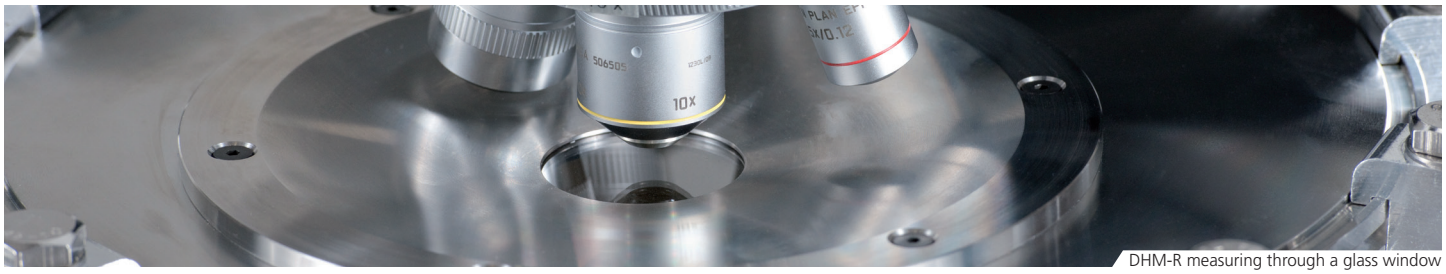
DHM® - R series

Reflection configured Digital Holographic Microscope (DHM®), a non-scanning and non-contact method for static and dynamic 3D topography as well as vibration characterization.



DHM-R measuring through a glass window

Unrivaled Speed

3D profilometry at unrivaled speed

DHM® measures the 3D topography map of a surface with a single acquisition, without any scanning mechanism required. It provides unbeatably fast acquisition, at camera rate of up to 1000 fps, enabling:

- Study of the 3D dynamic behavior of deformable samples
- Fast screen and analysis of large surfaces
- Routine inspections with high productivity
- Capture of 3D topographies on the production line, without stopping the sample

MEMS analysis, up to 25 MHz

The optional stroboscopic unit synchronizes the DHM® measurements with the excitation signal of a MEMS device. The analysis of this unique set of data provides:

- Time-sequence of 3D topographies
- Frequency resonances and responses
- Vibration amplitude with resolution of 5pm for out-of-plane and 1nm for in-plane displacements
- Characterization of complex motions and sample geometries, including in presence of holes

Measure in controlled environmental conditions

The unique optical configuration of DHM® enables the user to measure with optimal optical quality:

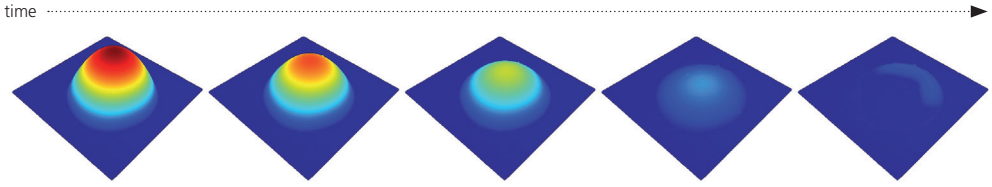
- Through glass and immersion liquids
- Inside environmental and vacuum chambers, under controlled temperature, humidity, pressure or gas composition

Measure topography of transparent patterns

The optional DHM® Reflectometry analysis software enables the measurement of:

- Topography of transparent structures
- Thicknesses and refractive index values of structured multi-layers with thicknesses ranging from 10 nanometers to tens of microns
- Topography of soft materials and liquids

Innovation



Time sequence of 3D topographies, limited by camera rate: evaporation of a liquid drop

DHM®

The Digital Holographic Microscopy (DHM®) is a patented technology. It records, with a digital camera, holograms produced by the interference between the beam reflected by the sample, and a reference beam generated inside of the microscope. The holograms are processed numerically to reconstruct a 3D optical map of the specimen.

The vertical calibration of DHM® is intrinsically defined by the laser wavelength. It provides high accuracy and reproducible data and measures with interferometric resolution, i.e. a subnanometric vertical resolution, and a lateral resolution limited by the choice of microscope objective.

Thanks to advanced numerical processing of the recorded hologram, sharp focus can be performed simultaneously or after measurement, as a post-processing without manually adjusting the height of the sample.


Reflection DHM®

Please visit **www.lynceetec.com** and contact us for more information and examples of applications.

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Three configurations of Reflection DHM® are available, differentiated by the number of wavelengths.

