

Information virtual indicator with combination of diffractive optical elements

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Abstract. A combination of diffractive optical elements for monochrome information virtual indicators is described. To reduce the spectral "blurring" of image in monochrome indicators with OLED-display or LCD-display with LED backlight the possibility of using the volume reflection hologram as a spectral filter is investigated. The theoretical and experimental results show that the volume reflection hologram can be used as part of a monochrome virtual indicator containing OLED-, LCOS- or LCD-display with LED-backlight and relief-phase gratings for output of radiation from substrate to reduce the spectral "blurring" of image.

1. Introduction

In recent years, displays and indicators based on diffractive optical elements (DOEs) are used in the information display systems and visualization systems, where the observed signs-symbolic information is superimposed on the real scene. In such systems the exit pupil of the optical system expands to required size due to the light guide plate with DOEs, which is a significant advantage of such systems [1-3]. Thus, the exit pupil of the virtual sign-symbolic indicator is about 40 mm when the exit pupil of the collimating optical system is relatively small (up to 10 mm) is provided. Due to the weight and size parameters of indicator are reduced.

Now, a number of signs-symbolic information displays and virtual indicators, based on light guide substrates and DOEs, are created. However, these indicators are primarily monochrome [1-4]. The use of the monochrome OLED-displays or LCD with LED-backlight in the indicators leads to spectral "blurring" of displayed image and reduce resolution of indicators. Currently the principles of construction of such devices are developed, as well as problems of radiation output from the light guide substrate by DOE are resolved [3,4]. But the issues of improving the resolution of indicators were considered not fully.

At the same time the combined DOE, combining several different DOEs in one single structure and having a number of advantages compared to single component DOEs, are known [5,6]. Combined DOEs form simultaneously several wavefronts and can provide the spectral selection of radiation. The use of such DOEs as part of the signs-symbolic information systems will improve the resolution of monochrome indicators.



2. Combination of diffractive optical elements in information virtual indicator

To solve these problems the use of combination different types of DOEs, produced on a single substrate and providing the input and output of radiation from the light guide plate and the spectral selection, is suggested. For input and output of radiation the transmissive diffraction grating (DG), which can be relief-phase (including multilevel) or volume, are used [6].

To reduce the spectral "blurring" of image in monochrome indicators with OLED-display or LCD-display with LED backlight the possibility of using the volume reflection hologram as a spectral filter is investigated. It is suggested to use a two-component combination of the DOEs, as shown in Figure 1, including a DG 2 on one surface of the substrate 1 to output radiation from the plate and on the other - a volume reflection hologram 3 with high spectral and angular selectivity. The volume reflection hologram functions as a narrow-band spectral filter. This allows you to select narrow spectrum from propagating radiation and reduce the image "blurring".

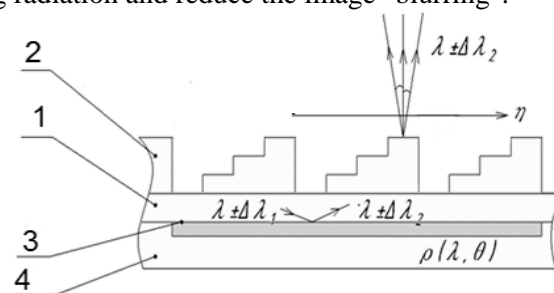


Figure 1. Diagram of combined diffractive optical elements consisting of substrate 1, DG 2, volume hologram 3 and protective glass 4

The holographic virtual indicator scheme consists of LEDs 1, lighting lens 2, cube prism 3, LCOS-display 4, collimating lens 5, light guide plate 5 with a combination of DOEs, i.e. diffraction gratings 6 of variable diffraction efficiency for the output radiation on one side of the substrate and the reflective volume hologram 7 on the opposite side. As a source of the formation of signs-symbolic information in the proposed scheme the LCOS-display that is illuminated by the beam splitter cube via LEDs matrix is used. When using high power LEDs or laser sources, such types of displays and indicators allow to observe the information on the background of bright objects. The disadvantage of this system is its size because of the presence of lighting lenses. OLED-displays, despite its compact size, have low brightness, which prevents their use in displays and indicators to form multicolor and monochrome signs-symbolic information.

