Physical Optics Corporation

Holographic Diffusers Can Efficiently and Cost Effectively Distribute Light

Many industries use some kind of light source in their products. For instance, industries that make laptop computers, flashlights, or projection-display screens need a dependable light source. Conventional light diffusers, such as frosted glass or plastic, tend to spread light inefficiently, which wastes energy and money. Physical Optics Corporation (POC) invented a new type of diffuser screen, but the time required to complete development and to bring the technology to market was still too long to attract private capital. In 1994, the company applied for and was awarded cost shared funding from the Advanced Technology Program (ATP) for a two-year project. With ATP funding, POC was able to overcome the technical barriers to cost-effective use of its technology, and develop a diffuser screen that could provide an intense, evenly distributed beam of light that was more than twice as efficient as previous diffusers. Moreover, the screen lowers the power consumption of computer displays up to 10 times, significantly increasing battery life for laptop computers. Through this innovation, POC also has been able to increase its market share both in the United States and abroad.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
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Research and data for Status Report 93-01-0205 were collected during October - December 2001 and January - March 2002.

Inventing a New Light Source is a Long-Term Project

Historically, overhead lighting, flashlights, liquid crystal displays (LCDs), projection displays, and even movie screens have been inefficient. Conventional frosted glass or plastic light diffusers scatter light equally in all directions, instead of directing light where it is needed.

Physical Optics Corporation tried to correct the problem of nondirectional light by developing new light-diffusion devices.

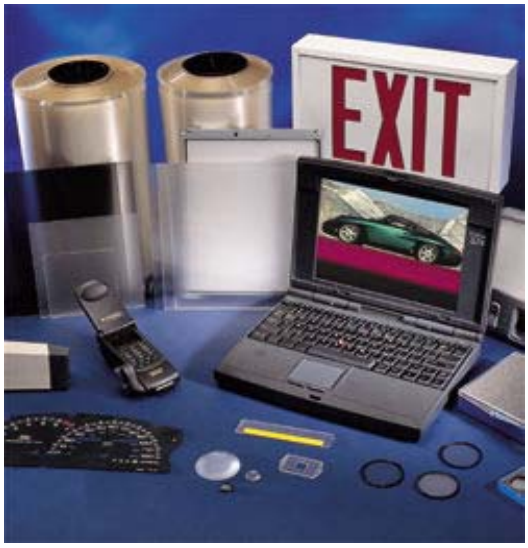
They also produce strong backscattering, so much of the light energy is scattered backward and is essentially lost. Over the years, plastics companies have attempted to create new and improved diffusers; however, on the whole, the new diffusers have remained inefficient and costly.

Physical Optics Corporation (POC) tried to correct the problem of nondirectional light by developing new light-diffusion devices, but the company lacked the funds to complete the necessary research and development (R&D). Traditional sources of capital were not interested in a high-risk project that would involve years of R&D before showing a profit.

ATP and POC's Partnership Changes Lighting

"None of this would have ever happened without ATP," said Rick Shie of POC. Mr. Shie was referring to POC's opportunity to pursue its idea that although the development of holographic technology was important, incorporating the improvements into useful devices was key. With ATP funding, POC honed the exacting science of holographic diffusers and made it reliable.

Holographic diffusers can increase the brightness of any traditional light source and greatly enhance the brightness and contrast of optical images. This effect is accomplished by using proprietary holographic



Laptop computers, flashlights, or projection-display screens are among the products that utilize holographic diffuser technology.

technology to produce screens and filters that sculpt beams of light by distributing most of the light into the desired direction. Beam shaping controls the vertical and horizontal intensity distributions of the beam, leading to directed light intensities. Holographic diffusers also can "homogenize" light beams, which can be described as restructuring light beams into a uniformly diffused beam without internal structure or "hot spots," regardless of the source (e.g., filament, lamp, and LCD backlighting).

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POC also developed high-resolution screens in a variety of sizes, shapes, and properties for a range of applications. The company developed projection (or reflection) screens capable of providing intense and directed light beams onto a surface and transmission screens that greatly enhance what was once a dull image.

POC Ensures Mass Production and Opens New Markets

Early versions of holographic diffusers were difficult to mass-produce because they were small and were based on volume scattering. Epoxy diffuser replicas were durable, but delicate and hard to mass-produce. Even with proper handling, cleaning, and storage in a clean environment, only a limited number of diffusers could be made from a single master.

POC's innovation has spawned new markets.

POC's surface-relief holographic scatterers, however, eliminated the painstaking process of producing optical holograms one by one, making mass-production possible. Being able to translate theory into practice was the next challenging step. POC persevered and developed two processes that would ensure mass-production capabilities:

(1) high-pressure molding for smaller products, and

(2) web production for larger applications.