- → **R1000 models are configured with a single wavelength and are the ideal tool for measuring smooth surfaces and vibrations.**
- → **R2100 models are configured for measuring simultaneously at two wavelengths for achieving measurement of complex or discontinuous structures.**
- → **R2200 models are R2100 with a third source to extend measurement capability, in particular for measuring transparent patterns**

Technical specifications

System			
DHM models	R1000	R2100	R2200
Number of laser sources	1	2	3
Operating wavelength (± 1.0 nm)	666 nm	666 nm, 794 nm	666 nm, 794 nm, 680 nm
Laser wavelength stability	0.01°/K at 666 nm		
Sample stage	Manual or motorized XYZ stages up to 300 mm x 300 mm x 38 mm travel range		
Objectives	Magnification 1.25x to 100x, standard, high NA, long working distance, water/oil immersion		
Objective turret	6 positions		
Computer	Dell workstation with latest multicore Intel® processor, high performance graphic card, optimized and configured for DHM with screen min 21inch and mouse		
Software	Proprietary Koala software based on C++ and .NET Additional optional software modules available for advanced analysis		
Data compatibility	Measurement data recorded in bin format, exportable in .txt format, recorded and reconstructed images exportable in .tif format or .txt array		

Performance			
Measurement mode	Single wavelength at 666 nm	Short synthetic wavelength at 4.2 µm	Long synthetic wavelength at 24 µm
DHM models	R1000, R2100, R2200	R2100, R2200	R2200
Accuracy [1] [nm]	0.15	0.15 / 3.0 *	20
Vertical resolution [2] [nm]	0.30	0.30 / 6.0 *	40
Repeatability [3] [nm]	0.01	0.01 / 0.1 *	0.5
Vertical measuring range	up to 200 µm	up to 200 µm	up to 200 µm
Max. height of steps with sharp edges	up to 333 nm [4]	up to 2.1 µm [4]	up to 12 µm [4]
Surface type	Smooth surfaces	Complex or discontinuous structures	Complex or discontinuous structures
Vertical calibration	Determined by interferometric optical filter, ±0.1 nm		
Acquisition time	Standard: 500 µs (optional 10 µs)		
Acquisition rate	Standard: 30 fps (1024 x 1024 pixels). (optional up to 1000 fps).		
Reconstruction rate	Up to 25 fps 1024 x 1024 pixels hologram (data analysis dependent). (optional up to 60 fps)		
Lateral resolution	Objective dependent, down to 300 nm **		
Field of view	Objective dependent, from 66 µm x 66 µm up to 5 mm x 5 mm **		
Working distance	Objective dependent, from 0.3 to 18 mm **		
Digital focusing range	Up to 50x depth of field (objective dependent)		
Min. sample reflectivity	Less than 1%		
Sample illumination	Down to 1 µW/cm2		
Stroboscopic unit	Compatibility with single and short synthetic wavelength		

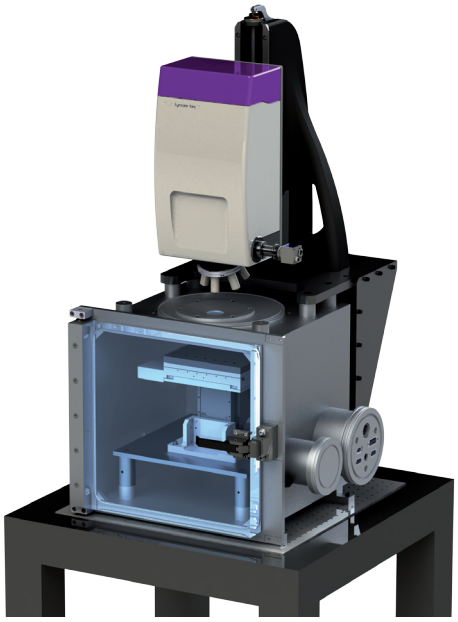
Power requirements	
Input voltage	85-260 VAC – 50/60 Hz
Power requirements	max. 250 W

Dimensions & weight	
Dimensions (L x W x H)	600 x 600 x 800 mm
Weight	48kg

1 As demonstrated by taking the temporal standard deviation on 1 pixel over 30 measurements
2 Defined as twice the accuracy
3 As demonstrated by taking the one sigma Rq value of 30 repeatability measurements without sample
4 Depends on the laser source(s) and operating wavelength(s)

