OVERVIEW

Technologies: Complete Photon Supply Chain Under One Roof.

Figure 1. Seeing The Whole Picture put in (in place of …..missing" on pct)

Unlike most of other companies Visus is not a "one – product" company and offers a complete range of technologies for virtually all LED markets including LED chip and lamp design. A control of a complete "photon supply chain" starting from an optimized photon generation and extraction at LED level and down to secondary light management optics enables to attain maximal performance not possible when considering only one system component, e.g. LED, lightguide panel or BEF.

All our products employ ground-breaking patented optical architecture belonging to FID (Flat Illumination Device) class of optical systems. In contrast to existing ubiquitous illumination devices FIDs operate with a sharply reduced number of powerful compact light sources and redistribute their flux with a surgical precision using hybrid multilayer waveguides and photonic couplers. A combination of optical technology along with novel waveguide materials and LED packaging and encapsulation culminated in a large family of ultra-slim and power efficient FIDs for virtually all of diversified multibillion markets for general and special illumination devices.
Key technologies include:

1.1. **ExFRACTOR™** waveguides with optimized flux extraction patterns.
1.2. Optimized **NLW** (Non-Linear Wedge) **Extratorless** waveguides with reduced profile & weight & cost and no need for extraction pattern,

1.3. **HOW™** Hybrid Optical Wave guides for LCD backlights, including large LCD TVs, general & automotive illumination and signage.
1.4. **TilEx**™modular backlights for large LCD TV.
1.5. Ultra-thin "Functional Flat Fiber" waveguides for LCD BLUs.
1.6. Ultra-thin "Flat Fiber" waveguides for keypad & keyboard backlighting
1.7. **FoCOUPLER**™ energy conserving ultra - compact foconic flux couplers for LED primary & secondary optics.
1.8. Brightness Enhancing & Diffusing Film components (BEFs etc):
    1.8.1. **SADO** ™ Stacked Amplifying Directional Optical Transflector Film.
    1.8.2. **SHUTLE** ™ Shaped Hollow Ultra-Thin Luminance Enhancement Film
1.9. Advanced Microreplication Technology for microprismatic extractors
1.10. **KEREN** ™ CAD/CAM Software Package is a most advanced pioneering proprietary software package enabling a fully automatic synthesis of various non imaging optical systems

Proven track record. Visus has been at a cradle of inventing a number of key optical systems and components which have turned into core technologies in LCD and lighting industries. In mid 80's it pioneered a development of light guides with distributed light extractors turned later into an indispensable core component of all LCD backlights. It also used for the first time 3M's SOLF (developed for a totally different application, namely hollow tubular light guides) for LCD backlights. Later it became known as **BEF,** another core component used in every LCD. In a general lighting first computer generated asymmetrical reflectors (car headlights, road & projection lighting) have been licensed by Visus. Today many of European cities and highways are lighted by these uniquely optimized reflectors. In Visual Ergonomics our methods based on Visual Field Visibility analysis have become a standard approach for Visual Performance evaluation recommended by CIE, IPS and other international standard organizations.

VISUS concentrates on finding immediate novel technological solutions to rapidly changing market demands and establishing a toll position by continuing patenting its intellectual property and building a significant IP portfolio. In this regard, VISUS has a constantly growing number of omnibus and CIP patents covering extensive technologies for compact illumination devices for virtually all of diversified multi billion markets for general and special illumination devices with a special emphasis of LED powered devices.

Visus continues to file under the CIP vehicle a number of follow-up patents relating to several classes of new illuminating systems, in particular to plastic light enhancing components (BEFs etc.), ultra bright LEDs (primary @ secondary optics) and LED powered lighting systems with energy conserving ultra compact optical couplers.

ExFRACTOR™ Flux Extractors for Planar Lightguide Panels (LGP).

Uniform flux extraction is a core problem of all edge-coupled backlight systems. In order to produce a uniform luminance Extractor density and/or shape should generally have a complex 2-D Distributions. Less known is a fact that there is a infinite number of solutions for any particular system. Indeed with a very low extractor density one can produce an even luminance already with a uniform density. However a resulting luminance would be low, as there are elevated flux losses caused by longer travel passes of photons inside a lightguide and reflection on side reflectors.

Our patented have a unique energy conservation property: light is extracted at a shortest possible distance from light sources. In this way a maximal luminance is ensured.

Our unique KEREN ™ CAD/CAM Software Package for non-imaging optics enables a fully automatical design of optimal **ExFRACTOR™** features in a series of gracefully converging iterations for any extractor shape: dot, spherical & CPC lenses, prismatic & cylindrical grooves etc. The resulting pattern is then antialiased (randomized) and postprocessed for immediate production of stamper for mold cavities, chemical & laser etching, EB lithography etc.

