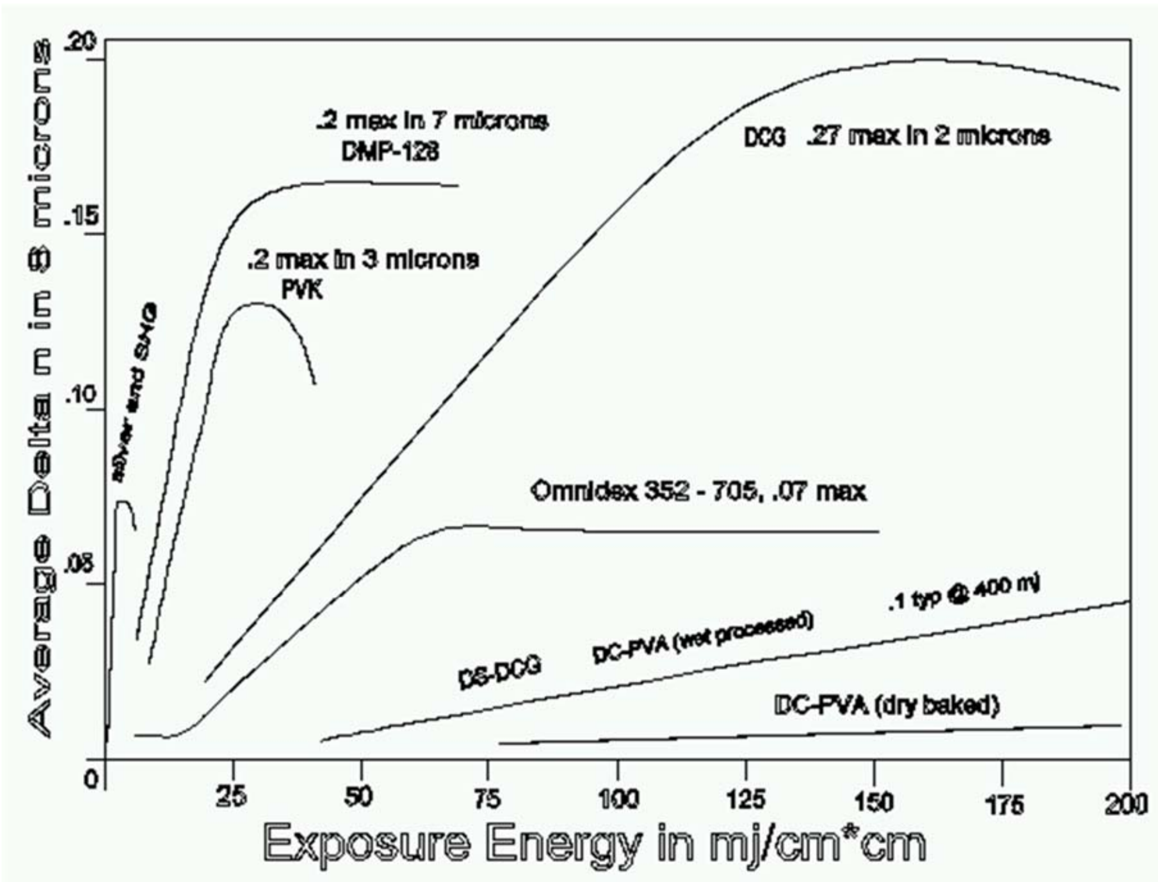
Media characteristics, tables and plots

Contents

Overall Comparison

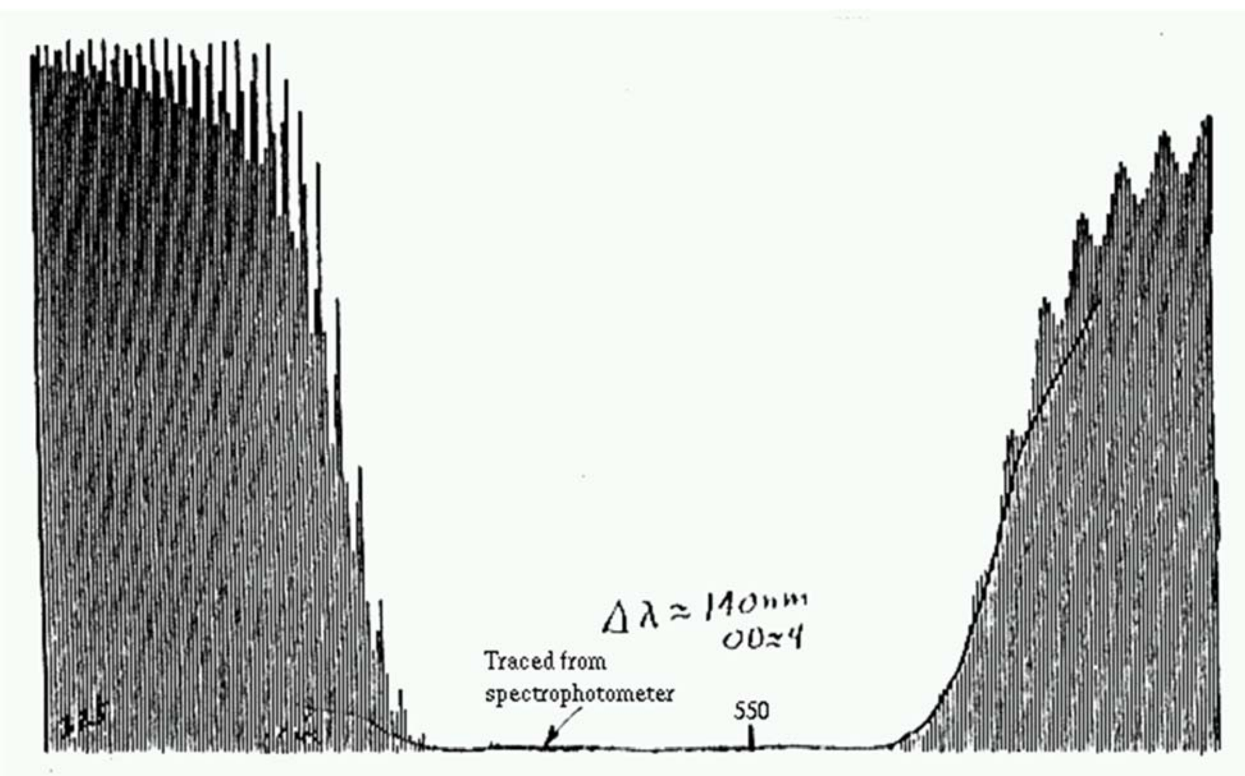


Material	DCG	DMP128	PVK
Sensitivity (mj/cm^2)	2-100 @ 442-532	30 @ 633-694	20 @ 488-532
Approximate available index mod (Delta n)	0.25	0.20	0.20
Max O.D. attained in notch filters	5	4	2.5

Useful thickness range (microns)	5-25	7-15	5-10
Available Spectral Bandwidths (nm)	10-150	10-100	20-100
Playback compared to record wavelength	red shift for broad and/or blue shift for narrow	variable blue shift	red broad/blue narrow
Minimum recommended protection	40 mil glass and epoxy	4 mil Aclar	4 mil mylar