* With / Without single wavelength mapping

** Objectives specifications on www.lynceetec.com/microscope-objectives



Reflection DHM® mounted on a vacuum chamber

DHM® systems are compatible with a large choice of options

- Objectives with extra-LWD, cover-glass correction, for immersion, etc.
- Motorized stage for automation and stitching
- Remote TCP/IP module for automation and remote control of DHM
- Stroboscopic unit for MEMS analysis
- Environmental chamber for measuring under controlled conditions

DHM® Stroboscopic module

For in-plane / out-of-plane full-field 3D measurements of ultra-fast moving micro-structures within a single acquisition

Used in conjunction with DHM, the Lyncée Tec stroboscopic module delivers dynamic contactless characterization of micro-devices with nanometer vertical resolution. Key features of the module are:

- frequency range up to 25 MHz
- user-selectable laser pulse freezing time down to 7.5 ns
- generation of any periodic or repeated impulse driving signal for characterization of key micro-structure parameters
- recording of external input signals
- continuous frequency scan to approach resonance

The stroboscopic package for DHM family of reflection and transmission configurations enables 3D dynamic response measurements and analysis of your products as they move for both material and life science applications.

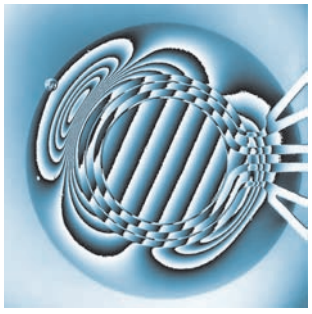
Fields of application include inertial and pressure sensors, inkjet heads, optical and RF MEMS/ MOEMS, cantilevers, micro-mirrors, micro-fuel cells, biochips, micro-fluidic devices… Packaged devices can easily be characterized through any glass window, as well as immerged samples.

Key device parameters can be characterized such as:

- shape, deformation, distortion and tilt / angle
- dynamic response
- critical dimensions
- surface texture
- thermal dilatation, elastic modulus...

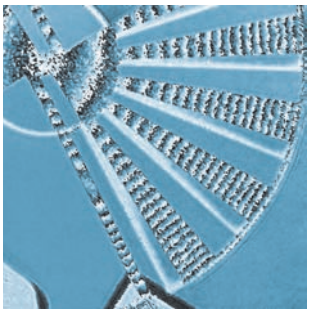
The modular design of DHM and its proprietary stroboscopic electronics permit its integration to MEMS probe stations and can control and drive up to max. 256 I/O cards simultaneously. Each one delivers a driving signal and allows the recording of synchronized digital and analog signals. The stroboscopic parameters can be adjusted at any moment by software and the response can be visualized in real-time. Furthermore non periodic movement capturing can be enhanced with an optional ultra fast camera.

The stroboscopic module comes with intuitive and powerful software integrated into Koala Software to synchronize illumination with device movements, to record, visualize and analyze the micro-device's functionality and true dynamic response.



a

b



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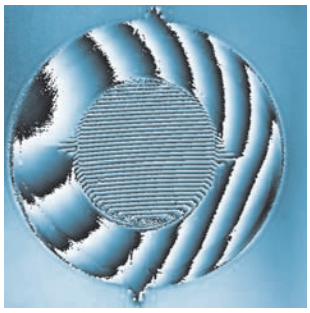

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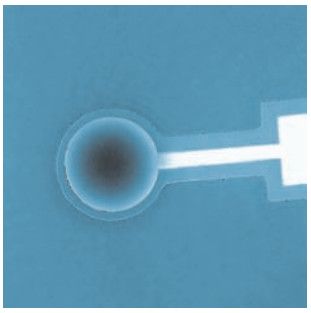

e

Precise measurements of displacements through extremely sensitive phase interpretation:
(a) Fabry-Perot cavity mirror
(b) Cantilever at resonance
(c) Variable capacitor
(d) High frequency mirror
(e) Membrane

