

# BRILLIANT FILM™ from TRIVIUM TECHNOLOGIES, INC. BRIGHTNESS OPTIMIZATION FILM

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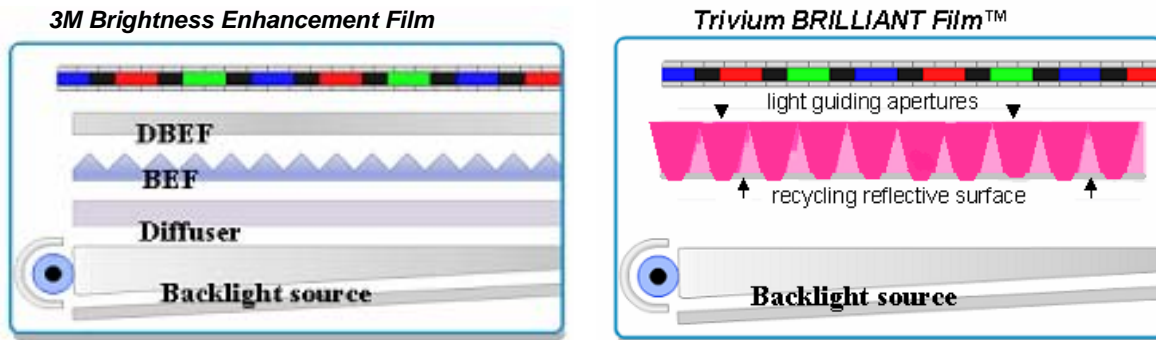
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## PREMISE

Trivium Technologies, Inc. of Cleveland, Ohio has developed a Brightness Optimization Film for transmissive LCD displays. Trivium's BRILLIANT Film™ is based on original patents and further enhanced patent-pending designs utilizing light guiding structures and a recycling layer within a single layer of film that highly collimates the Lambertian light output of the LCD backlight system to improve the display's brightness and viewability.

## BASE DESIGN CONCEPT

The Industry's current standard Brightness Enhancement Film (BEF) solution is a polymer film base with 90 degree triangular structures located on the film surface. To improve the performance of the BEF component, this film can be coupled with a second layer of BEF film installed perpendicular to the first layer, and separated by a layer of air. Additionally, a recycling reflective polarizing layer can be added for further performance optimization.



Comparatively, as illustrated above in an artist's rendering, Trivium's BRILLIANT Film™ requires only a single layer of film to collimate the backlight output and provide recycling for any light exiting at wide angles that would not have initially entered the wave guiding structures.

The basic components of the Trivium film include an optimal design of light-guiding structures that are embedded in the film. They can be created, as one example, through a microreplication process utilizing two polymers with a differing index of refraction to channel the collimated light towards the pixels. Small apertures are created in the film's back surface, which faces the backlight unit (BLU).

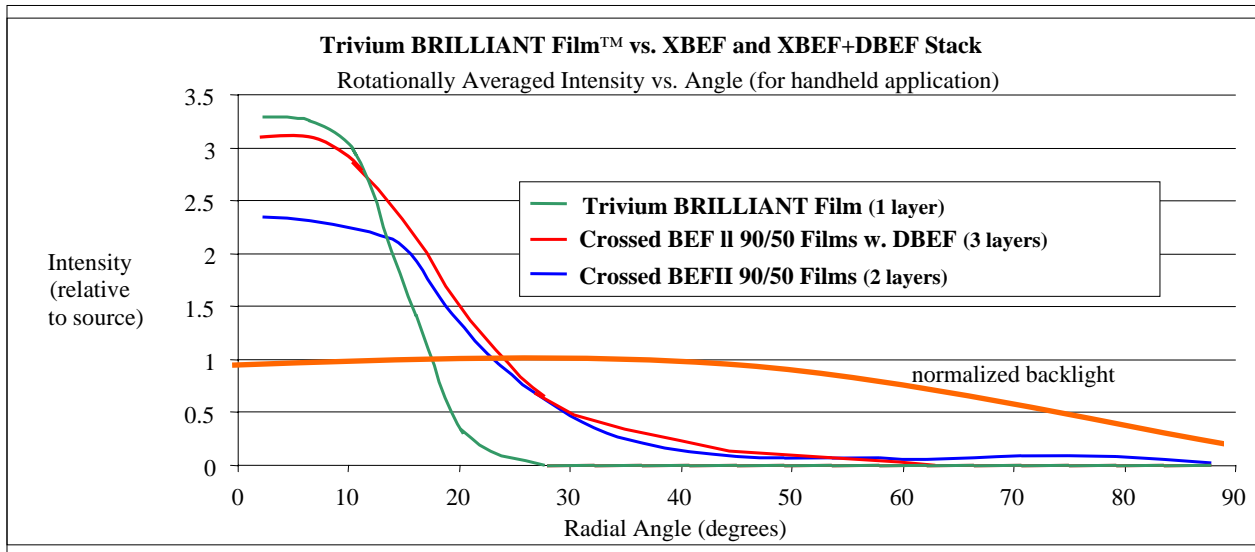
A reflective surface is applied to regions outside the apertures on the surface that also face the BLU, which recycles any light that does not initially or subsequently pass through the apertures into the light guiding structures. All light exiting the light guiding structures is collimated within a controlled parameter, based on the display application.

