Scienstry's Dark Films

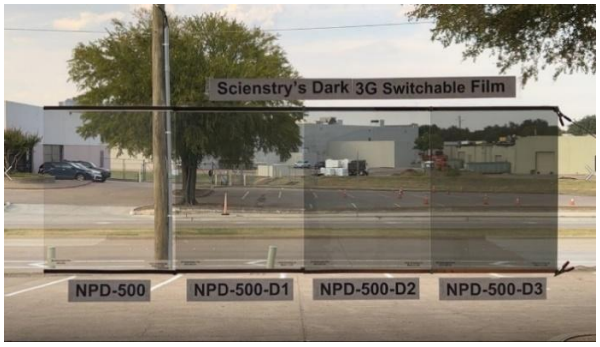
NPD-500-D1, NPD-500-D2 and NPD-500-D3

Adhering to the spirit of pursuing excellence and surpassing ourselves, we are proud to introduce new products, Scienstry's dark films, which combine many advantages. Although 3G Switchable Film™ and its glass products have been widely used in many outdoor applications, the milky color may not be most suitable for some applications, such as automobile glass and architectural glass. Scienstry's dark films NPD-500-D1, NPD-500-D2 and NPD-500-D3 are specially developed for such applications. These three products have the same basic features except differences in darkness.

In the liquid crystal display (LCD) industry, colored or darked products are usually made with dichroic technology or using liquid crystal dyes. Dichroic products often have problems such as UV instability, slow response, high voltage driving, very high cost and short lifespan. They are totally not suitable outdoor applications. With many patented technologies including UV- and IR-stable technologies, Scienstry's dark films (D1, D2 and D3) completely leapfrog the previous state of the art and create dark smart film/glass products with (1) UV- and IR-stable, (2) fast switching, (3) low voltage driving, (4) relatively low cost, and (5) very long life. Most importantly, the dark films and its laminated glass products have reached the final goal in liquid crystal smart glass field with features of being (6) **haze-free** and having (7) **very wide viewing angle**. According to traditional theories of polymer-dispersed liquid crystals (PDLC), it is impossible to have these two features simultaneously. Additionally, neither dichroic dark nor color films are UV-stable because liquid crystal dyes are naturally vulnerable to UV radiation. For over four decades, it is the first time for liquid crystal smart glass/film products to have the features of near haze-free and near absolutely wide viewing angle. Once again, our new theories and new structures work. These dark films are equal to add additional protection of low-e glass to Scienstry's patented UV- and IR-stable NPD-500 film. Therefore, the dark films can be used outdoor with or without lamination. Moreover, unlike other dichroic dark or color films with a slow switching time and high voltage driving, especially when the darkness is increased, all of the dark films have fast switching times and low voltage driving. The dark smart film/glass products are not expensive in comparison with other dichroic dark or color films.

Due to high brightness outdoors, automotive glass and architectural glass can have dark tints. It's been a dream that automobile smart glass and building smart windows could also have dark tints. Now, this dream has come true. The dark films are ideal for sunroofs of cars and façade glazing of buildings like IGU's. Rather than sacrificing any other functionalities, the dark film and glass are more stable for outdoor uses in comparing with milky white products of 3G Switchable Film™. For the first time, changing film darkness does not compromise photoelectric performance or fast switching speeds! Once again, Scienstry achieves its goals with new theories, new methods, and a strong capability of innovation.

Picture 1. Dark films (power-off)



Picture 2. Dark films (power-on)