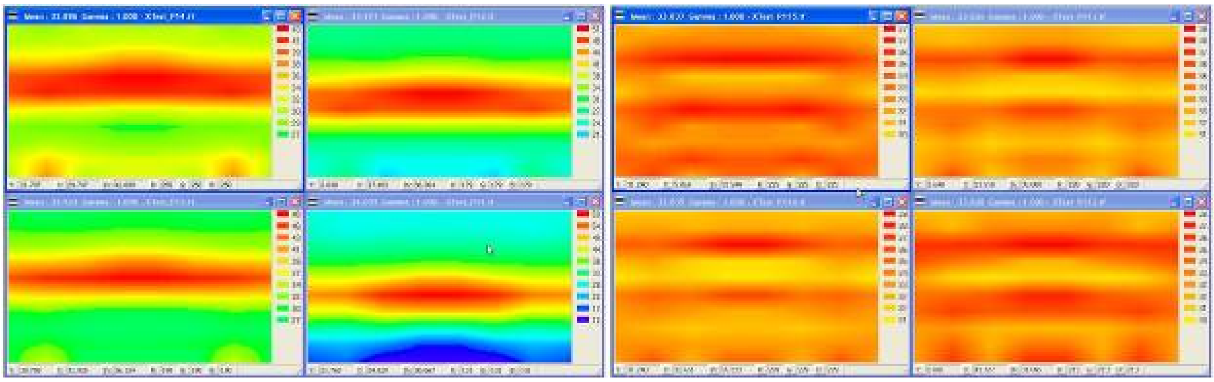

Figure 2 LUMINANCE DISSTRIBUTION AT INITIAL AND FINAL ITERATIONS NONUNIFORMITY IS IMPROVED FROM 5:1 TO BETTER THAN 1.1:1

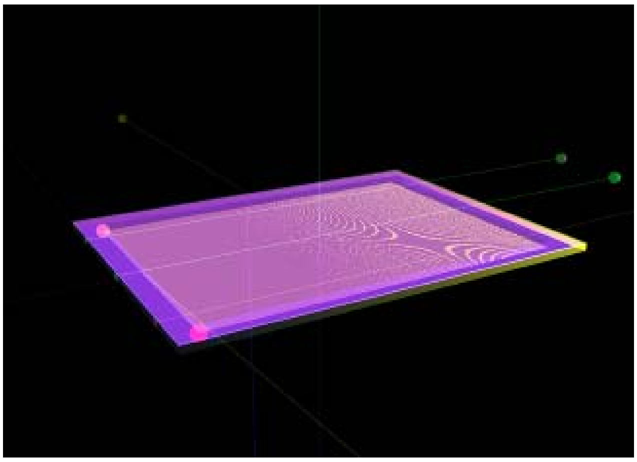

Figure 3 Fully Assembled 2.2” BLU with discontinuous V-Groove extractors.

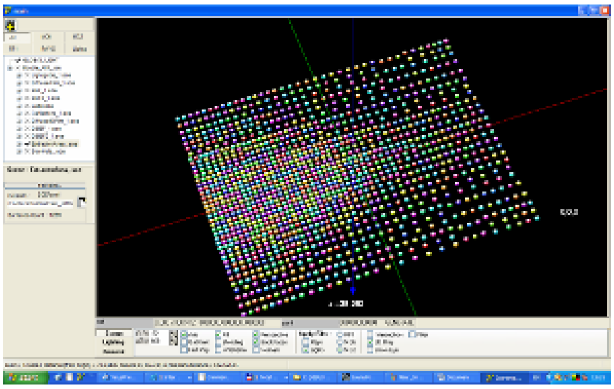

Figure 4 LGP with non-uniformly distributed simple spherical extractors. Actual extractor size: 20-50 um.

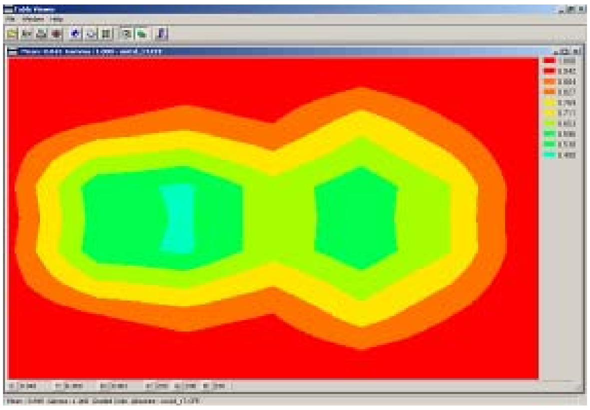

Figure 5. Example of Extractor distribution for ultra-thin microdisplay backlight. Notice a unique irregular pattern, which is very different from usual monotonically changing distributions.

