Recent Advances in Holographic Materials Chemical Processing from Geola

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Abstract

A general review of the current holographic materials available from Geola uab distribution network is presented. Recommended chemistries that may be employed with VRP-M emulsion for holograms producing with pulsed Nd:YAG or Nd:YLF lasers is reviewed. Reflection holograms made on VRP-M emulsion colour control techniques are briefly discussed. A new VRP-3 developer recipe suitable for VRP-M will is introduced.

1. Introduction

Geola currently distribute through it's network both Silver Halide and Dichromated Gelatin emulsions for holography applications produced by Mikron Plant at Slavich. All emulsions are passing full pre-sales control inspection. Table 1 summarises all the materials presently available from Geola's network.

The fine grain green-sensitive VRP-M emulsions are very close analogues to the old Agfa 8E56 products and can be used for both Pulsed and CW laser recording of holograms.

The fine grain PFG-01 material gives equivalent performance to Agfa 8E75 for CW recording. No analogue exists for 8E75 when used with pulsed Ruby radiation.

The PFG-03M emulsion is a super fine grain red sensitive emulsion for superior quality imaging. The PFG-03C material is a panchromatic equivalent to the PFG-03M.

Finally PFG-04 is a long-life Dichromated Gelatin emulsion for recording in the blue and green spectral ranges

All Silver Hallide materials now distributed by Geola are available coated onto glass or TAC film and cover a wide range of sizes.

Trade Name of Silver Halide Material	Description
VRP-M	Fine-grained green sensitive Silver Halide emulsion designed for reflection or transmission hologram recording. Average grain size is 35-40nm, resolving power is more than 3000 lines/mm, spectral sensitivity range includes 488nm, 514nm, 526nm, 532nm.
PFG-01	Fine-grained red sensitive Silver Halide emulsion for transmission or reflection hologram recording. Average grain size is 40nm, resolving power more than 3000 lines/mm, spectral sensitivity range 600-680nm (including 633nm, 647nm).
PFG-03M	Ultra fine-grained red sensitive Silver Halide emulsion designed for reflection hologram recording. Average grain size is 8-12nm, resolving power more than 5000 lines/mm, spectral sensitivity range includes 633nm, 647nm.
PFG-03C	Ultra fine-grained panchromatic (full colour) Silver Halide emulsion designed for colour reflection hologram recording. Average grain size is 8nm, resolving power more than 5000 lines/mm, spectral sensitivity range up to 700nm (457nm, 514nm, 633nm).

Table 1: List of Available Holographic Materials

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2. Fine Grain Silver Halide Material VRP-M

Currently there is only one emulsion available for the holograms recording with modern pulsed Nd:YAG and Nd:YLF lasers. It's fine grain emulsion VRP-M also suitable for hologram recording with green CW lasers. Characteristic curves of fine grain green VRP-M emulsions, showing spectral sensitivity versus wavelength, are shown in figure 1.

The VRP-M light sensitivity (CW radiation) is seen to peak at aproximately 75 microJoules/cm2 Figure 2 shows the optical density after exposure by CW radiation and development versus energy. Grain size characteristics for the VRP-M emulsions are presented in Figure 3. The diffraction efficiency versus exposure for reflection holograms recorded on VRP-M (using a pulsed laser (3)) is presented in figure 4. The maximum diffraction efficiency is seen to be >45%. Material life is more than two years.

The VRP-M emulsion used with pulsed radiation should be post-sensitized with the technique of latensification (see section below).

2.1. Recommended Chemistry for VRP-M

Table 2 shows a summary of various recommended processing schemes for use with Pulsed Neodymium lasers (526.5nm, 532nm). All these processing recipes work equally with CW Argon for both transmission and reflection holograms; however in this case latensification is usually not necessary and exposure is a little longer. VRP-3 is a modified VR-P developer described in [1]. In addition, for CW, you may obtain better results using the CW-C2 developer depending on your colour requirements [2]. Recently for the colour control of final reflection hologram copies we have started to use developed, bleached and washed hologram soaking in Sorbitol sollution. More details about this colour shifting technique will be given below.

