Progress in Holographic Materials: Silver Halide Film and Chemistry

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It has become my custom at these January SPIE presentations, to give a small summary of the progress made in the preceding year.

In the first place 1988 was a Photokina year at Cologne in Germany and once again Ilford presented a display of holograms all showing genuine applications for display holography rather than the concepts that had been presented in 1986. Most of the applications are well known, toys, point of purchase display, promotional giveaways, holographic watches etc, but there were also a few surprises such as the car with holograms incorporated into the bonnet and the holographic bistro tables.

The two most important technical developments of 1988 which had made considerable impact on the commercialisation of volume display holograms were:

a) the attention given to display lighting by holographic companies in the form of integral lighting units; and,

b) the development of line scanning techniques using a He-Ne laser.

The first of these gives the customer what he really wants. A hologram of reasonable size (from 8 x 10" up to 1m²) that can simply be plugged in without the need for fiddling about experimenting with different lamps and finding optimum viewing angles. An integral lighting unit for either transmission or reflection holograms constitutes and end product which is much more user friendly for the end user and therefore more marketable.

The second of these, line scanning, enables low cost copies to be made on film. The copies are of good quality and can be made in large quantities because the chemical system pioneered by Ilford can be used in a processing machine on a replenishment basis and is safe to use.

Another notable feature of 1988 was the consolidation of the Ilford SP695T blue/green sensitive glass plates for mastering for embossing. It is true to say that the biggest and most prestigious embossing companies in the world now use these plates to produce their masters. Their high speed, low noise and ability to record more information has firmly established them as the material of choice in this small but important market.

The quality of the result can be judged by all looking at the cover of the centenary edition of the National Geographic magazine, now available worldwide.

From the manufacturer's point of view, the full potential of these plates will only be realised when they are routinely used to produce reflection holograms also. The great stumbling block here is that it is commonly assumed that a reflection hologram made on green sensitive material with an argon laser will be green in colour, a fact which makes it less commercially desirable than a gold or yellow coloured one. To this end, Ilford is working with a few, selected, holographic companies to develop a good chemical technique for the post processing treatment of such holograms to shift the colour up to longer wavelength.

The perfection of such a simple processing step opens up a new field of application for these laboratories already equipped with expensive and reliable Argon lasers. The ability to make a large format gold coloured reflection hologram is a useful adjunct to the routine work of producing embossing masters and large format Bentons.

ILFORD HOLOGRAPHIC

SENSITISED PRODUCTS

SUMMARY

PRODUCT	FEATURES	APPLICATIONS
SP 673 RED	BIPS Factor	Contact copying He-Ne scanning
SP 672T BLUE GREEN	BIPS Factor High sensitivity Low scatter	Contact copying Large format H1, H2 Full colour
SP 695T PLATES	BIPS Factor High sensitivity Low scatter	Master for embossing Large format displays
NEW RED EMULSION	BIPS Factor	Ruby portraits He-Ne spread beam

Table 1

Table 1 reminds us of the holographic consumables available from Ilford during 1988 with the principal characteristics and applications. The most notable and distinctive feature of the Ilford red materials is seen to be the BIPS factor (Build-In Pre-Swell factor). This is essentially a shrink factor incorporated into the film at the factory. Its purpose is to enable a gold coloured hologram to be made from a He-Ne exposure using a non tanning developer and rehalogenating bleach but without the need to pre-swell the emulsion.

In these cases where the shrinkage is not required, for example in the production of tuned reflection masters, the BIPS actor can be removed by simply rinsing the sheet of film in clean water for about 30 seconds followed by careful drying. The film will now not shrink after processing and, incidentally, the sensitometric speed will be approximately double.

It should be known by now that the Ilford SP673T emulsion was designed as a copy film to be used in conjunction with a red laser but where the exposure conditions were of short time and high intensity. In a true commercial environment where time is money, copy holograms will not be made by using exposure times of many seconds or minutes. The settling times required are far too long and the danger of drop-outs due to movement or vibration too high.

