optotune

Optotune solutions for microscopy

Introduction

April 2021

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Product portfolio

Our solutions to enhance your microscopes

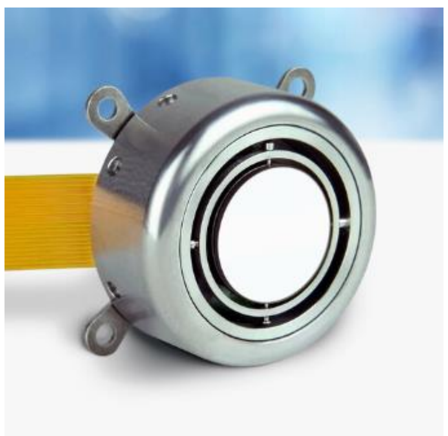
Focus tunable lenses

- Fast autofocus
- Fast detection
- Image stacking

Laser speckle reducers

- Homogeneous laser illumination field
- Noiseless
- Compact

Beam steering devices



- Sole reflection
- Wide angular range
- Compact

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Current situation

How do we move from 2D to 3D

Goals

- Imaging of 3D cell cultures
- Imaging of whole embryos
- In-vivo imaging

Limitations

- Depth of field DOF
- Mechanical vibrations
- Focusing speed

Solution

- 3D microscope

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Current solutions

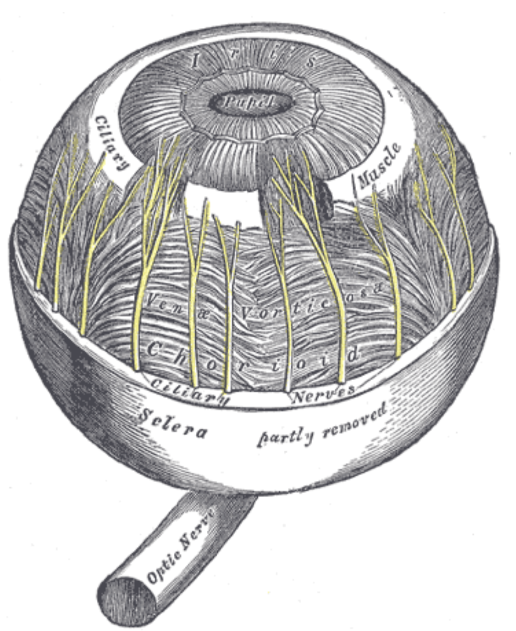
To focus along Z-axis

	Motorized Z	Piezo Z	Focus Tunable Lens	
				
Price	$$	$$$	$	3x cheaper than piezo’s
Speed	+	+++	+++ (100Hz)	100x faster than motorized Z
Travel Range	+++	+	++	e.g. 600 µm with 40x objective
Compactness	+	++	+++	No table-top controller
Vibrations	+	+	+++	No vibrations
Thermal Drift	+	+	+++	Temp. comp. sensor

