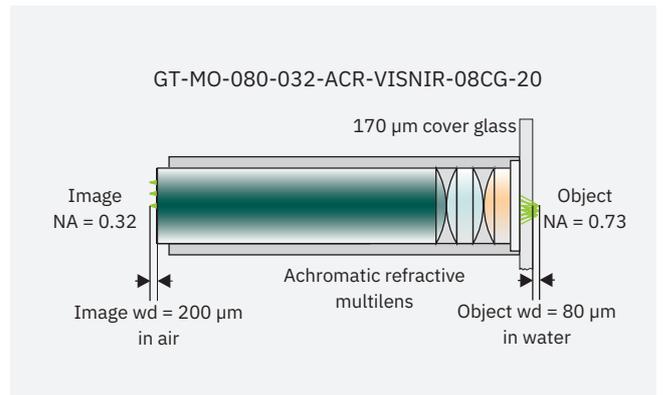
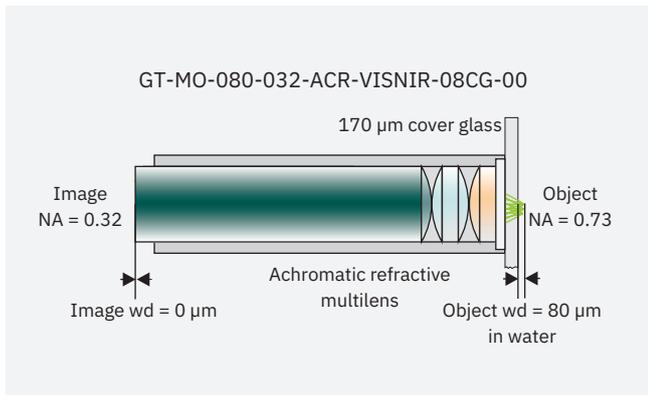
GT-MO-070-016-ACR-VISNIR-30-20 is optimized for wavelengths of 450 nm and 900 nm to achieve an ideal performance in SHG and TPF applications within a large field of view.

Four combinations of proximal and distal working distances are offered as listed below in the first 4 columns:

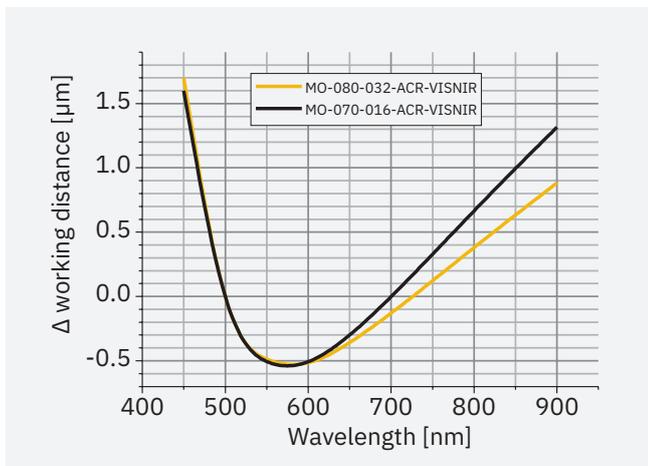
GT-MO-080-032-ACR-VISNIR-...	...08CG-00	...08CG-20	...08-00	...08-20	GT-MO-070-016-ACR-VISNIR-30-20
Object NA	0.73	0.73	0.79	0.79	0.7
Object WD in water (μm)	80	80	80	80	300
Designed for cover glass (μm)	170	170	none	none	none
Image NA	0.32	0.32	0.32	0.32	0.16
Image WD in air (μm)	0	200	0	200	200
Magnification	2.2*	2.2*	2.4*	2.4*	4.4
Dimensions ø / L (mm)	1.3/4.89	1.3/4.57	1.3/5.02	1.3/4.7	1.3/8.36

* depending on Image NA





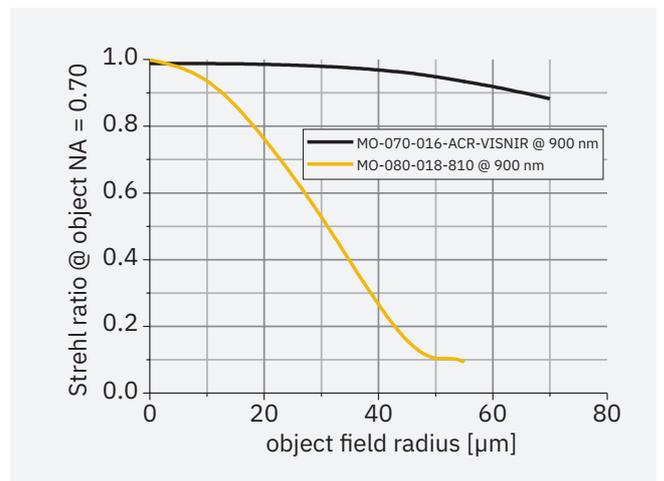
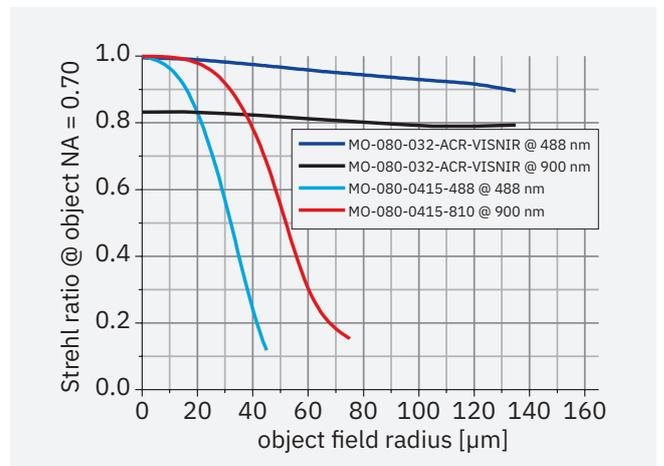
Chromatic Aberration in Object Space



Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

For handling and storage see the end of this brochure.

Field Dependent Strehl Ratio in Object Space (From Optical Design)



FieldAchromatic High NA chromatic and field corrected Endomicroscopic Imaging Objectives

The generation of GRINTECH's *FieldAchromatic* color and field corrected high-NA objectives resolve cellular details in micron resolution from center to the margin of the aperture

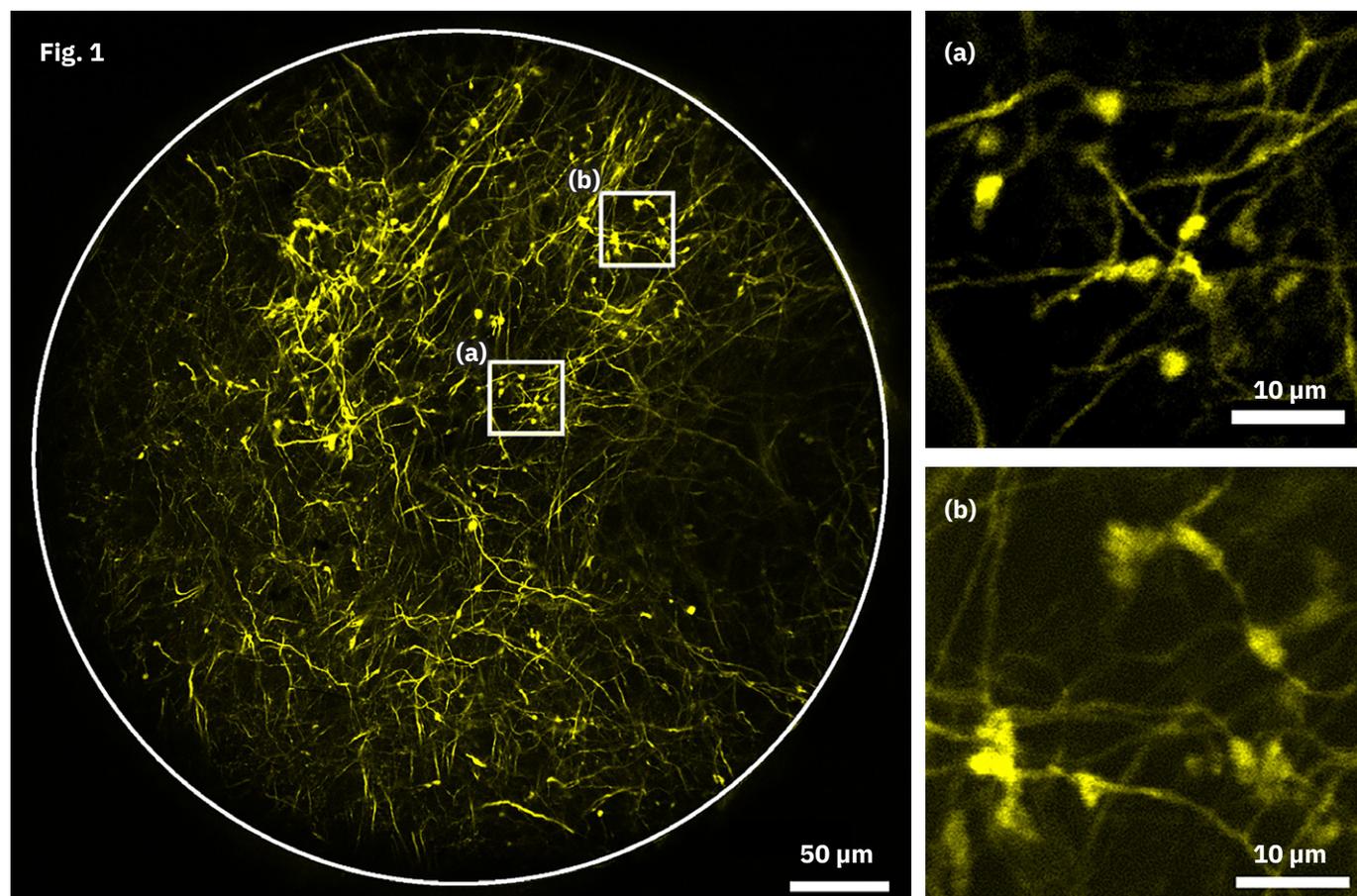


Fig. 1: Mouse brain section, PFA fixation, cover glass 170 μm confocally imaged in fluorescence (exc. 488 nm) with **GT-MO-080-032-ACR-VISNIR-08CG-00** coupled to Olympus FV1000 with MO 10 \times ; NA=0.4 with XYZ-Stage. White circle shows backside aperture of 1 mm corresponding to full object FOV of 450 μm , with optimal imaging quality in FOV of 360 μm . **(a)** and **(b)**: 40 μm \times 40 μm sections of the center and edge of object FOV.

