RAPTOR – A Retarder Coating for Precision Optics

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Retarders or waveplates are useful devices for modifying the polarization of light. Until recently these have always been freestanding optical elements, usually made using solid uniaxial crystals such as quartz, calcite or magnesium fluoride. Meadowlark Optics has specialized in application of new materials for polarization modification. We introduced liquid crystal variable retarders more than 25 years ago and precision polymer retarders before that. Liquid crystals are contained between flat windows and polymer retarders are freestanding sheets that are usually laminated in glass. Both have cost and angular field of view advantages over uniaxial crystal retarders.

Raptor retarders are a further advance because they are a thin film that can be spun coat onto flat or curved optical surfaces while maintaining the performance advantages of standard polymer retarders. The thickness of a quarter wave retarder coating for 632.8 nm is only about 1 micron since the Raptor polymer birefringence is about 0.13. Figure 1 shows the measured wavelength dependence of the birefringence.

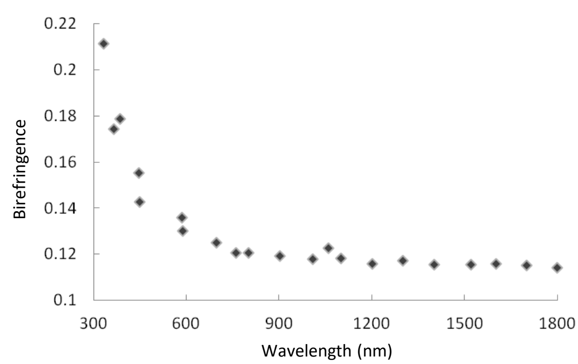

Figure 1: Shows the measured birefringence of the Raptor material

The Raptor polymer is birefringent because the long chain molecules align to an underlying alignment layer similar to that used for aligning liquid crystals. Thickness of this alignment layer is less than 0.2 microns. It can be either mechanically buffed or photo-aligned with linearly polarized light to produce the structure needed to align the Raptor polymer when it is applied by spin coating. Fast axis direction can be spatially varied over the retarder aperture by using photo- alignment material and exposing different portions of the alignment layer to different directions of linearly polarized light. Feature sizes smaller than a few microns are possible.[1,2] Figure 2 shows a coarsely patterned Raptor retarder between crossed polarizers.

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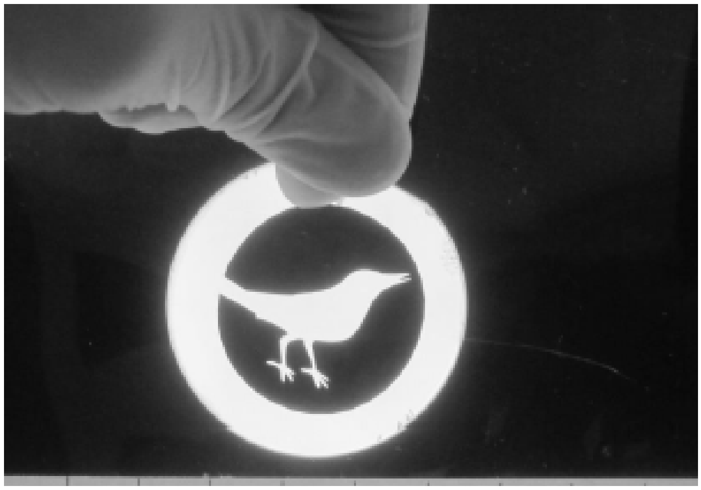

Figure 2: Shows a patterned Raptor retarder between polarizers

Raptor has no fundamental aperture size limit. We have produced retarder layers on 20 cm diameter fused silica wafers with good uniformity. Figure 3 shows a Raptor retarder on a 15 cm fused silica window. Crystal retarders are limited in aperture to about 15 cm in most cases because larger crystals are not available. We have successfully applied Raptor coatings to curved lens surfaces and to mirrors.

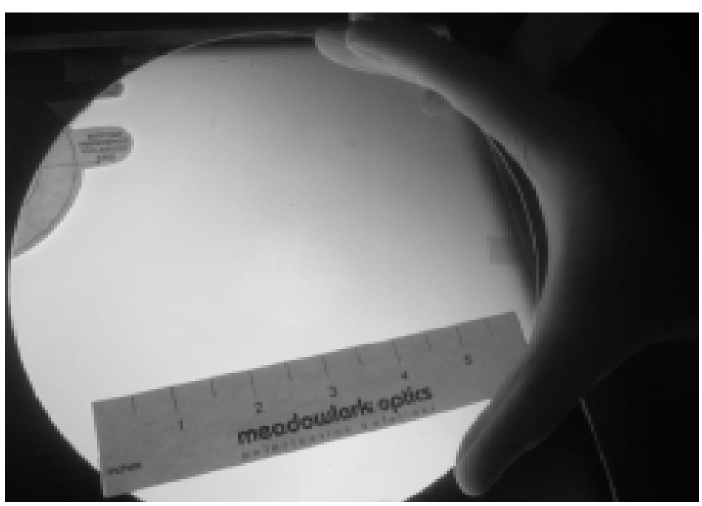

Figure 3: Shows the retardance uniformity of a Raptor retarder coating on a 15 cm diameter window between linear polarizers

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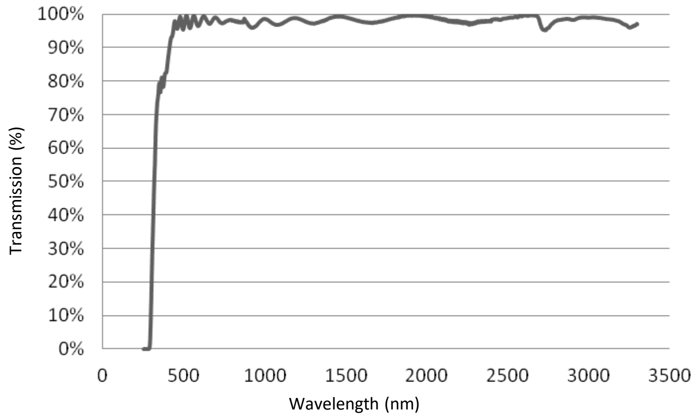

Figure 4: Shows the high IR transmission of Raptor retarder material

Raptor retarders have excellent transmission from about 400 nm to 3.3 microns3 as shown in Figure 4. This is an advantage over polymer and quartz retarders which are absorptive at wavelengths longer than 2.2 microns.

In summary the Raptor retarders have the several advantages over traditional crystal retarders:

1. They are a very thin coating that can be applied to other optical elements in a system,
2. They are true zero order which gives them a low retardance dependence on angle of incidence,
3. They transmit well in the IR out to at least 3.2 microns
4. They are available in larger aperture sizes, currently up to 20 cm diameter and
5. The fast axis direction can be patterned on a microscale.

REFERENCES:

1. Photonics News (March 2010).

2. Escuti et al. "Polarization gratings in mesogenic films." US Patent 7,692,759 B2. 6 April 2010.

3. Tran, Billy and Baur, Tom, “Reactive mesogen retarders and applications.” SPIE Proceedings Vol. 8489, (October 2012).

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