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# Liquid crystal optics

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We have found that the flexibility offered by liquid crystals permits them to be used in new optical elements to replace conventional laser system components and to provide novel solutions for existing device problems.

One such liquid crystal element is the liquid crystal polarizer/isolator (LCP). This single, passive liquid crystal device performs both functions of polarization and isolation for laser systems configured to propagate circularly polarized light. An LCP consists of a liquid crystal mixture composed of a helically structured, or chiral, compound and optically anistropic nematic compounds sandwiched between two glass substrates. By addition of chiral twisting agents into the nematics and utilization of alignment techniques to produce uniform orientation of the molecular axes, left-or right-handed circular polarizer elements are created. Selection of the nematic components on the basis of their intrinsic birefringence allows variation of the bandwidth of selective reflection of the liquid crystal element. The position of the selective reflection peak can be adjusted to the appropriate wavelength by varying the amount of chiral agent. Liquid crystal polarizers/isolators exhibit a high transmittance (approaching 99%) for incident circularly polarized light whose twist sense is of the opposite handedness. Polarized light of the same handedness as the device is reflected, with a contrast on the order of 10.[3]

The LCP device can also act as an optical isolator for protection of laser system from back-reflection. Any back-reflections of the passed radiation from misaligned optical surfaces or targets are blocked by the device due to a 180° phase shift in the handedness of the laser beam upon reflection.

In addition to its high optical transmission and high reflection contrast, the LCP offers other advantages over existing polarizers and isolators: 1) simple and inexpensive, with only two optical surfaces; 2) angularly insensitive to alignment (±10° from normal incidence), and 3) a high laser damage threshold (withstanding fluences in excess of 5 J/cm$^2$ at 1054 nm, 1 nsec). In addition, the liquid crystal polarizer/isolator is the only existing technology that can offer high optical quality at large apertures.

The liquid crystal polarizer/isolator is presently used in the OMEGA laser fusion system to reduce depolarization caused by stress induced birefringence in the laser amplifiers and to isolate the system from back reflections. Another application for liquid crystal polarizers/isolators is as laser cavity end mirrors that have a broad bandwidth and maintain the polarization sense of the beam.

Two liquid crystal elements of the opposite handedness used in series can function as laser-blocking notch filters. Such devices perform selective optical filtration by reflecting nearly all radiation at the specified laser wavelength and transmitting all other wavelengths. Liquid crystal apodizers that modify a laser beam profile without introducing diffraction effects are yet another device application of liquid crystal materials.

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# Production of kinoforms by single point diamond machining

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Kinoforms[1,2] are a subset of holographic optical elements. They have the advantage of being highly efficient and they are computer-generated, not optically constructed, so desired wavefront deformations can be readily achieved.

A kinoform may be thought of as a phased Fresnel lens. Ideally, each facet of the lens transforms the wavefront with no optical path error, and there is a step of an integral number of wavelengths (usually one) between adjacent facets. Thus, the kinoform can achieve diffraction-limited performance, while a conventional Fresnel lens cannot. Efficiency can approach 100% for a given wavelength when the facet profiles are properly designed and