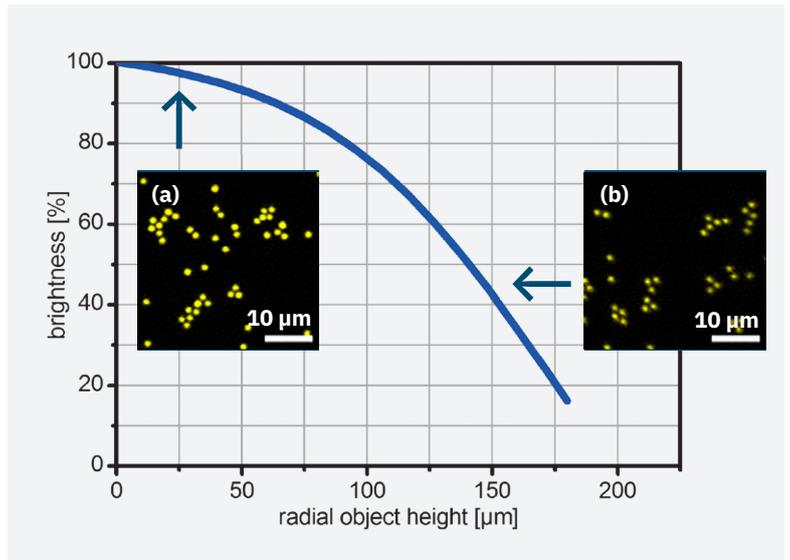
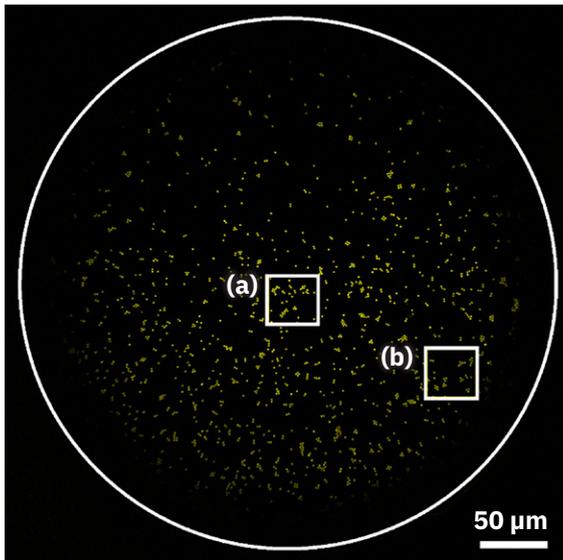


Fig.2: fluorescence beads with $\varnothing=2\mu\text{m}$ yellow/green acquired with **GT-MO-080-032-ACR-VISNIR-08-00**. Right: bead brightness depending on the radial object height. (a) and (b) $40\mu\text{m} \times 40\mu\text{m}$ sections from the center and edge of object FOV.

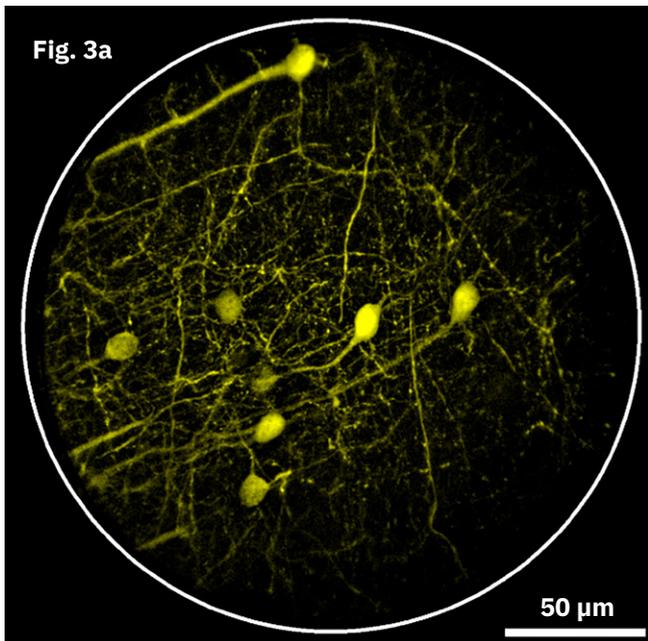


Fig.3a: **GT-MO-070-016-ACR-VISNIR-30-20** with full object FOV of $200\mu\text{m}$ (optimal imaging in $150\mu\text{m}$) compared to Fig.3b.

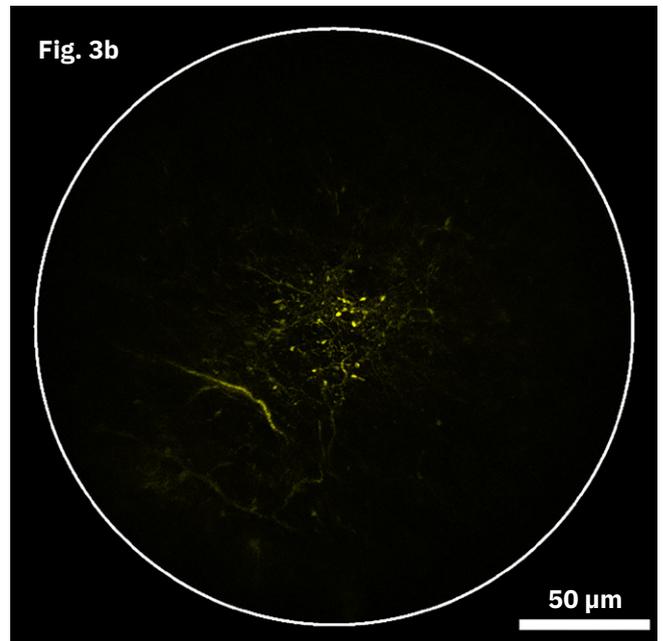


Fig.3b: **GT-MO-080-018-AC900-450** with FOV of $65\mu\text{m}$ (not offered anymore)

The usable field of view is increased to 300% in diameter compared to previous *SpheroCor* objectives. Now available also in 1.3 mm outer diameter instead of 1.4 mm. For more details, please contact GRINTECH.

FieldAchromatic High-NA chromatically and field corrected Endomicroscope Tube for CARS and non-linear imaging

GRINTECH's *FieldAchromatic* high-NA Endomicroscope tube with object Numerical Aperture of 0.50 features sub-micron resolution imaging with a field of view of 300 μm for CARS/2-Photon-Fluorescence/SHG modalities. It has a diameter of 3.0 or 2.2 mm and a rigid length of 178 mm. A GRIN-refractive multilens hybrid design allows chromatic and off-axis correction between 795 nm and 1029 nm.

Applications

- *In vivo* endomicroscopy
- Nonlinear optical endoscopy (CARS, SHG, TPF)
- Tissue imaging
- Proximal scanning
- NA conversion

GT-MO-050-009-ACR795/1029-10-50 represents a high resolution field- and NIR-chromatically corrected objective with a magnification of 5.6. The image side NA of 0.09 matches to low NA telecentric spot scanning. Chromatic correction is realized between 795 nm to 1029 nm together with an optimal performance.

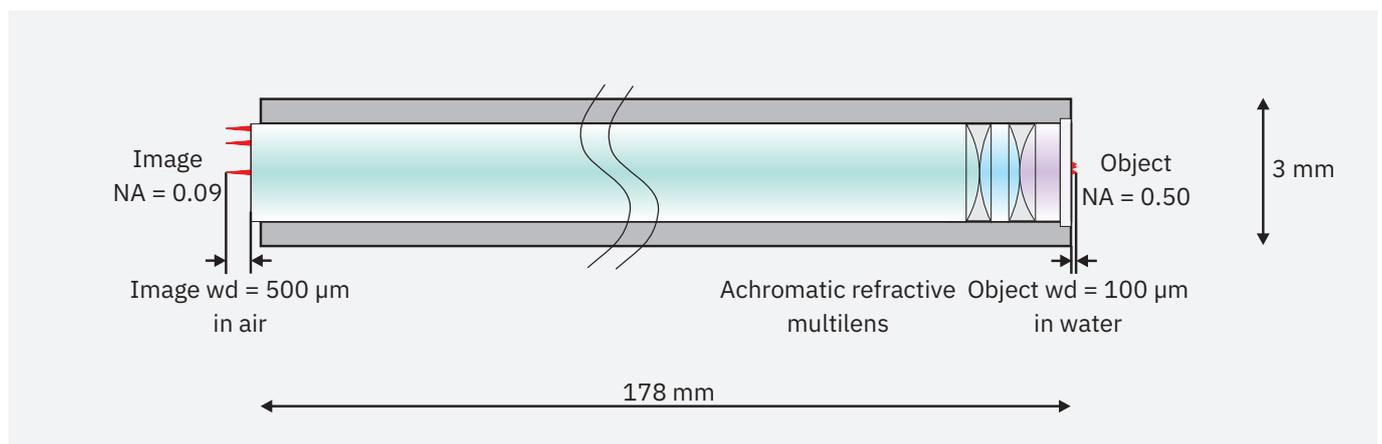
The optics is assembled in a stainless steel tube of 3.0 or 2.2 mm diameter (optional).

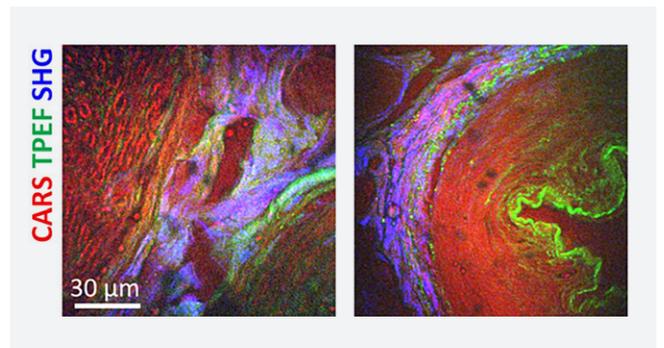
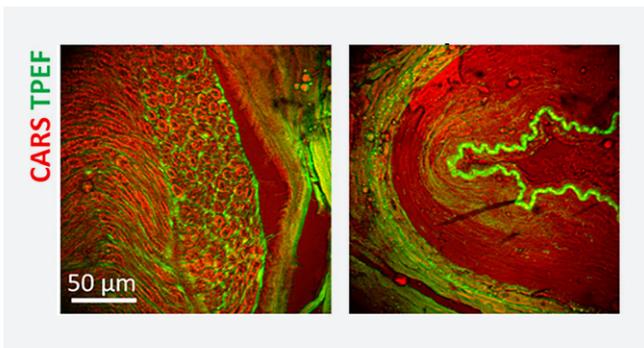
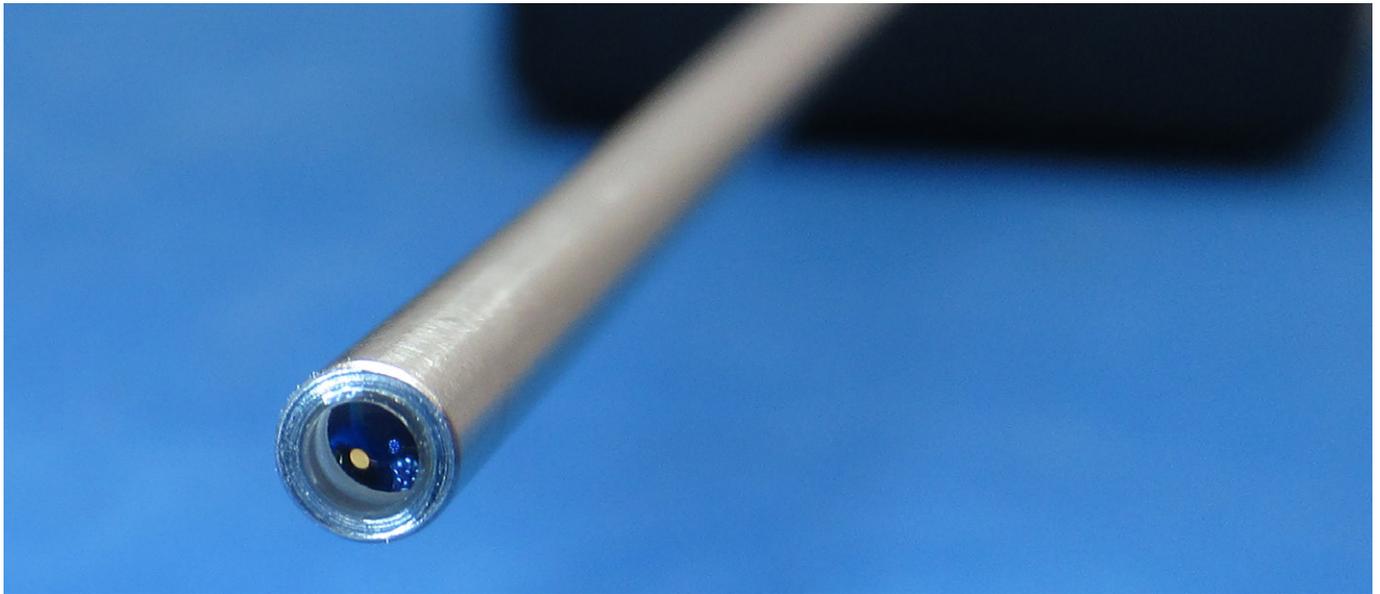
Specifications

