

Transmission VPHGS in Silver Halide Sensitized Gelatin

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- Introduction.
- Holographic Recording Materials.
- SHSG Processing.
- Experimental Results.
- Future Work



BACKGROUND

Holography Recording Materials

- Silver halide Emulsions $\Rightarrow$ Bleached process.
- DCG.
- SHSG
- Photopolymers
- SOL-GEL



DCG

General Holographic Properties

- Thin Layer 3 – 30 μm
- Diffraction efficiency tuned by incident angle.
- Spatial frequency up 6000 l/mm
- No pupil effect in optical systems.
- Large sizes (500 mm)
- Multiplexed gratings.
- Focalized gratings.
- Mass production by copy. (even with partially coherent light).



DCG

General Holographic Properties

- Wet processing.
- Spectral sensitivity $< 530 \text{ nm}$
- Energetic Sensitivity $\approx 100 - 200 \text{ mJ/cm}^2$
- Low scattering.
- Good surface uniformity
- Thickness $3 - 300 \text{ }\mu\text{m}$
- $\nu > 6000 \text{ l/mm}$



Photopolymers

General Holographic Properties

- Dry processing.
- Spectral sensitivity: Panchromatic.
- Energetic sensitivity: $50 \text{ mJ}/\text{cm}^2$
- Low scattering.
- Good surface uniformity.
- Thickness: $\approx 70 - 100 \text{ }\mu\text{m}$.
- $\nu < 6000 \text{ l}/\text{mm}$



SHSG

General Holographic Properties

- Wet processing
- Spectral sensitivity: Panchromatic.
- Low Scattering.
- Good surface uniformity.
- Thickness $5 - 9 \mu m$
- $\nu > 6000 l/mm$



Processing Procedure

Step	
1	Develop for 8 minutes AAC
2	Rinse in running water for 1 minute
3	Bleached in R-10 solution for 60 seconds after the plates has cleared
4	Rinse in running water for 5 minutes
5	Stop during 1 week
6	Rinse in running water for 2 minutes
7	Soak in fixer F-24 for 4 minutes
8	Wash in running water for 20 minutes
9	Dehydrated in 50 % isopropanol for 3 minutes
10	Dehydrated in 90 % isopropanol for 3 minutes
11	Dehydrated in 100 % isopropanol for 3 minutes
12	Dry in Vacuum Chamber



Processing Solutions

Developer Formula	
Ascorbic Acid	20 g
Sodium Carbonate	120 g
Distilled water	1000 ml
Bleached Formula	
Dichromate Potassium	2 g
Sulfuric Acid	10 ml
Potassium bromide	92 g
Distilled water	1000 ml



Historical evolution of photochemical process in SHSG

Authors	Plate	Photochemical model	Year
Pennigton, Chang, Graver	Kodak 649F	Hardening	1971-1980
Hariharan	Kodak 649F	Hardening(Developed)	1986
Boj, Fimia, Quintana	Agfa Gevart 8E75HD	Hardening	1986
Fimia, Pascual, Belendez	Agfa Gevart 8E75HD	Hardening	1988
V Weiss, Friessen	Kodak 649F	Microcavities	1988
Usanov	PFG03	Microcavities	1990
Beledenz, Neipp, Pascual	BB640, PFG01	Hardening	1998-2000
Kim, Phillips, Bjelkhagen	PFG03, PFG01	Microvoids	2001-2002

Photochemical model of latent image formation



Copy

- Transmittance.
- Low Scattering.
- All Wavelength.