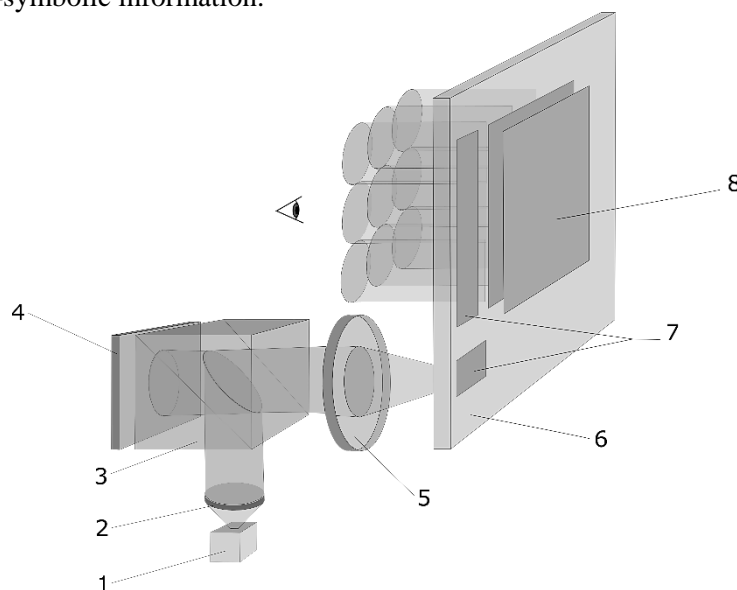


Figure 2. Diagram of information virtual indicator

Diffraction gratings (DGs) in this scheme are multilevel phase relief with triangular profile, i.e., DGs are essentially transmissive echelettes, i.e. DGs gratings having only one working diffraction order. It is necessary to increase the diffraction efficiency and thus reduce the radiation loss at the input and output it from the plate. Such elements can be obtained, for example, on thin transparent films and glued on the surface of light guide plate, which significantly simplifies the process of their manufacture.

For the combined DOEs based on reflection holograms the main parameters are defined: thickness is 20 mm, width of spectrum is 20 nm, the reflection coefficient is about 0.75, period of DG is 500 nm. Figure 3 shows the dependence of the diffraction efficiency and the shrinkage of the photosensitive material thickness for volume reflection holograms.

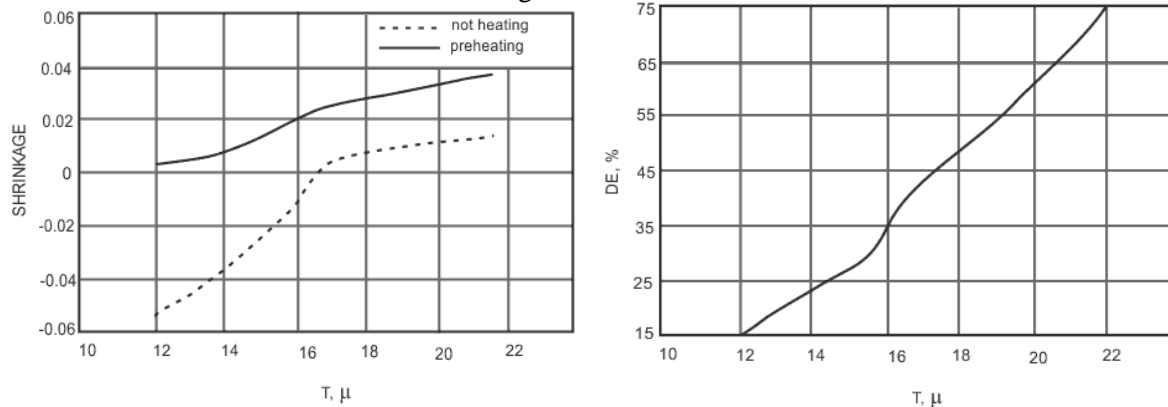


Figure 3. The dependence of the diffraction efficiency and the shrinkage of the photosensitive material thickness

3. The theoretical and experimental results

Figure 4 shows the experimental values of the spectrum of the reflected radiation from the volume hologram, depending on the angle of incidence. When the angle of incidence is about 50 degrees the reflection spectrum is the maximum and it is about 0.75 for a wavelength of 530 nm, and for angles of incidence are 45 and 55 degrees the reflection coefficient is greater than 0.6. The width of the reflection spectrum for the angle of incidence of 50 degrees is 20 nm and for a range of angles from 45 to 55 degrees is 25 nm, which is two times less than the radiation spectrum, for example, of OLED-display or green LED.