GT-MO-050-009-ACR795/1029-10-50

Object NA	0.50
Object WD in water (μm)	100
Image NA	0.09
Image WD in air (μm)	Approx. 500
Magnification	5.6
Dimensions \varnothing / L (mm)	3.0 or 2.2 / 178

GT-MO-050-009-ACR795/1029-10-50 schematic with dimensions





Images: Human nervus suralis – cryosection, images recorded through Endomicroscopic tube + Plan-Apo 5x/0.16 + Zeiss CARS LSM (Courtesy by TU Dresden) Reference: Zirak, P., *et al.* (2018). “Invited Article: A rigid coherent anti-Stokes Raman scattering endoscope with high resolution and a large field of view.” *APL Photonics* 3(9): 092409.

Variations due to modifications of the production process are possible. It is the user’s responsibility to determine suitability for the user’s purpose.

For handling and storage see the end of this brochure.

ReduCurv High-NA chromatic and field corrected Endoscopic Imaging Objectives with reduced curvature (NA 0.7, 2.2 mm diameter)

GRINTECH's 2023 variant of *ReduCurv* high-NA Endoscopic Imaging Objectives provide 70% reduced field curvature (compared to *FieldAchromatic* objectives) while offering object Numerical Apertures of 0.7 in a broad achromatic and field correction. These objectives are recommended for imaging of planar and very thin samples or where a very flat field of view is required.

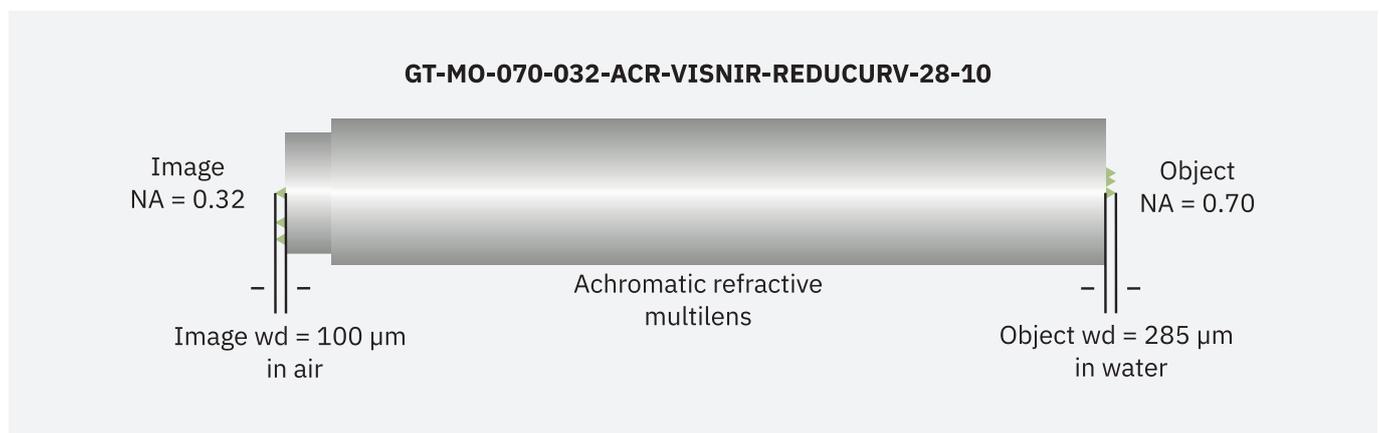
Applications

- *In vivo* endomicroscopy
- Single photon fluorescence microscopy
- Nonlinear optical imaging modalities (SHG, TPF)
- Tissue imaging
- Flexible fluorescence microscopy
- NA conversion, especially all applications to image thin and planar samples or where a flat field of view is required

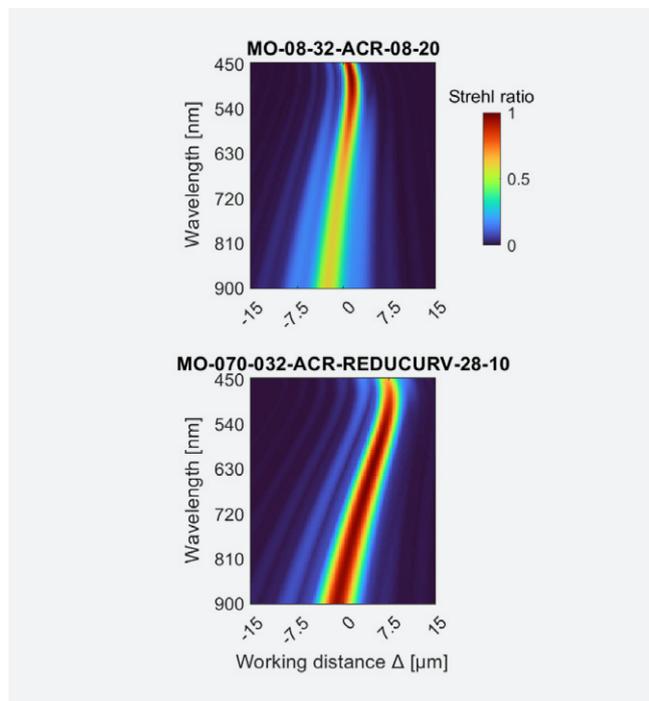
GT-MO-070-032-ACR-VISNIR-REDUCURV-28-10 represents high resolution field and color corrected objectives with a magnification of 2.2. The image side NA of 0.32 matches to imaging fiber bundles. Color correction is achieved from 450 nm to 900 nm with an optimal performance from 488 nm to 900 nm. The objectives are assembled in stainless steel mounts.

The *ReduCurv* micro objective type with reduced field curvature is offered so far as a version for usage without cover glass. Please compare specs with our *FieldAchromatic* series in the following table and note the different mechanical dimensions.

	GT-MO-070-032-ACR-VISNIR-REDUCURV-28-10	GT-MO-080-032-ACR-VISNIR-08-20 (for comparison)
Object NA	0.70	0.79
Object WD in water (μm)	285	80
Designed for cover glass (μm)	none	none
Image NA	0.32	0.32
Image WD in air (μm)	100	200
Magnification	2.2	2.3
Field curvature radius (mm)	2	0.55
Dimensions Ø / L (mm)	2.2 / 13	1.3 / 4.7

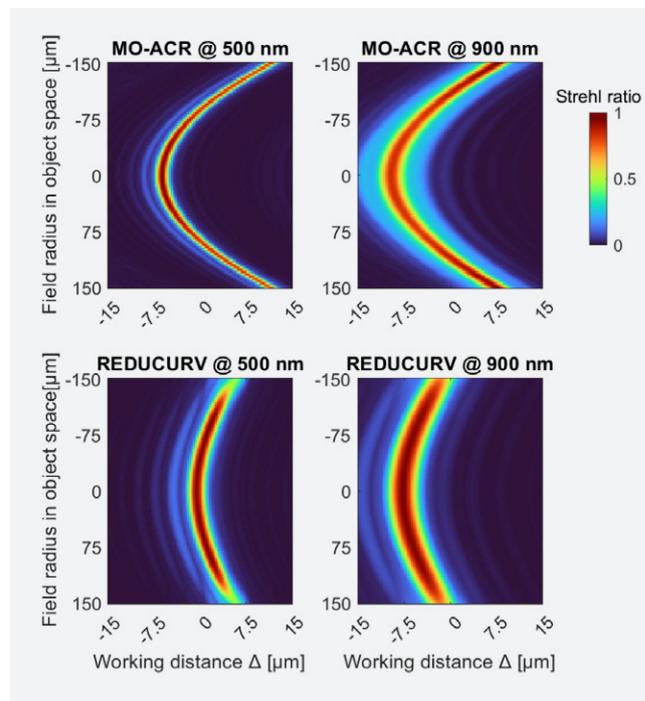


Chromatic Aberration in Object Space



upper part: *FieldAchromatic* version (for comparison), lower part: *Reducurv* objective

Field Dependent Strehl Ratio in Object Space



upper part: *FieldAchromatic* version (for comparison), lower part: *Reducurv* objective

Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

For handling and storage see the end of this brochure.

More information can be found here: Stark, S. L., *et al.* (2023). "Field curvature reduction in miniaturized high numerical aperture and large field-of-view objective lenses with sub 1 μm lateral resolution." *Biomedical Optics Express* 14(12).

ReduCurv High-NA chromatic and field corrected Endomicroscopic Imaging Objectives with reduced curvature (NA 0.5, 1.2 mm diameter)

GRINTECH's 2023 variant of *ReduCurv* high-NA Endomicroscopic Imaging Objectives with object Numerical Apertures of 0.5 provide 70% reduced field curvature (compared to *FieldAchromatic* objectives) combined with a broad achromatic and field correction. These objectives are recommended for imaging of planar and very thin samples or where a very flat field of view is required.

