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Figure 1 and Figure 2

Figure 1: Figure 1 and Figure 2

Abstract

Full Text

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PHYSICS

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NEW HIGH-RESOLUTION PHOTOGRAPHIC LAYERS AND THEIR INVESTIGATION BY THE METHOD OF HOLOGRAPHIC RESOLVOMETRY

(Presented by Academician E. K. Zavoiskii, 22 VII 1968)

One of the principal characteristics of photographic materials used in holography is their resolving power. Depending on the experimental arrangement, a resolution from hundreds of mm^{-1} to several thousand mm^{-1} is required.

The plant for technical photographic plates produces standard MIKRAT-VR plates for holography. However, in a number of cases the use of these plates does not make it possible to obtain holograms of sufficiently high quality. In this connection we undertook a special investigation devoted to the development of highly sensitive emulsions possessing the maximum possible resolving power for silver-halide photographic layers and optimal light sensitivity in the radiation region of the lasers used. Figure 1 shows the size-distribution curve of silver-halide microcrystals for the IAE-1 emulsion developed by us, obtained with the aid of an electron microscope. The average size of the silver-halide microcrystals is ~ 250 Å.

Fig. 1. Size-distribution curve of microcrystals.
Fig. 2. Diagram of the setup: 1 —laser, 2 —photoemulsion, 3 —mirrors, 4 —beam splitter, 5 —collimator, 6 —cylindrical objective.

The best projection resolvometers make it possible to measure the frequency-contrast characteristics (f.c.c.) of photographic materials having a resolution no better than 1200–1500 mm^{-1} ([1]). In addition, in projection resolvometry

Figure 3

Figure 2: Figure 3

Figure 4

Figure 3: Figure 4

the f.c.c. of the objective-photographic-material system is measured, i.e., the measurement results depend on the aperture and quality of the optics.

For measuring resolving power it proved expedient to use the phenomenon of interference ([2,3]).

A scheme analogous to that for holographic image recording was used, which made it possible to obtain the f.c.c. of photographic materials in the investigated range of spatial frequencies. The setup diagram is shown in Fig. 2. The beam of a Ne–He gas laser is divided into two; one of them is colli-

is formed, while the second is passed through a cylindrical objective. When these beams are superposed, an interference pattern arises, which is recorded by the photographic material under study. As a result,

Fig. 3. **a** –blackening curves of the IAE-1 emulsion at $\lambda = 0.63\,\mu$ (A_1), at $\lambda = 0.69\,\mu$ (A_2), and of the MIKRAT-VR emulsion at $\lambda = 0.63\,\mu$ (B_1), at $\lambda = 0.69\,\mu$ (B_2). **b** –dependence of the intensity of the diffraction maximum on spatial frequency for the IAE-1 emulsion (A) and for the MIKRAT-VR emulsion (B).

a diffraction grating is obtained, whose contrast can be judged from the ratio of the intensities of the first and zeroth diffraction maxima. Owing to the use of a beam with a cylindrical wavefront, the period of the diffraction grating is variable. The range of variation of the spatial frequencies is determined by the nonuniformity of the intensity across the beam cross section.

Using this method, the characteristics of two photoemulsions were investigated –the standard MIKRAT-VR emulsion and the IAE-1 emulsion.

In Fig. 3a the blackening curves of these emulsions are given for $\lambda = 0.63\,\mu$ (the wavelength of a Ne–He laser) and $\lambda = 0.69\,\mu$ (the wavelength of a ruby laser). The investigations were carried out at these wavelengths because the Ne–He laser and the ruby laser are at present the most widely used in holography.

Fig. 4. Reconstructed image of a section of a holographic scale with a hologram at 2000 mm^{-1} for the IAE-1 emulsion (**a**) and for the MIKRAT-VR emulsion (**b**).

The sensitivity of the IAE-1 emulsion and of the MIKRAT-VR emulsion is the same for $\lambda = 0.63\,\mu$ and is equal to $0.3 \cdot 10^{-3}$ J/cm^2. For $\lambda = 0.69\,\mu$, the sensitivity of the IAE-1 emulsion is considerably higher than that of the MIKRAT-VR emulsion; their values are respectively 10^{-4} J/cm^2 and 10^{-1} J/cm^2.

In Fig. 3b the dependences of the relative intensity of the diffraction maximum on spatial frequency are presented for both emulsions. The intensity was measured with a calibrated photodetector, whose sensitivity ($2 \cdot 10^{-8}$ W) made it possible to record diffraction maxima on the IAE-1 emulsion up to 2500 mm^{-1} and on the MIKRAT-VR emulsion up to 1800 mm^{-1}. However, visually the diffraction maxima on the emulsion

IAE-1 are observed up to frequencies on the order of 3000 mm^{-1}. The relative intensity of the diffraction maximum drops by 10% for the IAE-1 emulsion at $\nu = 2000$ mm^{-1}, and for the MIKRAT-VR emulsion at $\nu = 1300$ mm^{-1}. The contrast of the IAE-1 emulsion in the region of low spatial frequencies is significantly higher than the contrast of the MIKRAT-VR emulsion. To an intensity ratio I_1/I_0 equal to 10^{-3} there corresponds, for MIKRAT-VR, a spatial frequency $\nu = 1300$ mm^{-1} (a drop by 10% for MIKRAT-VR), whereas for the IAE-1 emulsion the same value of I_1/I_0 corresponds to the spatial frequency $\nu = 2300$ mm^{-1}.

Figure 4 shows photographs of the real image of an object reconstructed from holograms recorded, respectively, on the IAE-1 and MIKRAT-VR emulsions. The quality of the holograms obtained on the IAE-1 emulsion makes it possible to assert that these emulsions will find broad application in holography.

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