**MODELING RESULTS / COMPARATIVE PERFORMANCE**

Trivium’s Brilliant Film™ design was analyzed using the Industry-standard illumination design software, *LightTools*™ from Optical Research Associates. This software provides for extensive design and predictive performance analysis of optical systems. Trivium optimized the film’s design by experimenting with various shapes of light guiding structures, differing polymer materials, and several reflective surface designs.

Within the model, whereby a Lambertian backlight output was normalized to 1, the Trivium BRILLIANT Film™ boosted the on-axis intensity to approximately 3.3, with all light exiting within 25 degrees from dead center. This is the optimal Trivium design for handheld display applications. Wasted light, or light that otherwise exits at too wide of a radial angle in the 3M BEF/DBEF combination, can be processed to boost on-axis intensity of the Trivium BRILLIANT Film™.

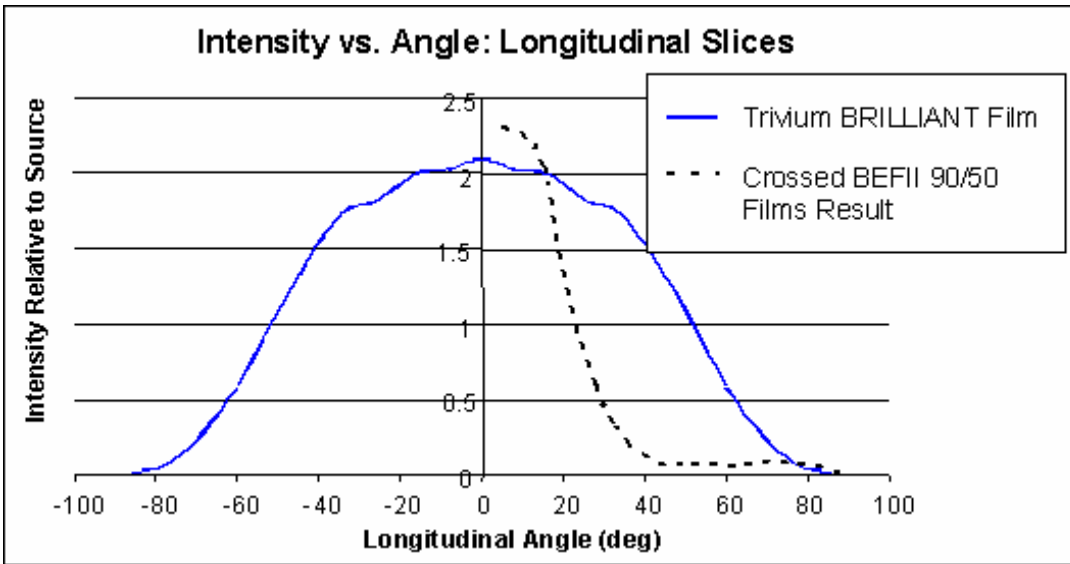
Trivium also used LightTools™ for a comparative analysis of the BRILLIANT Film™ versus multiple 3M brightness film configurations. As illustrated below, two crossed layers of 3M’s BEF 90/50 Film boosted the normalized backlight from 1 to approximately 2.3, which is supported by the published performance data from 3M. By adding a layer of DBEF to that configuration, the 3M solution further improves the performance to approximately 3.2, which is also found in the 3M published data. A single layer of the Trivium BRILLIANT Film™ improved the performance of the normalized backlight from 1 to approximately 3.3.