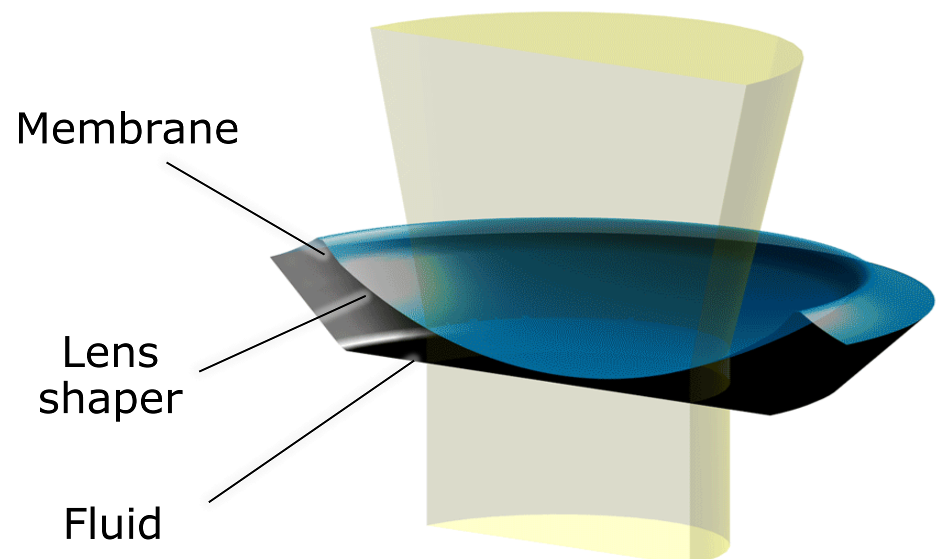
Working principle

Membrane with fluid and actuator

Human eye:
Ciliary muscle actuates
the lens curvature



Optotune lens:
Electromagnetic actuator
controls the lens curvature



See also: https://www.optotune.com/tunable-lenses

Our product range

Liquid lenses for microscopy applications

	EL-3-10-TC	EL-10-30-TC	EL-10-30-C(i)	EL-16-40TC
				
Focal power range	-13 … +13 dpt	8 … 22 dpt	-1.5 … +3.5 dpt +5 … +10 dpt	-2 … +3 dpt -10 … +10 dpt
Clear aperture	3mm	10mm	10mm	16mm
Outer diameter	10mm	30mm	30mm	40mm
Response time*	1 / 3 ms	4 / 9 / 20 ms	2.5 / 6 / 15ms	5 / 12 / 25ms
Wavefront quality RMS @525nm**	<0.07 λ	<0.15 λ	<0.1 λ	<0.15 λ
Absolute focal power accuracy (typical)	N/A	< 0.1 dpt	< 0.1 dpt	< 0.05 dpt
Typical use case	Machine Vision	Microscopy	Small and mid size sensors	Large sensors

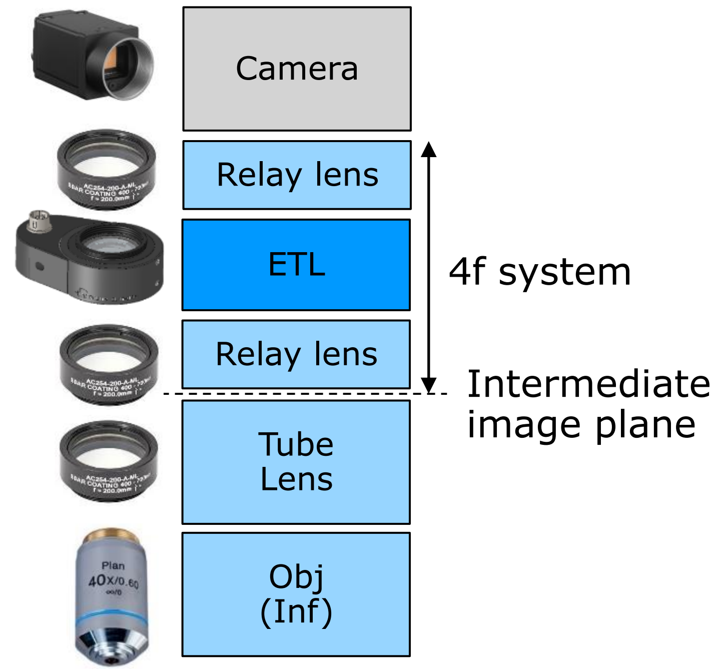
* 10-90% of step / settling time of a controlled step / settling time of rectangular step

** class 1 specification

Microscopy configurations

How ETL impacts on the image magnification

Non-telecentric	Telecentric



Non-telecentric

	Z-range with 5D lens	Mag change*
10x	2560 µm	7.5%
20x	640 µm	12.2%
40x	160 µm	23.7%