Thus either a high powered Krypton laser must be used or a relatively low powered He-Ne in the scanning mode.

An H3 contact copied hologram made with this material is on display at this conference for all to see. It was contact copied from a tuned reflection HeNe master. The exposure was made using a 25mWatt HeNe laser spread to a line 2mm wide and scanned across the surface of the film in about 2 seconds. No settling time was allowed. The exposure was then processed in Ilford SP678C developer followed by the new machine compatible Ilford rehalogenating bleach.

The result is a hologram that is a good gold colour with excellent blacks and is viewable in diffuse light. The light stability is also good enough for most practical purposes without the need for further treatment. Ilford is now optimistic that this new integrated system which has now emerged from the research stage will enable the mass markets for volume copy holograms to be exploited with a higher quality hologram product than was previously thought possible.

The combination of the Ilford red and blue/green emulsions has been spectacularly successful in enabling good quality full colour holograms to be made, most notably by Paul Hubel in Oxford, England, and Professor Kubota in Kyoto, Japan.

The significance of these holograms is that they show that silver halide is perfectly suitable for making full, natural colour holograms with astonishing realism, but it is our belief that such holograms will not be available cheaply, and in commercial quantities for another 2-3 years at least. Much work remains to be done on the materials and process side to make this a viable business.

At conferences such as these it is customary to announce something new and at SPIE 1989 we take the opportunity to present a new red sensitive emulsion first mentioned a few weeks ago in Kobe, Japan.

It has been apparent to Ilford for sometime that there are many users of He-Ne lasers who will not, or cannot use them in the scanning mode. These are workers using HeNe to make masters, in the widest sense of the word i.e. simple Denisyuks or H2 reflection masters.

For these holographers we have designed an entirely new emulsion with characteristics which make it ideally suited for spread beam work with a relatively low powered HeNe laser.

Temporarily known by the unexciting name of SP 737T, this product is designed to show high speed over long exposure times, with low intensity.