Click here for a video

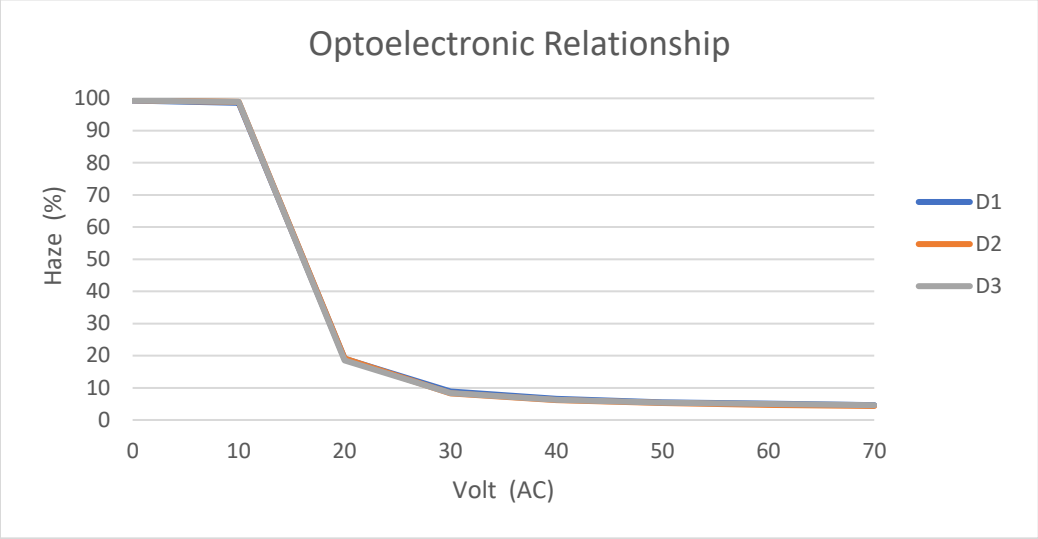


Fig. 1. Photoelectric Curves of Three Different Dark Films

Films			Patented and Special Features						
		Non-Linear Optics [2]	Spherical Scattering[3] and wide viewing angle	Anti-Water & Anti-Moisture[4]	Low Voltage Driving [5]	Wide Temp. Rang [6]	Anti-UV [7]	Anti-UV & Anti-Aging [8]	Anti-IR & Tinted [9]
1G	NCAP								
2G	PDLC								
3G [1]	NPD-100	√							
	NPD-200	√	√	√					
	NPD-300	√	√	√	√				
	NPD-400	√	√	√	√	√	√		
	NPD-500	√	√	√	√	√	√	√	
	NPD-500-D	√	√	√	√	√	√	√	√

Table 1. Feature comparison among different liquid crystal smart films

Note:

1. In the closed systems of earlier generations, 1G (NCAP) and 2G (PDLC), all of the components form a homogeneous polymer which needs to match refractive indices between the polymer and liquid crystal used. Then, the optical requirements, chemical requirements, and physical requirements are tied together; changing any component will destroy a balance that was obtained with a great effort. This inherent deficiency of PDLC system has been a significant barrier to improving product performance. Therefore, a developed formula is usually kept for many years. That's why 40 years later, people don't see much product improvement. In the 3G (NPD-LCD) system, a multi-layered structure like an onion is designed; the optical, chemical and physical characteristics are independent and do not constrain or conflict each other. Any component can be changed or adjusted without affecting optical performance. Many new materials for new features, such as anti-UV, can be easily added to the 3G NPD-LCD system. That is why 3G Switchable Film™ is capable of releasing many series of products with continued improvements. System progress often leads to the leapfrogging development of industrial revolution.

2. Most polymers used daily belong to a linear or uniform system like normal clear plastics. Non-linear polymer systems have gradually changed refractive indices with a layered structure like an onion. Such structure allows us to independently control various factors and allow addition of new components into the system without affecting optics. Such an open system has great flexibility to add new features.

3. Spherical scattering gives the most uniform scattering in any viewing angle and is the best result for both rear projection and front projection. After many years of development in projection industry, it is the first time that an ideal spherical scattering has been achieved. Spherical scattering allows use of a short-throw projector to avoid reflections from the projector and allows viewers to see a clear projected image from any angle, and also reduces driving voltage.

4. Anti-water and anti-moisture features are important to allow direct use of a liquid crystal smart film in air without lamination. 1G film is made of water-soluble polymer, so it must be laminated for use. 2G PDLC film is made of epoxy and can't be used near water or moisture. 3G Switchable Film™ is made of silicone- and fluorine-containing materials like those used in non-stick cookware. It is proven that 3G Film can be used in open air for over 20 years without lamination. Tests also show that 3G Film performance doesn't degrade even after having been submersed in water for weeks.

5. There are two patented technologies to be used in the 3G Switchable Film™ to lower driving voltage. The technologies include comb-shaped non-linear polymer and "cage theory" to make identical sizes of microdroplets. Please refer to our article "Look at Smart Glass in a Whole New Way" for detail.

