The possibility of expanding the spectral range for lens microscope objectives. Examples of optical design

Dmitry N. Frolov*, PhD; Olga A. Vinogradova, PhD; Vladimir N. Frolov, Liyun Wen
Project Labor-microscopes, Russia, China
* fronda@list.ru; phone: +7 (812) 933 25 78, www.labor-microscopes.ru

SPIE. COS PHOTONICS ASIA Beijing, China, 11 - 13 October 2018

Abstract. Some aspects of the expansion of the spectral range for lens objectives for microscope are considered. It is proposed to use two types of optics. The first type provides operation in the near ultraviolet range (NUV) plus a visible range. The second type provides operation in the visible and near infrared (NIR) spectral range.

1. Description.

Some researchers would like, for example, to more effectively use the possibilities of applying spectral ranges that extend into the shorter blue region of the spectrum (the near ultraviolet region in the wavelength range 360 – 400 nm). Other researchers would like to use a microscope to work in a longer (near infrared in the wavelength range 700 – 1700 nm) region. Aberration correction for the objective and microscope should extend from the visible range to the near infrared. We made optical designs and developed mechanical designs of two sets of objectives that are designed to work in such a spectral range. Correction of objectives aberrations of the first set is made in the range from 480 to 1800 nm, and the 1064 nm line is chosen as the main wavelength.

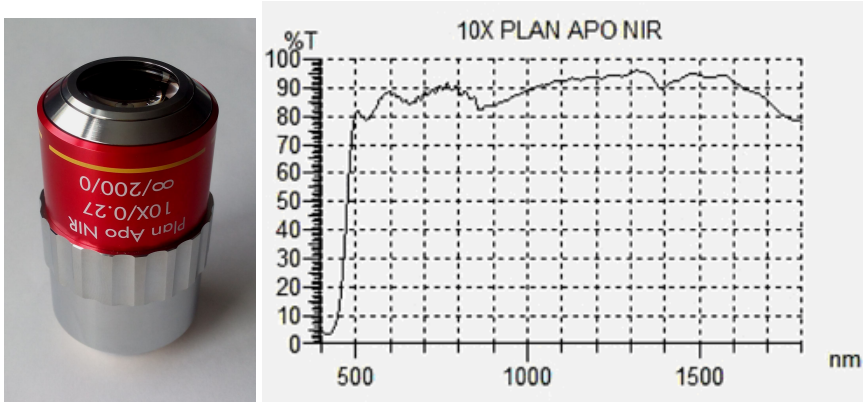


Figure 1. Pictures of NIR objectives of 10x and the transmission graph.

The numerical apertures of the objectives of this set are enlarged. In the second set of objectives, the operating spectral range is substantially expanded into a short spectral region (they corrected from 435 to 1800 nm), and the 546.07 nm line is selected as the main wavelength.

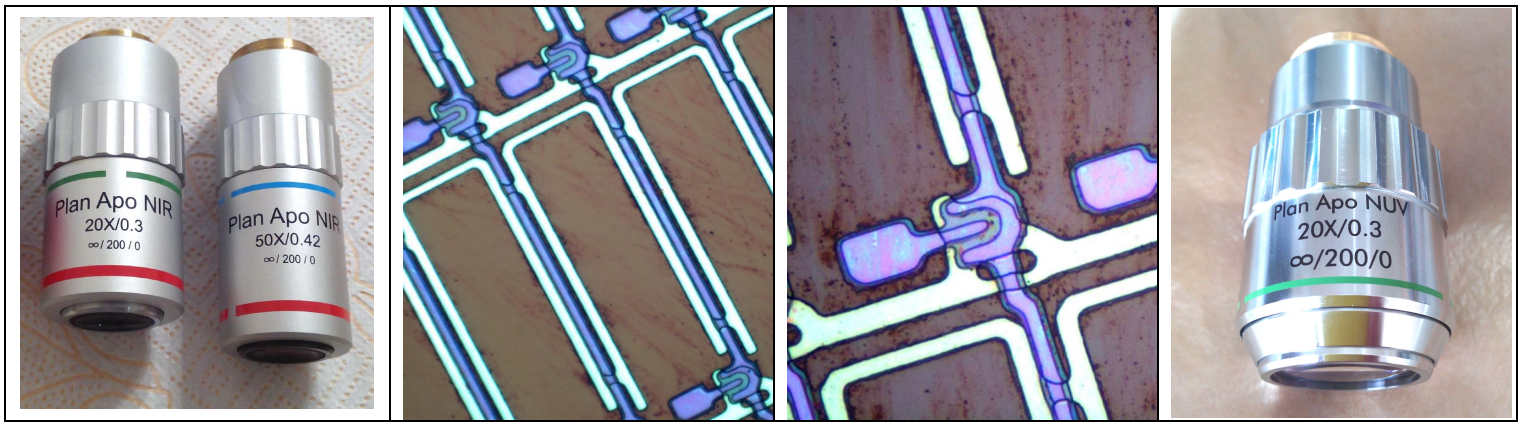


Figure 2. Pictures VIS+NIR objectives 20x, 50x and objects using of 20x, 50x and also picture 20x NUV objective.

