SPIE Newsroom

10.1117/2.1200706.0492

Making flat panel TVs cheap and really thin

Pavel Lazarev

Coatable birefringent films on glass or plastic can replace absorbing and stretchable polarizers in liquid crystal displays, thus reducing both their cost and thickness.

LCD TV is taking over the home television market because it offers good image quality in an attractively thin form. Cheaper flat-screen technology would speed market takeover. While strikingly thinner than cathode ray tubes (CRTs), LCDs are still thick compared to the LCD cell itself, which measures only about 4mm. The additional thickness is required for the ventilators and air space in the back to cool the device. Too much of light is absorbed by the components in the LCD TV and converted into heat. The thickness can be reduced, and possibly the cost reduced as well, by fighting heat generation and enhancing light efficiency in these devices.

We have developed highly-ordered molecular thin birefringent films (TBF™) that can be made via printing technology. We can make optical components much less expensively than the existing polymer-based films by taking out all supporting and optically useless layers.[1] Additionally, our films are very thin, which makes new functions possible. For example, we can make interference polarizers that are only one quarter the thickness of a wavelength. Interference polarizers do not absorb light and so can save energy.

We print molecules in highly-ordered layers. This allows us to print optical components that provide the same function as their conventional counterparts but are 200 times thinner. (For organic materials of a given purity, the cost is related to the manufacturing cost including economies of scale. Therefore, a design that uses less material will cost less to make than one that uses more of the same material, with the same purity.) We can print on glass,which means we use fewer supporting substrates: this also translates into lower cost.

We make molecules self-assemble into supramolecular stacks shaped like either rods or plates. Through the printing process we can force them to align in the needed direction (see Figure 1). By taking different molecules, we can make TBF retarders from phase-shifting plates with certain combinations of refractive indices such as negative A-plate or negative C-plate arrangements. If we need another combination of refractive indices, then we take a new molecule and again make biaxial films.

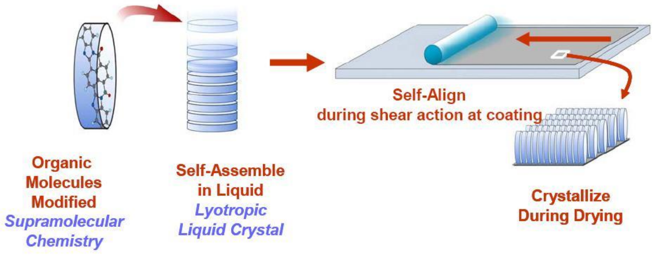

Figure 1. *Organic molecules self-assemble into supramolecular structures like this rod, then self-align again during the printing process.*

There are two stages in engineering the molecules to form the desired film structure. First, we must design the molecular structure that supports the desired optical function via certain values of the 3D refractive indices. Second, we must design the molecular features that support a self-assembly process. This must both in create the target supramolecular structure and allows the supramolecules to make a film with the desired orientation and uniformity when industrial wet-deposition processes are used.

We developed molecules with symmetric electronic properties that translate into certain desired symmetry of polarizability and hence refractive coefficients. The deposition process allows us to produce coatings in which we control the direction of the refraction axis. Depositing these molecular materials on the surface of a suitable substrate, such as glass or plastic, produces the macroscopic optical refraction characteristics of the film.

The process of deposition is printing or wet coating a liquid self-assembling material with subsequent drying, thereby transforming the liquid coating material into molecularly-oriented 1D crystalline or amorphous nano-film. This means that the kinetic

Continued on next page

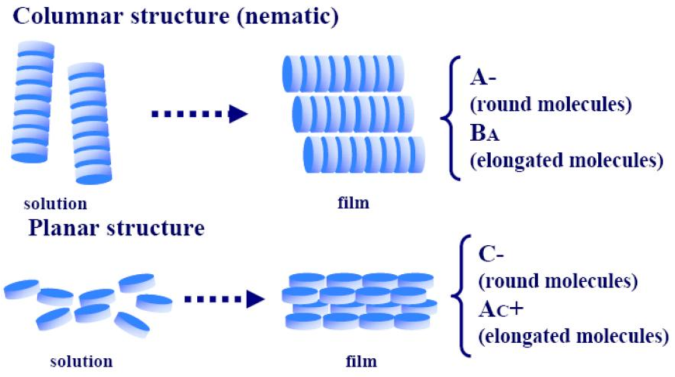

Figure 2. *Molecular and supramolecular packing that cause formation of different optical compensation plates from newly engineered compounds.*