6. Wide temperature range is important for liquid crystal smart films to be used in outdoor applications, especially for applications of automobile glass and exterior building glass. 3G Switchable Film™ has a wide temperature range of – 30 °C to + 80 °C or wider. It has been proven that 3G Film/glass products are very stable for outdoor uses of world-class projects for over 15 years with near zero defect rate. It should be noted that Scienstry's improvements in one feature has never compromised performance of other features. 3G Switchable Film™ can have the best scattering in the power-off state and the best transparency in the power-on state. 1G and 2G films usually must trade-off one feature for another; good transparency in power-on state means poor scattering level in the power-off state.

7. Outdoor applications are extremely challenging for the LCD industry. Most LCDs are still not suitable for outdoor use after half a century of development. All components of the 3G NPD-LCD system are UV-stable to achieve advanced features for outdoor applications.

8. Anti-UV and anti-aging features are important for LC smart films to be used as a permanent material. Patented UV-stable and IR-stable technologies are used to effectively stabilize 3G Switchable Film™. Tested

UV stability has greatly improved more than 50 times, and results derived from simulation experiments show that the service life time of laminated smart glass with 3G Switchable Film™ for outdoor use is over 50 years.

9. In the spirit of pursuing excellence, anti-UV and anti-IR and anti-aging features push the improvement to a higher level, from technology to aesthetics, practicality and durability.

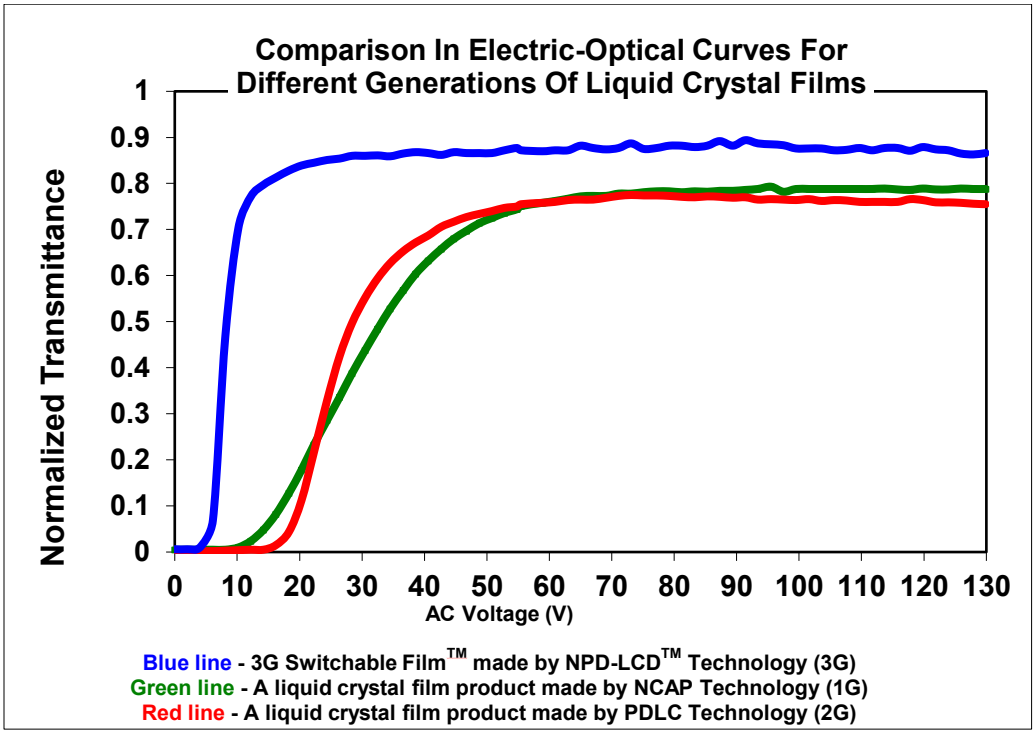


Fig. 2 Comparison of driving voltages and transparencies among different generations of LC smart films