Telecentric

	Z-range with 5D lens	Mag change
10x	1000 µm	0%
20x	250 µm	0%
40x	60 µm	0%

* Magnification changes are linear, it is possible to compensate it via software

Integrations

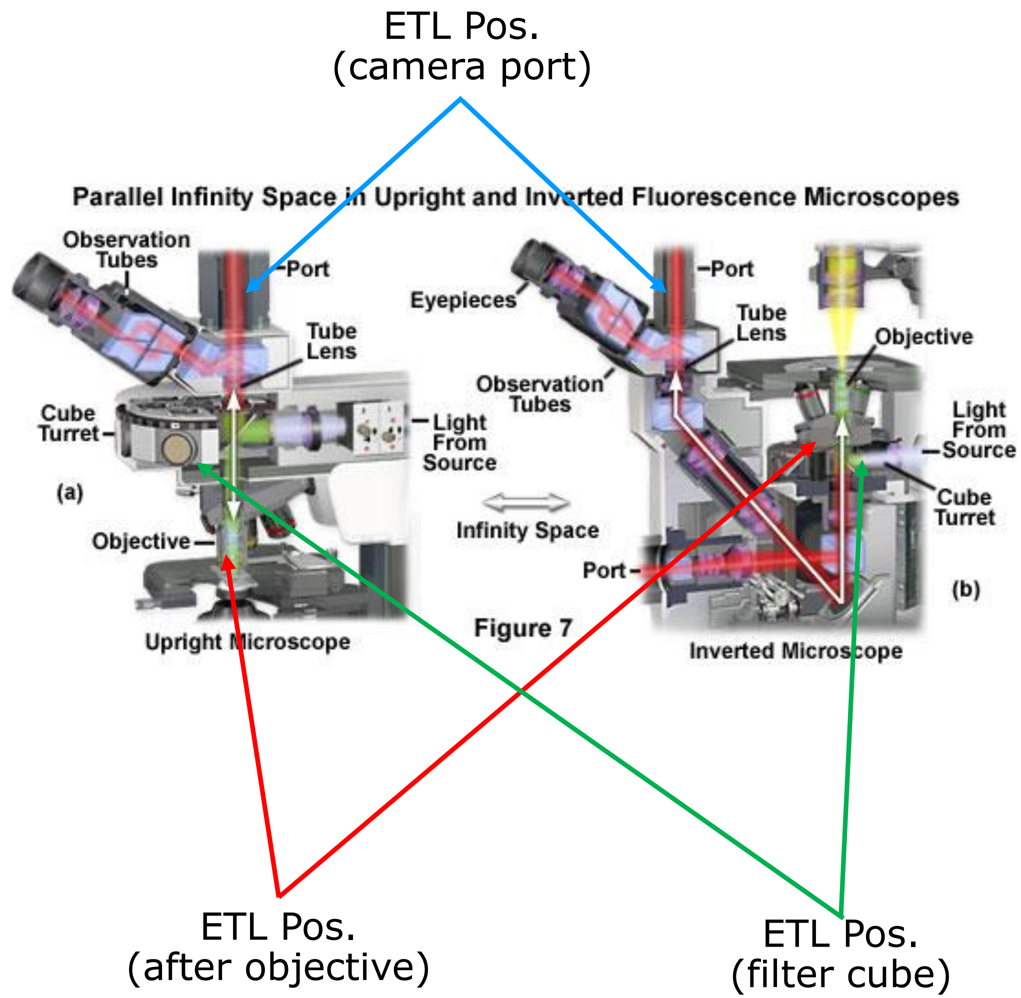
How ETL can become part of your systems

Digital inspection microscope	Scientific microscope

Tube lens

ETL Pos.