Resistance to water	poor	fair	excellent
Familiarity or experimentation period	13 years	6 mo.	6 mo.
Number of samples made	100	>200	>50

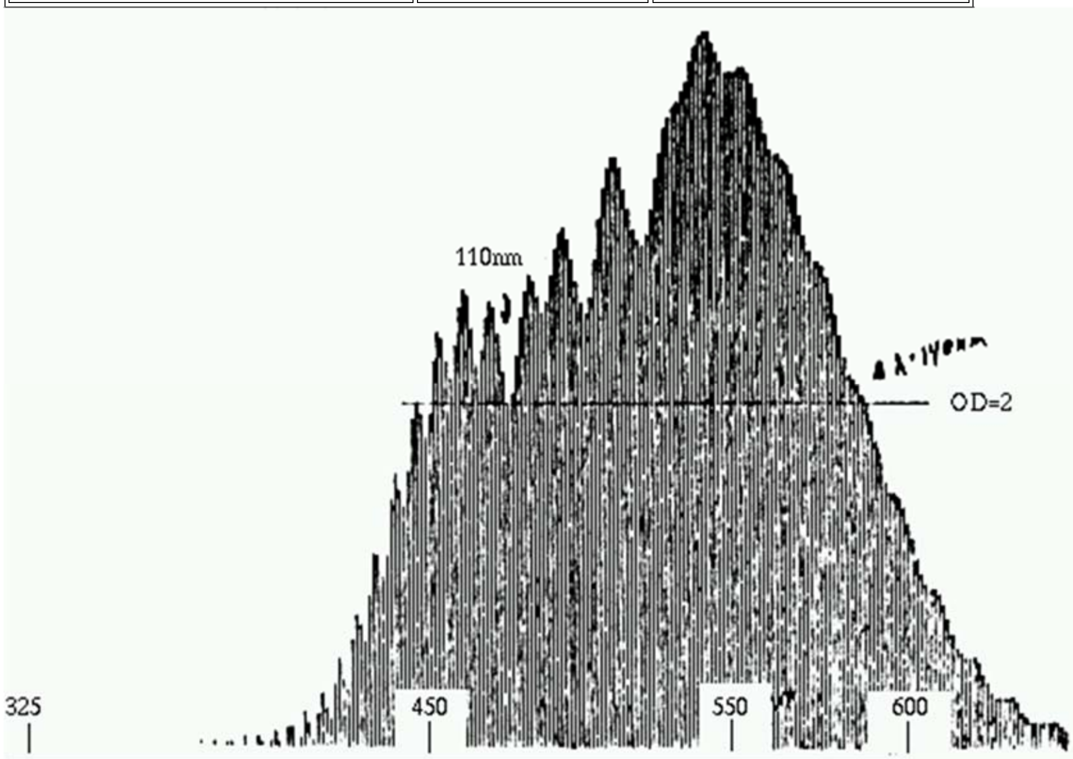
Notch filters or conformal reflectors where made in each of these materials and also in some of Dupont photopolymers. The dupont products have typically smaller bandwidths and lower maximum available index modulation, but the sensitivity is now in the 10 to 20 mj/cm*cm range and the sensitometric curves are similar to the DMP 128 curves in shape. The migrating photopolymers can not be over exposed in the reflection configuration and are fixed by white light or UV flood exposure or over exposure to laser light.