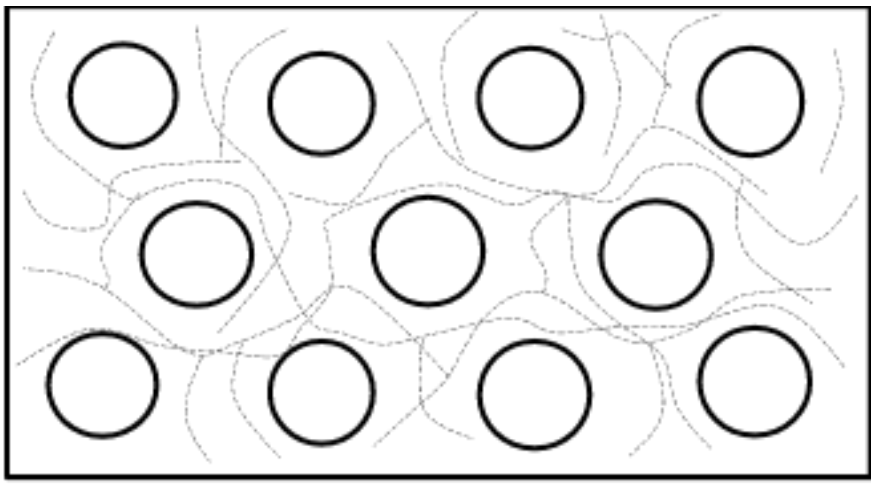


Fig. 3

Fig. 3 shows how the patented method of "Molecular Cage" creates identical sizes of liquid crystal microdroplets. This was considered impossible in physical chemistry before this invention because droplet size is a function of curing time and the state of the mother solution/material. However, with the patented ingenious method, a dissolved polymer networking/membrane system is used to divide the system into a plurality of uniform and identical "cages"

first. Since liquid crystal can't penetrate through the membrane, droplets sizes of liquid crystal are identical no matter when they are formed. Additionally, the uniformity of microdroplet size also reduces driving voltage and improves viewing angle because the new method avoids smaller droplets, which need high voltage to turn on and are partially responsible for producing haze.

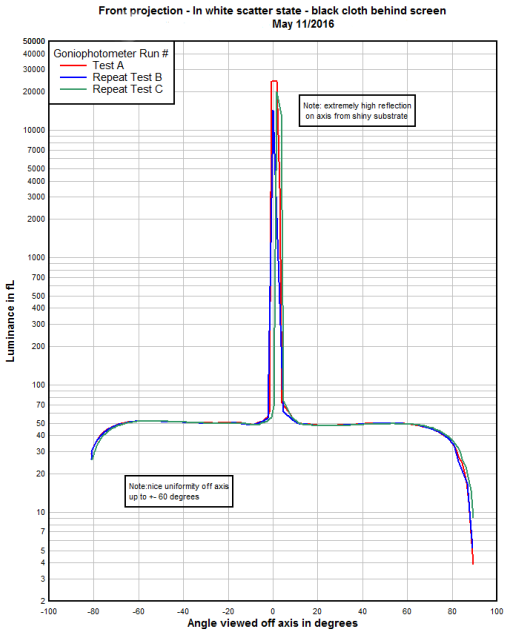


Fig. 4

Pic. 3

Fig. 4 shows test results of spherical scattering which can only be obtained by uniform microdroplets. A sample of 3G Switchable Film™ is set in a front projection mode and continually measures gain data while the sample was rotated 180 degrees for three times. Three curves merged into one curve show that the system is very uniform and stable. Gain readings are 50% at most angles, which perfectly match the expected result of spherical scattering theory. The center peak and curves in both sides are surface reflections in the test. Spherical scattering has many applications in the display industry. Spherical scattering also plays an important role in energy saving applications when 3G Switchable Film™ is used in external windows. Infrared is scattered or reflected away rather than being absorbed, so the windows don't heat up, reducing air-conditioning load.

Pic. 3 shows the visual effect of absolute wide viewing angle; in other words, having the same brightness and sharpness at any viewing angle. **Click here for a video.** Wide viewing angle of projection is very important for front projection. Spherical scattering allow to use a short-throw projector and avoid all reflections from a projector to viewer's eyes and therefore greatly improves image quality. Wide viewing angle is good for advertising as the audience can see a clear image from any angle. Spherical scattering can provide the most uniform brightness and sharpness over entire projected area. Uniform brightness and sharpness are important parameters in projection.