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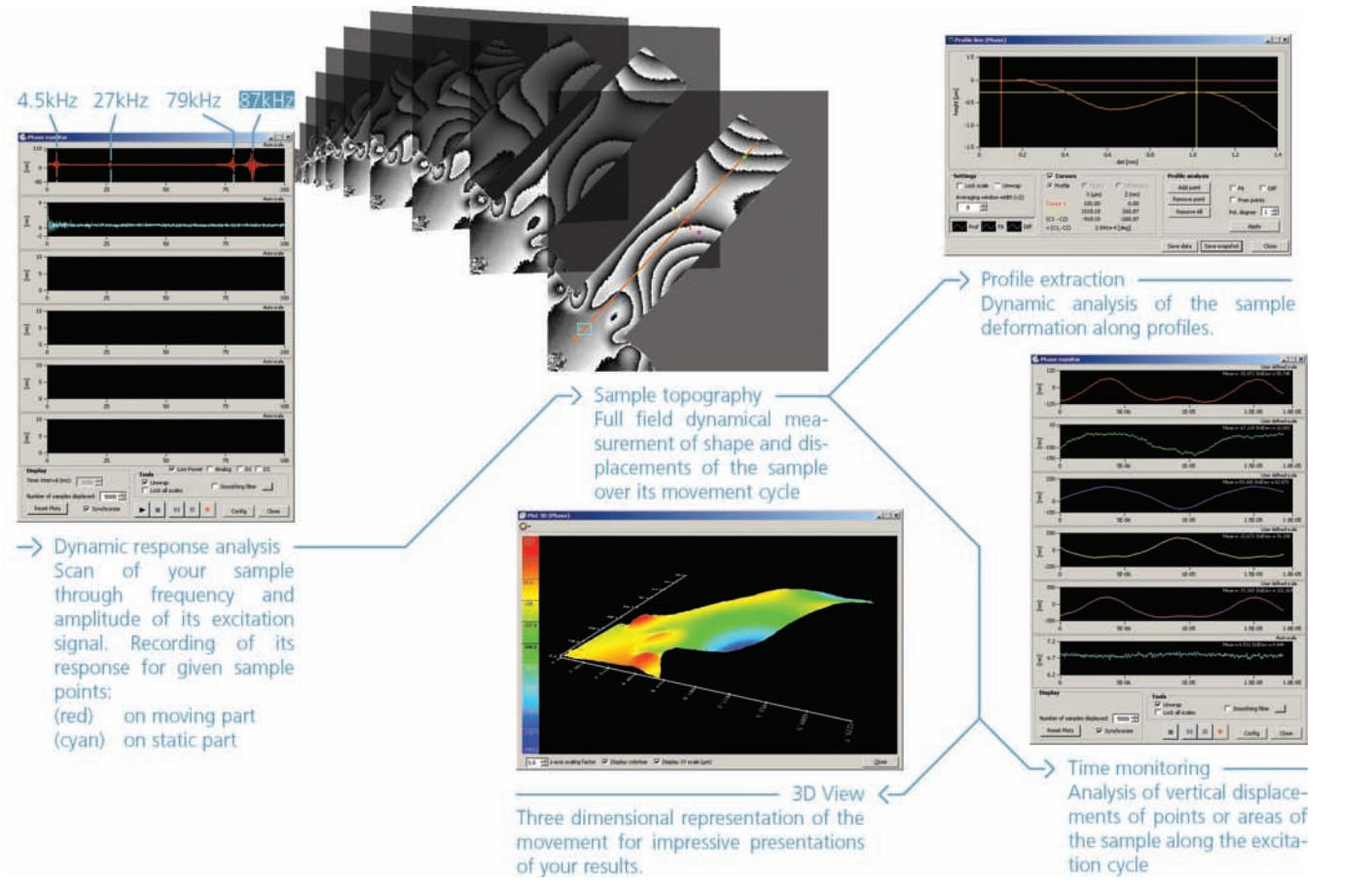
System configuration and performances

