Liquid Crystal Reference

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The following liquid crystals can be used to fill our devices:

- Nematic
- Smectic C*
- Smectic A*

All modulate light due to their inherent birefringence but each has characteristics, which only work well with certain applications. A brief description of the LC properties is given along with a typical configuration for using that LC. For additional information read this extract from one our papers or visit the LiqCryst web site at the Liquid Crysyal Group site at Hamburg (liqcryst.chemie.uni-hamburg.de).

Nematic

Nematic devices are good for displays (good amplitude uniformity, higher yield) or for applications where a large phase-only modulation depth is needed (2-pi or greater). The nematic LC molecules usually lie parallel to the surface of the device giving the maximum retardance due to the birefringence of the LC. When an electric field is applied, the molecules tilt parallel to the electric field. As the voltage is increased the index of refraction along the extraordinary axis, and hence the birefringence, is effectively decreased causing a reduction in the retardance of the device. Nematic devices have fast optical rise times (~50-1000 microseconds) but slow fall times (~2-4 ms for a 2-pi reflection-mode device). All LCs require a DC balanced drive signal to prevent destruction of the LC, this implies that every other "frame" should be the inverse of the previous frame. Nematic devices do not respond to the polarity of the applied electric field, i.e. +5 volts will result in the same optical modulation as -5 volts, thereby allowing useful modulation even during the "inverse" frame that is required for the DC balancing.

- Typical configuration - Nematic cell with layer thickness sufficient to provide at least two-waves of retardance at the desired wavelength.
- Modulation - applied electric field will result in a change in the index of refraction in one axis, ne, of the liquid crystal, a linearly polarized beam parallel to the ne axis will undergo a pure phase modulation, any other polarization state will result in a phase and amplitude coupled modulation
- Range - typically 2-pi phase retardation with 0 volts and 0 phase retardation with maximum voltage, or maximum amplitude with 0 volts and 0 amplitude with maximum voltage - responds only to amplitude of applied electric field - not sensitive to the polarity of the electric field, range can be several waves with a thicker liquid crystal layer but will respond much slower

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- Speed - 50-1000 microseconds rise time, 2-4 ms fall time, 10% - 90% of modulation depth, temperature and wavelength dependent, most visible wavelength, reflection mode devices will rise in ~100 microseconds and fall in ~2.5 ms

Smectic C*

Smectic C* devices are good for pure real-axis modulation and can also be used for up to pi phase-only modulation. Smectic C* devices are the most popular smectic devices due to their high speeds and modulation characteristics. A smectic C* device typically modulates light similar to a passive half-wave retarder. The applied electric field results in a rotation of the half-wave retarder's slow-axis about the optic axis. Smectic C* devices have fast optical rise and fall times (~50-150 microseconds). Smectic C* devices do respond to the polarity of the applied electric field. This results in an "inverse" image when the inverse frame is written in order to maintain the DC balance. For some applications, such as optical correlation utilizing binary phase-only modulation, this inverse image is identical to the "true" image and can therefore still be utilized. For other applications, the illumination source or detector should be pulsed to avoid "seeing" the inverse image.

- Typical configuration - Smectic C* cell with layer thickness equivalent to a half-wave of retardance at the desired wavelength.
- Modulation - applied electric field will result in a rotation of the slow-axis of the half-wave retarder, this will rotate a linearly polarized input beam or add/subtract phase to a circularly polarized input beam
- Optic Axis Range - typically 0° with maximum negative voltage to 45° with maximum positive voltage, range can be as large as 90° with some smectic C* mixtures
- Speed - 50-150 microseconds, 10% - 90% of modulation depth, temperature and wavelength dependent, most visible wavelength, reflection mode devices will respond in ~75 microseconds

Smectic A*

Smectic A* devices are used only when very high switching speeds are required. These devices must be operated at elevated temperatures and typically are not as robust as nematic or smectic C* devices. A smectic A* device can have optical rise and fall times as fast as 200 ns. These devices can exhibit tilt angles as high as ±25° but not at sub-microsecond speeds. Smectic A* devices modulate light in a similar fashion to the smectic C* devices, i.e. a rotating retarder.

- Typical configuration - Smectic A* cell with layer thickness equivalent to a half-wave of retardance at the desired wavelength.
- Modulation - applied electric field will result in a rotation of the slow-axis of the half-wave retarder about the surface normal of the device, this will rotate a linearly polarized input beam or add/subtract phase to a circularly polarized input beam
- Range - typically 0° with maximum negative voltage up to 50° with maximum positive voltage
- Speed - 200-900 ns, 10% - 90% of modulation depth, temperature and wavelength dependent, must be operated at elevated temperatures

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