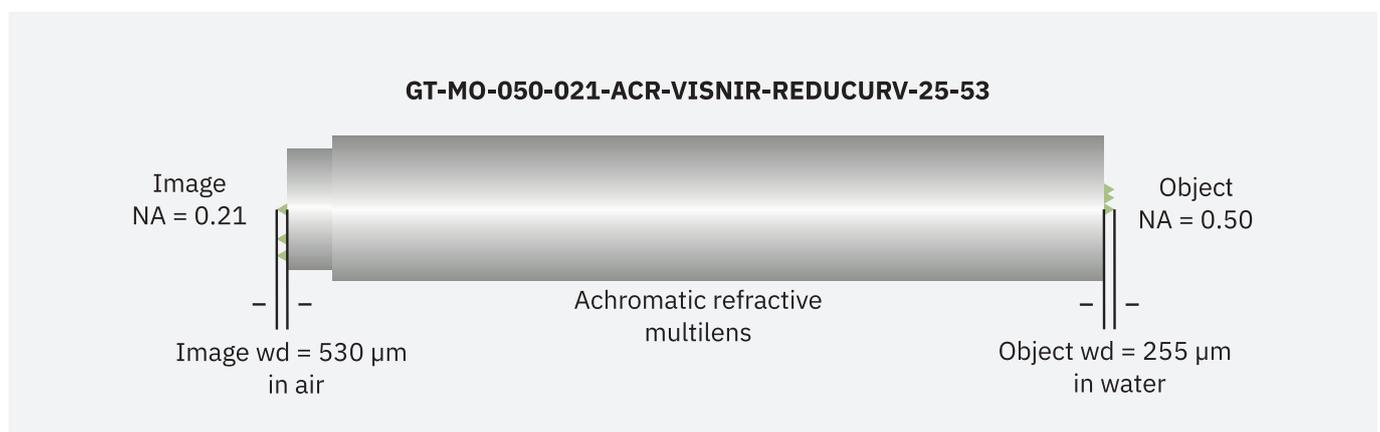
Applications

- *In vivo* endomicroscopy
- Single photon fluorescence microscopy
- Nonlinear optical imaging modalities (SHG, TPF)
- Tissue imaging
- Flexible fluorescence microscopy
- NA conversion, especially all applications to image thin and planar samples or where a flat field of view is required

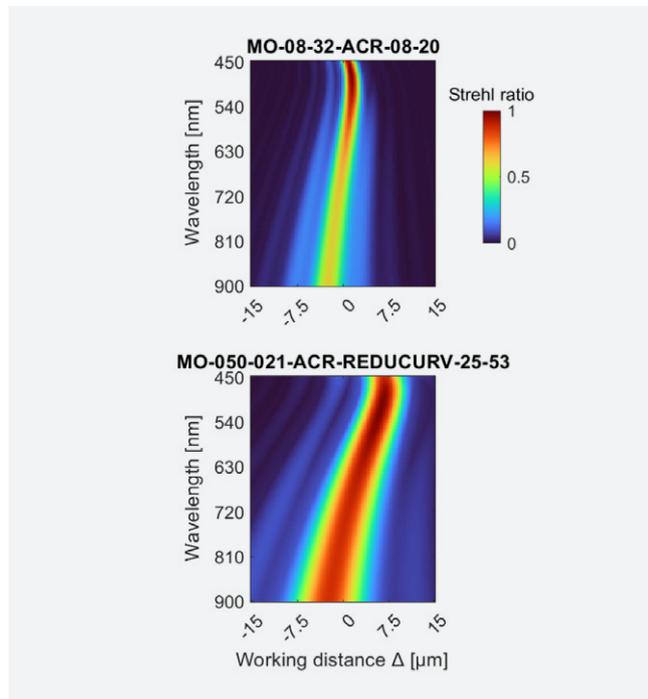
GT-MO-050-021-ACR-VISNIR-REDUCURV-25-53 features a diameter of 1.2 mm with NA = 0.5. The image side NA is in this case 0.21. Color correction is achieved from 450 nm to 900 nm with an optimal performance from 488 nm to 900 nm. The objectives are assembled in stainless steel mounts.

The *ReduCurv* micro objective type with reduced field curvature is offered so far as a version for usage without cover glass. Please compare specs with our *FieldAchromatic* series in the following table and note the different mechanical dimensions.

	GT-MO-050-021-ACR-VISNIR-REDUCURV-25-53	GT-MO-080-032-ACR-VISNIR-08-20
Object NA	0.50	0.79
Object WD in water (µm)	255	80
Designed for cover glass (µm)	none	none
Image NA	0.21	0.32
Image WD in air (µm)	530	200
Magnification	2.3	2.3
Field curvature radius (mm)	2	0.55
Dimensions Ø / L (mm)	1.2 / 5.0	1.3 / 4.7

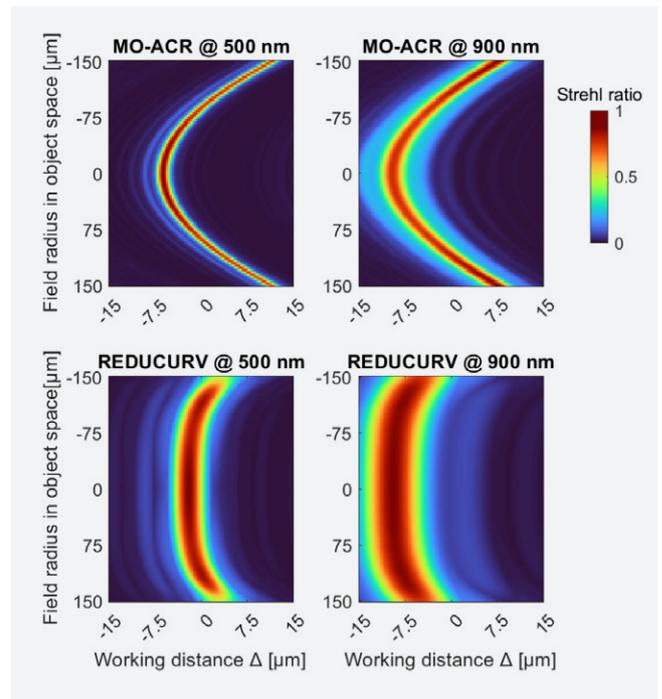


Chromatic Aberration in Object Space



upper part: *FieldAchromatic* version (for comparison), lower part: *Reducurv* objective

Field Dependent Strehl Ratio in Object Space



upper part: *FieldAchromatic* version (for comparison), lower part: *Reducurv* objective

Variations due to modifications of the production process are possible. It is the user's responsibility to determine suitability for the user's purpose.

For handling and storage see the end of this brochure,

Handling and Storage Instructions

Storage

GRIN lenses and lens systems should be stored in a dry environment. For short term storage, the plastic box or foam packing in which the lenses are shipped will provide adequate storage. Recommended storage temperature: -20°C – 80°C .

Storage boxes should ensure that the lenses do not touch each other to prevent chipping and scratches. Best is to use the original box.

Handling

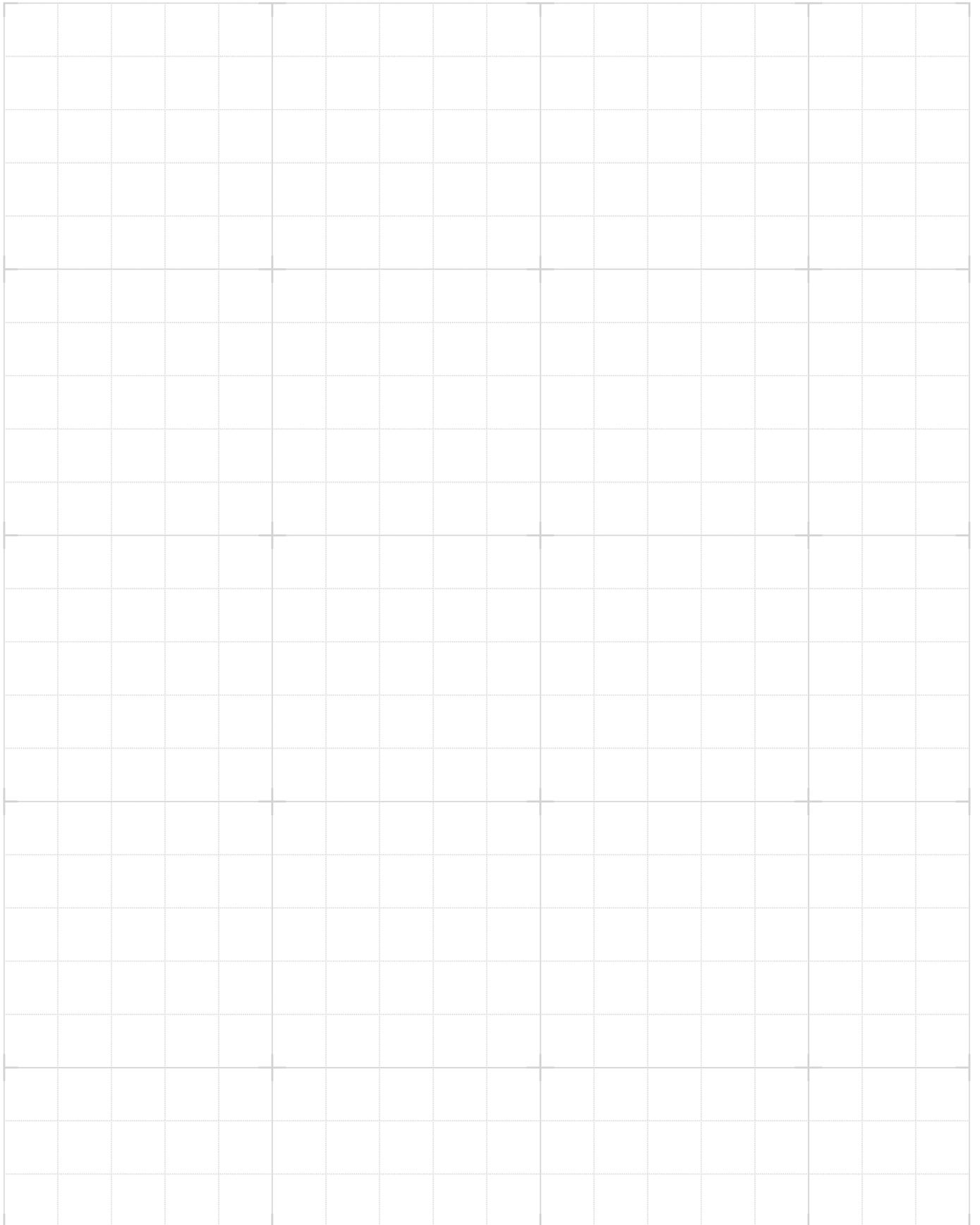
Lenses should be carefully handled with plastic tweezers, preferably those with a tapered end. Lenses should be picked up out of their individual compartments by firmly holding each on its side cylinder surface (not the polished ends). Especially small sized lenses may stick to the lens box material and can be lost during removal.

Cleaning

If it is necessary to clean the lens surfaces due some dust or other contaminant which may impair the optical performance. GRINTECH generally recommends the use of ethyl alcohol as a cleaning solvent, maybe combined with some smooth lintfree lens cleaning tissue.

Acetone may also be used, but it should be pure enough, otherwise it might leave some residue on the lens surface.

