Optical designs of the dioptric objectives for microscope with expanding the spectral range

Dmitry N. Frolov* , PhD; Olga A. Vinogradova , PhD; Alexey D. Frolov ,
Alexander D. Pavliy[1], Liyun Wen , Fanhua Jing
Project Labor-microscopes, Russia, China;
* fronda@list.ru; phone: +7 (812) 933 25 78, www.labor-microscopes.ru

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Abstract. The possibility of obtaining optics corrected in the spectral range to be wider than usual is shown. Such objectives can be used for micro spectral analysis, as well as for focusing light from different lasers – in the common focusing plane.

1. Introduction. Correction of chromatic aberration and secondary spectrum is the basis for creating optics for a wider spectral range than usual. Such optics can be a good tool for researchers in various applications of optics, for example, for micro spectral analysis, for focusing laser beams and other tasks. There are a large number of different lasers operating at different wavelengths. The variety of lasers as sources of radiation with fixed values of working wavelengths requires the development of special projection and receiving systems that can work with such lasers. There are known special radiation receivers – photoelectron multipliers, spectrophotometrical detectors, others, which are capable of operating in a wide spectral range. The creation of universal projection optical systems for operation in a wide spectral range remains an actual problem today.

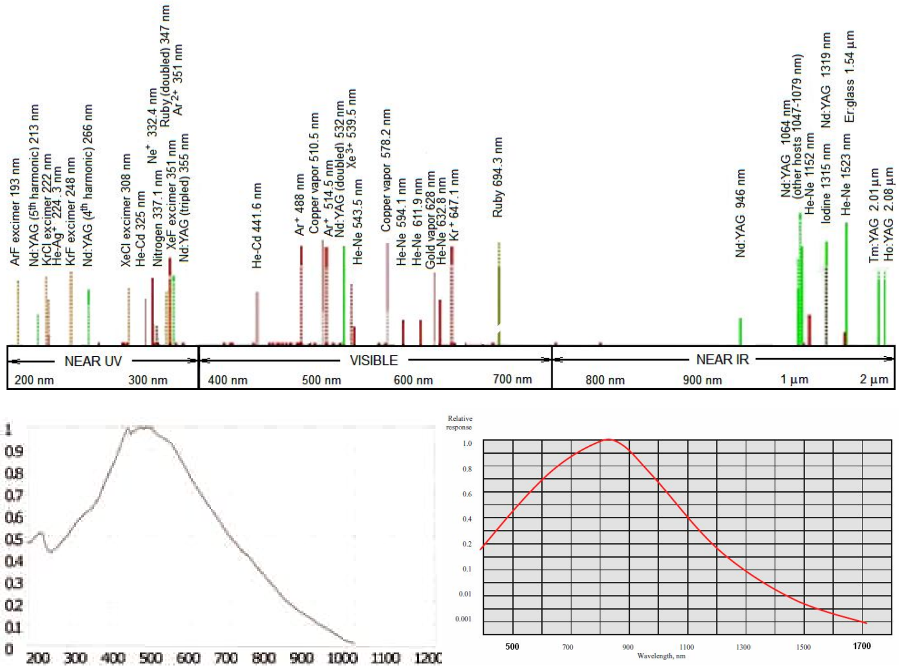


Figure 1. The main types of lasers and receivers.

2. Optical designs of two types of objectives.

2.1. The first type is the objectives for spectral range from 400 to 1100 nm, the aberration correction is **Plan Poly Apochromat**.

We made an optical design and fabricated objectives which the correction of aberrations was performed equally well for a wavelength range from 400 to 1100 nm, and one focusing plane was achieved for all wavelengths of the specified range (within the depth of focus). Thus, the principle possibility of an extended apochromatization band with respect to the conventional one is revealed. In this case, conventional silicate marks of optical materials can be used. Below at figure 2 is an optical-mechanical design and graphics of objective aberrations with magnification 20x and a numerical aperture 0.70. Also shown is a photo of the objectives.

