52.4: New, High Performance, Durable Polarizers for Projection Displays

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Abstract
Wire-grid polarizers are now available for broadband visible applications. This type of polarizer is very attractive for projection display applications because of its high efficiency, high contrast, and extreme temperature and flux tolerance. However, using wire-grid polarizers as drop-in replacements in existing architectures, significantly limits the possible applications of this new polarizer type. As with conventional polarizers, wire-grid polarizers come in a sheet format, but they reflect one polarization rather than absorb it. Therefore, care must be taken in the system design to control this reflected light. Other significant design issues will also be highlighted in this paper. Applied Digital Optics, Inc. and MOXTEK will discuss design issues concerning the use of ProFlux™ wire-grid polarizers in the illumination stages for projection, as well as other suitable applications. Conceptual designs will be presented.

1. Introduction
The paper will review the specifications for the ProFlux™ wire-grid polarizers, identify classes of possible applications that are well suited to this new type of optical component, and present design examples of the illumination stages for projection display applications. Data will also be presented to illuminate the significant differences between ProFlux™ wire-grid polarizers and conventional polarizers as used in projection displays. The design examples will use various lamps and other components in ways that utilize this new polarization technology to the best advantage.

2. Component Performance
The consideration of the optical and environmental specifications simultaneously of wire grid polarizers is critical in the design of optical systems using this new type of device in ways that have not been previously possible. Table I presents a summary of specifications of the ProFlux™ wire-grid polarizers. There are excellent references in the literature regarding polarization[1] and polarization methods for projection displays[2] that show many ways that polarization components have been implemented in the past. Since the ProFlux™ components have environmental properties that have not been traditionally available in existing polarizers, many new possible polarization applications can now be realized.

2.1 Optical Performance
The optical performance of the ProFlux™ wire-grid polarizers, is comparable to traditional dye polarizers, as shown in Figure 1. This can allow, in some cases, the use of wire grid polarizers as drop-in replacements in illumination systems that require robust polarizers due to high flux or temperature conditions. Figure 2 shows the typical extinction ratios as a function of wavelength, which if used in the illumination system can significantly affect the contrast of the system.

Table I. ProFlux™ wire grid polarizer specification summary.

Angle of Incidence	0°
Tp Ave:	>87%
Tp Min:	>85%
Extinction Ratio (Min)	>400
Extinction Ratio (Ave)	>900
Operational Temperature	-100°C to 200°C
Humidity	60°C at 90% RH
Adhesion	Scotch tape Mil-C-48497A

Figure 1. Transmission of ProFlux™ Wire Grid Polarizers at 0° Angle of Incidence

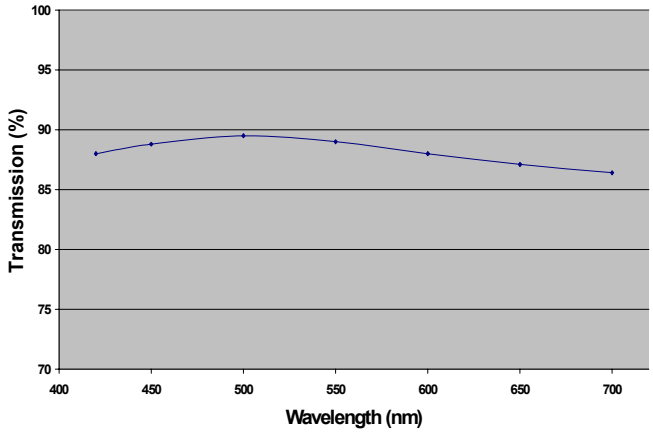

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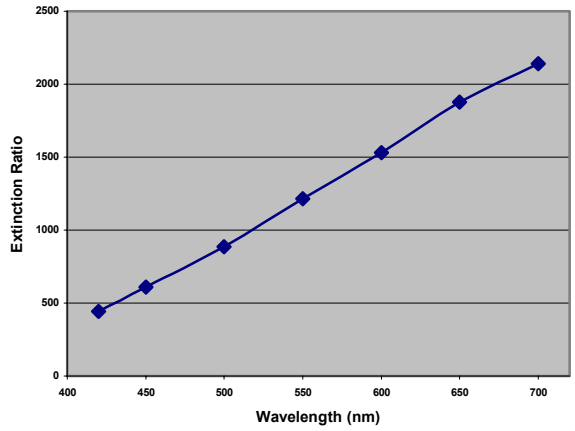
Figure 2. Extinction of ProFlux™ Wire Grid Polarizers at 0° Angle of Incidence