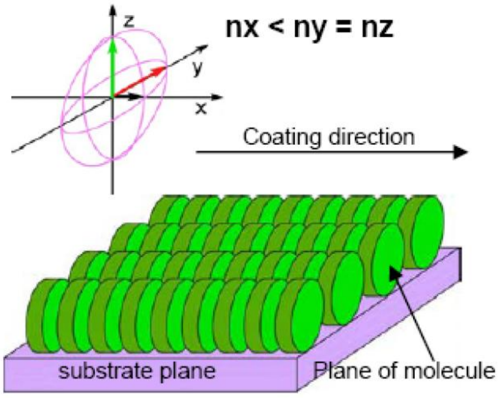

Figure 3. *Close packing of columnar supramolecules forms a uniaxial negative A-plate thin birefringent film (TBF).*

unit of the deposited material should be larger than the scale of hydrodynamic fluctuations in coating process. Supramolecules are the kinetic units and their size is determined by the strength and direction of molecular interactions in solution, which is determined in turn by the molecular reaction-center's structure and position on the molecule.

Figure 2 demonstrates molecular and supramolecular packing to form a number of arrangements, including uniaxial negative A-plates, negative C-plates, and biaxial B_A- and A_C-plates.

We have developed various coatable TBF retarders which exhibit strong birefringence for 450–700nm wavelength range and may work as either negative A-plate ($nx < ny = nz$, see Figure 3), negative C-plate ($nx = ny > nz$), and biaxial B_A-plate ($nx < nz < ny$) functions. The refractive indices for TBFs with negative A-plate, negative C-plate, and biaxial B_A-plate functions at a wavelength of 550nm are presented in Table 1.

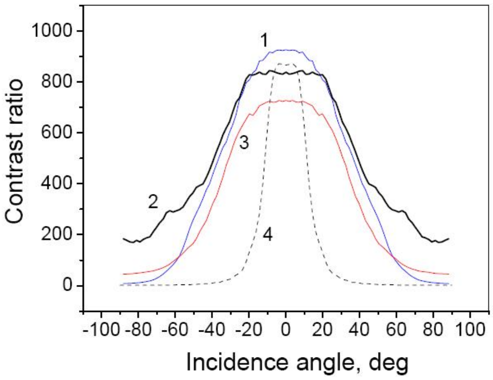

Figure 4. *Contrast ratio versus incidence angle at different wavelengths: curve 1 is at a wavelength of 450nm; curve 2 is at 550nm; and curve 3 is at 650nm. The dashed curve 4 is for the non-compensated design at 550nm.*

Table 1. *Refractive indices for TBF retarders at 550nm*

Function of TBF retarder	nx	ny	nz
negative A-plate	1.52	1.80	1.80
negative C-plate	1.46	1.74	1.74
biaxial B_A-plate	1.46	1.84	1.66

We simulated an LCD in different modes. In-plane-switched (IPS) and vertically-aligned (VA) modes are the first choice for the home-TV LCD market. Simulation allows us to optimize the type and thickness of TBF retarder that would make the best viewing-angle characteristics of a certain LCD design. TBF coatable retarders provide effective optical compensation of VA and IPS LCD modes. As an example the spectral performance of VA LCD design compensated by TBF with negative A-plate function is illustrated in Figure 4.[2] This figure shows the angular dependencies of the contrast ratio at three wavelengths (450nm, 550nm, and 650nm) for an azimuth angle of -45°.

A multilayer stack of negative A-plates with quarter-wave thickness can make an interference stack with polarizing capabilities. We are working on that.

In the future, absorbing polarizers will go away because the LCD TV market can not afford them: too much heat is produced and too much light is wasted. Coatable optical components are the future of LCD TV, and coating on glass will substantially reduce the cost.

Continued on next page

Author Information

Pavel Lazarev
Crysoptix Ltd.
Moscow, Russia
http://www.crysoptix.com

Pavel Lazarev is the director and founder of Crysoptix Ltd. He founded Optiva Inc. in California (1998-2004) and Nanotechnology MDT in Moscow (1988-present). He co-founded the journals: *Molecular Engineering* (1989), *Molecular Materials* (1990), and *Nanobiology* (1990). He received his PhD and Doctorate of Science from the Russian Academy of Sciences. Pavel Lazarev has authored more than 150 papers in scientific journals, and over 100 patents.

References

1. http://www.crysoptix.com
2. S. P. Palto, S. Remizov, I. Kasianova, N. Guselnikov, and A. Lazarev, *Vertically Aligned LCD Designs Optically Compensated by Thin Birefringence Films*, **Proc. 13th Int'l Display Workshops (IDW'06)**, pp. 311–314, December 6-8 2006. Otsu, Japan