Zoom lens



Techniques overview

Different techniques, different applications

3D Microscopy

Wide-Field

Two-Photon

Digital Microscopy

Confocal

Light Sheet

Raman Spectroscopy

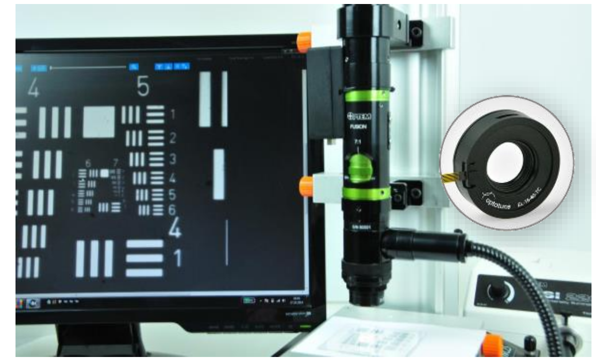
Integration: microscopy examples

Collaboration with our partners

Edmund optics | worldwide

NAVITAR

QIOPTIQ
Photonics for Innovation
An Excelitas Technologies Company



sanxo

Mvotem Optics ®
慕藤光

HeliconSoft

Integration example:
Tucsen microscope – automated zoom & focus

- Lens control fully integrated into system software
- Tunable lens: EL-10-30

- Video: https://youtu.be/5h5JyK8z_j8
- Website: http://www.tucsen.com/en.html

Off the shelf Z-focus solutions

Based on Optotune EL-10-30 and EL-16-40

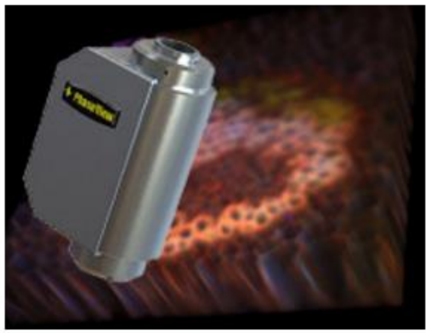
Life Sciences & Scientific Imaging

Microscopy Volume Imaging Solutions

Industries & Quality Control

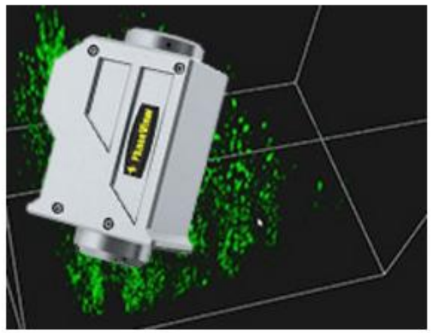
3D Solutions For Microscopes And Automated Vision Systems

PhaseView®



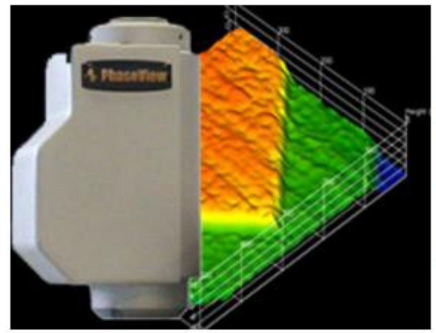
NeoScan

Fast Volume Scanning



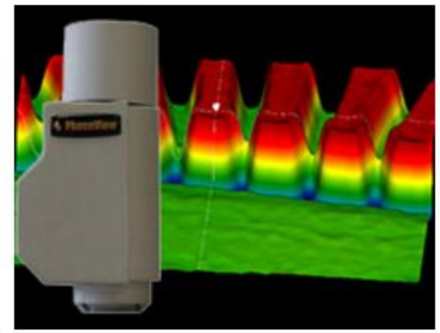
ThunderScan

Ultra High Speed Scanning



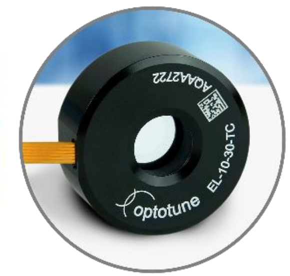
ZeeScan

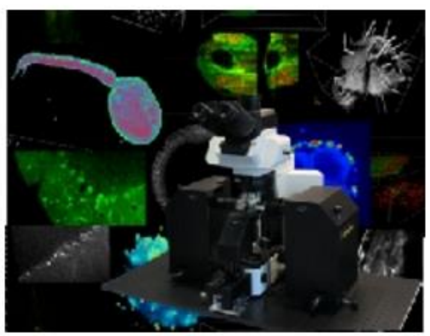
3D Add-On for microscopes



ZeeCam

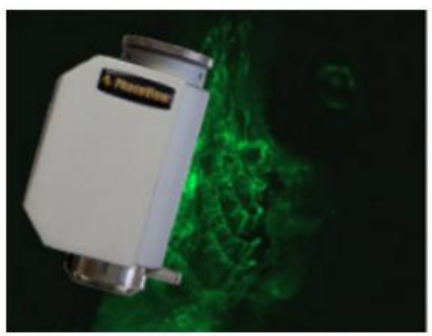
3d microscope camera





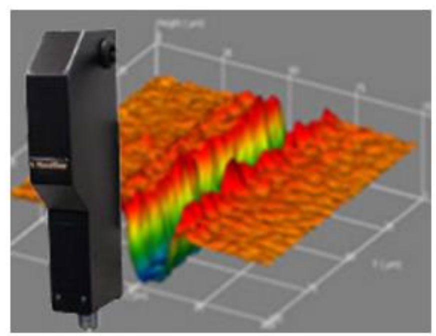
Alpha^3

Light Sheet Microscope



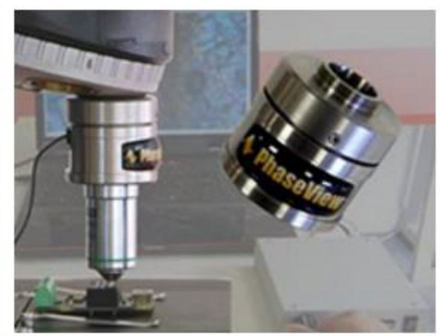
InSight

Real Time 3D Acquisition



ZeeScope

3d measurement microscope



SmartScan

Motorless focus control

www.phaseview.com

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Preferred partner to develop new technologies

