Slide 1

HOLOGRAPHIC METHODS OF DIFFUSERS FORMATION ON SILVER HALIDE PHOTOGRAPHIC EMULSIONS

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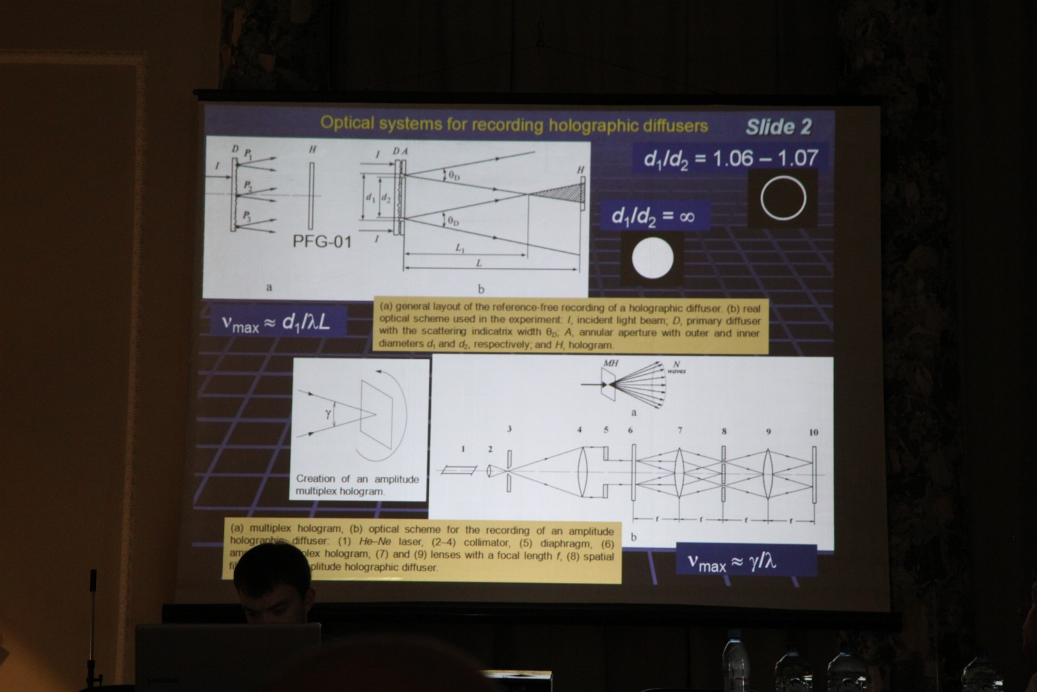
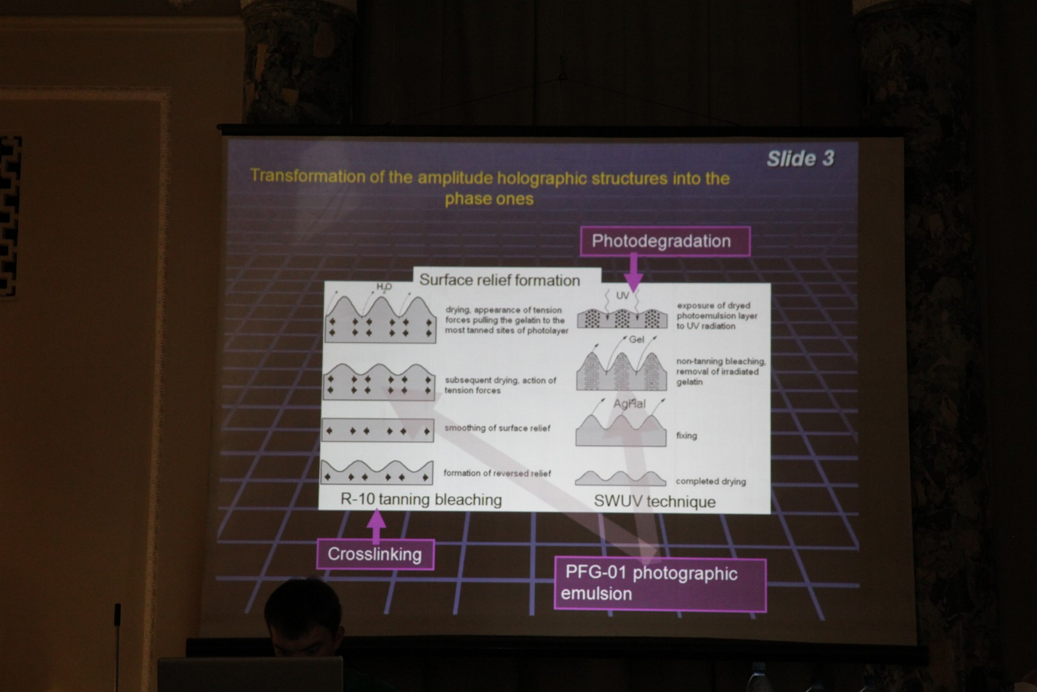
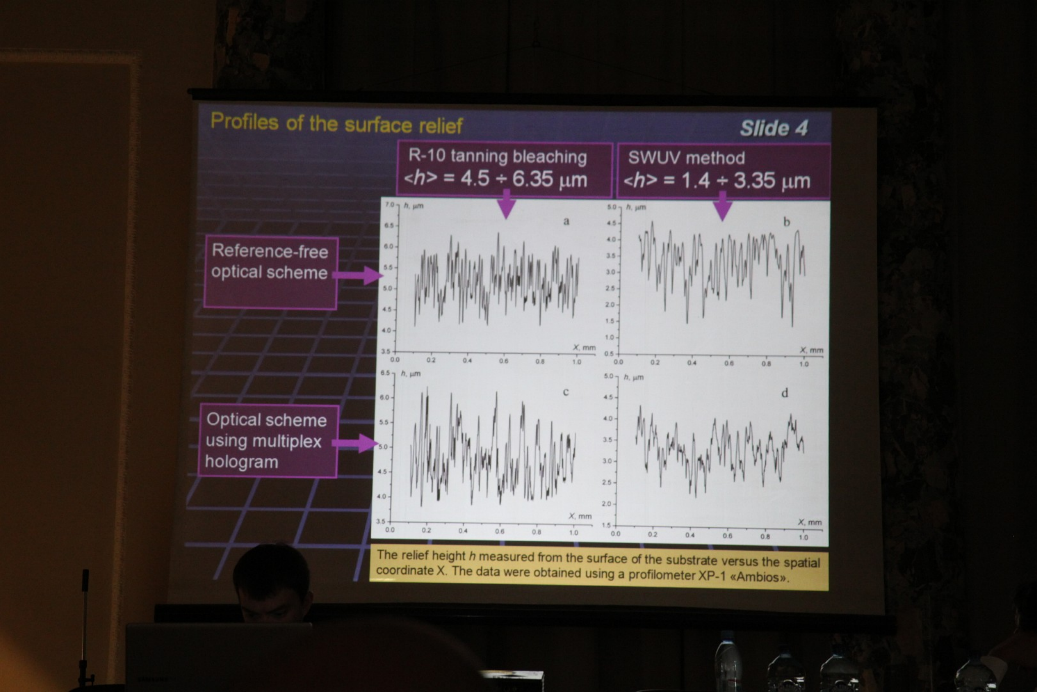
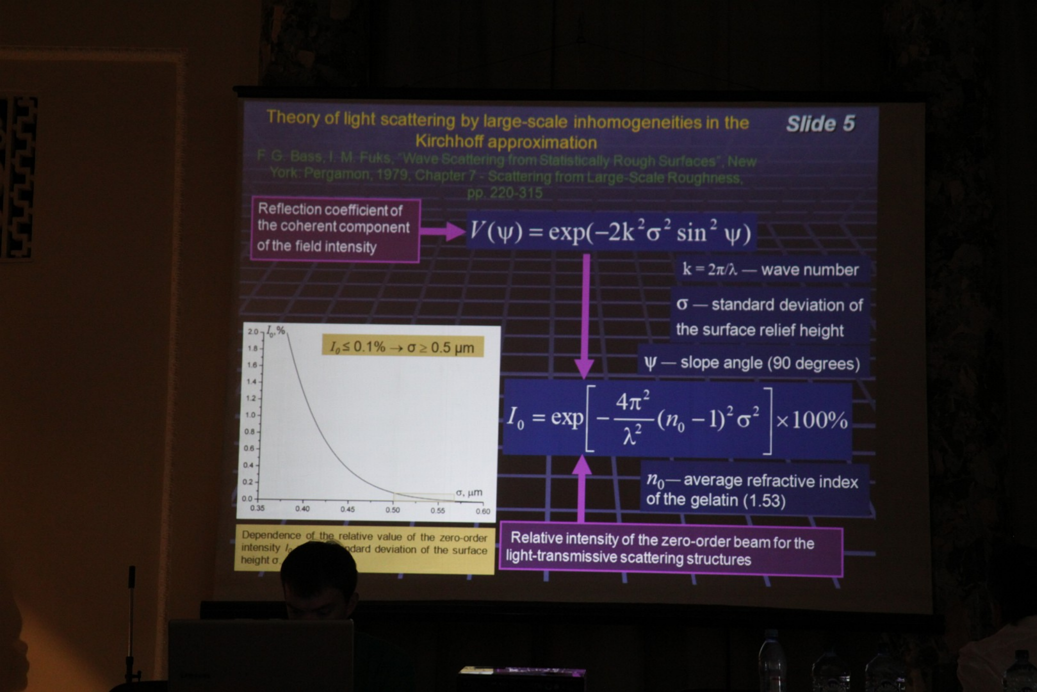