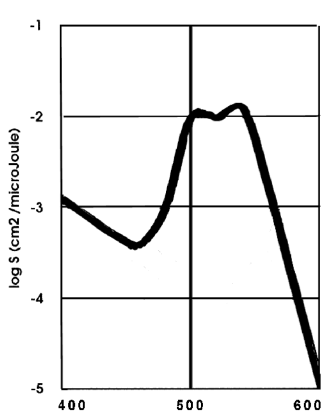

Figure1: Spectral Sensitivity curves for VRP-M.

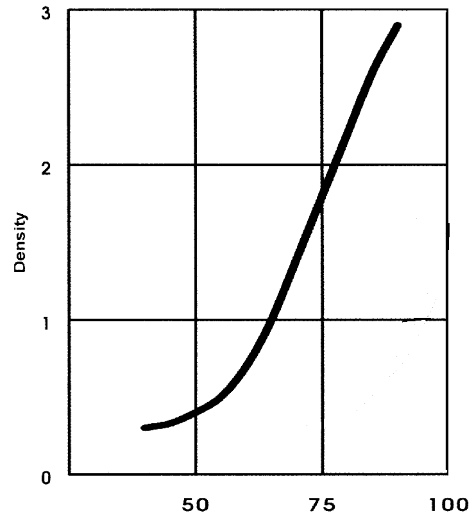

Figure 2: Characteristic curve for VRP-M

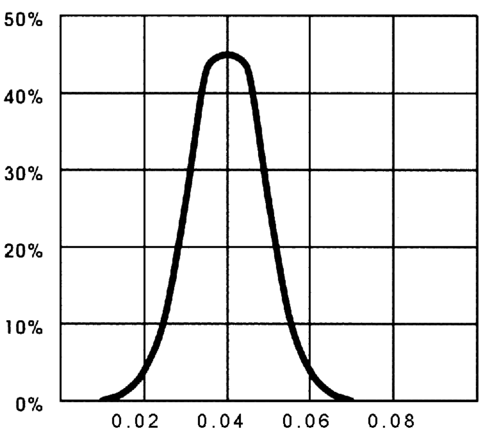

Figure 3: Grain Size distribution curve for VRP-M.

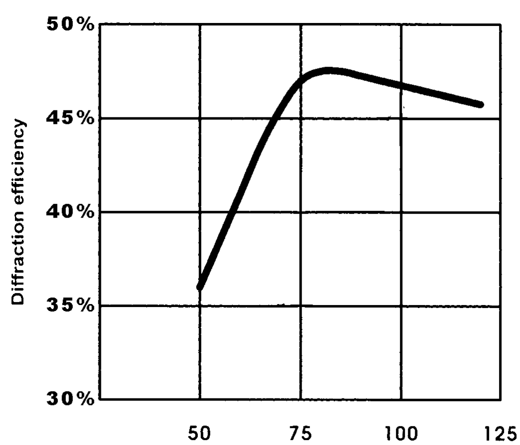

Figure 4: Diffraction Efficiency curves for VRP-M

	Mastering of Reflection or Transmission Holograms		Copying of Reflection (Final Colour Green) or Transmis-sion Holograms
	Recomend ed Procedure I	Recomended Procedure I	
Exposure	20 - 40 microJ/cm^2	20 - 40 microJ/cm^2	30 - 50 microJ/cm^2
Latensifi-cation	Yes	Yes	Yes
Develop-ment	**SM-6** 2 min	**VRP-3** 2 min	**SM-6** 2 min
Wash	Water 2...3min	Water 2...3min	Water 2...3min
Fixing	No	Yes	No
Bleach	PBU-Amidol until clear	FNPB bleach until clear	PBU-Amidol until clear
Wash	water 10...20min.	water 10...20min.	water 10...20min.
Final Wash	Water with wetting agent 1min	Water with wetting agent 1min	Water with wetting agent 1min
Slow Air Drying	Yes	Yes	Yes

Table 2: Recommended Chemistry for VRP-M with Pulsed Nd:YLF/YAG Radiation

SM-6 Developer	
Ascorbic Acid	18g
Sodium Hydroxide	12.0g
Phenidone	6.0g
Sodium Phosphate (dibasic)	28.4g
Wate	to 1.0L
VRP-3 Developer	
Methol	6g
Sodium Sulphite	50g
Hydroquinone	20g
Potassium hydroxide	17.4g
Water	to 1.0L
CW-C2 Developer 1 part A + 1 part B	
Part A	
Catechol	20.0g
Ascorbic Acid	10.0g
Sodium Sulphite (anhydrous)	10.0g
Urea	100.0g
Water	to 1.0L
Part B	
Sodium Carbonate	60.0g
Water	to 1.0L
Note: For CW-C2 develop for 2mins at 20C.	