Publications using Optotune Lenses for Microscopy

Four-dimensional visualization of zebrafish cardiovascular and vessel dynamics by a structured illumination microscope with electrically tunable lens

Chen Chong, Li Simin, Wen Gang, Liang Yong, Wang Linbo, Yang Guang, Jin Xin, and Li Hui, Biomed. Opt. Express 11, 1203-1215 (2020) https://doi.org/10.1364/BOE.382114

Speeded-Up Focus Control of Electrically Tunable Lens by Sparse Optimization

Iwai, D., Izawa, H., Kashima, K. et al. Speeded-Up Focus Control of Electrically Tunable Lens by Sparse Optimization. Sci Rep 9, 12365 (2019). https://doi.org/10.1038/s41598-019-48900-z

Large depth-of-field 3D shape measurement using an electrically tunable lens

Xiaowei Hu, Guijin Wang, Yujin Zhang, Huazhong Yang, and Song Zhang, Opt. Express 27, 29697-29709 (2019) https://doi.org/10.1364/OE.27.029697

Experimental validations of a tunable-lens-based visual demonstrator of multifocal corrections

Vyas Akondi, Lucie Sawides, Yassine Marrakchi, Enrique Gambra, Susana Marcos, and Carlos Dorronsoro, Biomed. Opt. Express 9, 6302-6317 (2018) https://doi.org/10.1364/BOE.9.006302

Cell mechanotransduction with piconewton forces applied by optical tweezers

Fabio Falleroni, Vincent Torre, Dan Cojoc, Frontiers in cellular nanoscience (2018), https://doi.org/10.3389/fncel.2018.00130

All-optical microscope autofocus based on an electrically tunable lens and a totally internally reflected IR laser

M. Bathe-Peters, P. Annibale, and M. J. Lohse, Optics Express Vol. 26, Issue 3, pp. 2359-2368 (2018), https://doi.org/10.1364/OE.26.002359

Three-dimensional Two-photon Optogenetics and Imaging of Neural Circuits in vivo

B. W. Yang, L. Carrillo-Reid, Y. Bando, D.S. Peterka, R. Yuste, bioRxiv preprint (2017). https://doi.org/10.1101/132506

NeuBtracker—imaging neurobehavioral dynamics in freely behaving fish

B. P. Symvoulidis, A. Lauri, A. Stefanoiu, M. Cappetta, S. Schneider, H. Jia, A. Stelzl, M. Koch, C. C. Perez, A. Myklatun, S. Renninger, A. Chmyrov, T. Lasser, W. Wurst, V. Ntziachristos, G. G. Westmeyer, Nature Methods - Brief communication (2017). doi:10.1038/nmeth.4459

High-speed dual-layer scanning photoacoustic microscopy using focus tunable lens modulation at resonant frequency

B. K. Lee, E. Chung, S. Lee, T. J. Eom, Optics Express, Vol 22, pp. 26427 (2017). doi.org/10.1364/OE.25.026427

Quantifying three-dimensional rodent retina vascular development using optical tissue clearing and light-sheet microscopy

B. J. N. Singh, T. M. Nowlin, G. J. Seedorf, S. H. Abman, D. P. Shepherd, J. Biomed. Opt., Vol 22, Issue 7, (7), pp. 2035-2046 (2011). doi:10.1117/1.JBO.22.7.076011

Three-dimensional multiple-particle tracking with nanometric precision over tunable axial ranges

B. G. Sancataldo, L. Scipioni, T. Ravasenga, L. Lanzanò, A. Diaspro, A. Barberis, and M. Duocastella, Optica Vol. 4, Issue 3, pp. 367-373 (2017)

Reduction of coherent artefacts in super-resolution fluorescence localisation microscopy

A. P. Georgiades, V. J. Allan, M. Dickinson, T. A. Waight, Journal of Microscopy (2016); doi: 10.1111/jmi.12453

High-speed microscopy with an electrically tunable lens to image the dynamics of in vivo molecular complexes

Y. Nakai, M. Ozeki, T. Hiraiwa, R. Tanimoto, A. Funahashi, N. Hiroi, A. Taniguchi, S. Nonaka, V. Boilot, R. Shrestha, J. Clark, N. Tamura, V. M. Draviam and H. Oku, Rev. Sci. Instrum. 86, 013707 (2015)