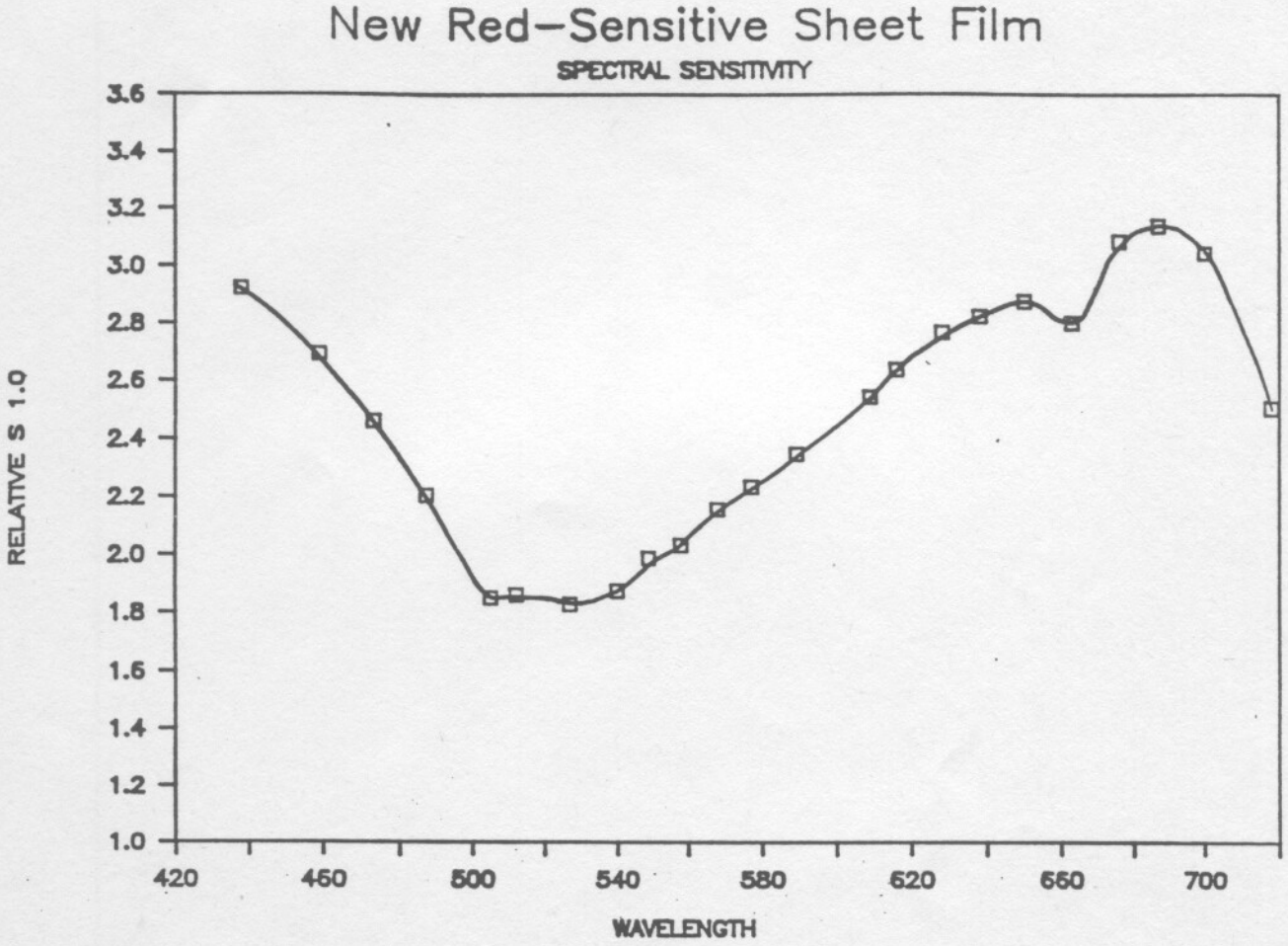

Figure 1

In figure 1 we show the relative sensitivity of the emulsion throughout the viewable spectrum. It can be seen that sensitivity is good throughout the red region and it also has good blue speed. This curve shows only relative sensitivity as absolute sensitivity depends on precise exposure conditions and processing but it is worthy to note that even in the green region where sensitivity is a minimum to enable the use of green safelights, the emulsion is still ten times more sensitive than DCG. Thus, this red sensitive emulsion has a green speed of approximately 1000 micro Joules per cm^2, whereas in the red, reflection holograms are typically made with an exposure of 25-100 micro Joules per cm^2 even over a period of minutes.

