Dye Sensitization of holographic emulsions

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Introduction

Silver halide emulsions used for holography need to have a grain size of the order of 50 nm or so, so that the extremely high resolutions necessary for holographic data may be captured. However, most commercial silver halide holographic emulsions with this kind of grain size are only sensitive to a narrow range of wavelengths and designed to be used with a narrow band, coherent source. Commonly available commercial, panchromatic, silver halide emulsions sensitive to a wider gamut are designed to be used for photography and hence have too large a grain size to be suitable for holography. For full colour holography, where the emulsion is exposed to multiple coherent sources, the material needs not only to have an appropriate grain size but also to have dyes present in the emulsion to be sensitive to a wide range of wavelengths so as to be able to expose it to a larger gamut. These are not easily available.

In this work, we have sensitized holographic emulsions with dyes so as to extend their sensitivity to a gamut beyond the intended commercial gamut.

Materials

The following materials were used in this work. The actual emulsion used, red sensitive Kodak SO-173, was used due to availability. Similar results should be attainable with any red sensitive holographic film.

1. 100ml 70% Isopropyl
2. 40ml 91% Isopropyl
3. 22mg Dimethylaminostyrlmethylpyridinium iodide (sigma-aldrich cat. no. 336408)
4. Holographic film Kodak SO-173
5. kodak photo-flo 200 solution
6. Amber led safelight

Mixing the dye:

A stock solution of 22mg of dye to 40ml 91% Isopropyl was made up. From this a working solution 5mg of stock to 100ml 70% Isopropyl was used. This was added to 1 part photo-flo to 200 parts H_2O.

Procedure

Anti-halation wash

The Kodak SO-173 emulsion has an anti-halation coating. This was washed out under a safelight for 5 minutes. The anti-halation backing was washed off so that a single-beam Denisyuk hologram may be exposed with the sensitized and unsensitized film. The film was then immersed in a photo-flo solution (as above) for one minute and dried by hanging it

Sensitization:

When the film had dried, it was placed in a working solution of the dye (mixed as above), and soaked for 5 minutes. The film was then soaked in 70% IPA solution to wash off the excess dye that had adsorbed on the emulsion surface. It was then immersed again in a photo-flo solution and dried.

Testing:
Both un-sensitized and newly sensitized films were exposed to laser light from both a DPSS laser at 532nm and a DPSS laser at 650nm. The intensity of the exposing beam at the film position was measured at 0.56mW for the DPSS laser and 35 microwatts from the red DPSS. All power readings were read using a Pocket Laser Power Meter 840011.

In the first experiment, two films were used, one sensitized with dye and one without. A thin black paper strip was placed in the middle of each film, so as to show an unexposed region of the film. Both films were then exposed to the green laser (532nm). The films were then developed in Kodak D19 at room temperature for about 20 seconds and washed for 5 minutes.

Next, two films were sensitized and exposed to the red laser (650nm). Again a center strip was added to show an unexposed region. In this case, the exposures were tiled so as to show the effect of increased exposure as follows: This was done by means of a small square area of the films being exposed by covering the entire film with a card except for a small square region. The card was then withdrawn so as to expose a new, small square section while exposing the previously exposed region again. This was repeated 5 times to give 5 small, square areas. Thus the first square area was exposed for 5 exposure periods of 5 seconds each, the next for 4 exposure periods, etc. This resulted in a range of exposures from 5 seconds to 35 seconds.

Finally, two holograms were made on sensitized film, exposed in a single beam Denisyuk geometry, one with red and one with green lasers.

Results

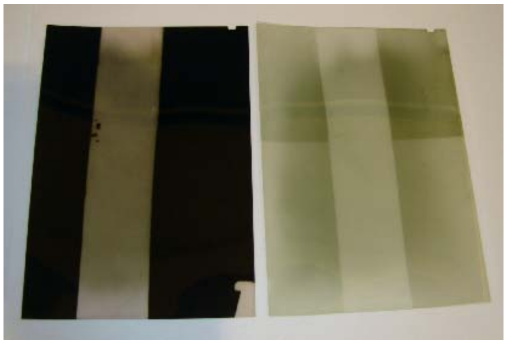
Fig 1

Fig 1 shows two films, one newly sensitized and one un-sensitized and both exposed to the green laser. The left hand film has been sensitized and the right is originally sensitized. It can be seen that the left hand, sensitized, film has darkened so showing the dye has “taken”, while the right hand film shows that the un-sensitized film had little sensitivity in the green.