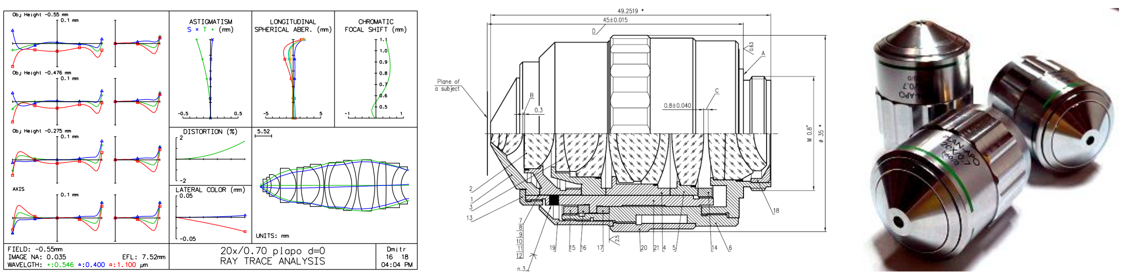


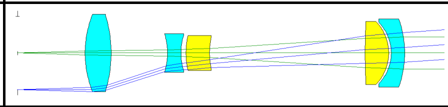
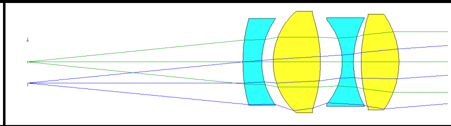
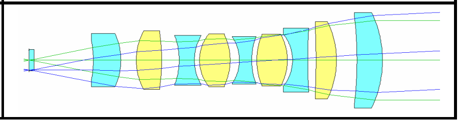
Figure 2. Optical-mechanical design and graphics of aberrations of objective Plan PolyApochromat 20x0,70.

2.2. The second type is the objectives for spectral range from 200 to 2000 nm, the aberration correction is **Plan Multi Apochromat**.

If we include in the optical design only crystals, we can expand the bandwidth of the spectral transmission to the near-UV region. In our country, objectives are produced that have apochromatization in the spectral range of 250 – 800 nm. But some researchers needs optics which can provide focusing of laser radiation at wavelengths of 248, 222, 213 and even 193 nm. Such optics too can expand the focusing range for the near-IR region for lasers operating at wavelengths of 1315, 1523 and even 2010 and 2080 nm.

Thus, the corresponding apochromatization, the objective can operate as a poly-apochromate in the spectral range from 193 to 2080 nm without refocusing. We made an optical design and manufactured such an objective. Thus, the principal possibility of further expansion of the apochromatization band has been revealed. In this case, some kinds of crystals are used as optical materials. Below (figure 3) the optical design and the graphics aberrations of the objective with 10x magnification and a numerical aperture of 0.20 is present. Also shown is a photograph of the objective.

Table 1. Main technical parameters and basic optical layouts of some Plan Multi Apo objectives.

Magnification	NA	WD (mm)	F' (mm)	R (μm)	DF (μm)	FOV on object (mm)	FOV on image (mm)	The principal optical layout
2.5x	0.03	8.0	80	11.1	370	8.8	22	
5x	0.10	23	40	3.32	33.3	4.4	22	
10x	0.20	5.5	20	1.66	8.32	2.2	22	

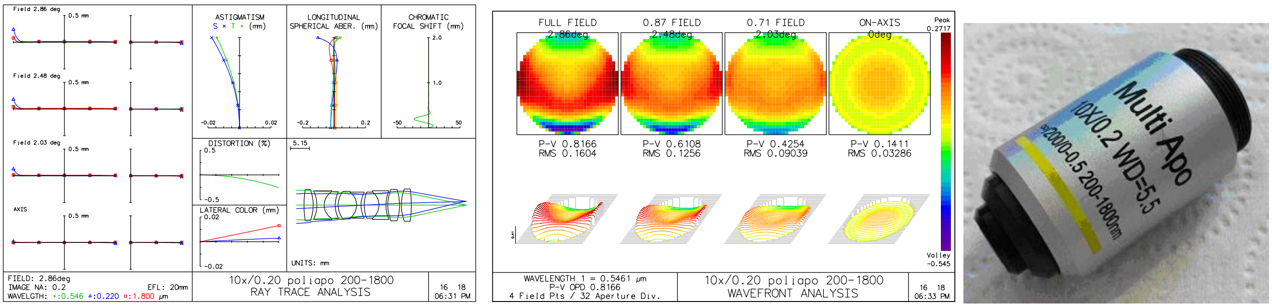


Figure 3. Graphics aberrations of objective Plan Multi Apochromat 10x0,20.

3. Conclusion. The principal possibility of extending the working spectral range relative to conventional objectives is shown for two types of new objectives. In the first type, where conventional silicate glasses are used, the objective is apochromatic in the wavelength range from 400 to 1100 nm. In the second type, where some crystals are used as optical materials, the objective is apochromatized in the spectral range from 200 nm to 1800 nm. In both types of objectives, for all wavelengths of the operating spectral range, a single plane of focusing of the rays is conserved.