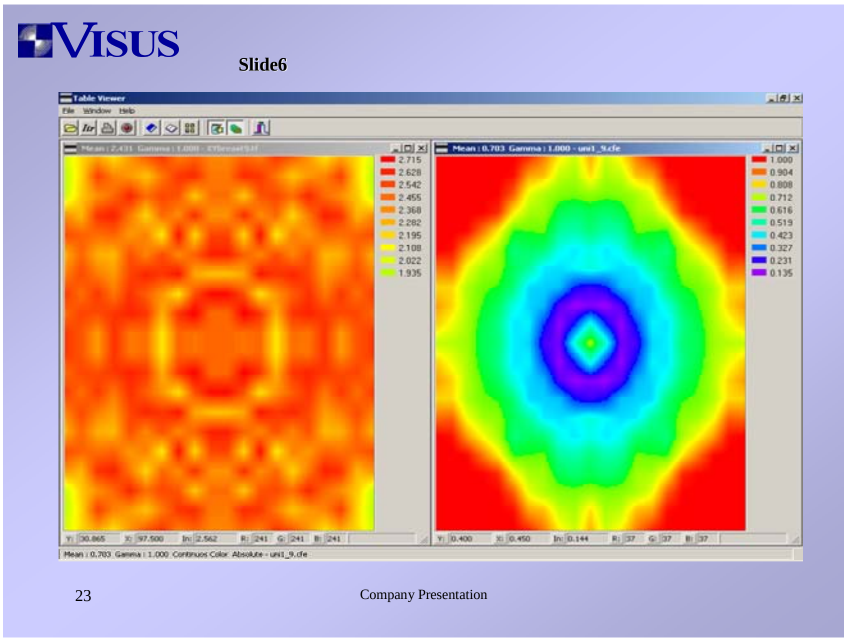

Figure 6. Face-coupled Backlight. Complex 2-D flux Extractor Distributions (right) Producing Uniform Luminance (left).

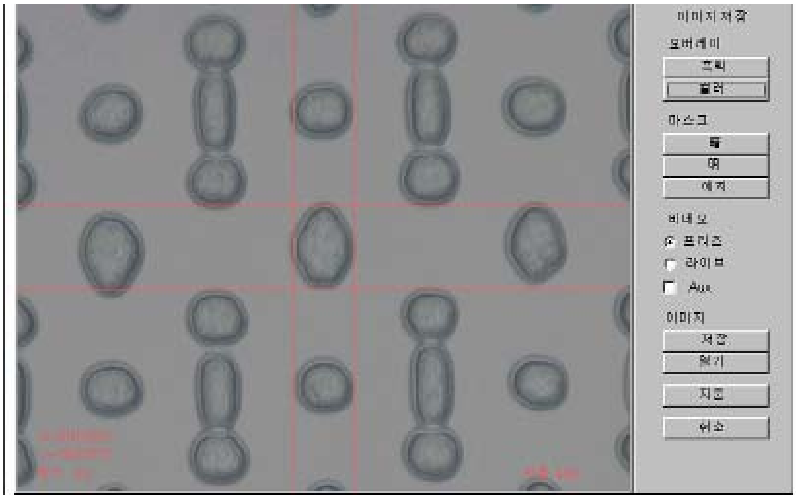

Figure 7. Stamper with complex 50um spherical and V-Groove lenses.