Multi-depth photoacoustic microscopy with a focus tunable lens

Kiri Lee, Euiheon Chung, Tae Joong Eom, Proc. of SPIE Vol. 9323 93233O-1 (2015)

Calcium transient prevalence across the dendritic arbour predicts place field properties

M. E. J. Sheffield, D. A. Dombeck, Nature 517, 200–204 (2015)

3d high- and superresolution imaging using single-objective SPIM

Remi Galland et al., Nature Methods 3402, 1-4 (2015)

Fast imaging of live organisms with sculpted light sheets

A. K. Chmielewski, A. Kyrsting, P. Mahou, M. T. Wayland, L. Muresan, J. F. Evers & C. F. Kaminski, Scientific Reports 5, Article number: 9385 doi:10.1038/srep09385 (2015)

A rapid image acquisition method for focus stacking in microscopy

D. Clark, B. Brown, Microscopy Today, Volume 23, Issue 04, pp 18-25 (2015)

Rapid quantitative phase imaging for partially coherent light microscopy

B. José A. Rodrigo and Tatiana Alieva, Optics Express, Vol. 22, Issue 11, pp. 13472-13483 (2014)

Investigation of diffraction-based measurement errors in optical testing of aspheric optics with digital micromirror devices

Stephan Stuerwald, Robert Schmitt, J. Micro/Nanolith. MEMS MOEMS 13(1), 1-8, (2014)

Product portfolio

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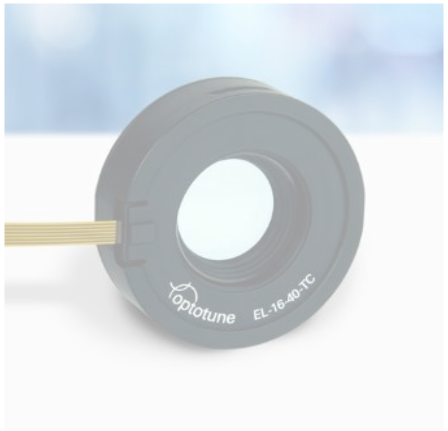


- Fast autofocus
- Focus detection
- Image stacking

Laser speckle reducers

- Homogeous laser illumination field
- Noiseless
- Compact

Beam steering devices

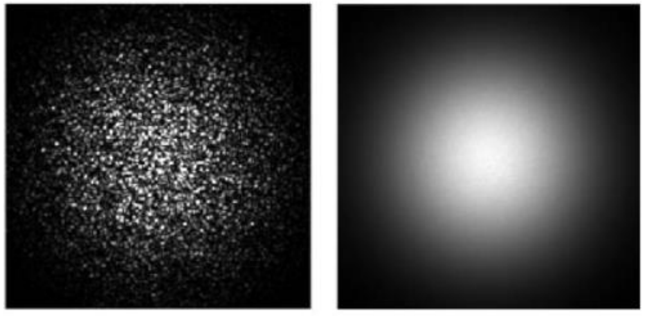
- Sole reflection
- Wide angular range
- Compact