Volume Phase Relations

Half- maximum of the efficiency bandwidth (FWHM)

Kogelnik Theory

$$\frac{\Delta\lambda_{eff}}{\lambda} = \frac{\Lambda}{d} \cot \alpha$$

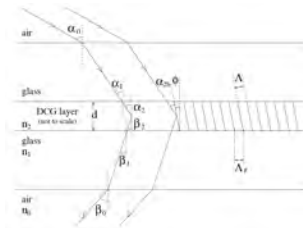
$$\Delta\theta = f(\lambda, d)$$

$$\text{Non-linear process} \Rightarrow \Delta\lambda_{eff}$$

$$DCG \Delta n \approx 0.1$$

$$SHSG \Delta n \approx 0.1$$

$$\text{Photopolymers } \Delta n \approx 0.1$$



I.K Baldry et al Astronomical Society of Pacific. 116, pp 403-414

(2004)



Gratings Evaluation

Tunning parameter

$$P_t = \frac{\Delta n \cdot d}{n \cdot \Lambda}$$

The diffraction efficiency variations with Bragg Angle.

$$n \cdot \Lambda \longrightarrow \alpha, \lambda$$

$$\Delta n \cdot d \longrightarrow \text{Modulation in the photosensible material}$$



Geometry

Problems

Symmetric

Asymmetric



Shrinkage



Control

$\Rightarrow$ Photochemical processing



High Energetic Sensitivity in SHSG

$$\begin{array}{c} \Downarrow \\ E = I \cdot t \\ I \downarrow \qquad t \downarrow \\ \Downarrow \\ \text{Mechanical stability} \\ \text{High Size} \approx 300 \text{ mm} \end{array}$$



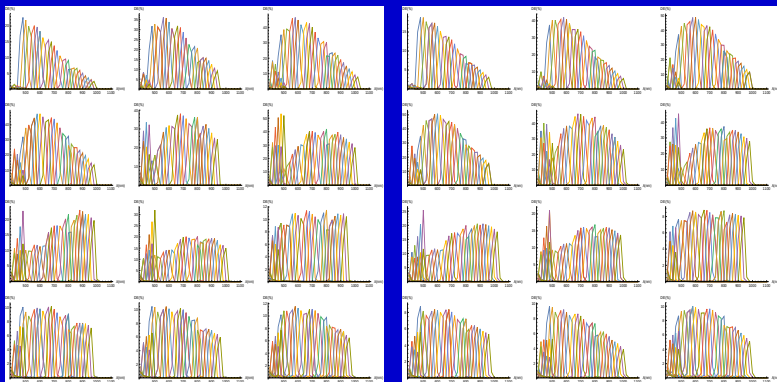
Experimental Results

Plate characteristic

The plate was BB640, ultrafine grain emulsions with a nominal thickness of $9\text{ }\mu\text{m}$. The recording was performed with asymmetric geometry a 30^0 degrees between the light beams of wavelength 632.8 nm (He-Ne laser), which give a raise a spectral frequency of 800 l/m . The exposure was between 46 to $2048\text{ }\mu\text{J/cm}^2$.



SHSG Emulsions (Cryogenic Process).



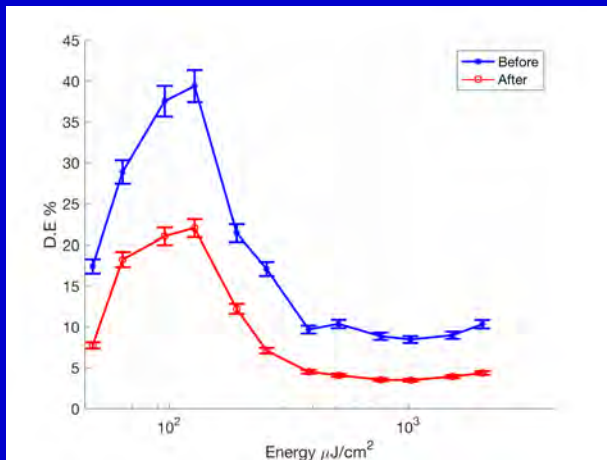
(a) Before

(b) After

Figure: Diffraction efficiency as function of reconstructed wavelength. Energy=46, 64, 96, 128, 192, 256, 384, 512, 768, 1024, 1536, and 2048 $\mu\text{J}/\text{cm}^2$