2.2 Environmental Performance

The environmental performance of wire-grid polarizers is significantly more robust than traditional polarizers. Wire grid polarizers reflect unwanted light instead of relying on absorption, which significantly reduces the heat loading of the component. The reflective nature coupled with the significantly higher operational temperatures make the component ideally suited to high flux applications.

3. Applications

Based on the unique properties of wire grid polarizers there are many ways that they can be implemented. Some applications are drop in replacements for current projection architectures, while others allow the possibility of new and innovative implementations.

3.1 Conventional Applications

Since the polarizers are mounted on a plane glass substrate, it is possible to use the ProFlux™ polarizers in a similar fashion to how traditional dye polarizers and cube beam splitters are currently used in projection applications.

Conventional projection displays based on TFT or LCoS microdisplays require polarized light for their operation. Thermal loading of dye polarizers in illumination optics is a significant problem in such displays,. The end result of such thermal loading can vary from reduced product life-time, all the way to catastrophic failure of the polarizer in mere minutes in a worst case scenario. Using wire grid polarizers can eliminate these problems and can potentially allow a better thermal management solution, allowing more air-flow to different locations of the projector or in some cases eliminate a fan.

The dichroic cube beam splitters could also potentially be replaced to allow lightweight, cost effective, robust polarization solutions.

3.2 Innovative Applications

Using the unique properties of wire-grid polarizers it is possible to explore new architectures, which exploit possibilities that have not been possible with previous methods of polarization. Ideal applications of these innovative solutions tend to be in high flux, high temperature applications. Also there will be a focus on reflections at normal incidence, since this is not a mode of operation for dichroic type polarizers.

4. Design Examples

Using the ProFlux™ wire-grid polarizers three potential design examples have been generated which demonstrate new architectures, which were previously not feasible with traditional polarizers

4.1 Retro-Reflection for High Intensity Discharge Lamps

Using the unique high flux and temperature properties of the ProFlux™ wire-grid polarizers it should be possible to return the unwanted polarized light back through the lamp arc and rotate the polarization to increase brightness as shown in Figure 3. This should allow for an increase in usable output while recycling the unwanted polarization. Other reflector configurations are possible, which can accomplish the same type of polarization recovery.

Because of the optical aberrations induced by the light passing through the lamp envelope, the shadowing by the electrodes, Fresnel reflection losses and other miscellaneous effects, the light that is returned through the bulb is not as efficient as the light that comes directly from the arc. Regardless of these loss mechanisms, significantly more light can be collected, especially for Etendue limited applications. Since typical HID lamps were not designed to have light being passed back through the arc, there is expected to be differences in the thermal loading of the bulb from the nominal design. This may significantly affect the lifetime of the lamp. An illumination designer should work with the lamp manufacturer in order to optimize the cooling of the lamp to maximize the lamp life.

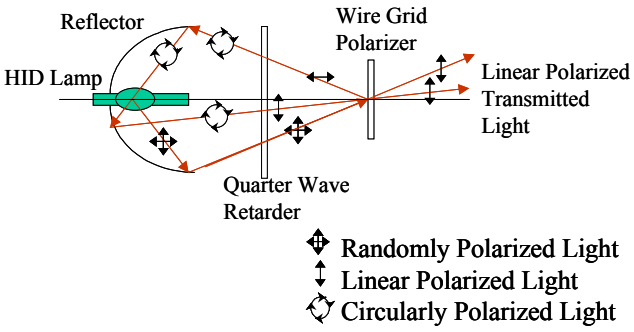


Figure 3. Polarization recovery using a wire grid polarizer and HID lamps.

