Technology
Arts Sciences
TH Köln

Course Manual LMK

Light microscopy

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− General information

Long name	Light microscopy
Approving CModule	LMK_BaET, LMK_BaET
Responsible	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Valid from	winter semester 2022/23
Level	Bachelor
Semester in the year	winter semester
Duration	Semester
Hours in self-study	78
ECTS	5
Professors	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Requirements	mathematics; vector calculus complex numbers physics / optics: geometrical optics wave optics
Language	German
Separate final exam	Yes

Literature

keine

Final exam

Details

As long as the number of participants is not too high, oral examination is preferred of written exams.

Lowest competence level checked is knowledge. This could be e.g. structural components that are present in every microcsope, the raypath of a transmission and a reflexion microscope with Köhler illumination, the location of the angular apertur and the phase ring in a Zernike phase microscope or the reason for the direction selectivity in a differential interference contrast microscope.

The next competence level is related to skills. Examination could be done by the calculation

	of required parameters of key components in a microscope, either on the basis of given application specifications or by the specification of some compontents, that are already in use. Furthermore it can be checked, if the setup of Köhler illumination can be explained, ideally with explanatory statements. The highest competence level adressed is methodical expertise. It can be checked by the discussion of a real world task: E.g.: Determine the radius of curvature of a lens. Here the choice of the right type of microscope is already important. Furthermore the process of data ackquisition and the data manipulation good methodical expertise. Another task could be to measure quantitatively the relative phase shift of two structures in an object.
Minimum standard	Correct answer of at least 50 % of the questions
Exam Type	EN mündliche Prüfung, strukturierte Befragung

Lecture / Exercises

Learning goals

Goal type	Description
Knowledge	depth of field paraxial, on the object side near and far point hyperfocal distance wace optical, on the image side amplitude- and phase objects law of Lamberr-Beer optical density phase, refraction index and optical distance Abbe's theory of image formation relative phase of diffraction orders of amplitude objects of phase objects phase microscope with phase disc location and size of zero'th diffraction order spatial coherence diffraction artefacts Zernike location and size of zero'th diffraction order spatial coherence the priniciple of Babinet diffraction artefacts visibility and contrast attenuation in the phase ring coherence visibility of interference temporal coherence lenght of wavetrains spectral composition of wavetrains time shifted arrival of amplitude split wavetrains fast change of interference patterns coherence time spatial coherence spatially split wavetrains phase shift in spatially split wavetrains in dependence of the location of the origin spatial overlay of interference patterns spatial coherence length interferometer Michelson compensation plate

Special requirements

none

Accompanying material	lecture notes as downloadable file
Separate exam	No

second interference pattern
Mach-Zehnder
phase shifts on reflexions
complementary interference patterns
contrast of unequal splitted wavefronts
ambiguity of intereference patterns
white light interferometer
interference colors and contrast function

interference microscope
Linnik
sorted pairs of objectives
Michelson
long work distance objectives
Mirau
Schwarzschild objectives
differential interference contrast
birefringence
modification of Huygens' principle
indicatrix
Wollaston-, Nomarski- and Smith prisms
splitting below resolution
interference colors
base optical path difference and lambda plate
coherence requirements in the DIC
temporal
spatial
transmission-interference microscopes
Leitz' Mach-Zehnder interference microscope
interphaco microscope

Skills	calculate depth of field convert optical density, dynamic in images and absorption coefficients into on another determine phase discontinuities at interfaces quatitatively calaculate sizes of phase rings and angular apertures of Zernike phase microscopes calculate the strength of diffraction orders and derive image contrast from them estimate temporal coherence from bandwith of frequencies and wavelengths and vice versa estimate spatial coeherence from lightsource size and distance and vice versa draw ray paths of the different interference micorscopes and explain them calculate the requirements regarding coherence in the different interference microscopes calculate geometries from ackquired interferograms predict colors in white light interferometry explain and compare physically and technically the underliying principles of different microscopes

Expenditure classroom teaching

Type	**Attendance (h/Wk.)**
Lecture	2
Tutorial (voluntary)	0

Practical training

Learning goals

Goal type	Description
Skills	set up Köhler illumination balancing lengths and angles in interferometers prepare objects for microscopy set up, adjust and use microscopes, especially bright field dark field reflexion transmission Zernike phase contrast Linnik interference contrast differential interference contrast choose a suitable microscopy principle for a given object and task tell artefacts from object details judge image quality write scientific report describe the task descirbe the idea of the solution explain the experimental setup explain the data processing make error analysis present the results and make a critical discussion

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Practical training	2
Tutorial (voluntary)	0

Special requirements

none

Accompanying material	Instrcutions for the experiments as downloadable files. Operating manuals for complex equipment as downloadable files.
Separate exam	Yes

Separate exam

Exam Type	EN Projektaufgabe im Team bearbeiten (z.B. im Praktikum)

Details	1) Written examination questions related to the experiment have to be prepared at home and shown at the beginning of the laboratory. 2) The underlying ideas of the experiment have to be explained at the beginning of the laboratory. 3) Make the experiment alone (preferred) or in a team of two. - Build up and adjust your own setup - Acquire / measure date with this setup 4) Write a documentation on the experiment. It will be checked wih regard to - completness - scientific and precise language - correctness - understanding of the interrellations and interpretation of the results
Minimum standard	All written tasks must have been delt with. The basic ideas of the experiment must have been understood. All experiments must have been performed. The reports must be free of systematical errors.