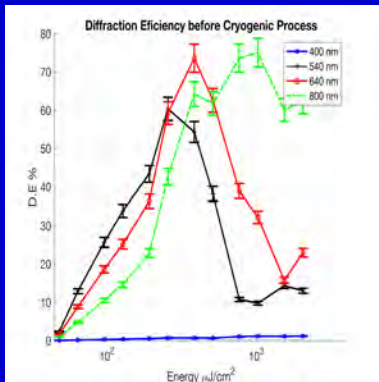
SHSG Emulsions



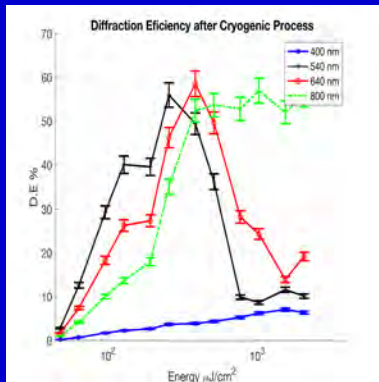
Diffraction efficiency for SHSG as function of energy before and after cryogenic process measured at 540 nm



Bleached Emulsions (Cryogenic Process).



(a) Before

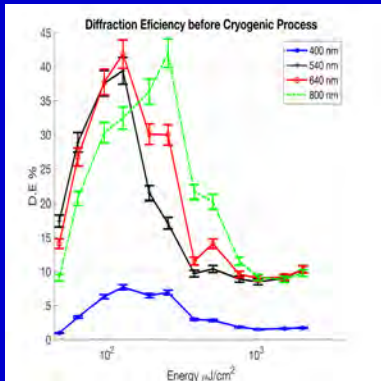


(b) After

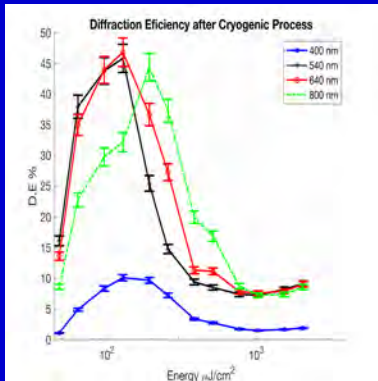
Diffraction efficiency as function of reconstructed wavelength. Energy=46, 64, 96, 128, 192, 256, 384, 512, 768, 1024, 1536, and 2048 $\mu\text{J}/\text{cm}^2$



SHSG Emulsions (Cryogenic Process).



(c) Before

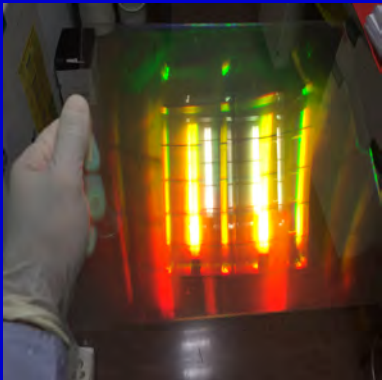


(d) After

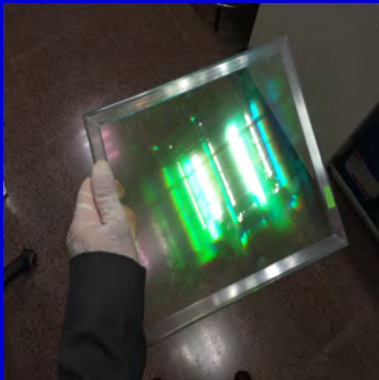
Diffraction efficiency as function of reconstructed wavelength. Energy=46, 64, 96, 128, 192, 256, 384, 512, 768, 1024, 1536, and 2048 $\mu\text{J}/\text{cm}^2$



SHSG



(e) Red Wavelength



(f) Green Wavelength

Holographic Reflection Gratings ($20 \times 25 \text{ cm}$)



THANKS
FOR YOUR
ATTENTION