DCG #1 BB



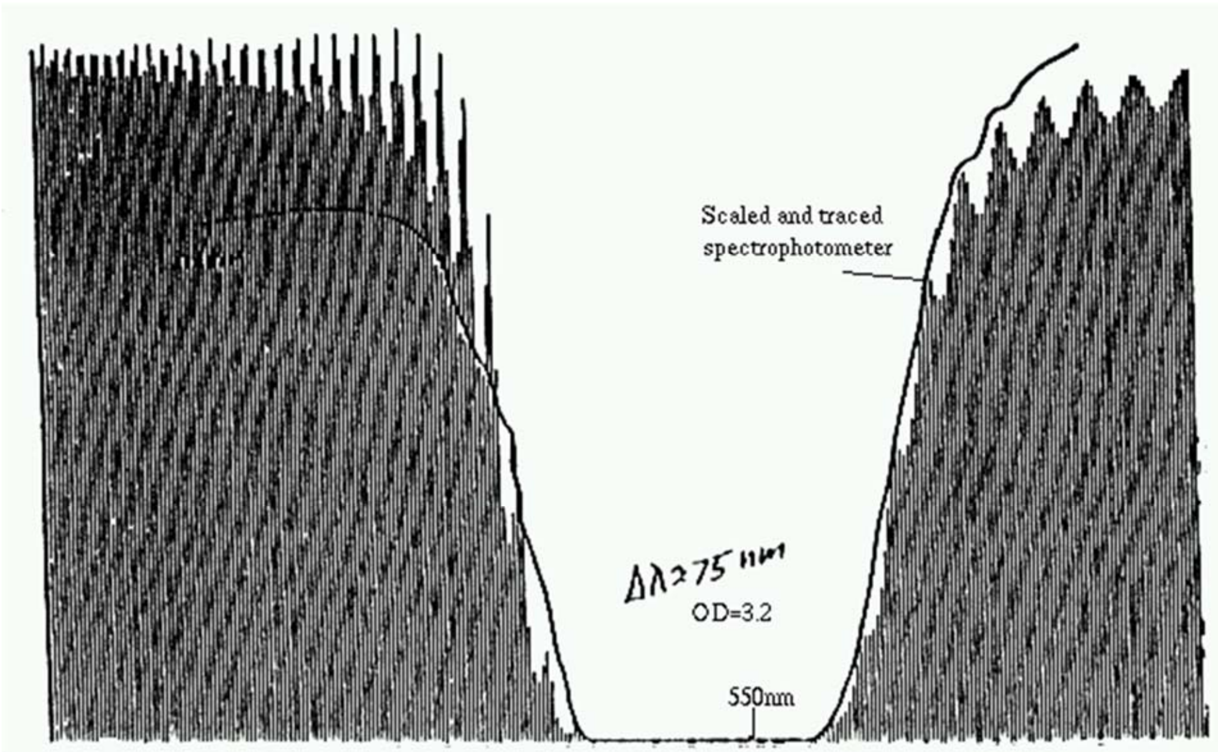
n = 1.560	nl = 0.180	d = 9.00um	lambda center = 550.nm

Scan from 325.000 nm to 775.000 nm		
Minimum %T = 0.0365	Maximum %T = 99.9966	
Multiple layer dielectric theory	38.00% Damping	9.00% Chirp