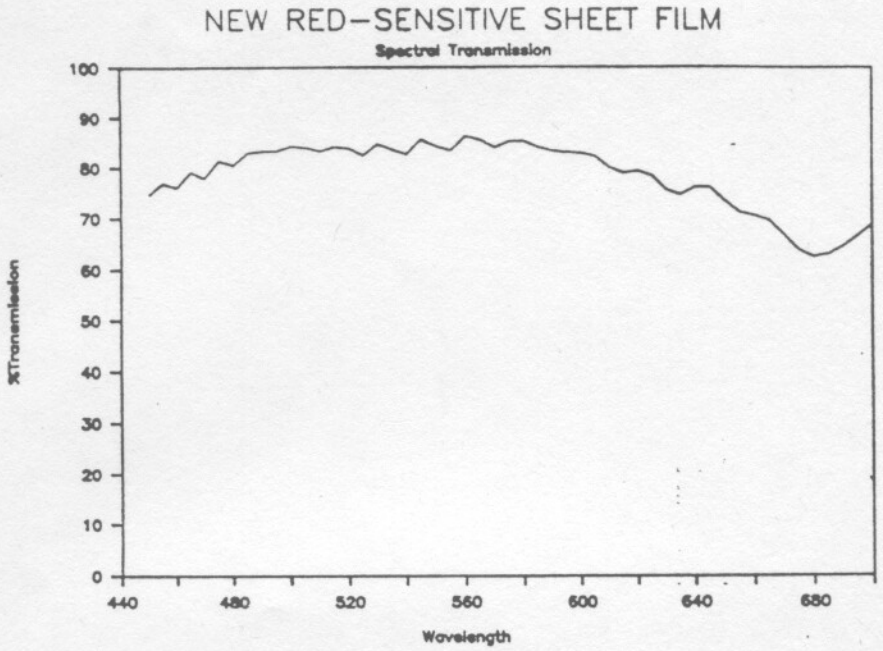

Figure 2

Figure 2 shows the spectral transmission characteristics of the unexposed film where it can be seen that at 633nm almost 80% of the light is transmitted thus ensuring good beam ratios for Denisyuk recording.

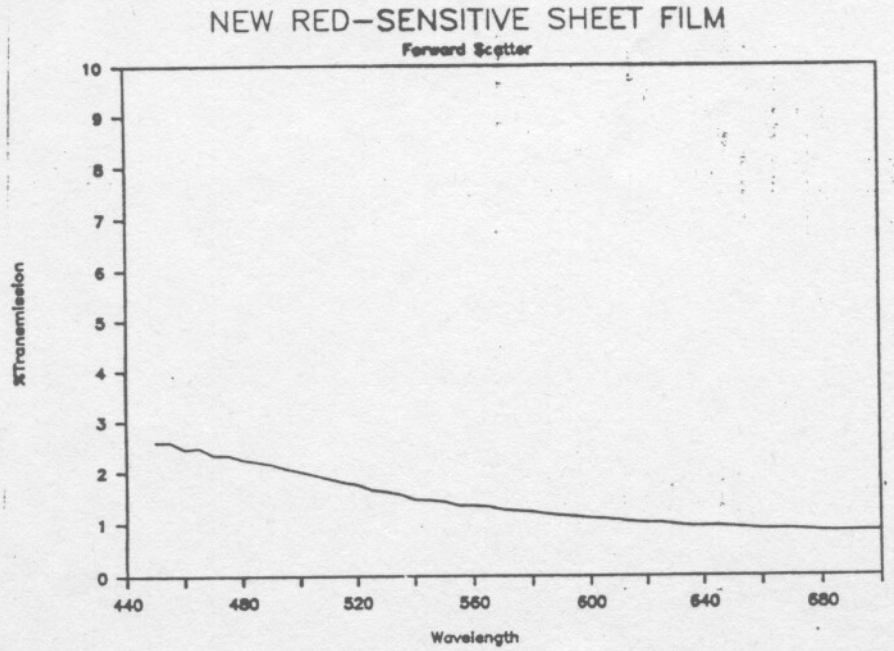

Figure 3

When we look at the forward scatter data in Figure 3 we see that speed has not been achieved by increasing crystal size. The scatter in the red is well below 1% and this low figure has not been obtained by masking with antiscatter dye or the spectral transmission properties shown in Figure 2 could not have been realised.

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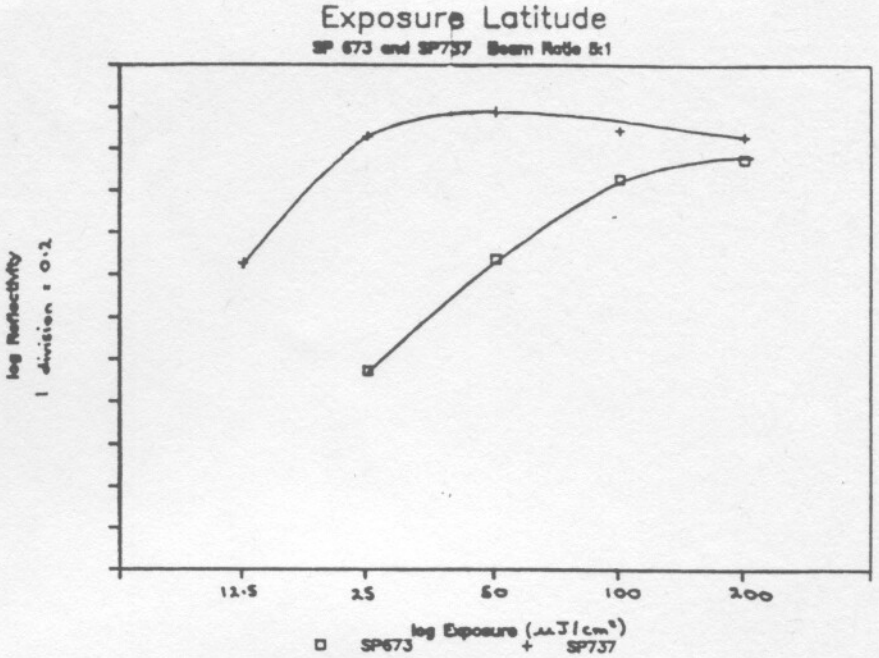