4.2 Retro-Reflection for Electrodeless Lamps

Electrodeless lamps for projection displays have recently been developed[3]. Using the unique properties of a wire-grid polarizer with an electrodeless lamp it should be possible to recycle the unused light back into the lamp cavity, allow scattering to take place and reradiate the light in the useable polarization as shown in Figure 4.

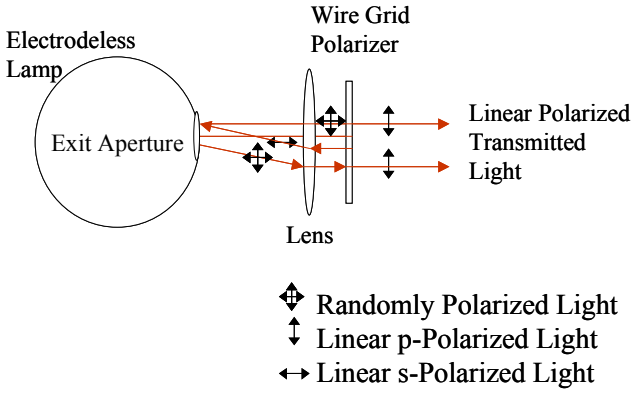


Figure 4. Polarization recovery using a wire grid polarizer and electrodeless lamps.

4.3 Large Screen Venue 3-D Projection Entertainment

Large screen 3-dimensional projection entertainment applications require polarized light in order to condition the images for the left and right eyes of the viewer. Because the screens are so large, tens of thousands of lumens are typically required in order to achieve acceptable brightness. This can present a significant problem for a conventional dye polarizer as they tend to deteriorate over time due to the high flux and heat that is generated from polarizing the light. This situation mandates large airflow over the polarizers at the exit of the projection lens and periodic changing of the polarizers. Using the ProFlux™ wire-grid polarizers, as shown in Figure 5, it should be possible to eliminate the use of organic polarizers, allowing for a low maintenance solution.

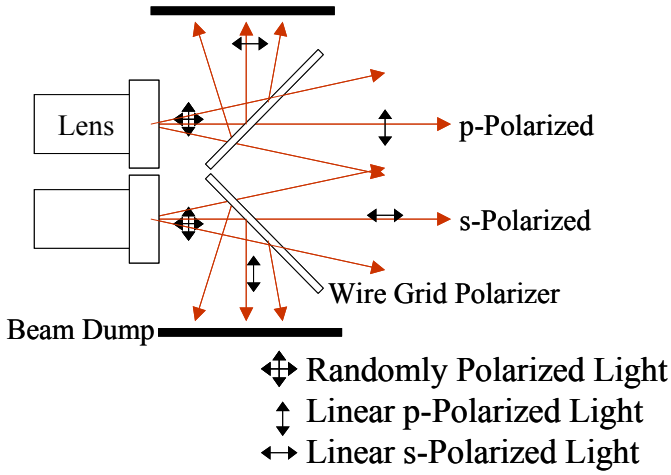


Figure5. 3-D polarization for large screen projection entertainment displays.

5. Conclusions

Polarization optics in projection displays is a fundamental issue in system design. Conventional polarizers limit the lifetime, flux levels, and other performance aspects of these displays. ProFlux™ wire-grid polarizers offer a significant performance advantages if used appropriately. They constitute a technology critical to the continued progress of LCOS and other liquid-crystal projection architectures.

6. References

[1] Bennett, J. and Bennett, H. Polarization. Handbook of Optics, W. G. Driscoll (ed.) McGraw-Hill, New York, 1978

[2] Stupp, E. and Brennesholtz, M. Projection Displays. John Wiley & Sons Ltd., West Sussex, England. pp. 125-140.

[3] Kipling, B. Turner, P. and Stelner. High-Brightness Electrodeless Lamp for Projection Displays. SID pp. 1080-1083 (1999).