

Course “Testing methods for optical elements and systems”

Field of study: Methods for testing of optical elements and image quality of optical systems

Course level: Master

Specialization: 200400.68 Optical Design

	Hours						
Semester	Workload	Lectures	Practical work	Lab.	Seminar	Independent studies	Tests
Autumn	108	17	-	51	20	20	Exam

Abstract

Course “Testing methods for optical elements and systems” covers the area connected with the estimation of optical elements and optical systems quality during manufacturing. Basic methods for testing of optical surfaces (flat, spherical and aspherical) and inhomogeneity of refraction index are discussed, focusing on interferometric testing methods. The scheme of interferometers and the layout for testing different objects are considered. Attention are also paid to the mathematical basis of wavefront description and interferogram processing. Methods and setups for testing of optical system quality are also dealt with. Laboratory practicum gives practice of adjustment optical measurement devices, practical work with optical elements and also measurement results processing.

The course gives understanding of theoretical basic of interferometric test methods, Hartmann method and other optical characteristics control methods and gives experience of working using real optical instruments and equipment, develops practical skills of testing optical element and systems.

Goals and Objectives of the Course

Knowledge of

- Principles of testing of quality of optical elements and systems
- Special features of testing methods for different optical systems
- Range of application of different testing methods
- Mathematical apparatus used for description of wavefront and for measurement results processing
- Criteria of image quality for different optical elements and systems

Theoretical Skills

- be able to estimate quality of optical elements and system
- be able to apply different quality criteria

Practical Skills

- be able to receive interferogram for optical surface,
- be able to process and analyse interferogram using special software
- to be able to set up and adjust the scheme for interferometric control of optical elements.
- To be able to deal with special software for generating and processing of interferogram
- be able to process and interpret the results of testing of the optical elements and systems

Course prerequisites:

Knowledge in optics basics (geometric and wave optics), physics (theory of interference and diffraction); knowledge of mathematics (differential and integral calculus, basics of complex variable theory, the theory of series); knowledge of simple optical devices (a microscope, a telescope system, an objective); ability to assess adequacy of measurement results using knowledge of physics, optics and mathematics; skills of working with personal computer and software for mathematical calculation.

Course structure

Volume of the course: 3.0 ECTS credits, 108 hours

Chapter	Types of activities					Total in hours
	Lectures	Practical work	Laboratory work	Seminar	Independent studies	
Theoretical basic of optical testing methods	4	-	8	5	5	22
Interferometric testing methods and schemes of interferometers	6	-	18	4	4	32
Schemes and methods for testing optical elements and systems	7	-	25	11	11	54
Total:	17	-	51	20	20	108

Section 1. «Theoretical basic of optical testing methods».

- 1.1** Basic principles of the optical testing methods. Concept of the quantitative and qualitative control.
- 1.2** Features of the optical elements and systems.
- 1.3** Requirements to the testing errors
- 1.4** Theoretical basics of the image quality control.
- 1.5** Main characteristics of the image quality.

Section 2. «Interferometer schemes and interferometric methods of testing».

- 2.1** Principles of the interferometric methods. Equation of interference
- 2.2** Principal schemes of the interferometer, types of the interference image.
- 2.3** Basic schemes of the interferometers
- 2.4** Registration and processing of the results with the amplitude registration.
- 2.5** Wavefront description.
- 2.6** Interferogram decoding using methods based on separation of the components in the frequency field
- 2.7** Phase-shifting interferometry

Section 3. «Schemes and methods of the testing of the optical elements and systems».

- 3.1** Schemes for flat wavefront testing.
- 3.2** Testing the large- dimension flat
- 3.3** Testing of inhomogeneity of refraction index by the interferometry method.
- 3.4** Testing of spherical surfaces using interferometer
- 3.5** Testing of the aspherical surfaces using method of conjugate surfaces and using null-correctors
- 3.6** Testing of the objectives and telescopic systems using interferometer.
- 3.7** Control schemes for Hartmann method.
- 3.8** Measuring of the optical transfer function
- 3.9** Measuring of the Point Spread Function
- 3.10** Measuring of the function of energy concentration (encircled energy)

Lectures

Hours	Theme
3	Basic principles of testing methods. Objects for testing.
3	Characteristics and criteria of image quality

2	Interferometric testing methods. Schemes of interferometers.
2	Registration and processing of interferogram. Phase-shifting interferometric methods.
2	Flat wavefront testing. Testing of inhomogeneity of refraction index
3	Testing of spherical and aspherical surfaces. Testing of the objectives and telescopic systems .
2	Measurement of encircled energy and modulation transfer function.

Laboratory work

Hours	Theme
4	Wavefront reconstruction for given interferogram
6	Testing flat surfaces on Fizeau interferometer
5	Receiving interferogram and its processing using Fourier transform
6	Testing flat surfaces by phase-shifting method
8	Testing the refractive index inhomogeneity using Fizeau interferometer
8	Testing the image quality of the objective on Fizeau interferometer
6	Processing the results of Hartman control method
8	Measuring the modulation transfer function using rectangular cycles test-object

Independent studies

- Preparing for laboratory and practical works
- Writing reports
- Home work

Assessment Methods

- Test;
- Laboratory work;
- Home tasks
- Personal skills of a student are estimated;
- Exam