Current situation

How do we improve laser illumination

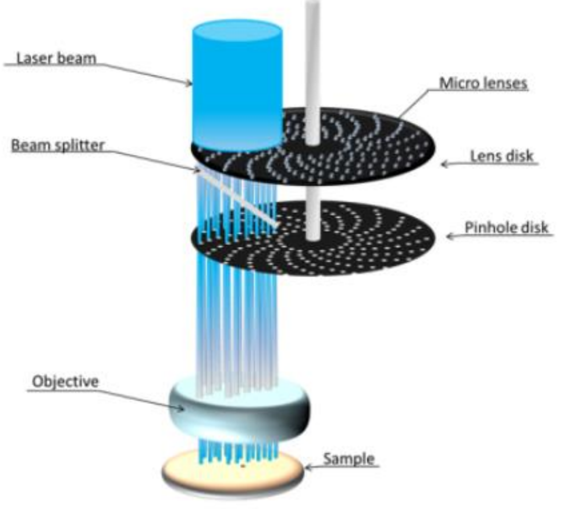
Goals

- Even illumination field
- Better contrast
- Higher image quality



Limitations

- Noise
- Size
- Isotropic diffusers



Solution

- Laser speckle reducer

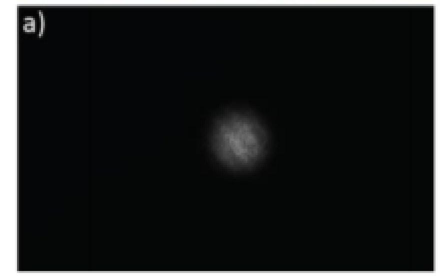
Our product range

Laser speckle reducers for laser applications

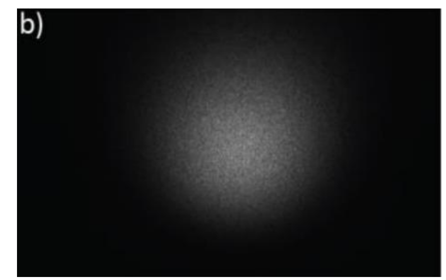
LSR-3005

LSR-4C

	LSR-3005	LSR-4C
Aperture	5 mm	18.5 mm
Size (L x H x D)	48x48x8.8 mm	40x40x3.8 mm
Standard diffuser angle	8.5°	8.5°
Oscillation frequency	300 Hz or 180 Hz	120 Hz +/- 10Hz
Oscillation amplitude	0.3 mm	0.8 mm
Electronics	Included	Included
Transmission	> 93	> 98 (coated) >94 (uncoated)
Operating Life time	2.000 h	> 40.000 h



No LSR – Contrast 0.27



LSR OFF – Contrast 0.26

LSR ON – Contrast 0.06

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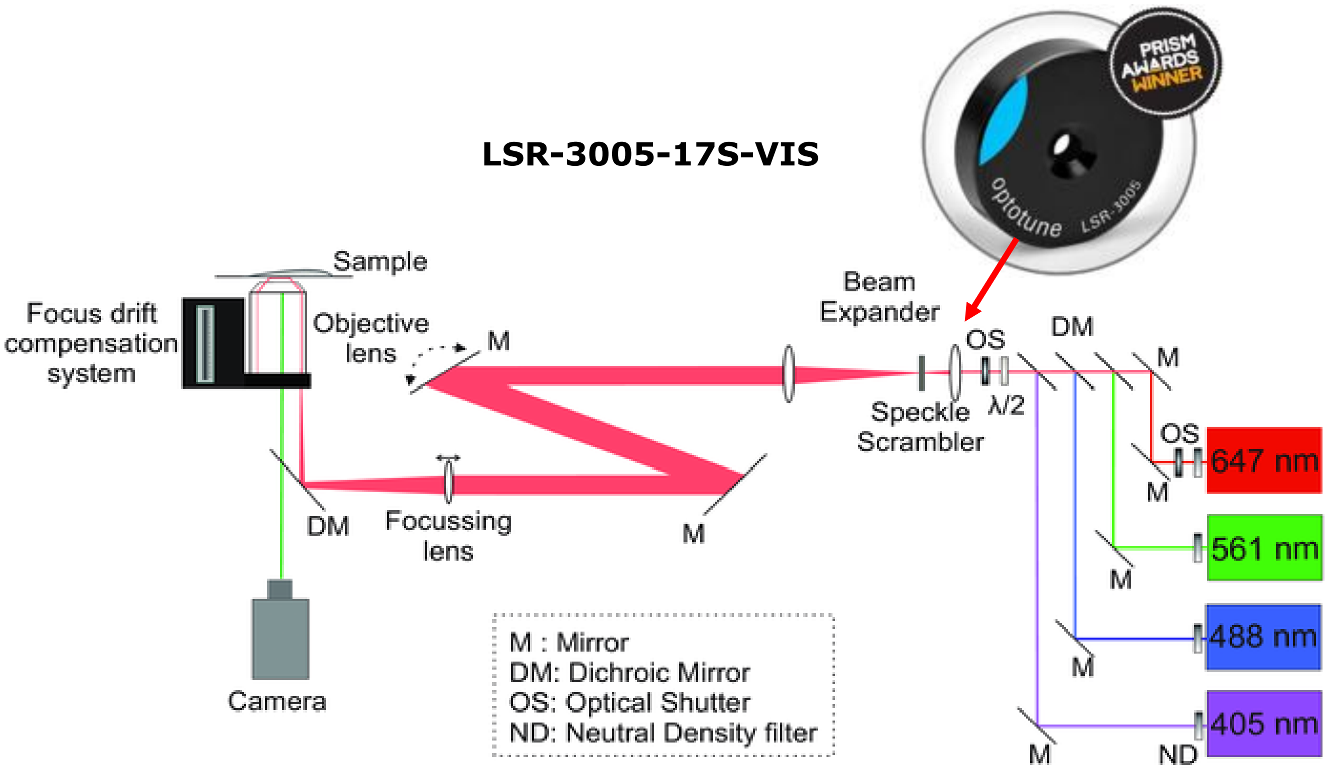
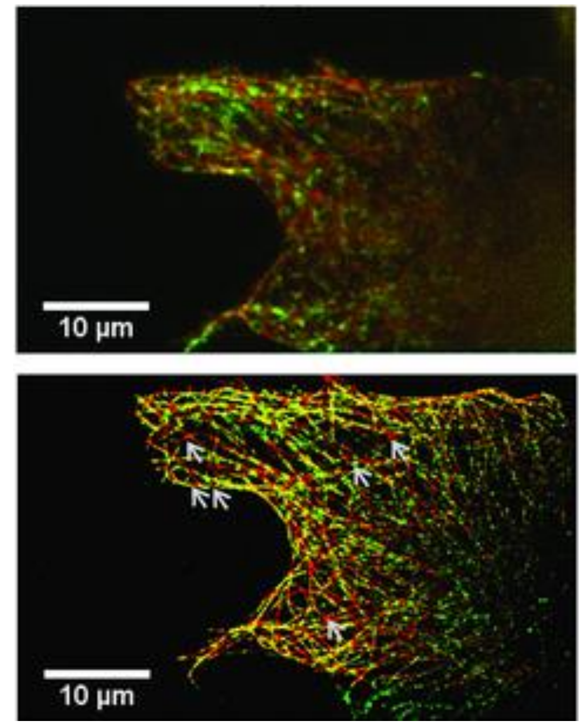
Application example