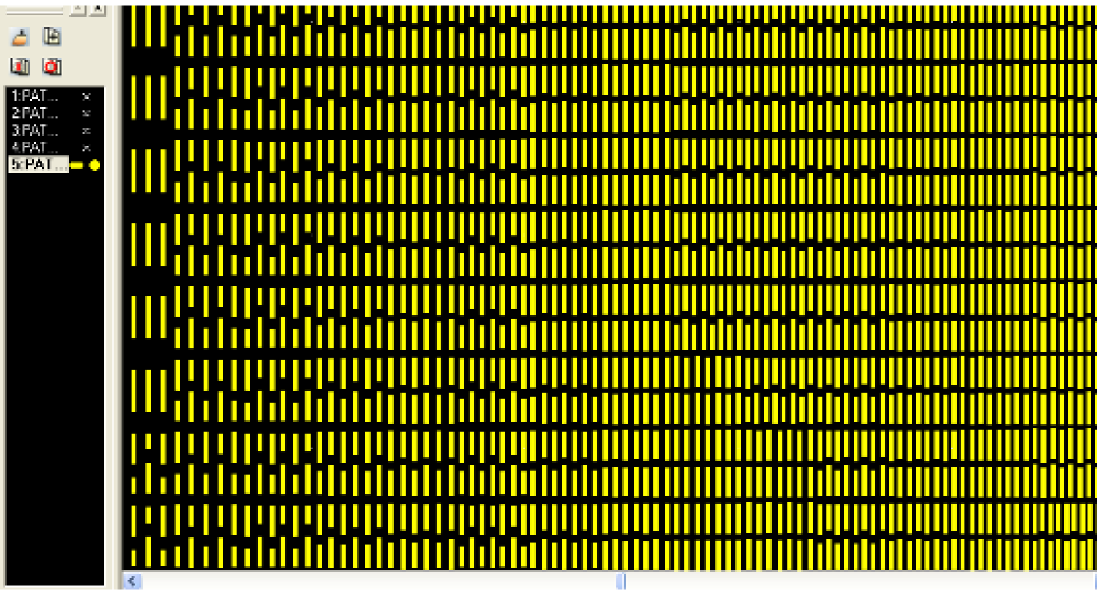

Figure 8. Magnified fragment of 50um V-Groove pattern.

Hybrid Optical Waveguide ("HOW")

Patented Hybrid Optical Waveguide ("HOW"), represents a new generic compound class of systems with functionally distinct cooperatively acting optical entities. These include:

1. Principal Radiation Carrier (**PRC**);
2. An extended planar or wedge Waveguide Ejector with distributed flux extraction means termed Hybrid Optical Pipe Ejector (**HOPE**);
3. Distributed Optical Pipe Ejectors (**DOPE**) with directional flux ejection properties;
4. Distributed Optical Pipe Injectors (**DOPI**).

The HOPE, DOPE and DOPI are also referred to herein as Secondary Radiation Carriers (SRC).
Depending on geometry and coupling architecture of these entities HOWs can be configured to perform a variety of functions related to transfer, distributed injection, and distributed directional ejection of a radiant energy. Some combinations of PRCs and SRCs are described below:

1. PRC – Planar waveguide ejector referred to hereinafter as a Hybrid Optical Pipe Ejector **(HOPE);**
2. PRC – DOPEs providing distributed discontinuous (localized) quasi-lambertian or directional flux ejection over the whole length of PRC;
3. PRC – DOPIs providing distributed flux injection over the whole length of PRC;
4. Doubly Hybrid PRC – DOPIs/DOPEs providing distributed flux injection and ejection over the whole length of PRC; and
5. Multiple active and passive PRCs-SRCs providing distributed flux injection and ejection through PRC apertures.

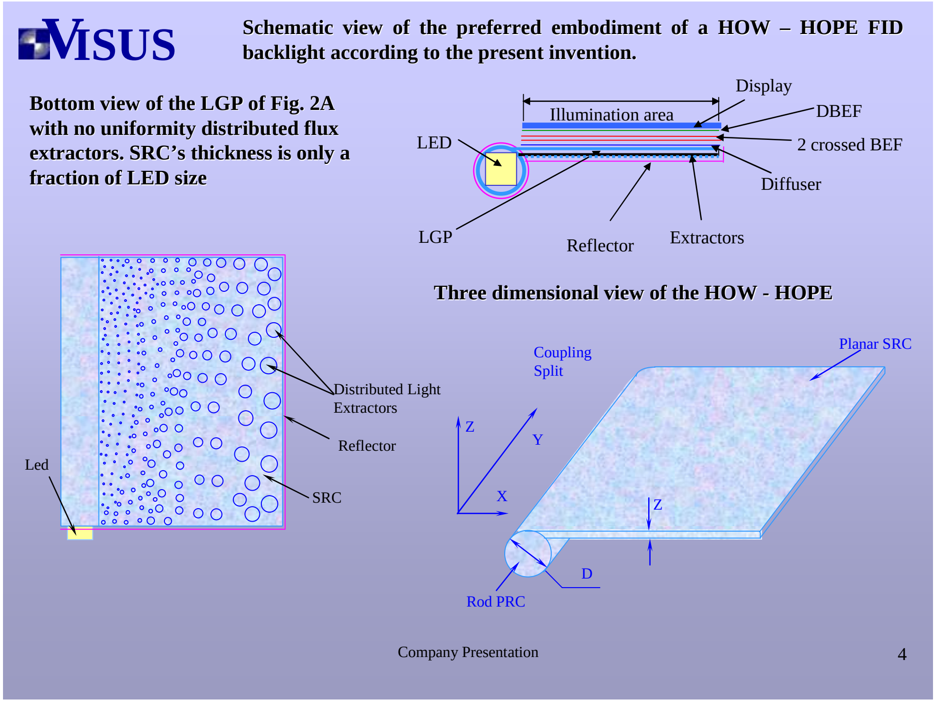

Figure 9. **Ultra-thin HOW™ Backlight PRC – HOPE configuration. Thickness of HOPE lightguide can be X10 and more smaller than a size of coupled LED.**