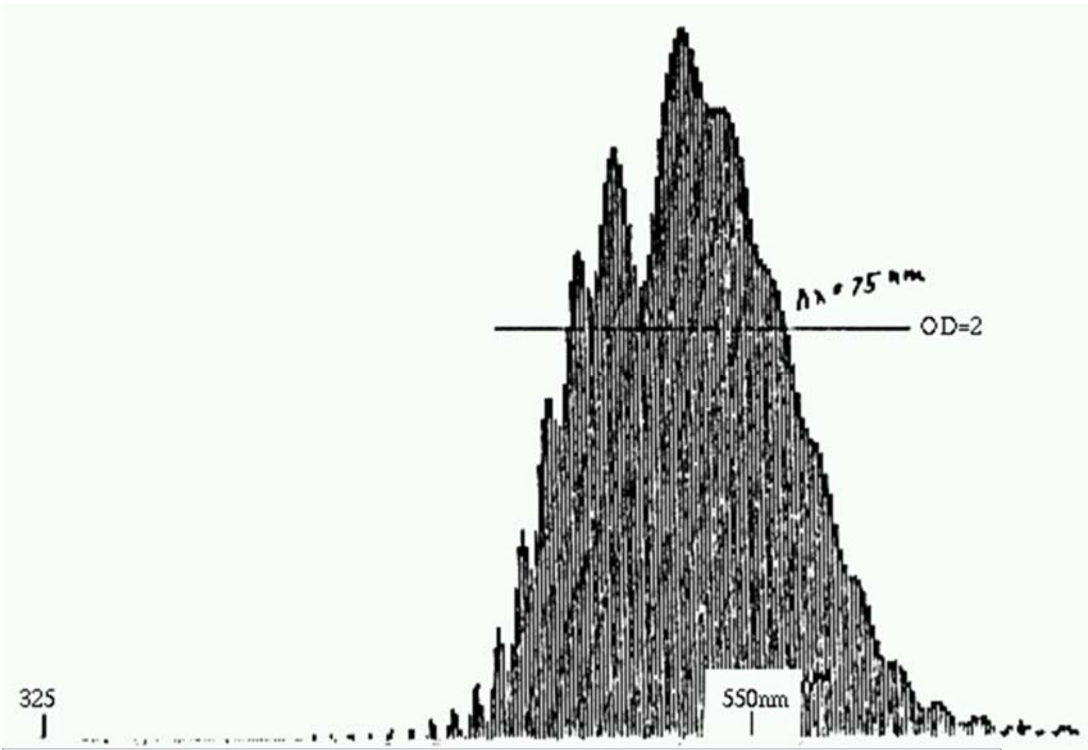


n = 1.560	nl = 0.180	d = 9.00um	38.00 % Damping, 9.00 % Chirp
Scan from 325.000 nm to 775.000 nm			
Maximum OD = 3.437	Minimum OD = 1.479E-05		

DCG #2 MB



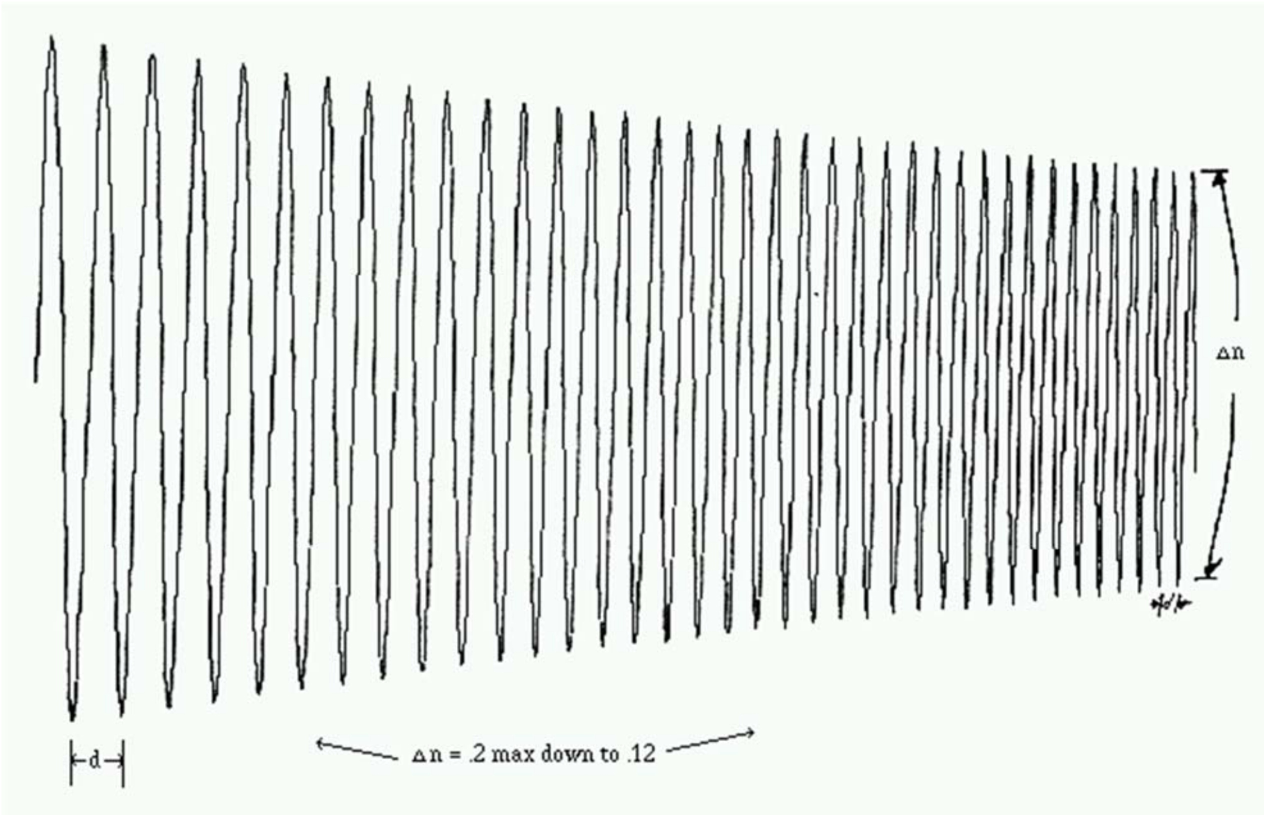
n = 1.560	nl = 0.140	d = 9.03um	lambda center = 525.nm
Scan from 300.000 nm to 750.000 nm			
Minimum %T = 0.0030		Maximum %T = 99.5860	
Multiple layer dielectric theory		36.00% Damping	3.00% Chirp



n = 1.560	nl = 0.140	d = 9.03um	lambda center = 525.00nm
Scan from 300.000 nm to 750.000 nm			
Maximum OD = 4.522		Minimum OD = 1.802E-03	
Multiple layer dielectic theory		36.00 % Damping	3.00 % Chirp

Reflectors in 10 microns of DCG can be processed to have all of the above characteristics. The time, temperature and alcohol concentrations all affect bandwidth and density.