As a result, POC's innovation has spawned new markets, such as flashlights for aircraft inspections, enhanced blood analyzers, heat-resistant directed lighting, automotive dashboard display panels, semiconductor mask homogenizers, credit card security products, and data-storage technology.

Holographic Technology Doubles Diffuser Efficiency

Successful development of a new type of diffuser screen with holographic technology resulted in an intense, evenly distributed beam of light. This innovation has allowed POC to develop light diffusers that are more than twice as efficient as previous diffusers. In addition, the diffusers can lower the power consumption of a computer display by up to 10 times, compared with typical cathode ray tube displays that use approximately 110 watts of energy.

POC has expanded its initial business strategy. It has formed alliances with various original equipment manufacturers (OEMs) and has agreed to license its technology to specific application providers. POC also established a dedicated production facility for holographic diffusers that currently produces 100,000 parts per month.

Conclusion

In May 1996, Physical Optics Corporation (POC) created a subsidiary, Farlight Inc. (which was sold to Farlight LLC in 2000), to commercialize the holographic diffuser technology for industrial and residential lighting applications. POC is actively pursuing potential new applications for the technology, such as the next generation of display screens (reflection and transmission), large screens for high-definition television, computer displays in a variety of sizes, cockpit and car dashboard screens, and ATM displays.

During the course of the ATP project, POC evolved from a low-revenue research and development business into a manufacturing and marketing company with $20 million in annual revenues. Through contracts with large automotive companies, such as Ford Motor, as well as with computer component providers, POC will continue to improve the efficiency of lighting sources.

PROJECT HIGHLIGHTS
Physical Optics Corporation

Project Title: Holographic Diffusers Can Efficiently and Cost Effectively Distribute Light (Holographic Graded Index Non-Lambertian Scattering Screens and Components with Light-Shaping Capability)

Project: To develop innovative techniques and manufacturing processes for holographic scattering screens and diffusers capable of controlling, distributing, and efficiently using light from a variety of sources for flashlights, LCDs, projection displays, laptop computers, and other applications in which tailored lighting is required.

Duration: 2/1/1994-1/31/1996
ATP Number: 93-01-0205

Funding (in thousands):

ATP Final Cost	$ 850	49%
Participant Final Cost	870	51%
Total	$1,720	

Accomplishments: During this ATP-funded project, Physical Optics Corporation (POC) perfected new holographic systems for recording diffusers with desired scattering distributions. The company also developed the technology for surface-relief holographic diffusers, substantially improved coating and processing techniques for deep-surface structures, and refined fabrication techniques for high-resolution diffusion masters.

A number of trade press and journal articles were written about this technology. The following is a sample of articles related to the ATP project:

- Lerner, J. M., R. L. Shie, and Joel Peterson. "Holographic Light Shaping Diffusers." The Aerospace Lighting Institute, Advanced Seminar. Los Angeles, CA. Feb. 1994.
- Shagam, R. N. "Diffusers Simplify Aircraft Inspection." Photonic Spectra. Nov. 1994.
- "Light Shaping Diffusers Improve Aircraft Inspection." Fiberoptic Product News. 11.2. Feb. 1995: p.13
- Kreifeldt, Erik. "Fish Fear New Diffusers." Optics & Photonics News. 6.9. Sept. 1995: p.8.

POC received the following patents for technologies related to the ATP project:

- "Viewing screen formed using coherent light" (No. 5,609,939: filed December 14, 1994, granted March 11, 1997)
- "Homogenizer formed using coherent light and holographic diffuser" (No. 5,534,386: filed February 23, 1995, granted July 9, 1996)
- "Illuminated display with light source destructing" (No. 5,956,106: filed February 1, 1996, granted September 21, 1996)

Commercialization Status: Since the conclusion of the ATP project in 1996, POC has pursued several commercialization channels, such as in-house manufacturing and marketing, strategic alliances with various original equipment manufacturers (OEMs), and licensing agreements with specific application providers. Furthermore, POC established a dedicated production facility for the holographic diffuser that currently produces 100,000 parts per month. Significant demand prompted POC to create a subsidiary, Farlight Inc. (now Farlight LLC), to commercialize the holographic diffuser technology for lighting applications. As a result, POC now has annual revenues in excess of $20 million.

Outlook: The outlook for this technology is excellent. After POC introduced its holographic diffusers into the marketplace in the late 1990s, the technology has been adopted for new applications, and industry continues to recognize its benefits. Some of the promising new markets are fiber-optic telecommunications products, high-resolution imaging in homes, and security-control products. As POC moves into the data-storage security area, in addition to its diffuser applications, the company is poised to expand into additional domestic and international markets.

Composite Performance Score: * * *

Number of Employees: Eighty-five employees at project start, 170 (including subsidiaries) as of May 2002.

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