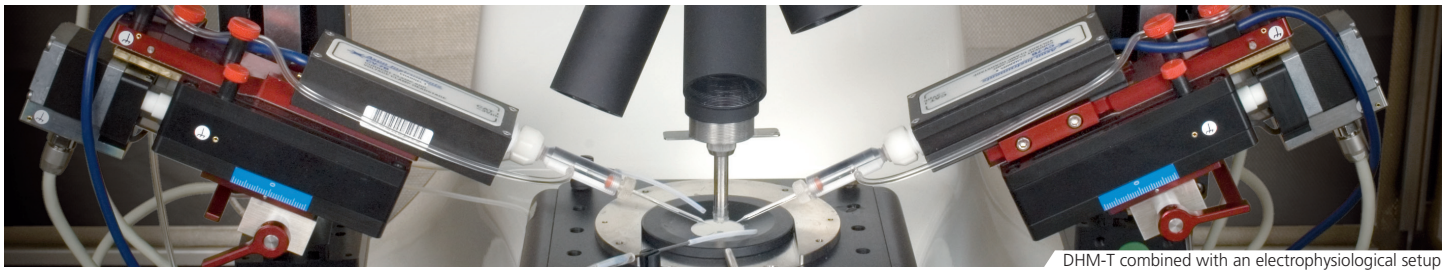
Fundamental frequency analog output:	0.1 Hz to 25 MHz	
Measurement points per fundamental cycle:	frequency dependent: up to 2^{15} points	
Laser pulse length:	down to 7.5 ns, up to 2^{32} repetitions	
Synchronization precision:	< 5 ps	
Waveform amplitude resolution:	14 bits	
Waveform generator:	predefined DC, sine, triangular, rectangular or user-defined form	
Analog output and offset:	0 to ±10 Volts with ±2% accuracy (up to ±200 Volts with optional M-22100, max. 100 kHz)	
Analog output impedance / max. current:	50 Ω / 100 mA	
Number of inputs:	2 analog (-10 V to +10 V) and 2 digital 3.3-5 V TTL, synchronized with the measurement	
Analog input impedance:	100 kΩ	
Device control:	preset or user-defined amplitude and / or frequency scanning duty cycle	
Stroboscopic module configuration:	M-16000	basic stroboscopic module including master board and one I/O card (M-22100)
	M-22100	additional I/O card for master board (M-16000) or slave board (M22040)
		includes 1 analog output ±10 V, max. 25 MHz, I_{max} 100 mA
		up to 4 I/O cards per board
	M-22040	additional slave board for up to 4 additional I/O cards (M-22100)
		max. 64 boards, 256 excitation signals
High power module configuration:	M-16010	motherboard for up to 2 amplification cards (M-22110)
	M-22110	×20 amplification card for 1 analog output ±200 V, max. 100 kHz, I_{max} 10 mA
Compatibility:	DHM R1100 series & DHM T1001	



Specifications are subject to change without notice

DHM® - T series

Transmission configured Digital Holographic Microscope (DHM®) for applications in life science and material science: a unique experimental set-up enabling characterization of light transmitting samples.



DHM-T combined with an electrophysiological setup

Biological Imaging

Label-free biological microscopy

DHM® enables non-toxic quantitative measurements of individual living cells and cultures up to confluence:

- Time-lapse
- Multi-well plate screening
- Diagnostic

Investigate unexplored biological processes

The quantitative phase measurement of DHM® can be interpreted in terms of many underlying biological processes:

- Channel activity
- Cell viability
- Intracellular concentration
- Morphology changes

Perform multimodal imaging

An optional module enables simultaneous DHM® and fluorescence measurements:

- Correlate DHM® measurements with well known measurement protocols
- Use the DHM to decrease the number of necessary fluorescence labelling
- Enhance understanding of cellular mechanism

Optical Profilometry

Transmission configured optical profilometer

The transmission DHM® enables the measurement of multiple sample characteristics:

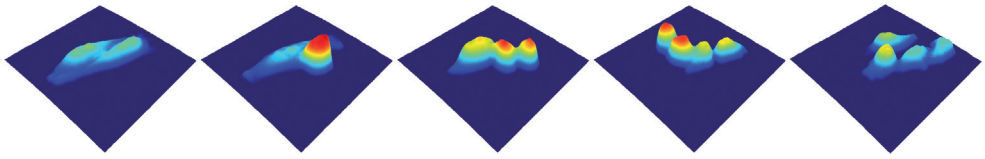
- Sample optical topography
- Thickness variability
- Size and location of internal structures and defects
- Refractive indices and concentration
- Birefringence

Investigate innovative materials and devices

The benefits with fast dynamical measurement have been demonstrated in numerous applications:

- Micro-optics
- Micro-fluidics
- Stress and constraints analysis
- Liquid Crystal Displays (LCD)
- Biophysics
- Wettability of coatings and structures
- Fluids and gas dynamics
- Dissolution and crystallization
- Particle velocimetry

time ····►



Time sequence of 3D optical map of quantitative phase measurement , limited by camera rate: division of HeLa cells

DHM®

The Digital Holographic Microscopy (DHM®) is a patented technology. It records, with a digital camera, holograms produced by the interference between the beam transmitted through the sample, and a reference beam generated inside of the microscope. The holograms are processed numerically to reconstruct a 3D optical map of the specimen.

The vertical calibration of DHM® is intrinsically defined by the laser wavelength. It provides high accuracy and reproducible data and measures with interferometric resolution, i.e. a subnanometric vertical resolution, and a lateral resolution limited by the choice of microscope objective.

Thanks to advanced numerical processing of the recorded hologram, sharp focus can be performed simultaneously or after measurement, as a post-processing without manually adjusting the height of the sample.