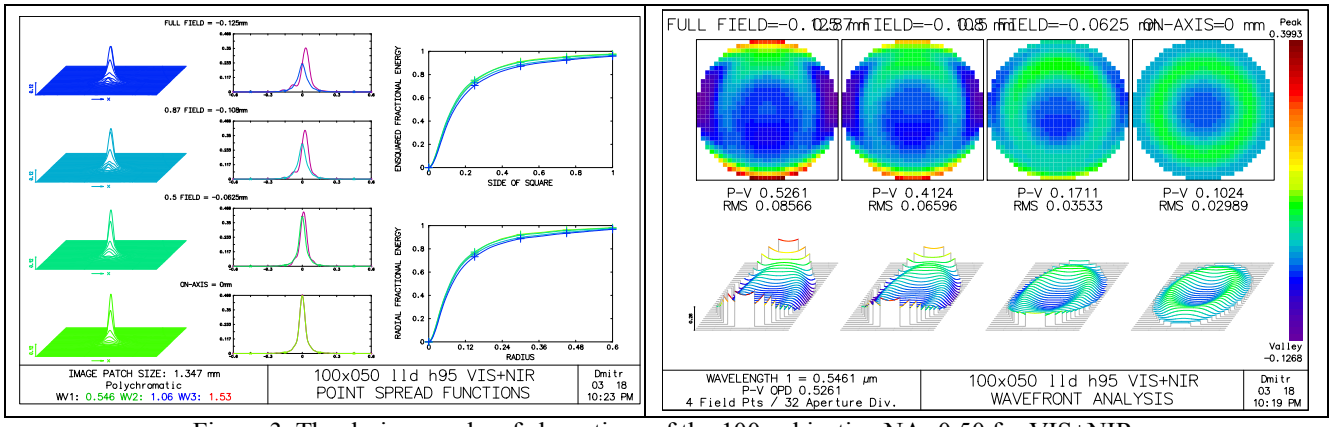
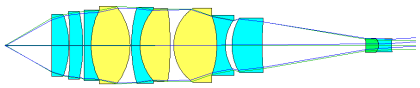
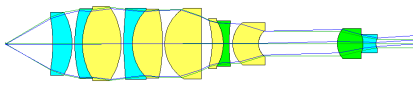
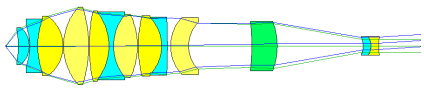
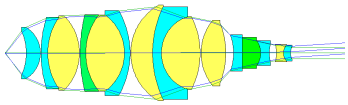
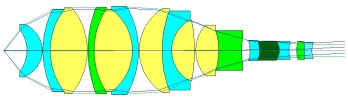
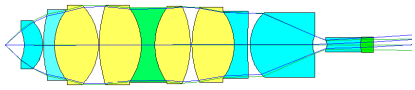
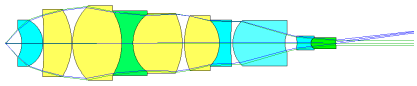
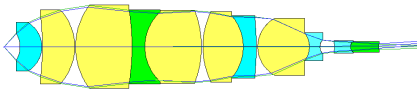


Figure 3. The design graphs of aberrations of the 100x objective NA=0.50 for VIS+NIR.

Table 1. Main technical parameters of some objectives 100x and more magnifications.

Magnifica-tion	NA	WD (mm)	F' (mm)	R (μm)	DF (μm)	FOV on object (mm)	FOV on image (mm)	Remark ("main" spectral line and working spectral range)	The principal optical layout
100x	0.50	10	2	0,67	1,33	0.28	28	NUV+VIS (λ =546.07 nm, 355-800 nm)	
100x	0.50	8.7	2	0,67	1,33	0.28	28	VIS+NIR (λ =546.07 nm, 435-1800 nm)	
100x	0.80	1.8	2	0,42	0,52	0.28	28	NUV+VIS (λ =546.07 nm, 355-800 nm)	
100x	0.80	3.2	2	0,42	0,52	0.28	28	NUV (λ =546.07 nm, 365-650 nm)	
100x	0.80	3.2	2	0,42	0,52	0.28	28	VIS+NIR (λ =1064 nm, 480-1800 nm)	
250x	0.70	1.3	0.8	0,48	0,68	0.112	28	VIS+NIR (λ =1064 nm, 480-1800 nm)	
500x	0.75	1.5	0.4	0,44	0,59	0.056	28	NUV (λ =546.07 nm, 365-650 nm)	
500x	0.75	1.1	0.4	0,44	0,59	0.056	28	VIS+NIR (λ =1064 nm, 480-1800 nm)	

2. Conclusion. Some justification is given for the need to expand the spectral range relative to the usual one, which was previously determined by the parameters of a microscope working with human eyes. Today, the microscope from the device for visual observation by eyes turned into an instrument that uses sources and receivers of radiation in spectral ranges in which the human eye is not sensitive. However, new methods of microscopic research require the use of such spectral ranges. We have proposed sets of objectives for such microscopes. New objectives are distinguished not only by extended spectral ranges, but also by modern approaches to the quality of aberration correction and image quality – taking into account the use of digital image receivers.