LSR boosts image quality in super-resolution fluorescence microscope



LSR off

LSR on



MRC5 cells stained with Alexa Fluor 647

Ref: P. Georgiades et al., Journal of Microscopy (2016), http://onlinelibrary.wiley.com/doi/10.1111/jmi.12453/full

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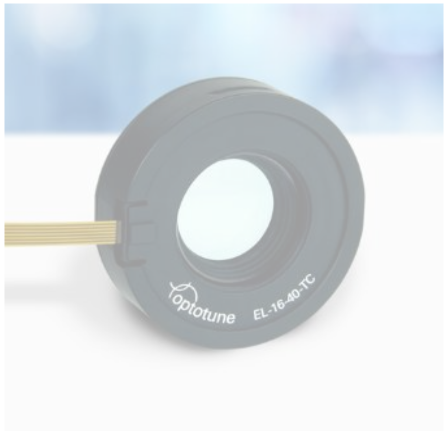

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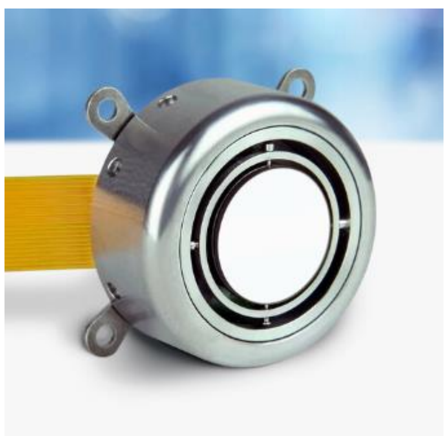

- Sole reflection
- Wide angular range
- Compact

Current situation

How do we improve your scanning system

Goals

- Change the Light Plane
- AOI selection
- Laser scanning

Limitations

- Size
- Center of rotation not on mirror surface
- Double reflection

Solution

- 2D mirror

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Our product range

2D Mirrors

	MR-15-30 standard	MR-10-30 2 resonant axis
Mirror size	15 mm	10 mm
Mechanical tilt – fast axis (half angle)	25°	12.5°
Full-scale bandwidth – fast axis	20 Hz	280 Hz
Mechanical tilt – slow axis (half angle)	25°	25°
Full-scale bandwidth – slow axis	20 Hz	20 Hz
Mech. Repeatability RMS typical	30-100 µrad	30-100 µrad (slow axis)
Footprint	30x14.5	30x14.5
Position feedback	yes	yes

shaping the future of optics

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