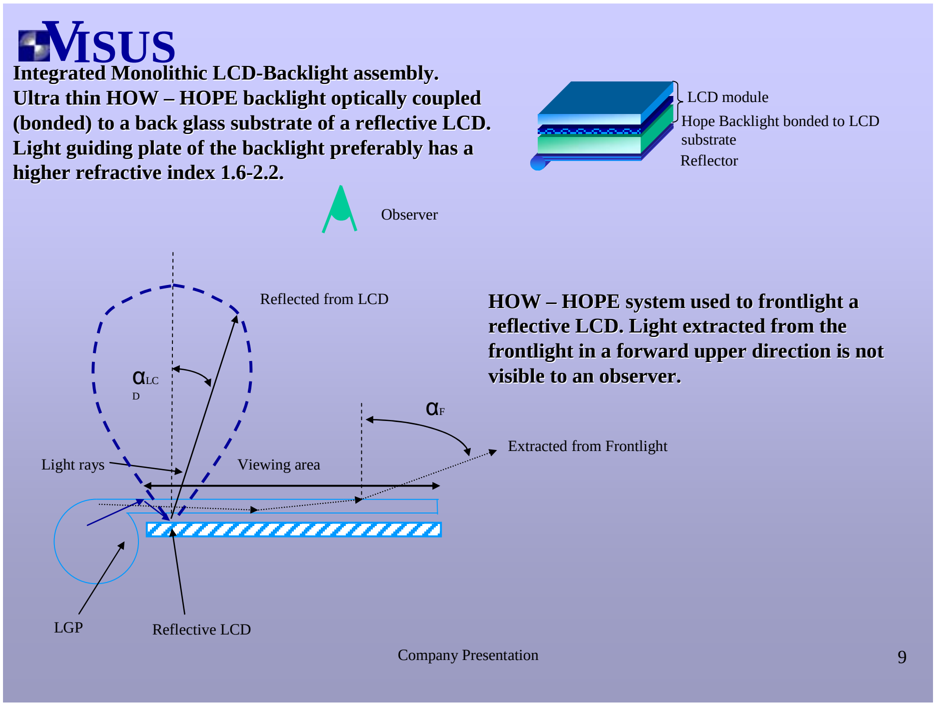

Figure 10. **Ultra-thin HOW™ - HOPE LCD-Frontlight monolithic unit. Frontlight is being directly bonded to LCD glass.**

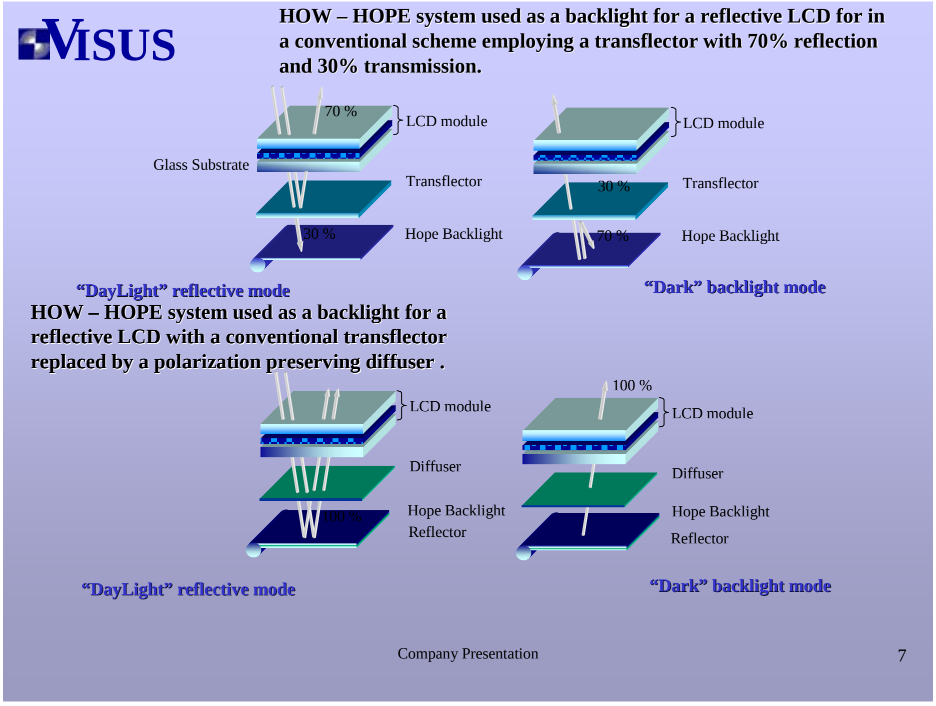

Figure 11. **Ultra-thin HOW™ - HOPE (lower part) with no parallax enables to remove a conventional Transflector film and triple a resulting LCD luminance.**