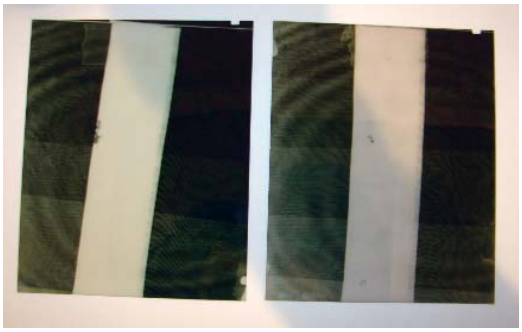
Fig 2

Fig 2 shows stepped exposure of both newly sensitized and originally sensitized films to the red laser. In both cases, there is sensitivity to the red. This seems to indicate that the original red dye is still present in the film, even after sensitizing with a green dye.


Fig 3


Fig 4

Fig 3 shows a single beam Denisyuk shot on newly sensitized film using the 532nm green laser. And fig 4 shows a single beam Denisyuk shot with a red laser also on newly sensitized film. This shows that the dye sensitization maintains the spatial frequencies necessary for holography. Also, fig 4 again shows that the original red dye is still present and in sufficient quantity to maintain the frequency range.

Conclusion

It has been shown that it is possible to shift a commercial red-sensitive film into green sensitivity by sensitization with a green dye. It has also been demonstrated that the original red dye is still present and is still capable of imaging at holographic frequencies. This brings up the possibility of exposing commercially available red sensitive films to a multi-line coherent source and making full colour holograms.

Acknowledgement

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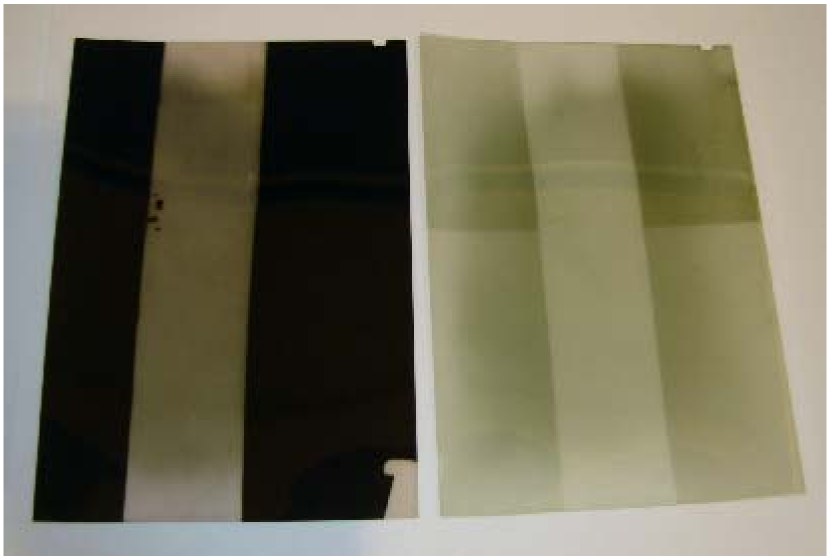

Fig 1

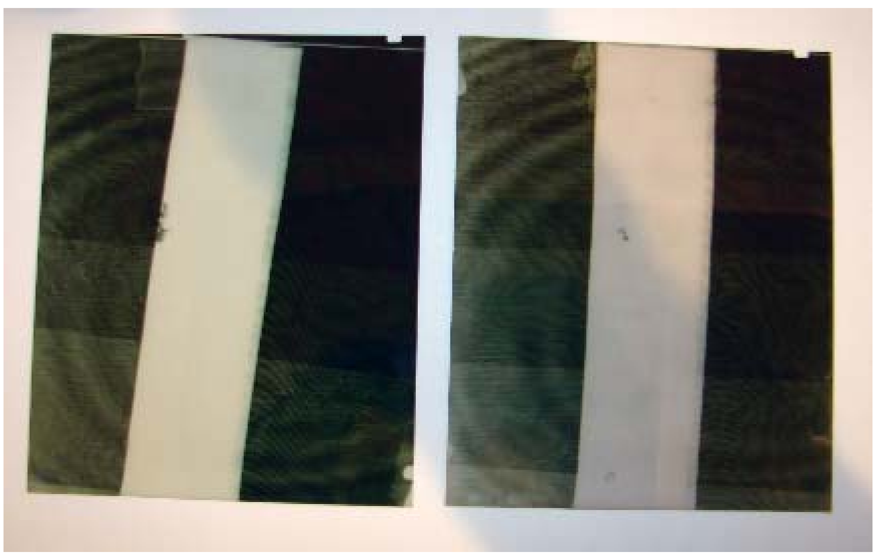

Fig 2

Fig 3

Fig 4

Color single beam Denisyuk shot