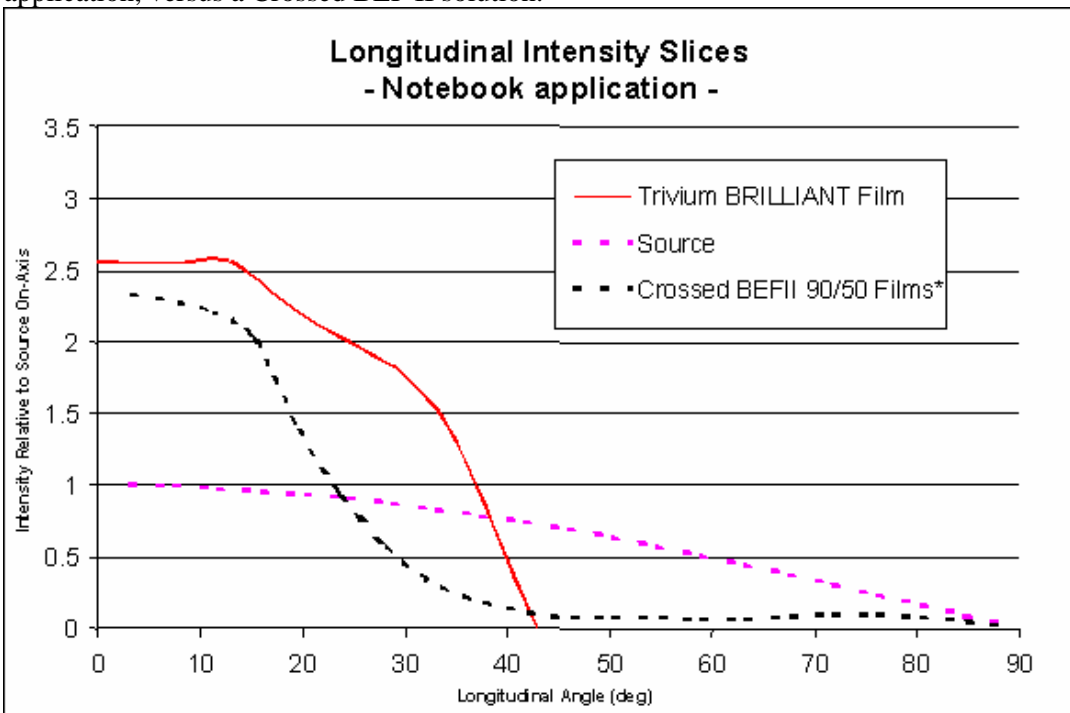
Alpha prototypes of Trivium’s film design were completed in 2004, and performed to the predictive analysis of the model. Final beta prototypes were designed to further enhance the film’s performance and to insure manufacturability using current processes. These beta prototypes of Trivium’s BRILLIANT Film™ will be completed in Q1, 2006.

### APPLICATION-SPECIFIC DESIGN AND OPTIMIZED PERFORMANCE

The LightTools™ modeling also suggested that, by slightly modifying the shape of the light guiding structure, the Trivium BRILLIANT Film™ could provide a substantial boost in on-axis intensity while spreading the light output further in a horizontal direction from dead center, while keeping the vertical spread constant. For a large display application such as an LCD TV, this capability could prove substantial and unique. See the graph below.



A slight modification in film design improves the performance for a Notebook PC application, versus a Crossed BEF II solution.



#### **PATENT PROTECTION**

Since its inception in 2000, Trivium has filed over 200 claims for light management films with the United States Patent and Trademark Office, and other major countries worldwide. Three US Patents have been granted to date, while five other major filings are in process. The first US Patent has also been granted in several other countries, with more in process.

#### **TRIVIUM BRILLIANT FILM™ VALUE PROPOSITION**

- Trivium has designed and patented a unique film for optimizing the backlight output in an LCD display.
- According to the LightTools modeling results, the single layer of Trivium film should outperform the current BEF, XBEF, and DBEF configurations.
- The Trivium BRILLIANT Film™ offer a thinner profile inside the LCD stack than the equivalent XBEF plus DBEF stack.
- The performance boost provided by the Trivium BRILLIANT Film™ can contribute to extended battery life in mobile displays by increasing the efficiency of the backlight system.
- Multiple companies are working to refine the mass-manufacturing process for the Trivium design.
- The Trivium film may offer the LCD manufacturer improved performance at a lower price point.
- The Trivium film can enable the use of lower power-consuming backlights, and may allow for the removal of other light management films in the LCD stack, such as privacy films or diffusing films.
- Trivium has multiple designs for the BRILLIANT Film™ that are tailored to the display application, size, and viewing angle: handheld, mid-size, or large format.

#### **PROJECTED TIMELINE TO MARKET**

Trivium Technologies has contracted with a microreplication company to manufacture beta prototype samples for testing in LCD displays from several leading vendors. The beta sample films should be completed in Q1, 2006 with final systems testing to immediately follow.

Mass-manufacturing ramp up could produce limited film volume by Q2, 2007.

BEF, XBEF, and DBEF are registered tradenames of 3M Corporation.

BRILLIANT Film is a registered tradename of Trivium Technologies, Inc.

All performance data quoted herein is based on predictive performance analysis software supported by experimental performance results from Trivium's alpha samples 3M's BEF, XBEF, and DBEF films. Actual performance in an application may vary.

**Minor changes in 4/06 to White Paper for accuracy.**

**Dr. Richard Hansler**

Dr. Richard Hansler spent 42 years as a senior scientist at the world-renowned GE Nela Park lighting laboratory, where he was instrumental in the development of a number of new types of lamps and methods for manufacturing them. He has 75 patents on lamps and novel optical devices with several patents pending. Shortly after retiring in 1996, he formed the Lighting Innovations Institute, where he has drawn on his vast technical knowledge and wide industry contacts to continue to push the boundaries of lighting technology. Since its inception, the Institute has received well over \$1 million in funding from such federal agencies as the Federal Aviation Administration and NASA, and additional support from private industry. Dr. Hansler holds a doctorate in physics from Ohio State University, and is an adjunct physics professor at John Carroll University. He occasionally serves as an expert witness in legal cases that center on his technical specialty.

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