Figure 12. **Doubly Hybrid PRC – DOPIs/DOPEs providing distributed flux injection and ejection over the whole length of PRC large core side emitting fiber for neon-like signage systems. This system enables to inject orders of magnitude higher flux into a core fiber and directionally ejects it without fiber attenuation losses, resulting in ground-breaking cost & performance improvements. Right: Actual devices with continuous & discrete lighting**

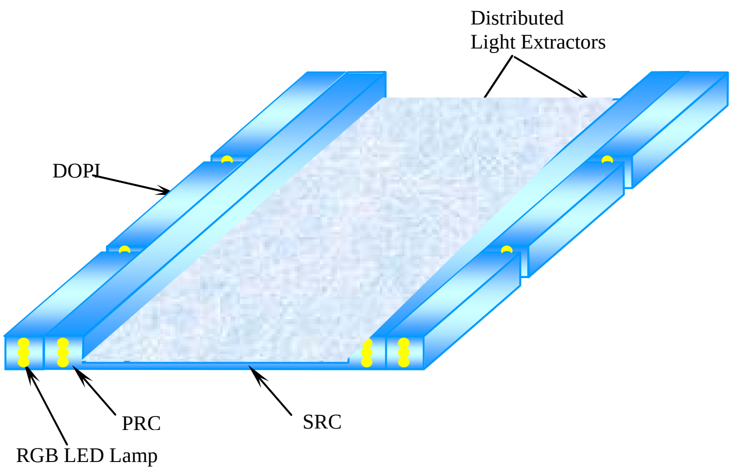

Figure 13 **Hybrid Distributed Optical Pipe Injector - Ejector (DOPE – DOPI) for ultra-thin highbright large LED backlights.**

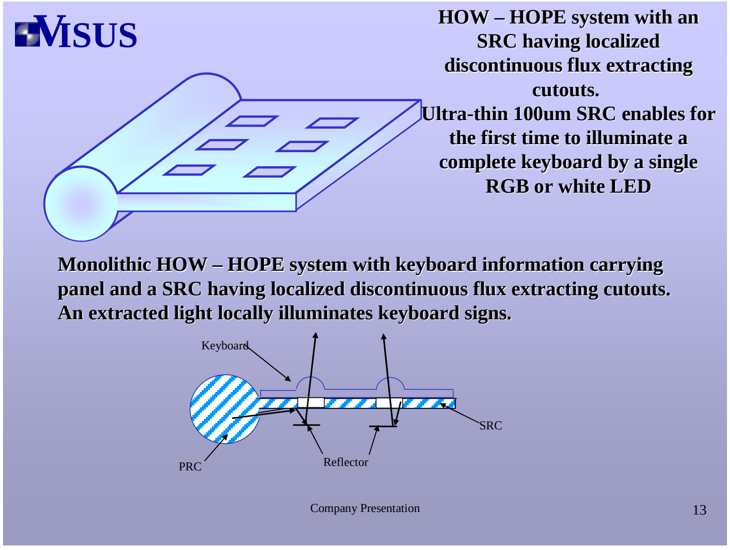

Figure 14. **Ultra-thin HOW™ Keypad & Keyboard backlights feature up to x50 power efficiency compared to standard systems and use just one low-grade LED as a replacement for 10-20.With a thickness of 100 – 200 um suitable for the slimmest MP and large keyboards**

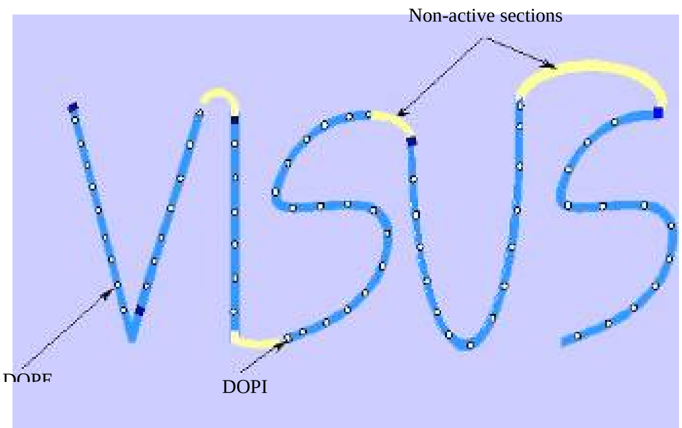

Figure 15 HOW – DOPI – DOPE system configured for signage channel letter has drastically reduced cost and makes for the first time a use of LEDs affordable also for large scale signage applications. Miniature DOPI Light Engines with few high efficacy LEDs and flexible fiber with directional point-like DOPE light extractors.