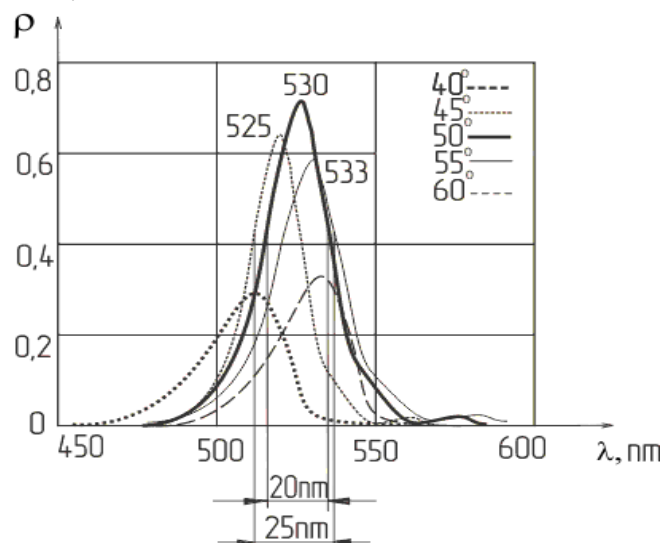


Figure 4. The dependence of the spectrum reflected from the volume hologram for different wavelengths and angles of incidence

Photography of the experimental sample of the light guide substrates with DOEs combination is shown in Figure 5. The developed experimental sample is a parallel plate made of optical glass. A distinctive feature of the construction is that the combined DOE is two flat parallel plates glued together. The first plate contains on one of its surfaces DG, and the second plate - volume hologram. The DOE's production in this case occurs separately and independently at every plates, which simplifies the technological process of manufacturing the substrate.



Figure 5. The experimental sample of the light guide substrate with a combination of DOEs and image of the test-object

The resolution of virtual indicator is controlled visually using the test-object at stand, which shown in Figure 5. The images of the test-object, obtained with combination DOEs, based on volume hologram, and without it are presented in Figure 6. Figure 6 shows images of the test-object, obtained with the combined DOE (left) and without it (right), i.e. with relief-phase DG. When the exit pupil size of about 50 mm and more the blurring and coloring of image are observed. However, when using the combined DOE, this effect is minimized. Thus, the resolution provided by using the experimental sample with a combined DOE is 50 lines/mm, and without it is less than 30 lines/mm.

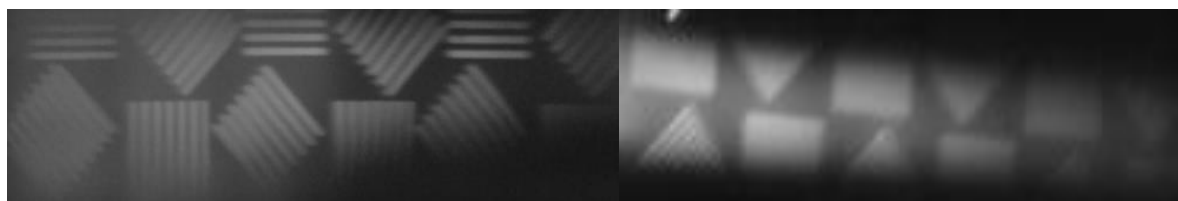


Figure 6. The image of the text-object with a combination of DOEs and without it

4. Conclusion

Thus, the experimental results show that the volume reflection hologram can be used as part of a monochrome virtual indicator containing OLED-, LCOS- or LCD-display with LED-backlight and relief-phase gratings for output of radiation from substrate to reduce the spectral "blurring" of image.

Acknowledgments

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