Notes



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Gradient Index Optics

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Jijok-ro, Yuseong-gu

Daejeon 34071 Republic of Korea

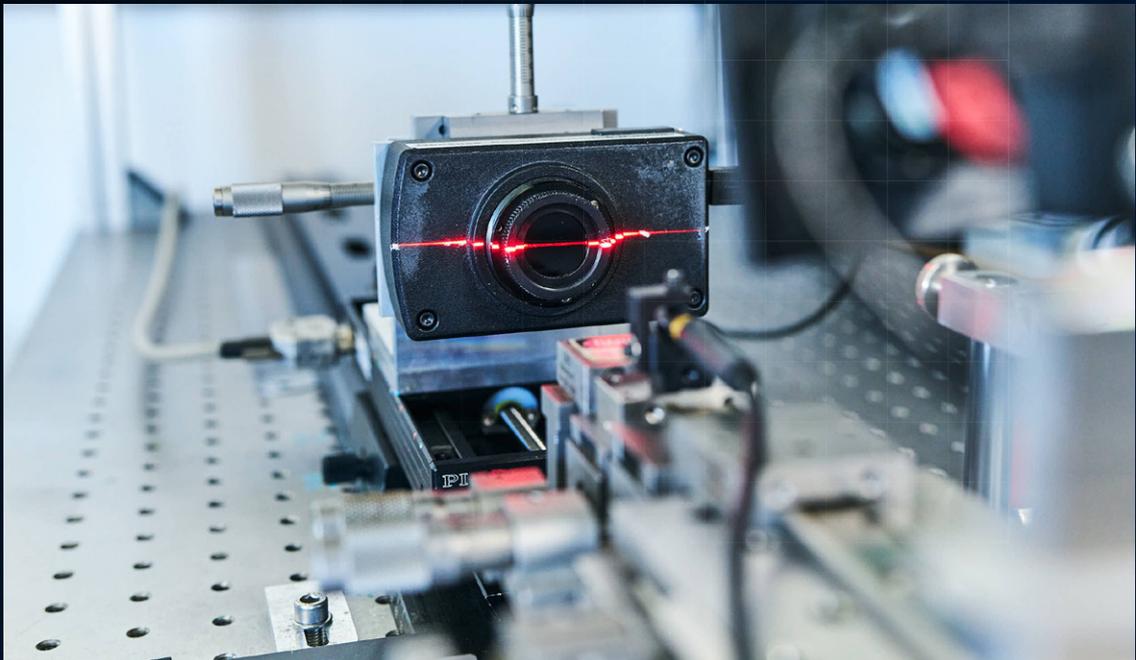
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GRINTECH

Gradient Index Optics

Laser Line Modules



Ultra compact GRIN lens-based laser line modules for high precision cutting-edge technologies

GRIN micro-optical components with plano-optical surfaces generate a homogeneous laser line from a Gaussian beam of a single-mode laser diode.

- Red laser diode: QDLaser – QLF063A-AA, $\lambda = 660 \text{ nm}$, PLD = 50 mW
- Red, green, blue wavelengths are available as standard
- Exceptionally compact module size of 6.50 mm × 14.0 mm
- Weight of only 1.5 g
- High uniformity homogeneity of the laser line, up to +/- 5% for different wavelengths
- Almost diffraction-limited focus size

Applications: 3D Contour Mapping, Optical Adjustment, Machine Vision, Biomedicine

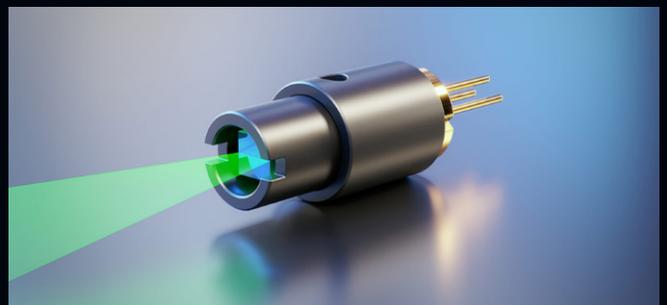
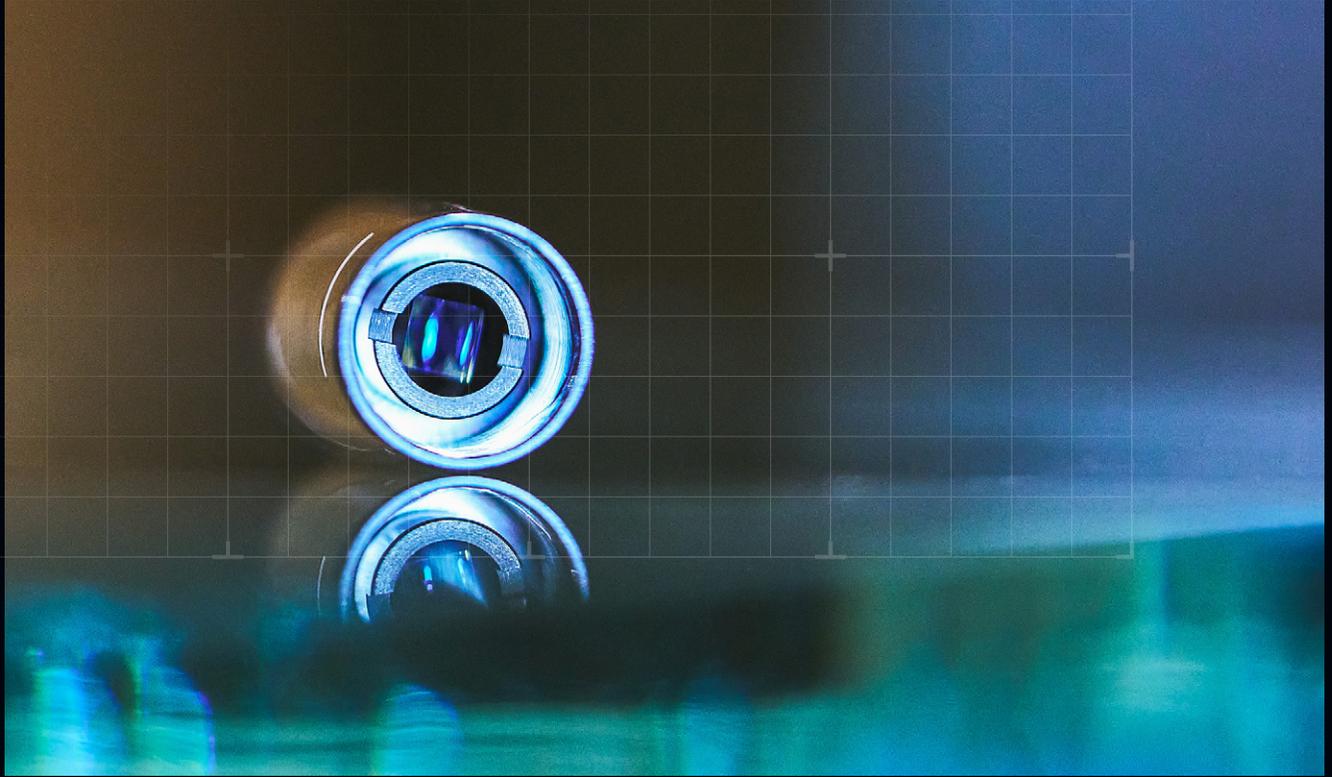
GRINTECH offers cylindrical lenses with a numerical aperture of 0.5 in a standard thickness of 1.0 mm. Typical applications include:

- Fast Axis collimation of high-power laser diodes
- One-dimensional beam shaping
- Light sheet generation

Customizable at the customer's request

On request, the following are possible:

- Adaptation to laser diodes according to customer requirements and feasibility
- Module size adjustment
- Working distance and divergence angle changes according to feasibility
- Design wavelength change
- Anti-reflective coatings



Ultra compact GRIN lens-based laser line modules for high precision cutting-edge technologies

Smaller than the most compact modules for industrial applications on the market, with a diameter of 6.50 mm and a length of 14 mm. Gradient-Index Micro-Optic Components with plane optical surfaces generate a homogeneous laser line from a Gaussian beam of a single-mode laser diode with a line uniformity up to +/- 5% and a diffraction-limited focus size.

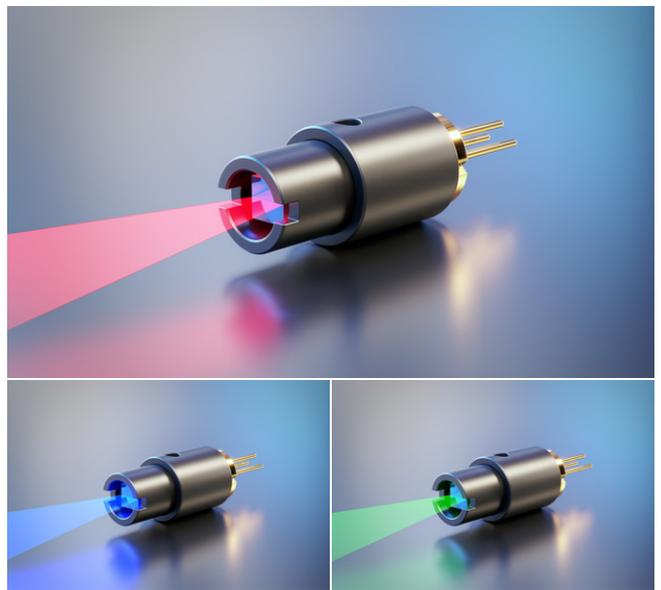
GRIN-Optics laser line modules are performed by a team of experts who have more than two decades of experience in the specialized field of micro-optics.

Features

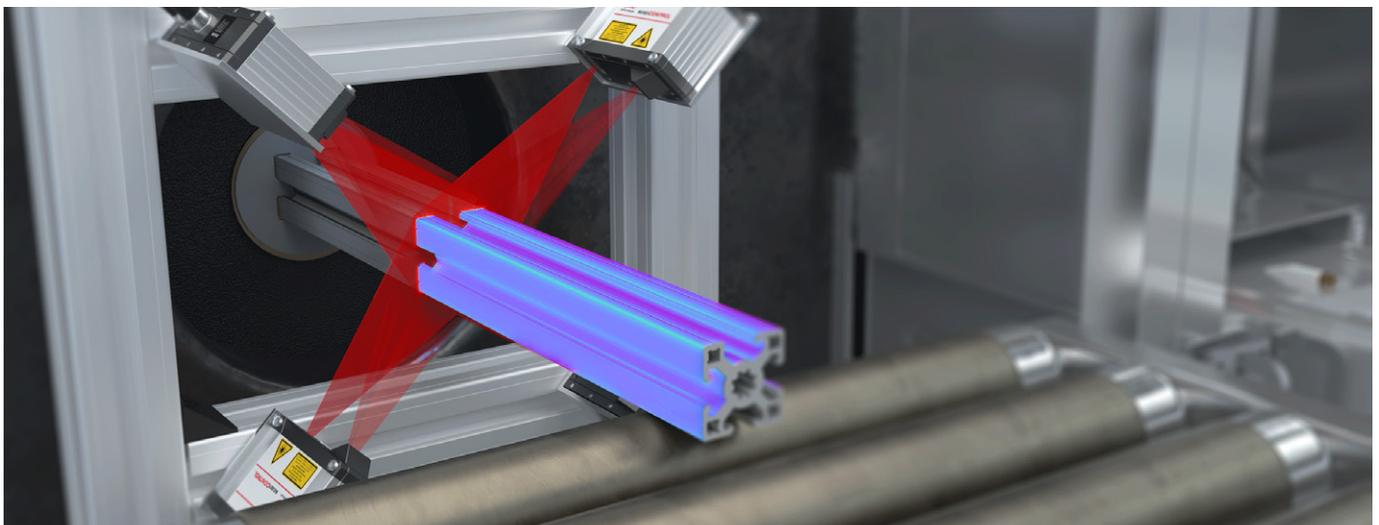
- Gradient Index Lenses generating a thin homogeneous laser line from a unique GRIN doublet lens unit
- High uniformity homogeneity of the laser line, up to +/-5% for different wavelengths
- Excellent line straightness
- Pointing and focus stability
- Exceptionally compact module size of 6.50 mm x 14.0 mm
- 2 housing diameters 6.50 mm and 8.00 mm as standard, as well as custom sizes on request
- Red, green, blue wavelengths available as standard
- Close diffraction-limited gaussian focus size
- Weight of only 1.5 g
- Variety of configuration options