Refractive index change as a function of depth for 901 points

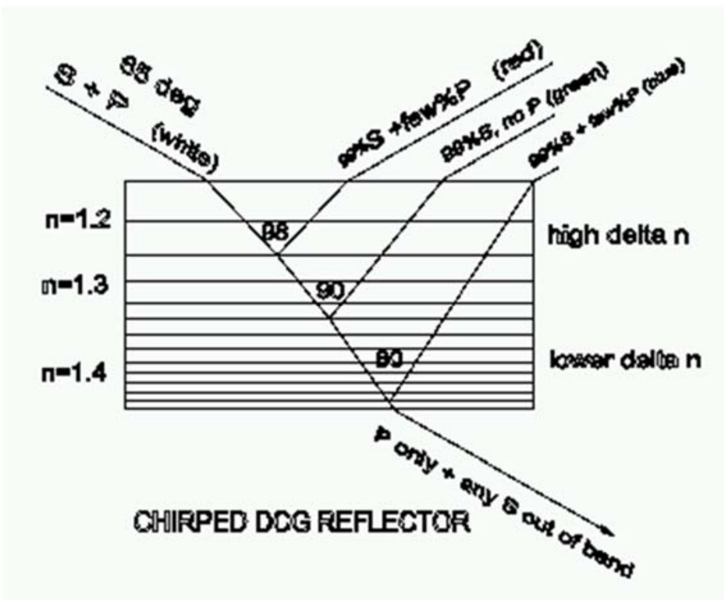


Model of chirp in spacing and gradient in delta n

Broadband effects in DCG, DMP 128 and other materials arise from processing induced chirps in the spacing of the fringe planes much like the variable spacing and amplitudes shown here. Absorption of light during exposure contributes to a broader bandwidth by introducing an exposure amplitude gradient in the index modulation through the depth of the film. The processing gradient caused by the diffusion of developers or solvents into the film may enhance or reduce the gradient depending on whether the film was exposed film side up or film side down (especially in a single beam configuration). This explains why two single beam reflection holograms can appear to be very different in color and bandwidth if one was shot film side up and the other film side down.

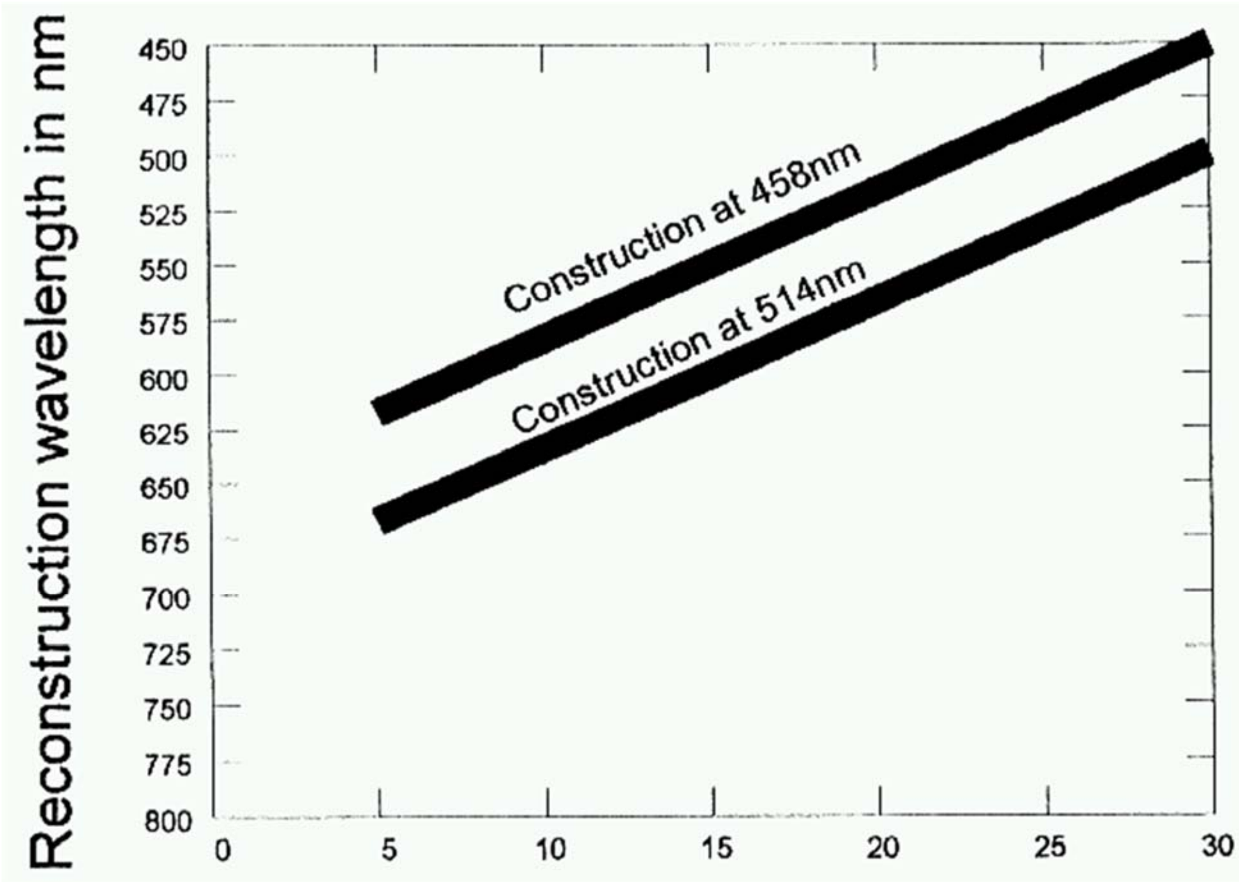
This plot and the previous plots of amplitude and density and the following plots for DMP 128 were modelled using a program that takes into account a linear chirp in spacing and an exponential gradient in refractive index modulation resulting from absorption of the exposure light. A newer version will plot curves that have nonlinear chirps and generates shapes that more closely match those obtained in a scanning spectrophotometer.