Figure 4

Perhaps most exciting of all is the data contained in Figures 4 and 5. The data show how the exposure latitude of the new emulsion compares with SP673T at two beam ratios. In figure 4 the beam ratio of 5:1 corresponds to bright image areas and here it is seen that the reflectivity of the hologram is fairly linear over the range 25-200 micro Joules per cm² unlike SP673T which required a minimum exposure of 200 uJ per cm² to reach maximum diffraction efficiency.

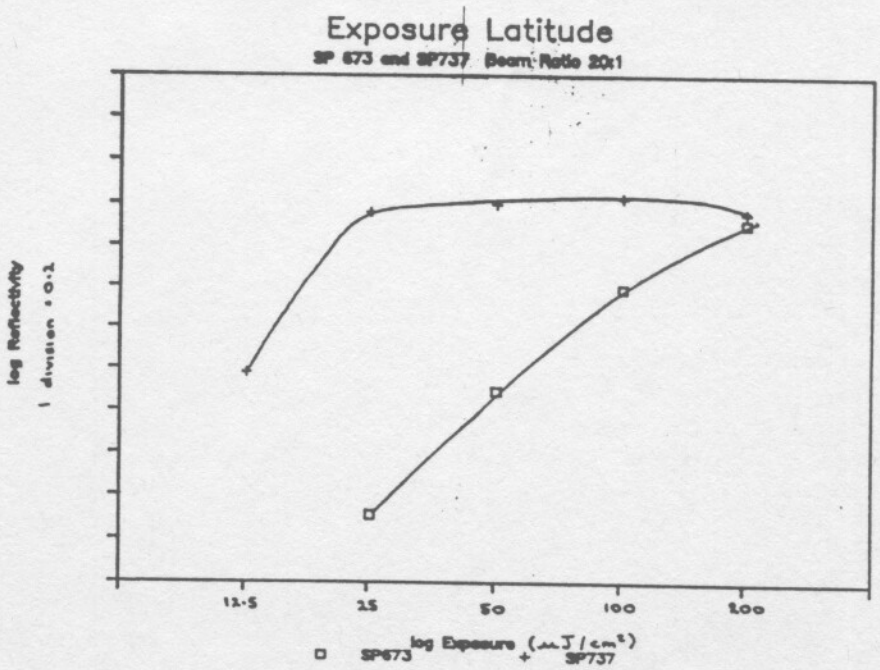

Figure 5

Figure 5 shows that the same trend is followed in dim image areas where the beam ratio may drop to 20:1 or less. Again, the plateau is reached at 25 uJ per cm² indicating that the emulsion is very forgiving of under or over exposure.

VOOD

We believe that this film will be a great value in schools and colleges and to the interested hobbyists who do not exercise much control over their exposure conditions, furthermore the quality of results obtained will be good using the ecologically safe processing chemistry offered by Ilford.

Finally, it should be noted that in addition to achieving this high speed performance at long exposure times, the speed has also been increased to pulse ruby laser making the material ideally suited for recording pulse ruby portraits where exposure time is very short, typically 20ns, and intensity must be kept very low to ensure complete safety to the subject during open eye portraiture.

The low noise and general image cleanliness under such conditions must be seen to be fully appreciated.

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