Applications

- 3D contour mapping
- Optical alignment
- Machine vision
- Biomedicine



Application: 3D contour mapping with Laser Line Triangulation Sensors (courtesy of Micro-Epsilon)

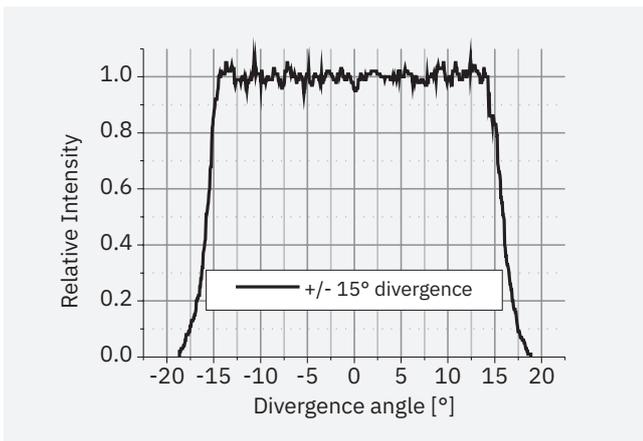


Optical Specifications

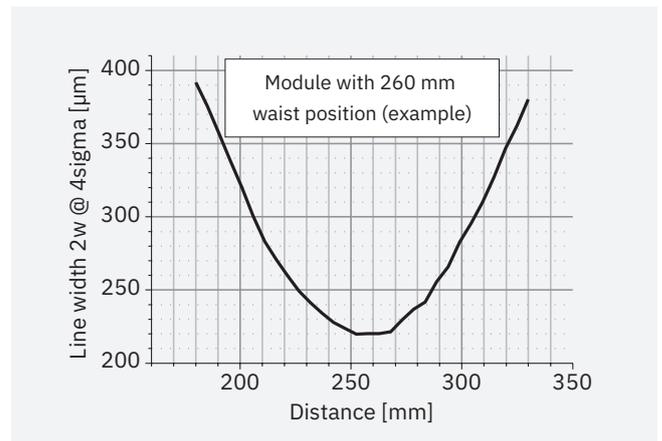
- Fan divergence angles : $\pm 10^\circ$, $\pm 15^\circ$, $\pm 20^\circ$
- Focus distance: 80 mm – infinity, Gaussian shape
- Line width in focus: $2w@4\sigma/\text{Distance} = 0.91 \mu\text{m}/\text{mm}$,
- Example: approx. 182 μm line width ($2w@4\sigma$) in 200 mm distance
- Far field divergence depending on line widths, approx. according to Gaussian beam laws Squint angle: $\leq 2^\circ$
- Single Mode Laser diode TO-56 package (driver on request)
- Red laser diode: QDLaser – QLF063A-AA, $\lambda = 660 \text{ nm}$, PLD = 50 mW
- 450 nm and 520 nm wavelength – are also available
- Transmission efficiency: $P_{\text{out}}/P_{\text{LD}} = 90\text{--}95\%$ with anti-reflex coated GRIN optics

Mechanical Specifications

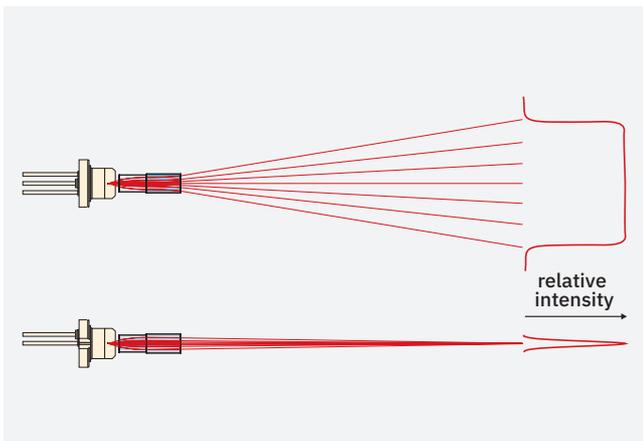
- Weight: 1.5 g
- Dimensions version 1: $\varnothing 6.50 \text{ mm} \times 14.0 \text{ mm}$
- Dimensions version 2: $\varnothing 8.00 \text{ mm} \times 14.0 \text{ mm}$
- Package material: anodised black aluminium



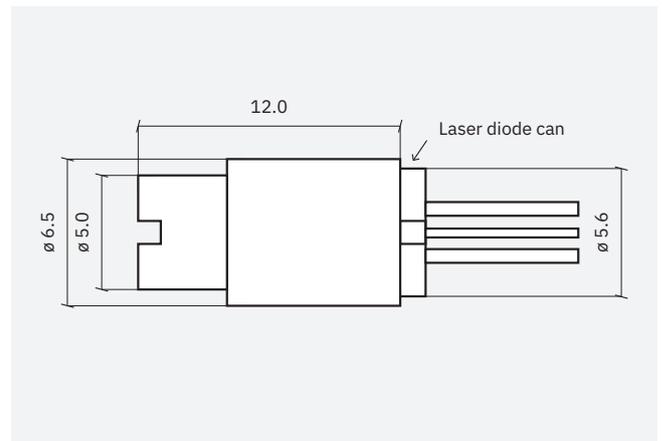
Far Field Divergence



Axial dependence of Line Width



Principle of laser line generation by GRIN optics



Dimensions Version 1

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GRINTECH

Gradient Index Optics

Positioning Unit & Handling Tools



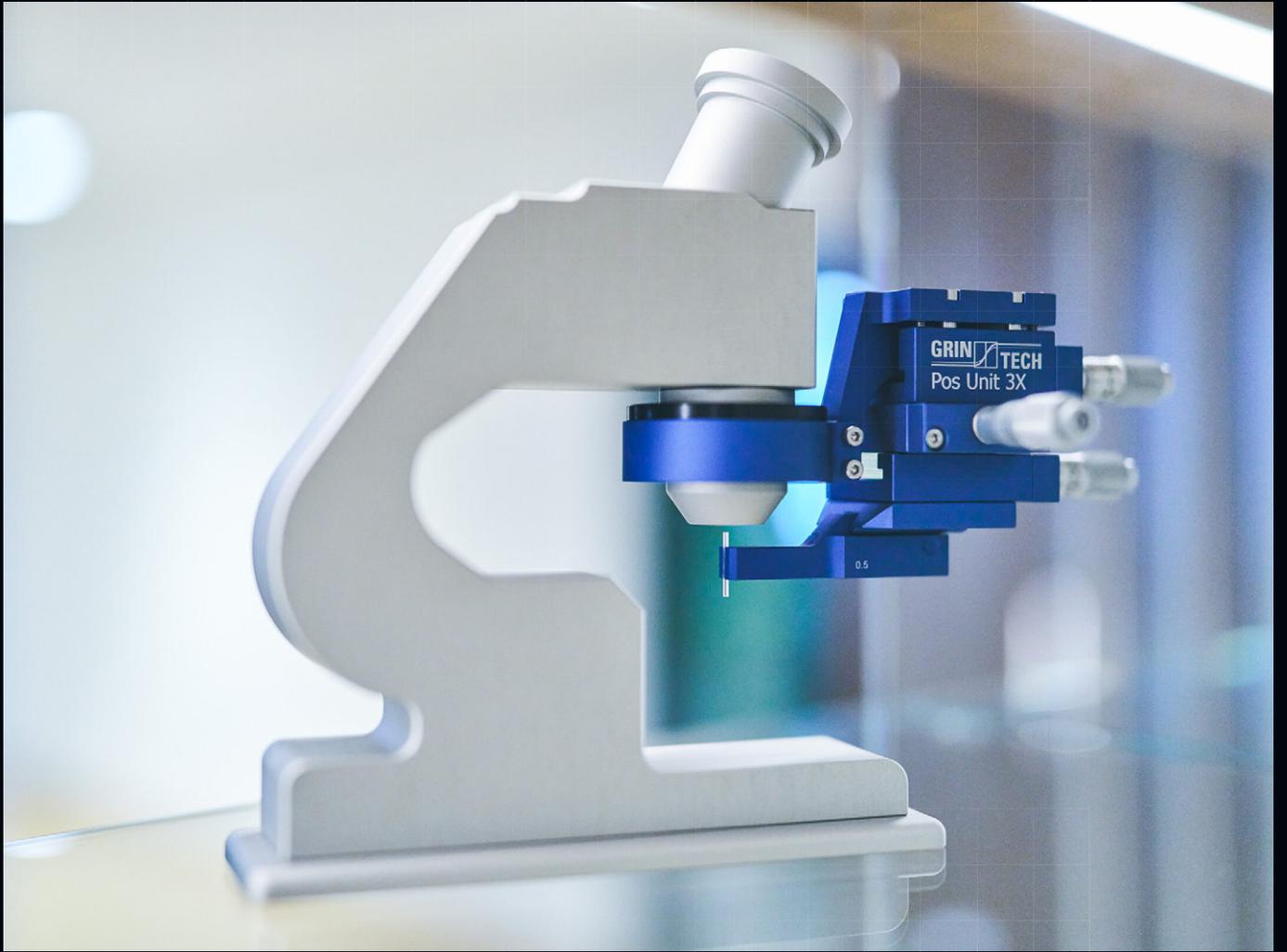
Accurate positioning and easy handling of GRIN microsystems

- 3-axis positioning of GRIN microsystems in relation to a microscope objective
- Bracket for 30 mm microscope objective diameter (standard)
- Adapter rings are available for smaller microscope objective diameters
- Travel: 5 mm in xyz, 10 μm reading accuracy
- Easily pick up and drop GRIN lenses with a snap-on system
- Jaw holder fits exactly to the jaws of the previous model
- Magnetic holder for PosUnit 3X and as a handling tool for all GRIN lenses
- Various prism groove sizes available for diameter: 0.5/0.7/1.0/1.2/1.4 mm
- Elastically mounted snap-in system for easy pick-up, placement and handling of GRIN lenses, which are now guided by a precise axis

Customizable at the customer's request

On request, the following are possible:

