# Optical design of the objectives for microscope with direct image projection on digital receiver

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**Abstract.** The theoretical and practical aspects of creating optical systems of objectives for digital light microscopes are considered, in which the image of the object under investigation is projected directly onto the electronic receiver. The results of optical designs are presented.

**1. Introduction.** In a digital light microscope observation through the eyepieces may be absent and replaced by directly projection onto an electronic receiver for formation imaging on monitor (screen of PC or TV). The special objective is the main element in a digital light microscope. From its technical and consumer characteristics depends, how much it is possible to replace an ordinary microscope, in which an observer studies the image through the eyepieces to digital microscope, in which an observer studies the image in screen. In the optical system of a digital microscope, as in a conventional microscope, several objectives can be used with different parameters of the input numerical apertures and linear fields on the object.

Table 1. Exemplary magnification values for a digital microscope objectives

| | | | | | |
|---|---|---|---|---|---|
| 1/4" | 100x0.90 | 40x0.65 | 20x0.40 | 10x0.25 | 5x0.10 |
| 2y=0.2мм | 8x 0.90 | | | | |
| 2y=0.5мм | | | | | |
| 2y=1.0мм | | 4x 0.50 | | | |
| 2y=2.0мм | | | | 2x 0.25 | |
| 2y=4.0мм | | | | | 1x 0.125 |
| 1/2" | | | | | |
| 2y=0.2мм | 8x 0.90 | | | | |
| 2y=0.5мм | | | | | |
| 2y=1.0мм | | | 4x 0.50 | | |
| 2y=2.0мм | | | | 2x 0.25 | |
| 2y=4.0мм | | | | | |
| 1" | | | | | |
| 2y=0.2мм | 8x 0.90 | | | | |
| 2y=0.5мм | | | | | 4x 0.50 |
| 2y=1.0мм | | | | | |
| 2y=2.0мм | | | | | |
| 2y=4.0мм | | | | | |

**2. Magnification and aperture of digital microscope objective.** Along with the traditional requirements for obtaining a congruent image of the object under investigation, specific conditions must be met, such as ensuring the relationship between the parameters of the object and the receiver. If we assume that the resolving power of the receiver is limited by the size of a single "elementary" structure – a pixel, then we can determine the output numerical aperture of the objective. The table 1 shows a of exemplary magnification values of objectives for a digital microscope, based on the traditional requirements. A linear field on the object is also taken into account.

**3. Aberration correction of a digital microscope objective.** If the investigated object is not self-luminous, the lighting system is used in the optical system of a digital microscope, and then a special design is required to correlate the parameters of the receiver, especially the non monochromatic receiver, with the parameters of the light source of the microscope. This design is a kind of convolution of two functions; as the initial data for the design, the spectral characteristics of a particular receiver and the spectral composition of the radiation in a specific light microscope are used. The obtained results of the calculation can be used to design the optical scheme of the objective.

Such residual aberrations of the optical system as curvature, astigmatism and distortion in the objective for digital microscopes should be corrected with particular care. It is necessary to achieve a good correction of aberrations in the spectral range extended from 400 to 1000 nm.

We made the optical and mechanical design of three special objectives (linear magnification/ numerical aperture) 1.6x/0.30, 3.2x/0.50, 12.5x/0.90. Figure 1 shows an example of the optical design and mechanical design of 3.2x linear magnification objective and a numerical aperture of 0.50.

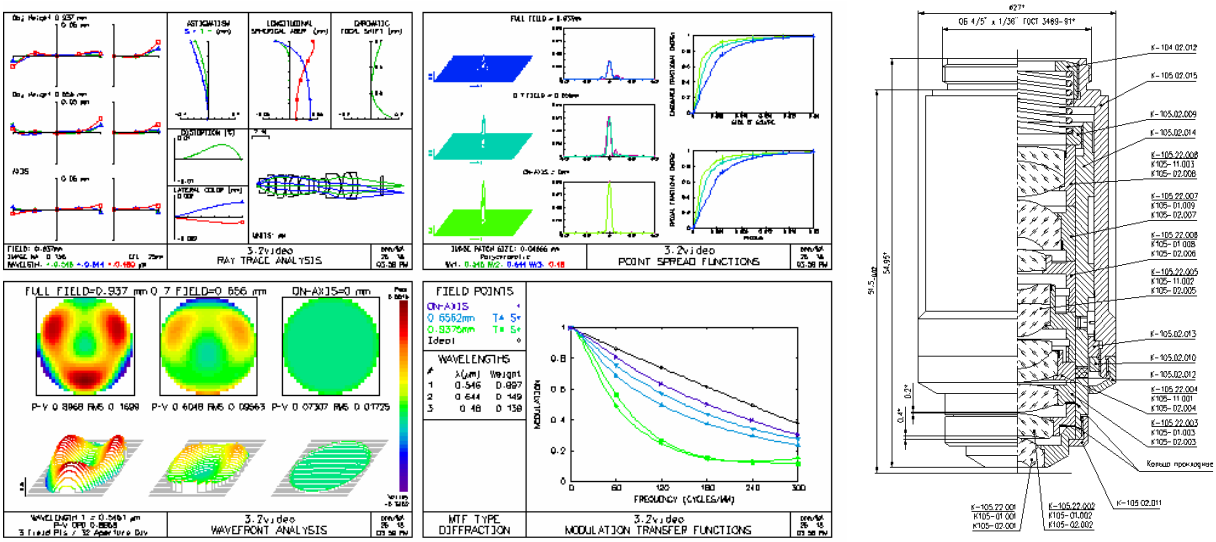


Figure 1. Optical, mechanical designs and graphics aberrations of objective 3.2x/0.50.

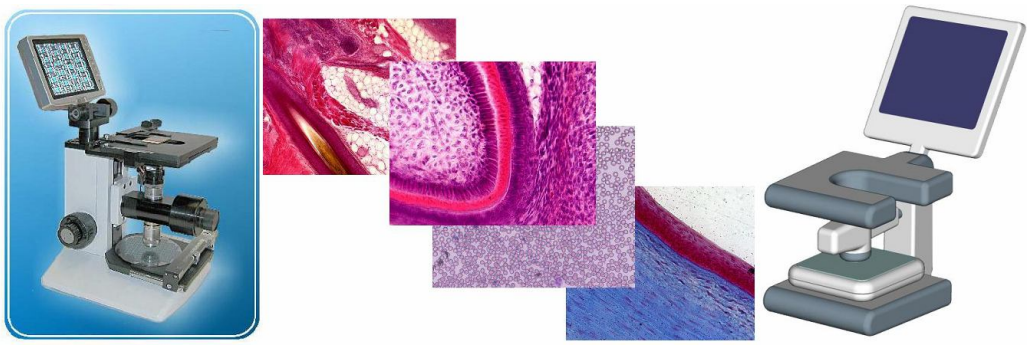

Figure 2. Pictures of a digital microscopes and images of biological objects.

**4. Conclusion.** We have developed a special technical solution for a light digital microscope. This solution allows you to apply a direct projection of the image of the object after the objective – directly on the plane of the digital receiver. Then digitally, this image is transmitted to the screen, where it can be studied by the researcher. Figure 2 presents photographs of a prototype digital microscope, images of biological objects, as well as a design model of a new-generation digital light microscope.