Please visit **www.lynceetec.com** and contact us for more information and examples of applications.

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Two configurations of Transmission DHM® are available, differentiated by the number of wavelengths.

→ **T1000 models are configured with a single wavelength and are the ideal tool for studying simple living cells as well as measuring transparent material samples with smooth surfaces**

→ **T2100 models are configured for measuring simultaneously at two wavelengths, extending measurement capability**

Technical specifications

System		
DHM models	T1000	T2100
Number of laser sources	1	2
Operating wavelength (± 1.0 nm)	666 nm	666 nm, 794 nm
Laser wavelength stability	0.01°/K at 666 nm	
Sample stage	Manual or motorized XYZ stages 114 mm x 76 mm x 38 mm travel range	
Objectives	Magnification 1.25x to 100x, standard, high NA, long working distance, water/oil immersion	
Objective & condenser turret	6 positions	
Computer	Dell workstation with latest multicore Intel® processor, high performance graphic card, optimized and configured for DHM with screen min 21inch and mouse	
Software	Proprietary Koala software based on C++ and .NET Additional optional software modules available for advanced analysis	
Data compatibility	Measurement data recorded in bin format, exportable in .txt format, recorded and reconstructed images exportable in .tif format or .txt array	

Performance		
Measurement mode	Single wavelength at 666 nm	Short synthetic wavelength at 8 µm [4]
DHM models	T1000, T2100	T2100
Accuracy [1] [nm]	1.0 [4]	1.0 / 5.0 [4] *
Vertical resolution [2] [nm]	2.0 [4]	2.0 / 10.0 [4] *
Repeatability [3] [nm]	0.02 [4]	0.02 / 0.05 [4] *
Vertical measuring range	up to 500 µm	up to 500 µm
Max. height of steps with sharp edges [6]	up to 1.0 µm [4] up to 3.5 µm [5]	up to 7.0 µm [4] up to 22 µm [5]
Vertical calibration	Determined by interferometric optical filter, ±0.1 nm	
Acquisition time	Standard: 500 µs (optional 10 µs)	
Acquisition rate	Standard: 30 fps (1024 x 1024 pixels). (optional up to 1000 fps).	
Reconstruction rate	Up to 25 fps 1024 x 1024 pixels hologram (data analysis dependent). (optional up to 60 fps)	
Lateral resolution	Objective dependent, down to 300 nm**	
Field of view	Objective dependent, from 66 µm x 66 µm up to 5 mm x 5 mm**	
Working distance	Objective dependent, from 0.3 to 18 mm**	
Digital focusing range	Up to 50x depth of field (objective dependent)	
Sample illumination	Down to 1 µW/cm2	

Power requirements	
Input voltage	85-260 VAC – 50/60 Hz
Power requirements	max. 250 W

Dimensions & weight	
Dimensions (L x W x H)	600 x 350 x 500 mm
Weight	30 kg

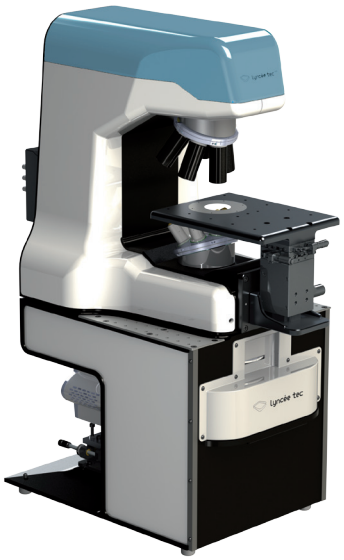
1 As demonstrated by taking the temporal standard deviation on 1 pixel over 30 measurements
2 Defined as twice the accuracy
3 As demonstrated by taking the one sigma Rq value of 30 repeatability measurements without sample
4 Converted value for measurements in air and with sample refractive index n = 1.5
5 Converted value for measurements in water and with sample refractive index n = 1.5
6 Depends on the laser source(s) and operating wavelength(s)

* With / Without single wavelength mapping

** Objectives specifications on www.lynceetec.com/microscope-objectives

DHM® systems are compatible with a large choice of options

- Objectives with extra-LWD, cover-glass correction, for immersion, etc.
- Motorized stage for automation and stitching
- Remote TCP/IP module for automation and remote control of DHM
- Stroboscopic unit for MEMS analysis
- Dipping tip for immersion measurement in well plate and open chambers
- Fluorescence module to combine DHM with epifluorescence measurements
- High-speed camera to extend measurement capabilities



Transmission DHM® combined with a Fluorescence module