- Adapter rings for smaller microscope objective diameters

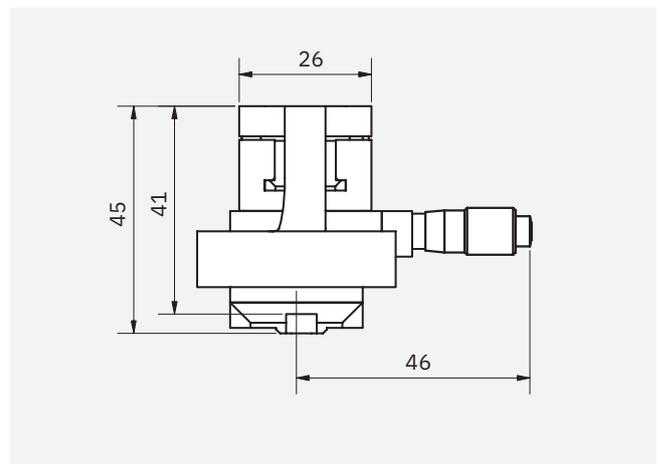
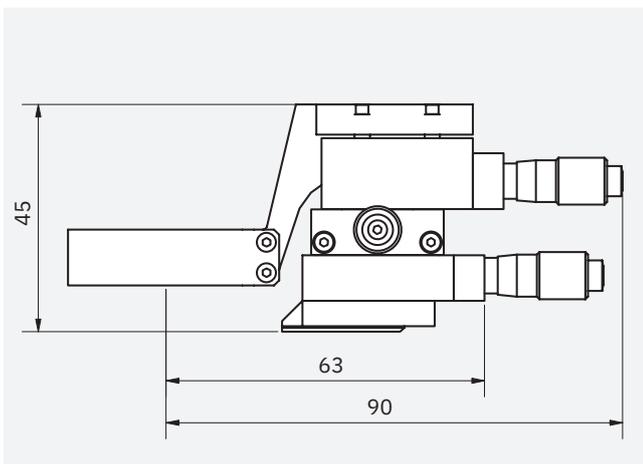


PosUnit 3x for GRIN-Needle Endomicroscopes & High NA Objectives

XYZ Stage and objective mounting to connect and align to microscope objectives

Applications and Properties

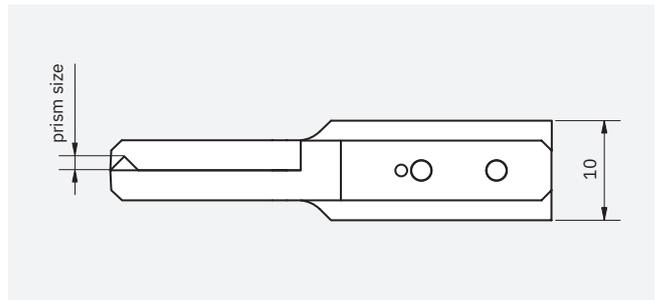
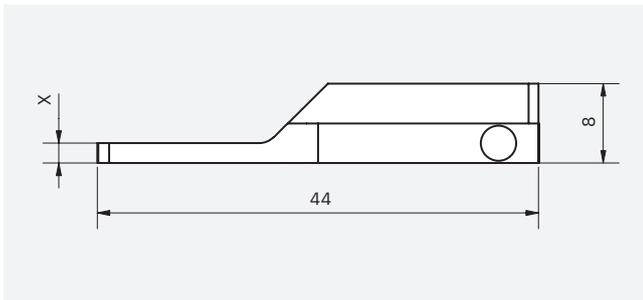
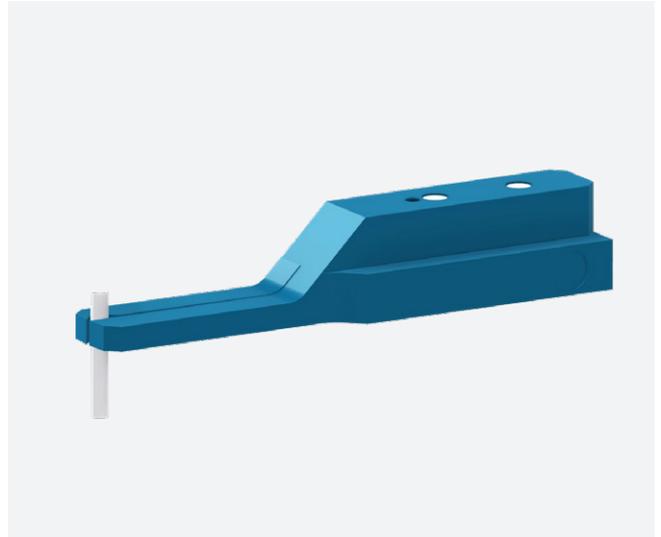
- Holding, handling and three-axis-positioning of GRIN-microsystem relative to microscope objectives
- Mounting for microscope objective diameter 35 mm (standard)
- Smaller microscope objective diameters are possible with assistance of an adapter ring
- Stable and reliable construction of the XYZ-stage
- Adjustment travel: X – 5 mm, Y – 5 mm, Z – 5 mm with scale reading in all axis, bar distance 10 μm .
- Easy pick and drop of GRIN Lenses with a resiliently mounted snap system
- Jaw seat fits exactly to the jaws of the previous model
- Durable anodized aluminum surface
- Clamping unit not included



Clamping Unit

Applications and Properties

- Holding device for grin lenses to be accommodated within the Pos Unit 3X
- Different prism groove sizes available for
- Diameter: 0.5/0.7/1.0/1.2/1.3 mm
- Different tension heights (x) available: 2/4 mm
- Resiliently mounted snap system for easy pick and drop and handle of GRIN Lenses, now guided by precise axis
- Magnetic holder for PosUnit 3X
- Durable anodized aluminum surface

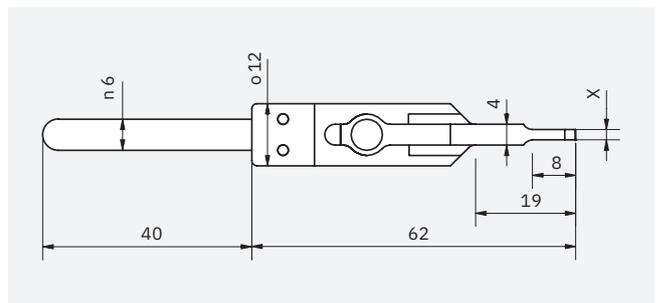
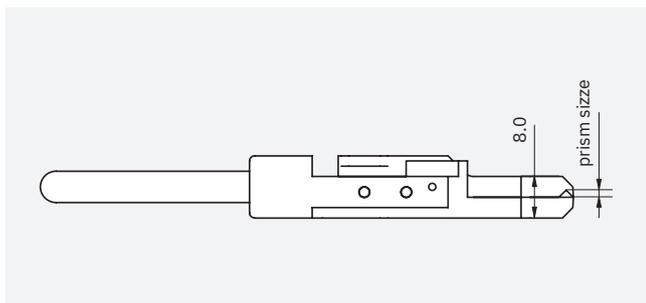
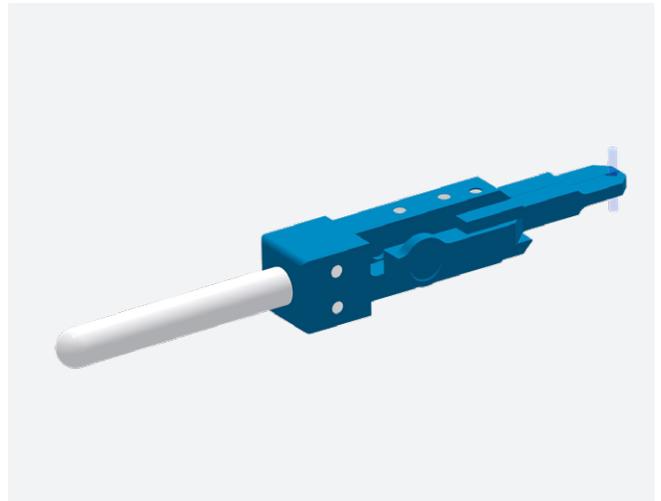


GRIN Lens Gripper for GRIN-Lenses, Needle Endomicroscopes and High NA Objectives

GRIN Lens Gripper

Applications and Properties

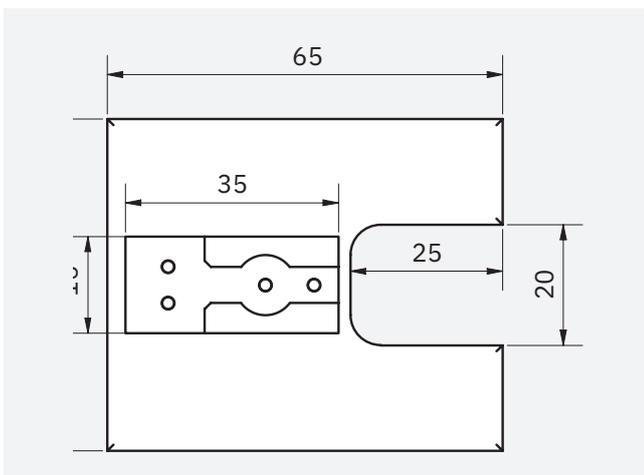
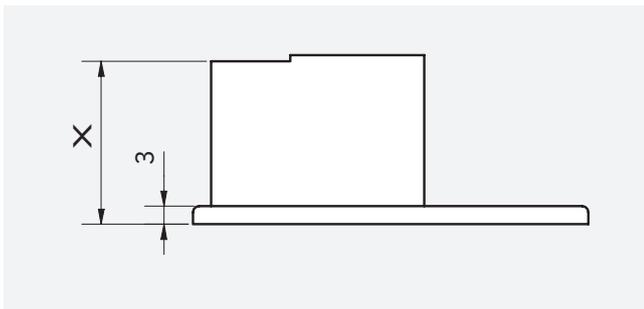
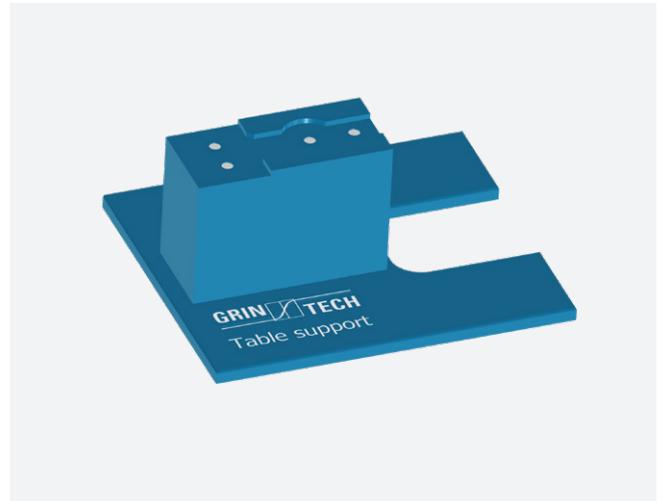
- Basic Unit – GRIN Lens Gripper
- Holding device for grin lenses
- Different prism groove sizes available for diameter: 0.5/0.7/1.0/1.2/1.3 mm
- Different tension heights (x) available: 2/4 mm
- Springy-loaded snap system for easy pick up and handle micro-optics
- Durable anodized aluminum surface
- Lens gripper not included



Tool Table Support

Applications and Properties

- Table support for GRIN Lens Gripper
- For cleaning and inspection on table
- Horizontal and vertical storage of the lens axis possible
- Shelf heights (x) available in 8.5 mm and 27 mm from the table surface
- Magnetic holder
- Durable anodized aluminum surface
- Lens gripper not included