Optical systems for recording holographic diffusers
Slide 2
PFG-01
a
b
$d_1/d_2 = 1.06 - 1.07$
$d_1/d_2 = \infty$
$\nu_{max} \approx d_1/\lambda L$
(a) general layout of the reference-free recording of a holographic diffuser. (b) real optical scheme used in the experiment: I, incident light beam; D, primary diffuser with the scattering indicatrix width θ_D; A, annular aperture with outer and inner diameters d_1 and d_2, respectively; and H, hologram.
Creation of an amplitude multiplex hologram.
MH
N waves
(a) multiplex hologram, (b) optical scheme for the recording of an amplitude holographic diffuser: (1) He–Ne laser, (2–4) collimator, (5) diaphragm, (6) am... plex hologram, (7) and (9) lenses with a focal length f, (8) spatial fi... plitude holographic diffuser.
$\nu_{max} \approx \gamma/\lambda$


Slide 3
Transformation of the amplitude holographic structures into the phase ones
Photodegradation
Surface relief formation
H2O
drying, appearance of tension forces pulling the gelatin to the most tanned sites of photolayer
subsequent drying, action of tension forces
smoothing of surface relief
formation of reversed relief
R-10 tanning bleaching
UV
exposure of dryed photoemulsion layer to UV radiation
Gel
non-tanning bleaching, removal of irradiated gelatin
AgHal
fixing
completed drying
SWUV technique
Crosslinking
PFG-01 photographic emulsion

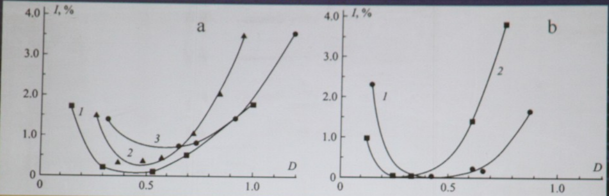

Profiles of the surface relief
Slide 4
R-10 tanning bleaching
<h> = 4.5 ÷ 6.35 μm
SWUV method
<h> = 1.4 ÷ 3.35 μm
Reference-free optical scheme
Optical scheme using multiplex hologram
a
b
c
d
h, μm
X, mm
The relief height h measured from the surface of the substrate versus the spatial coordinate X. The data were obtained using a profilometer XP-1 «Ambios».