Functional Flat Fiber (FFF)

Reinventing LGP: Functional Flat Fiber (FFF) With Microprismatic Exfractors™

In cooperation with one of its manufacturing partners Visus has developed unique 0.1-0.2mm FFF lightguides (also referred as LGF – lightguiding film), which will fundamentally change backlighting technology by producing BLU with a thickness of a customary optical film.These new BLU are ideally suited for LED lamps undergoing rapid miniaturization.

FFF multilayer lightguide is basically different from a common PMMA plate. It represents a planar analog of a well-known cylindrical optical fibers used in telecommunications and some lighting applications. It has a number of key practical benefits:

- **With a thickness of just 0.1 – 0.4 mm** FFF can be effectively coupled to the latest HB ultra-compact SMT LEDs and reduce device profile & weight. Customary compression molding is relatively slow and cannot produce less than 0.4 – 0.6 mm thick LGP.
- **FFF with a light Extraction** micro-array is manufactured by a continuous (roll to roll) high performance microreplication methods (5 – 50 m/s) drastically reducing manufacturing cost & time. Millions FFF can be produced within a few shifts.
- Higher collimation around Line-Of-Sight.
- **Flexible.** Can be used in future flexible LCDs.
- **FFF can be directly bonded** or laminated to any metal or plastic substrate of any color including BLACK without seriously degrading its optical performance. Can simplify mechanical mounting directly on walls, doors etc.
- **Enhanced handling** & scratch & dust & humidity & UV resistance. Any scratches, dust deposition, water drops produce uncontrollable leakage of light reducing BLU luminance. Our FFF is free of all mentioned shortcomings, as the light propagates inside an optically protected “core”.
- **Ideal for outdoor applications –** no degradation under rain, strong UV radiation.

Figure 16. Enlarged image of 0.2mm FFF with uniform luminance. Dot size 30-50um.

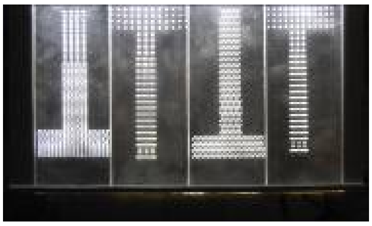

Figure 17. FFF with letter “T” for EXIT sign with directional microlens extractors.

FoCOUPLER™ Foconic Optical Couplers for LEDs.

It all starts at a chip…

Development of efficient high-brightness LED light sources involves fundamental studies of emission mechanisms in ZnS- and GaN-based wide-bandgap compound semiconductors. While internal quantum efficiency (i.e. electron to photon conversion)has been constantly improving external quantum efficiency continues to remain appallingly low, so that 50 – 90 % of a generated flux is trapped and absorbed inside a chip. Realization of illumination sources and fixtures for general market using LEDs calls for a significant improvement of EQE..

Visus Photonics achieved a significant progress in developing realistic practical designs based on the innovative concepts of LED chip design and EQE (or simply Extraction Efficiency) conserving optical architecture by considering both optimal chip shape (mesostructures) and encapsulant primary and secondary optics.

Unique Foconic volume and EQE conserving couplers are integrally formed with LED as its primary optics replacing a conventional encapsulator lenses. Focon is a complex compound elliptic-hyperbolic conical section with a minimal thickness approaching a theoretical limit. Special math apparatus based on Light Field Theory has been developed to generate these smooth surfaces by our optical SW KEREN ™.

1. New foconic **FoCOUPLER**™optocouplers ensure brighter LED with higher EQE with a thinner die structure meaning less expensive and more efficient chip and, not less important more compact and effective lamp size, e.g. more compact secondary optics;
2. Design of Dye configuration, Primary and secondary LED Encapsulant Optics are intimately intermingled to produce an optimal lamp package. With a coupler optics tailored to a given chip and particular application one can attain the most effective solution. Unfortunately, it is often not the case, as many chip makes do not fully realize all practical implications, which the latter has on an end product and prefer standard less effective encapsulation design, if any.
3. Foconic couplers have also a second major function: adaptation of an inherently lambertian intensity distribution of an LED to a particular application. Thus LED can turned into a side-emitting type allowing more uniform BLU.