Table 3: Developers suitable for VRP-M.

PBU-Amidol Bleach	
Potassium Persulphate	10.0g
Citric Acid	50.0g
Cupric Bromide	1.0g
Potassium Bromide	20.0g
Amidol	1.0g
Wate	to 1.0L
FNPB Bleach	
Ferric Nitrate	150.0g
Potassium Bromide	30.0g
Water	to 1.0L
Note: Before use dilute 1:3	

Table 4: Bleaches for VRP-M with Pulsed Nd:YLF/YAG Radiation

2.2. Latensification[1]

Unlike Agfa emulsions the VRP-M emulsion have peak sensitivities to exposures in the millisecond regime. In order to obtain optimal sensitivity to exposures either much longer or much shorter than this timeframe the simple technique of latensification should be used.

Latensification is usually done directly after the holographic exposure. Before you can apply the process you must work out a latensification time appropriate for your system. This procedure is as follows: Place a 25W lamp with a dark green filter (although white light also works) at a distance of 1m from a test holoplate or film such that its light uniformly illuminates the emulsion. You will need to try several exposure times ranging from 0 to around 4 mins and then look at how the emulsion develops. So start with zero exposure time and then under your normal safelight conditions develop the plate. The plate will darken a little. This is called the fog level. After development put this control plate into a STOP bath, wash it and keep it handy.

Now you must start to make a series of test exposures with small test plates. Start at about 0.5 mins and go up to around 4mins. After each exposure develop your plate and match the darkening of this plate to your control plate. If it is the same you need more exposure so go back again and repeat the process. Stop when you get a result that is just marginally darker than the fog level. This is then the correct latensification exposure for your geometry. Now after every proper holoplate exposure you must take your plate and illuminate it exactly as described above for the time that you have worked out. Then all processing is as normal. Latensification stabilizes and enhances the latent image formed by the holographic exposure.

3. Colour Control

For green lasers the colour of reconstruction of a reflection hologram usually remains in the green part of the spectrum. Most processing techniques can shift this colour by shrinking the emulsion but this leads to a shift into the blue. In order to produce a shift in the red direction a pyrogallol developer and the PBU-Amidol bleach can be used. Further red shifting can be attained by use of a final bath of Potassium Iodide or by heating the emulsion before the exposure as described in [2].

Another colour shifting technique is final hologram soaking in Sorbitol solution. This leads to the emulsion expanding and as a result to a uniform shifting of the replay wavelength to the red region. Colour adjustment in this case is performed by controling Sorbitol concentration in the solution. After hologram drying one needs to prevent humidity change inside the emulsion. For this it is possible to cover the emulsion by black self-adhesive film or by a glass plate. In order to obtain a blue colour of replay of the reflection hologram, the emulsion should be presoaked in Sorbitol before the exposure.

We would like to thank to Bernadette and Ron Olsons for this colour shift technique introduction to VRP-M emulsion.

Conclusion

VRP-M emulsion may be successfully used for all pulsed holography applications by implementing chemical processing and latensification described in this article. Colour control of final reflection hologram may be easily done by hologram soaking in Sorbitol solution.

References

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Biography

Stanislovas J. Zacharovas received his M.S. in Physics from the Vilnius Pedagogical Institute 1982 and a Ph.D. in Semiconductors Photoconductivity from Institute of Semiconductors Physics, Vilnius in 1989. Since 1983 he has worked in the Magnetic Semiconductors Group at Institute of Semiconductors Physics and since 1998 at GEOLA uab. His work has primarily focused on the induced photoconductivity in magnetic semiconductors investigation, on to control of solid-state laser radiation parameters and laser radiation interaction with Silver Halide emulsions. Now he is a managing director at GEOLA uab.