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HOW™ Hybrid Optical Waveguides: Fundamentally New Optics for Ultra-thin Lighting Systems

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 HOW 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 OpticalPipe 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.

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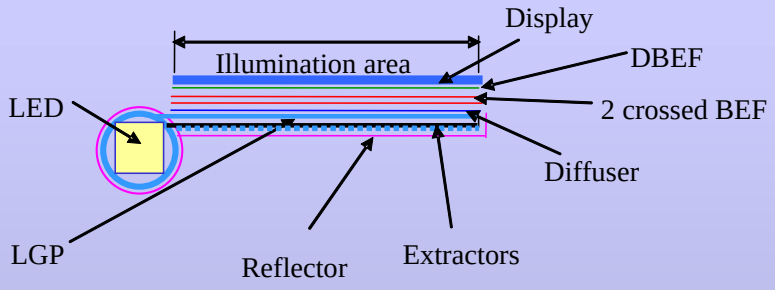
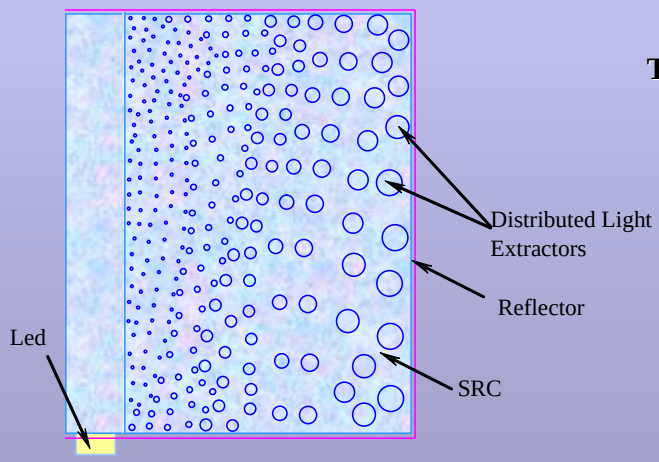
Schematic view of the preferred embodiment of a HOW backlight according to the present invention. – HOPE FID



Bottom view of the LGP of Fig. 2A with no uniformity distributed flux extractors. SRC's thickness is only a fraction of LED size



Three dimensional view of the HOW - HOPE

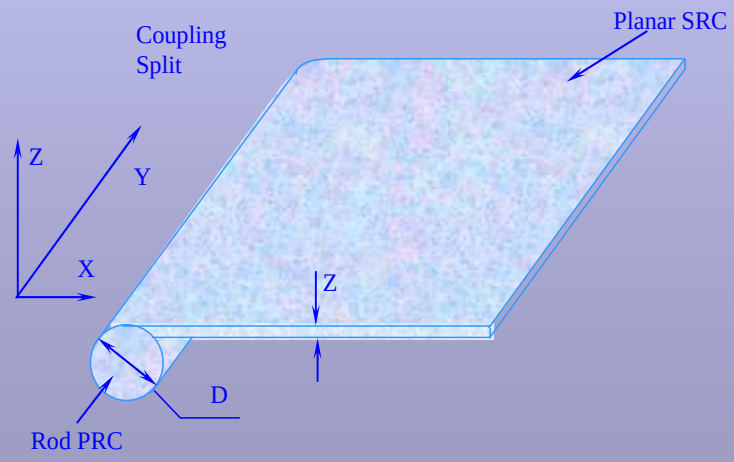


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Figure 1. Ultra-thin HOW™ Backlight PRC – HOPE configuration. Thickness of HOPE lightguide can be x10 and smaller than a size of coupled LED.