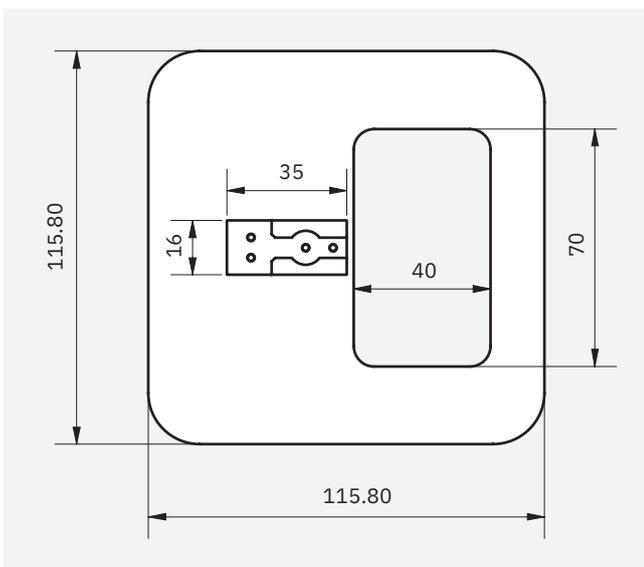
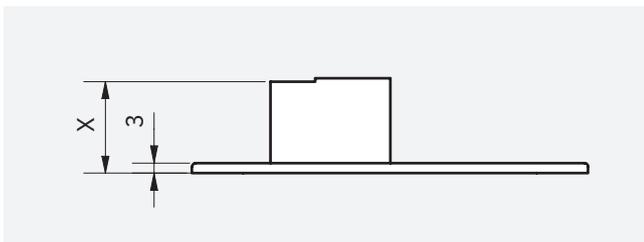


GRIN Lens Gripper for GRIN-Lenses, Needle Endomicroscopes and High NA Objectives

Tool – Microscope support

Applications and Properties

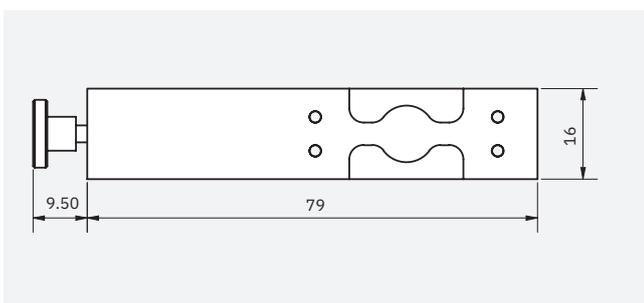
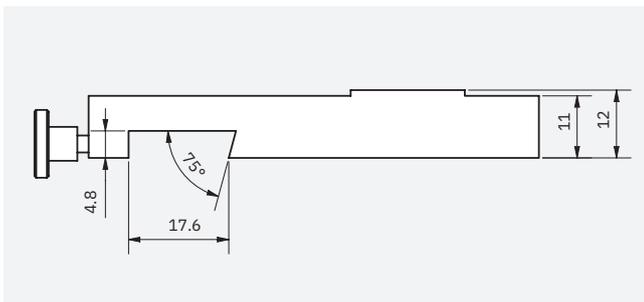
- Microscope support for GRIN Lens Gripper
- For cleaning and inspection on Microscope
- Horizontal and vertical storage of the lens axis possible
- Shelf heights (x) available in 8.5 mm and 27 mm from the Support surface
- Magnetic holder
- Durable anodized aluminum surface
- Lens gripper not included



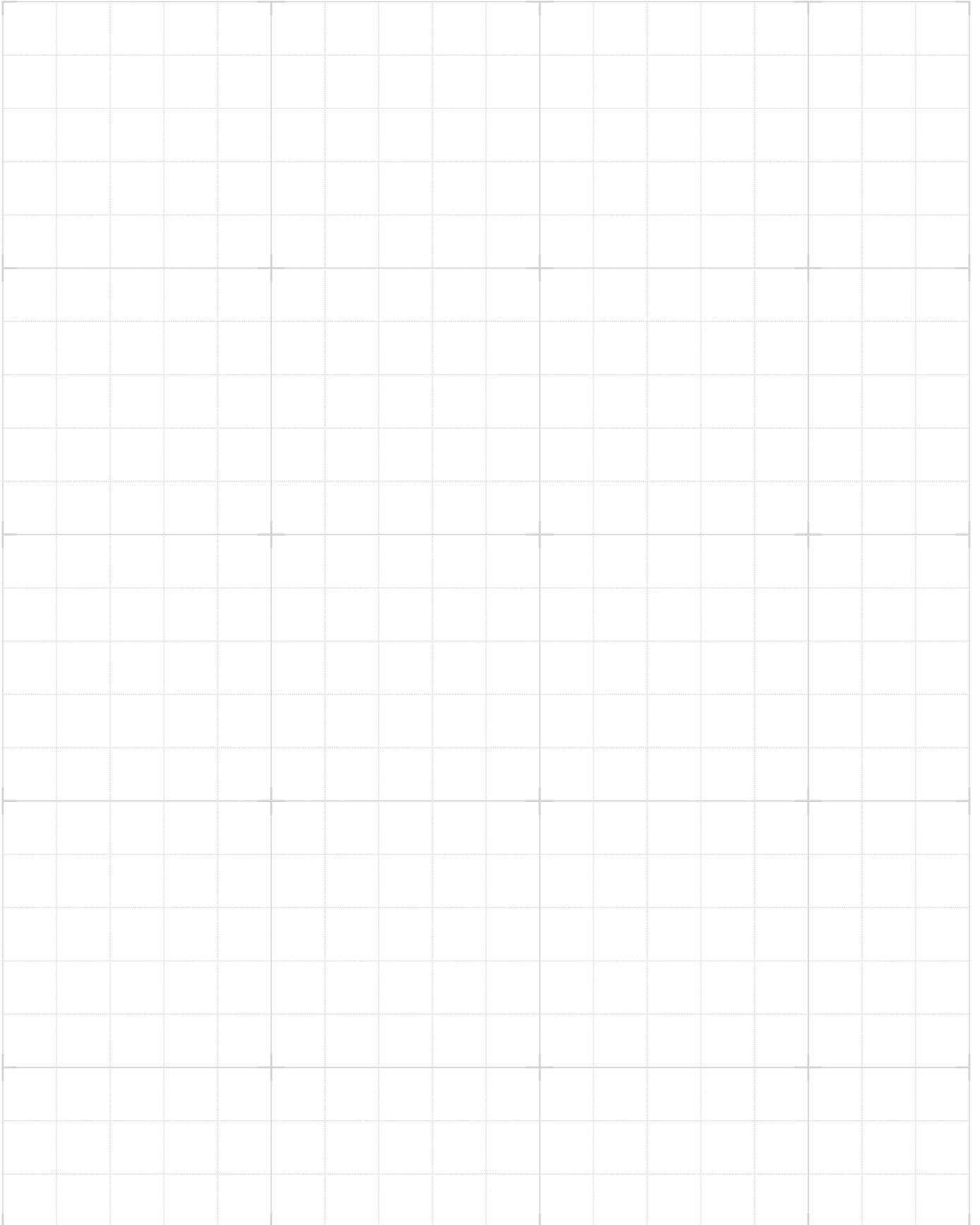
Tool Mounting Bracket

Applications and Properties

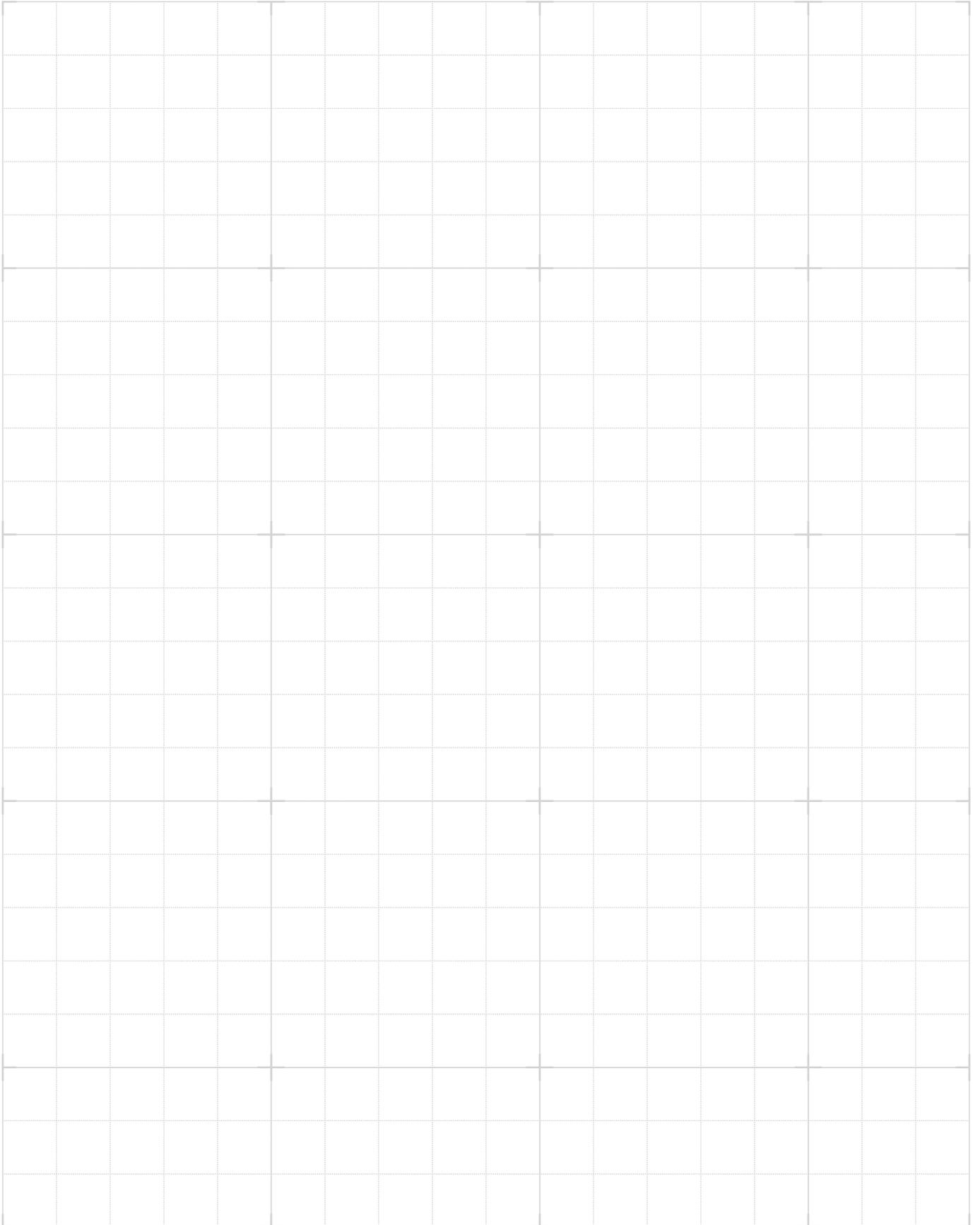
- For mounting GRIN Lens Gripper on Newport ULTRAalign™ system
- Measuring and inspection on Newport ULTRAalign™ system
- Magnetic holder
- Durable anodized aluminum surface



Notes



Notes



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