Theory of light scattering by large-scale inhomogeneities in the Kirchhoff approximation
Slide 5
F. G. Bass, I. M. Fuks, "Wave Scattering from Statistically Rough Surfaces", New York: Pergamon, 1979, Chapter 7 - Scattering from Large-Scale Roughness, pp. 220-315
Reflection coefficient of the coherent component of the field intensity
$V(\psi) = \exp(-2k^2\sigma^2 \sin^2 \psi)$
k = 2π/λ — wave number
σ — standard deviation of the surface relief height
ψ — slope angle (90 degrees)
$I_0 = \exp\left[-\frac{4\pi^2}{\lambda^2}(n_0 - 1)^2\sigma^2\right] \times 100\%$
n_0— average refractive index of the gelatin (1.53)
Relative intensity of the zero-order beam for the light-transmissive scattering structures
I_0, %
$I_0 \leq 0.1\% \rightarrow \sigma \geq 0.5$ μm
σ, μm
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.35
0.40
0.45
0.50
0.55
0.60
Dependence of the relative value of the zero-order intensity I_0 ... dard deviation of the surface height σ

Experimentally measured values of the non-scattered components of the light passing through the diffuser

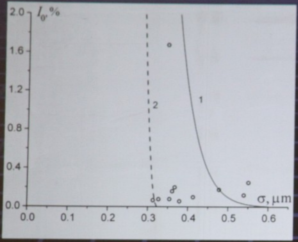
Slide 6



Plots of the zero-order intensity I_0 versus the mean optical density D of the primary silver image for (a) holographic diffusers that are obtained using ground glass in the reference-free optical Gabor scheme and processed with the aid of the SWUV method. Ratio d_1/d_2 of the outer and inner diameters: (1) 1.07, (2) 1.06, (3) ∞ and (b) holographic diffusers that are obtained using the multiplex hologram and processed by means of (1) R-10 bleaching agent and (2) the SWUV method.

Primary diffuser	Circular aperture, ground glass	Annular aperture, ground glass	Multiplex hologram
Ratio d_1/d_2 of the outer and inner diameters	∞ 	1.06 – 1.07 	1 
I_0 [illegible] %	0.74	0.1 – 0.2	0.05 – 0.07

Zero-order intensity for random and regular structures



The intensity of the zero-order diffraction I_0 versus σ. Circles, experimental values for the diffusers obtained by means of the multiplex hologram. Curve 1, theory for the scattering of light on the rough surface in the Kirchhoff approximation. Curve 2, theory for regular structure such as sinusoidal grating.

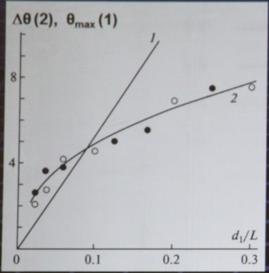
1 – purely random structure

$$I_0 = \exp\left[-\frac{4\pi^2}{\lambda^2}(n_0-1)^2\sigma^2\right]\times 100\%$$

2 - purely regular structure diffraction grating

$$I_0 = J_0^2\left[\frac{2\sqrt{2}\pi(n_0-1)\sigma}{\lambda}\right]\times 100\%$$

Scattering indicatrix of the holographic diffusers



Plots of (1) the limiting angle of scattering θ_{max} and (2) the width of holographic diffuser scattering indicatrix $\Delta\theta$ versus the relative size of aperture of the primary diffuser d_1/L. Circular aperture $d_1/d_2 = \infty$

d_1/L - relative aperture of the primary diffuser

Limiting scattering angle of the holographic diffuser θ_{max} recorded in a linear mode (amplitude recording)

$$\theta_{max} \approx \lambda \cdot \nu_{max} \approx d_1/L$$

Reference-free optical Gabor scheme using a common ground glass

$$\theta_{max} \approx \gamma$$

Optical spatial filtering scheme using an amplitude multiplex hologram

Conclusion

Investigations showed that it is efficient to use the method of chemical hardening of silver halide photographic emulsion in the presence of dichromates, as well as the method of the gelatin photolysis by short-wave UV radiation to form sufficiently deep relief-phase structures which is necessary to obtain holographic diffusers with high optical performance.