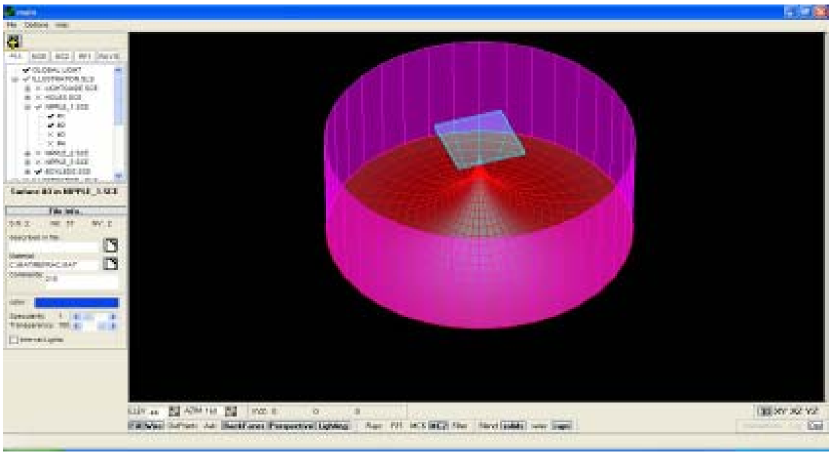

Figure 18. Foconic volume and EQE conserving CRATER™ coupler with an ejection aperture restricted by TIR angles. Optimal for LEDs coupled to large lightguides with extractors (BLU, large planar sources). Generated by our optical SW KEREN ™. Actual Scale.

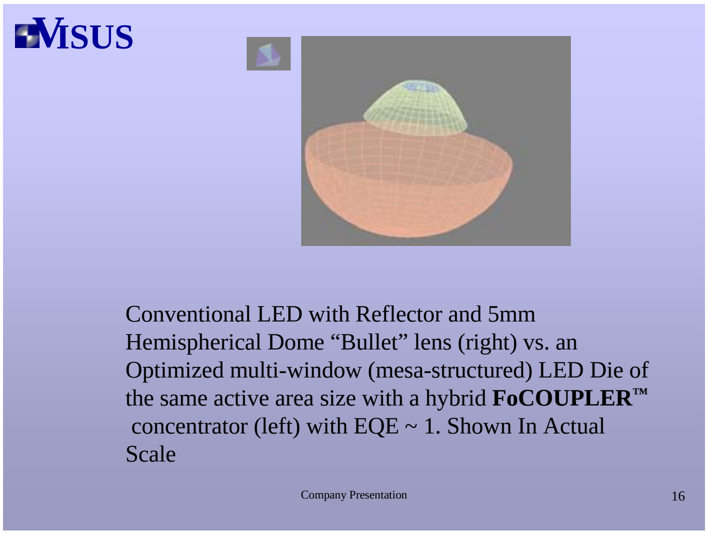

Figure 19

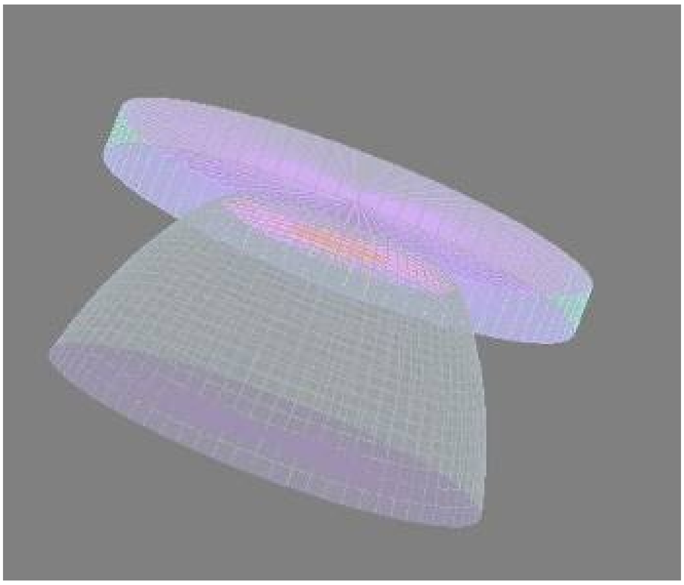

Figure 20. Example of CPC-like foconic microlens producing maximal flux collimation and EQE.

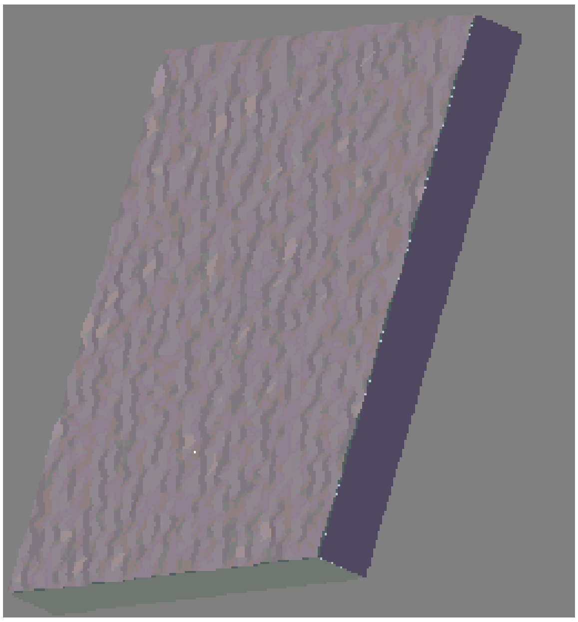

Figure 21. Controlled roughening of LED die improves EQE.