Effects of gradient in n on polarizer performance



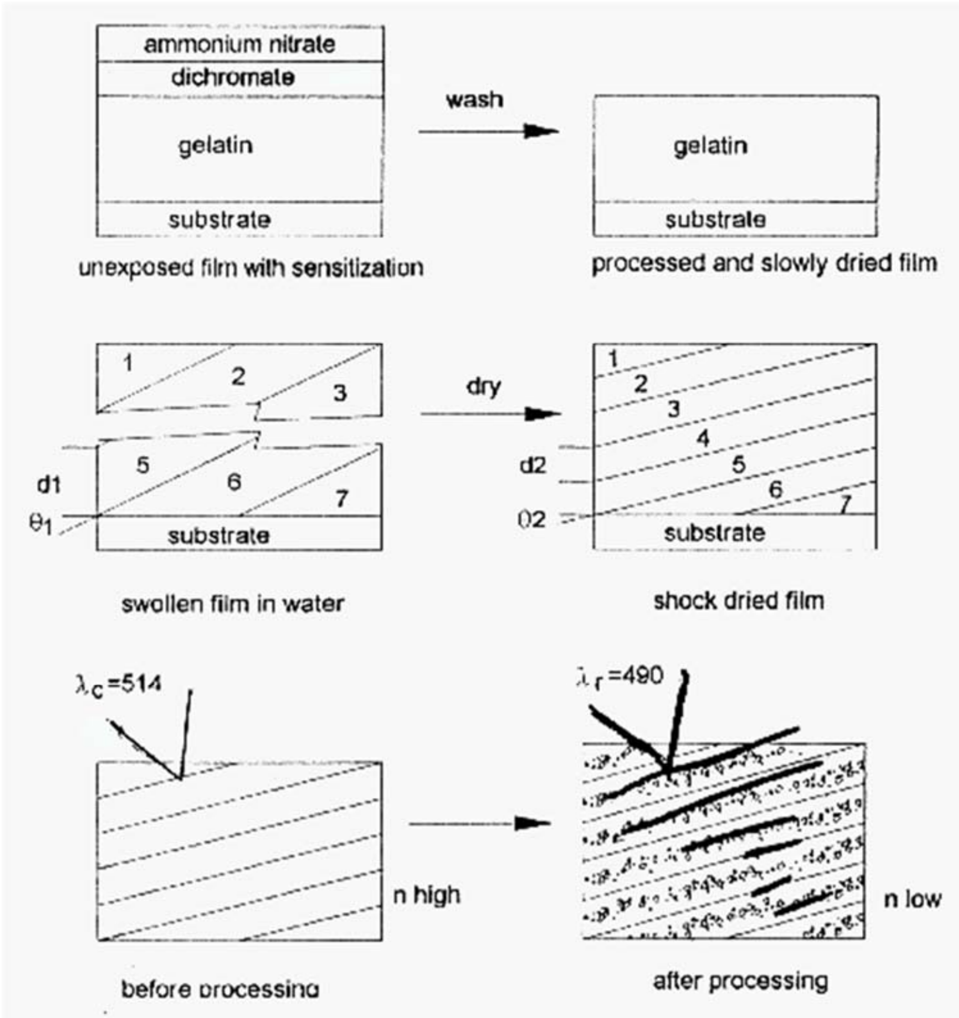
most S light reflected in high delta n region
spectral bandwidth is approx. 150nm

Another way to view the chirp in a plain mirror is shown above where the additional effect of a varying average n through the film is also seen. The fringes near the surface are seen to have wide spacings reflecting Red light with high efficiency because the delta n is highest there. As light travels deeper in finds shorter paths, higher n and lower delta n. The changing n makes a difference in the internal reflection angle, but not the external. This reflector acts as an efficient polarizer for green light because no P polarized light can be internally reflected. It is quite good at other colors as well.

