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Newsletter

Holography

HOLOGRAPHY NOTE

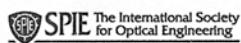
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Holography

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BB-640 photographic emulsion from HRT for recording silver-halide sensitized gelatin holograms

Dichromated gelatin (DCG) is, in some respects, an almost ideal recording material for recording volume phase holograms for imaging (holographic optical elements) and display holography. This is due to its high diffraction efficiency, high resolution, and low absorption and scattering. However, from the outset, bleached emulsions have been, and continue to be, the most frequently used photographic material. This is due to its photochemical characteristics: high spectral and energetic sensitivities. Unfortunately, the increase in diffraction efficiency obtained with bleached emulsions was always accompanied by a high level of scattering and holograms recorded in this material tend to darken when exposed to ambient light due to the known printout effect.

Silver-halide sensitized gelatin (SHSG) has proven to be a good alternative to DCG in the production of transmission holograms. SHSG is a process that improves the results in DCG (spectral and energetic sensitivities) and obtains similar diffraction efficiencies and noise level. In SHSG process, the exposed emulsion is developed, bleached and fixed and the silver halide grains are eliminated from the emulsion. The recorded holographic image is due to the variation in the degree of hardening between the exposed and non-exposed zones of the emulsion.¹

Kodak 649F emulsions were used in the first studies on SHSG holograms. However, in the last few years, some optimized procedures for SHSG holograms derived from Agfa plates have been published, showing that this emulsion is suitable for obtaining high quality SHSG transmission holograms.^{2,3} The fact that Agfa has stopped manufacturing its most common holographic emulsions (8E56 HD and 8E75 HD) is a matter of great importance that worries people related to holography.⁴ Particularly, in relation to hologram processing techniques in SHSG, it will be necessary to find new emulsions and optimize their processing. Since Agfa announced its decision, several photographic emulsions have sprung up in the market, like SLAVICH, Red Star, or the BB series from Holographic Recording Technologies (HRT). Nevertheless, these emulsions have different characteristics than Agfa plates: in grain size, the type and rate of the gelatin hardness, and/or their silver content. Thus, many of the chemical procedures developed for Agfa materials cannot be used with these new emulsions. As a result, tips on how to use for BB-640 plates have recently been published.⁵

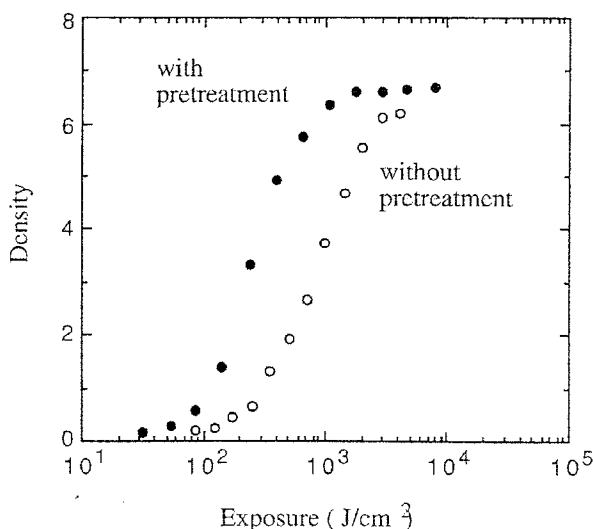


Figure 1. Density as a function of exposure for BB-640 plates, with and without pretreatment.

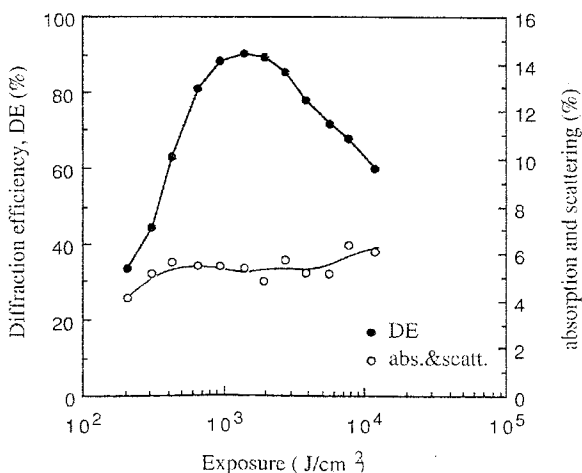


Figure 2. Diffraction efficiency and absorption and scattering for silver-halide sensitized gelatin holographic gratings of ~1200 lines/mm recorded in hypersensitized BB-640 plates and bleached at 70°C.

At our lab we have begun to study the possibility of recording silver-halide sensitized gelatin holograms using the new BB-640 plates as photographic material.⁶ This emulsion is very clear and has a sensitivity range from 580 nm to 660 nm. Although their energetic sensitivity is lower than Agfa emulsions, their smaller grain sizes⁷ (20-25 nm for BB-640 versus ~44 nm for coated Agfa 8E75 HD emulsions) offer a higher signal-to-noise ratio. In addition, BB-640 emulsions are hardened to a high degree⁷

making their gelatin too hard to be used directly for recording SHSG holograms. We solved the problem of the low energetic sensitivity and the hardening of the gelatin emulsion by soaking the unexposed plates in a weak fixer (a solution of distilled water with sodium sulfite and urea) for 10 minutes at 20°C. For holographic gratings developed with D-19 and fixed with F-24, this pretreatment produces a softening of the gelatin in the BB-640 emulsion and increases the sensitivity by a factor of ~2.6. There is also a significant increase in diffraction efficiency. Figure 1 shows the D-logE curves for BB-640 plates with and without pretreatment when Kodak D-19 developer and an incident intensity of 500 $\mu\text{W}/\text{cm}^2$ were used.

To study the possibilities of BB-640 emulsion for recording SHSG holograms, unslanted holographic transmission gratings with a spatial frequency of ~1200 lines/mm were recorded by using two collimated beams of equal intensity from an HeNe laser. The exposed plates were processed using a modification of a previous processing schedule for Agfa plates.² We hypersensitized the plates before exposure, increased the temperature of the bleach bath from 50°C to 70°C and dried the processed plates at low relative humidity (<20%). The developer used in these experiments was Kodak D-19, a nontanning developer. However it is important to note that oxidation products of this developer, which have a local tanning action, also contribute to the formation of the latent image. A rehalogenating bleach and a non-hardening fixer (Kodak F-24) were also used.

The diffraction efficiency (DE) η and the transmittance τ were corrected to take into account Fresnel losses and the absorption of the glass substrate. A percentage as a function of exposure, calculated as $100 - \eta - \tau$, was taken as the loss due to absorption and scattering. Figure 2 shows the DE and the absorption and scattering as a function of exposure for hypersensitized plates bleached at 70°C. As can be seen, a high DE of ~90% was achieved and the total losses caused by absorption and scattering

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BB-640 photographic emulsion

(continued from p. 4)

tering are lower than ~6%. We have observed that DE increases significantly by using hypersensitized plates and the increase in the bleach bath temperature from 50°C to 70°C barely increases absorption and scattering. DE achieved with BB-640 plates is higher than obtained with Agfa 8E75 HD emulsion,^{2,3} and the values of the absorption and scattering are lower when BB-640 plates are used. It is felt that these experimental results may be the best obtained at the present time for SHSG holographic gratings, and they confirm the application of SHSG derived from BB-640 plates for recording high quality transmission holograms. These results also show that BB-640 photographic emulsions from HRT are one of the best alternatives to Agfa 8E75 HD emulsions.

The influence of the developer and the study of the modulation transfer function have been recently analyzed⁸ and experiments with reflection holograms and diffuse-objects are also planned.

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