Geometrical Optics. Practical 4.
STUDY OF THE MICROSCOPE

Equipment and accessories: microscope, objective micrometer, ocular micrometer, mirror with a slit, millimeter scale on a vertical stand, diffraction grating, glass plate.

1 Introduction

A microscope is an instrument that allows one to to see objects that are too small to be seen by the naked eye. It is an optical system that provides an imaginary magnified image of an object located relatively close to the first lens of the system. In most cases, the microscope is used in conjunction with the eye; with the combined effect of these optical systems, a real image of the object is created on the retina of the eye, greatly enlarged compared to the image seen by the naked eye. The ratio of the above images determines the subjective magnification of the microscope. For different observers, in view of the difference in the optical power of the eye, this increase may be somewhat different. Using the average (for different eyes) value of the distance of the best vision, it is possible to express the angular magnification of the microscope through its optical parameters:

$$MA = \frac{D \cdot \Delta}{f_1 \cdot f_2}, \tag{1}$$

where D is the optimal (best) vision distance, Δ is the tube length (i.e., distance between objective back focal plane and the focal plane of the eyepiece), $f_{1,2}$ are the focal lengths of the objective and eyepiece (ocular) lenses correspondingly.

The most important characteristic of a microscope is its resolving power, that is, the ability to separately represent two points of an object. The resolving power of a microscope, like any optical device, is limited by the finite dimensions of the wavelength of the light wave.

2 Description of the microscope

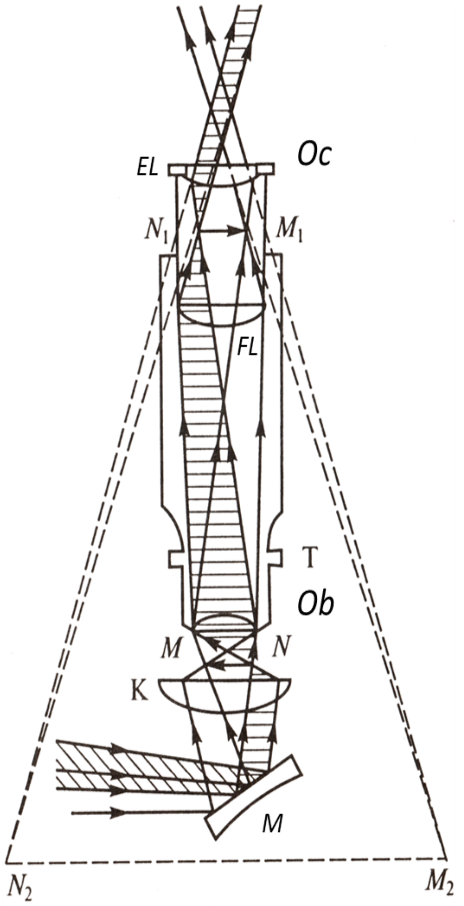

Figure 1: Schematic representation of an optical microscope.

The microscope (as shown in Fig. 1) consists of a tube T, in the lower part of which the objective lens Ob is located, and in the upper part an eyepiece (or ocular lens) Oc is installed. The objective lens is a system of lenses mounted into a single frame (in the figure shown as a single lens). The eyepiece consists of two collecting lenses mounted into a small tube. One of the lenses is called the field lens FL, and the other is called the eye lens EL. The tube of the microscope is located above the table, onto which the examined object MN is placed. Under the table is a mirror M so that the rays from any light source are directed through the condenser K to the object. The tube of the microscope with a screw is put in such a position, in which the object MN is located slightly further than the main focus of the lens. The real image of the object M_1N_1 is formed at the other side of the lens. This image is viewed through the eyepiece of the eyepiece EL, which in this case works like a magnifying glass, creating an imaginary image M_2N_2. Usually, a microscope has several objective lenses of different optical power; a convenient change of lenses is done with a turret device at the bottom of the tube. Accurate, calibrated movement of the tube is carried out using a micrometer feed.

3 Measurement and data processing

3.1 Task 1. Finding of the microscope subjective magnification

To determine the magnification of the microscope, place the objective micrometer on the microscope stage and adjust the focus that the micrometer scale is clearly seen. On the side of the microscope, place a vertical millimeter scale (25 cm apart). On the eyepiece of the microscope, place the inclined mirror with a slit so that you can simultaneously see the division of both the vertical scale and the objective micrometer. Counting the number of micrometer divisions that corresponds to a certain number of millimeters, find the desired increase (the scale of the objective micrometer scale is 0.01 mm).

3.2 Task 2. Determination of the ocular scale division value and the size measurement of a microobject

For measurements, between the eyepiece lenses, insert an ocular micrometer - a glass plate with a scale. Find the division value of this scale, using an objective micrometer (see the previous task). Further, place an object (for example, a diffraction grating) on the microscope stage instead of the objective micrometer and determine its characteristic dimensions.

3.3 Task 3. Measurement of the thickness of a glass plate

There are two marks scraped on the top and bottom surfaces of a glass plate. Focus the microscope so that you can see a distinct image of one of the marks (for example, on the bottom surface of the plate). Using a micrometric feed, move the tube and find a distinct image of the other mark. Find the translational movement of the tube using the micrometer feed scale. This translation corresponds to the optical thickness of the glass plate h_{opt}. The actual thickness h of the glass plate can be deduced knowing the refractive index of the glass n: $h = n \cdot h_{opt}$.

4 Questions

1. How to determine the lens magnification and the eyepiece magnification?
2. Why does the microscope objective usually consist of many (up to ten) lenses, and the eyepiece is usually made up of two lenses?
3. How should the ocular scale be positioned relative to the focal plane of the eyepiece and the image obtained with the lens?
4. Why is it impossible to determine the thickness of a glass plate, knowing only the movement of the tube?
5. Get an expression for the resolution of the microscope.
6. Indicate possible ways of increasing the resolution of an optical microscope.