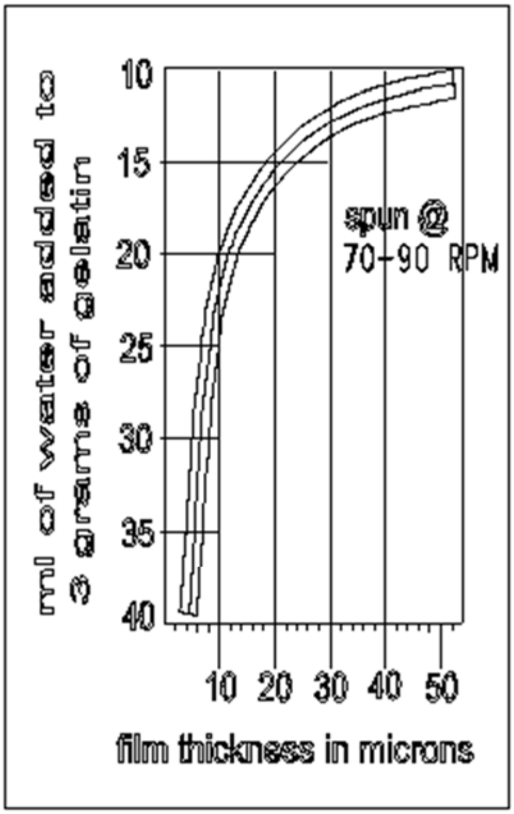


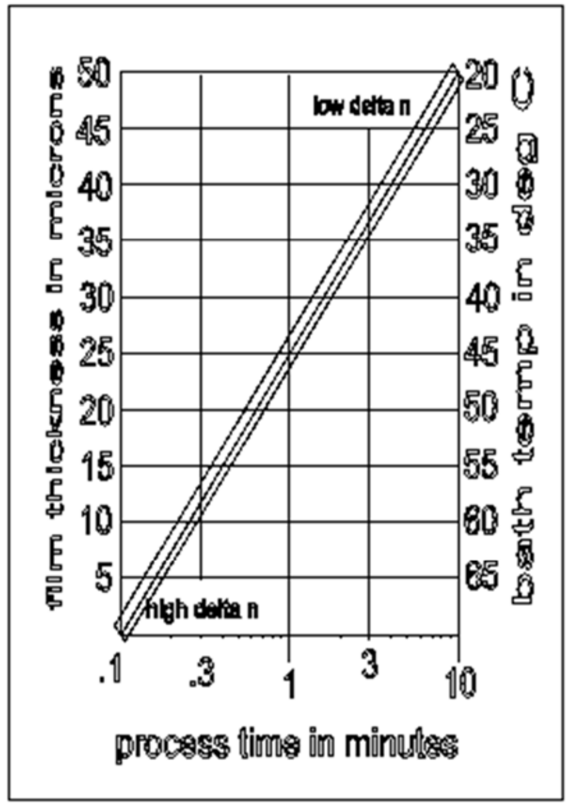
Dicromate as % of gelatin by weight

The Color that DCG reconstructs at can be controlled by how much sensitizer and other dissolved solids are contained in the film before exposure. The sensitizer is washed out and the film loses from 5 to 30% of it's original thickness but processing causes 10 to 50% swelling, depending on how thick the film is and how hot the solvents are and on ph and an time and prehardening among other things.



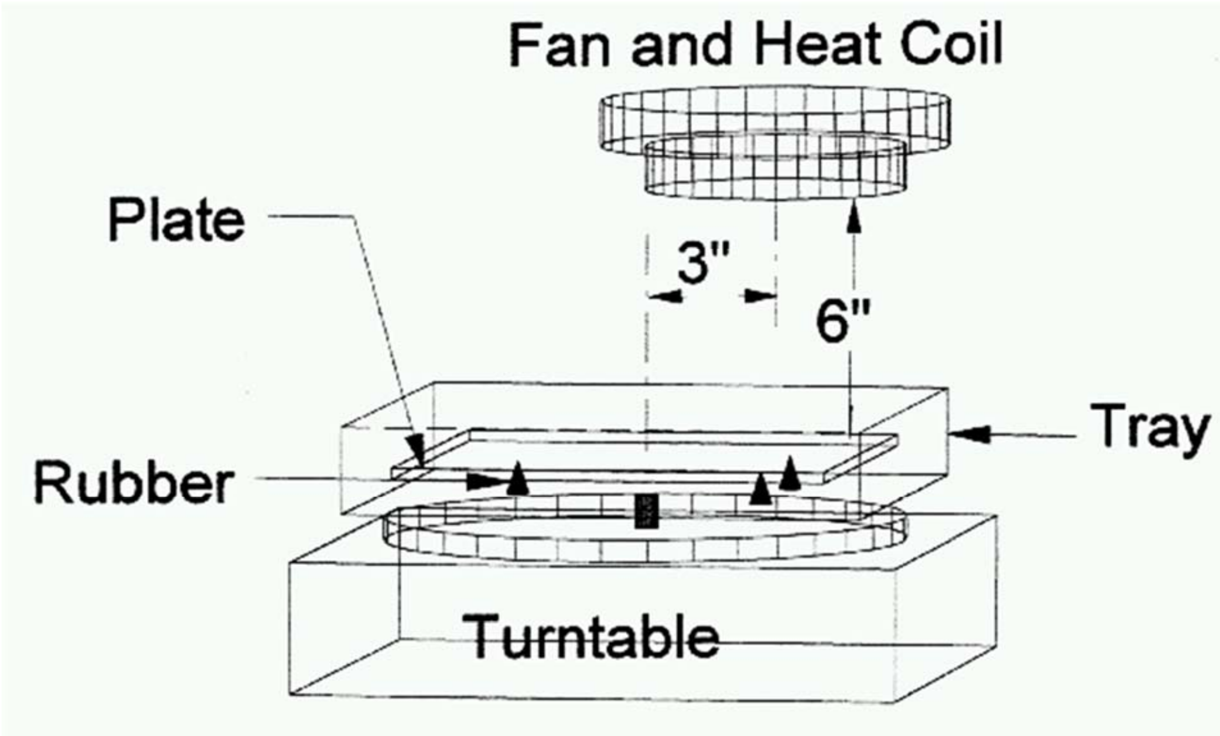
Color control can be done easily and repeatably in films of 8 to 20 microns by simply controlling the concentration of dichromate and keeping all processing steps conservative and constant. The graph above is a rough guide to reconstruction colors as a function of two popular exposure wavelengths and dichromate concentration. These numbers are typical of 8 to 10 micron films processed for 1 to 2 minutes in fixer followed by 30 seconds in each water and alcohol bath. The alcohol was about 49 deg C (120 degrees F), as usual processes vary with gelatin selection and condition.



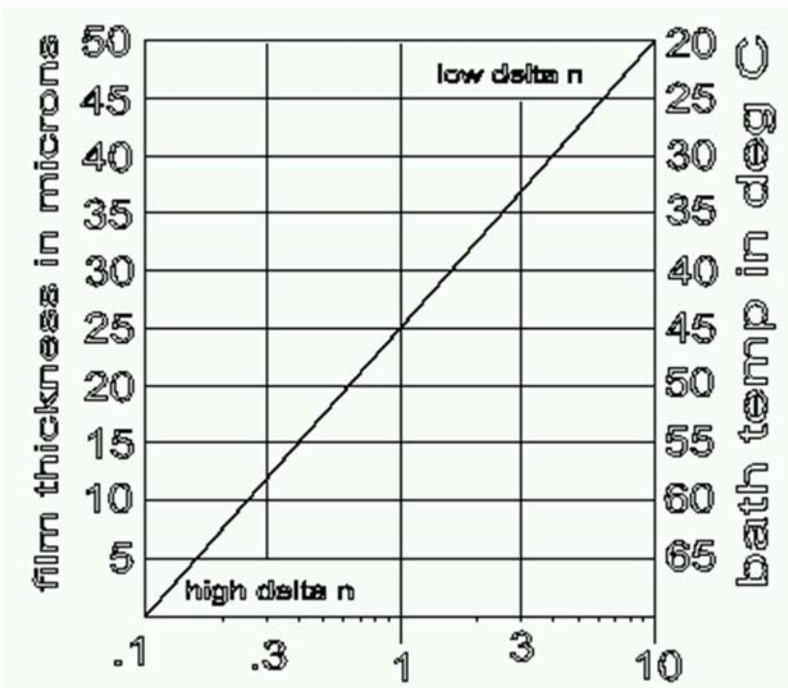


Spin coating at 70 to 100 RPM

The thickness of a DCG film may be controlled with wire thickness and water concentration when using a meyer bar or may be controlled with rotation speed and water concentration on a simple turntable made from an old phonograph player. The graph above gives approximate thickness of a standard mixture of 10 grams of dichromate and 30 grams of gelatin in from 400 to 100 ml of water at 60 degrees C. 40 to 50 micron films are spun at 70 RPM, most others are at 100 RPM. Films over 20 microns thick stick to glass better if they are baked for at least 1 hour at 150 deg F and in water saturated air.



Spin coater



Processing is either a cool single phase low modulation method or a warmer 2 phase higher modulation process. In between is an unstable region that will produce blotchy reflection holograms where the color difference between blotches is on the order of 50 nm or so. The unstable region is also defined by alcohol/water concentration and again depends on the source and condition of the gelatin. It is sufficient to know that it exists and that it may be avoided by changing temperatures or specific gravities up or down. Film thickness also strongly affects the choice of processing. Thin films are best done in such a way as to maximize the delta n and this is done with hot baths and short process times. Thick films require low delta n to take advantage of the angular and spectral selectivity available in thick films and are best processed at or near room temp for long times in each bath. The plot above is a guide to a starting point, the dots are regions we have worked in.

Last modified on 6/3/99