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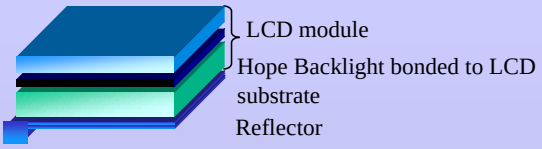
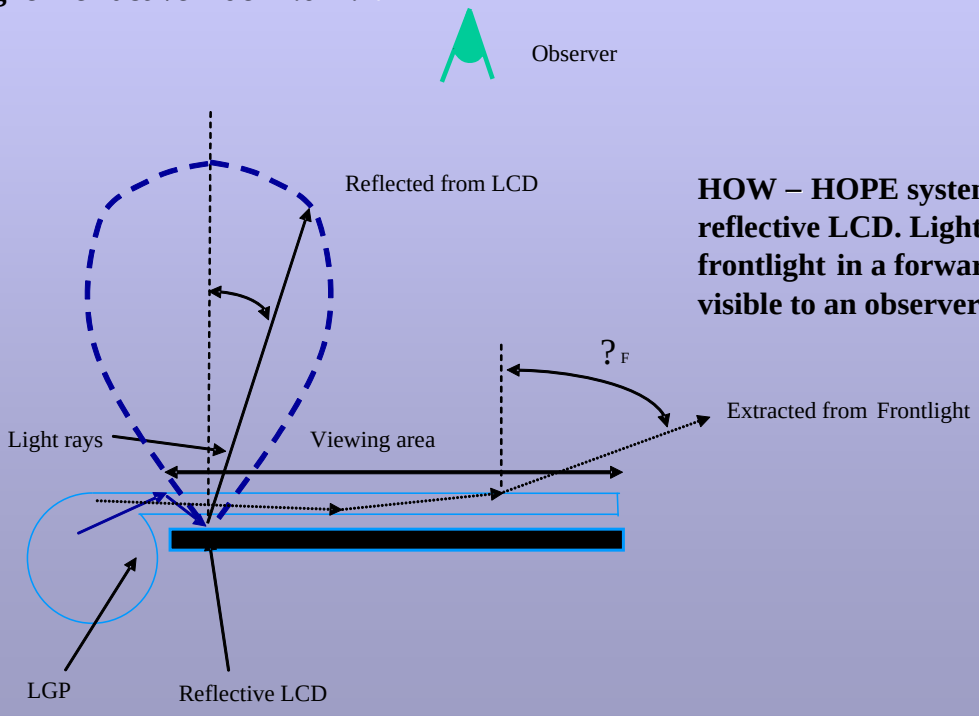
Integrated Monolithic LCD -Backlight assembly.
Ultra thin HOW - HOPE backlight optically coupled (bonded) to a back glass substrate of a reflective LCD. Light guiding plate of the backlight preferably has a higher refractive index 1.6 -2.2.





HOW – HOPE system used to frontlight a reflective LCD. Light extracted from the frontlight in a forward upper direction is not visible to an observer.

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Figure 2. Ultra-thin HOW™ LCD-Frontlight monolithic unit. Frontlight is being directly bonded to LCD glass.

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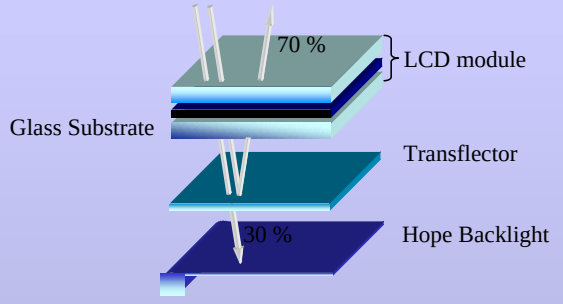
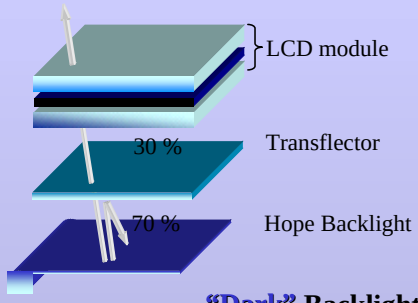
HOW–HOPE system used as a backlight for a reflective LCD for in a conventional scheme employing a transflector with 70% reflection and 30% transmission.

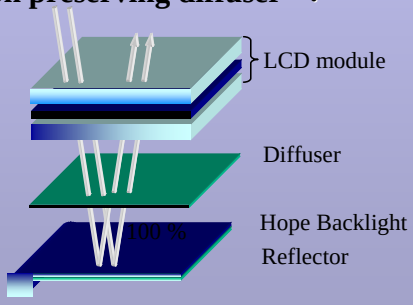


"DayLight" Reflective mode

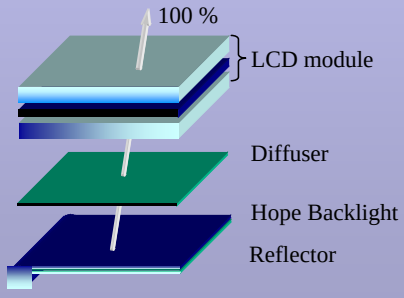


"Dark" Backlight mode

HOW – HOPE system used as a backlight for a reflective LCD with a conventional transflector replaced by a polarization preserving diffuser .



"DayLight" reflective mode



"Dark" backlight mode

Figure 3. Ultra-thin HOW™ - HOPE (lower part) with no parallax enables to remove a conventional Transflector film (upper part) and triple a resulting LCD luminance.

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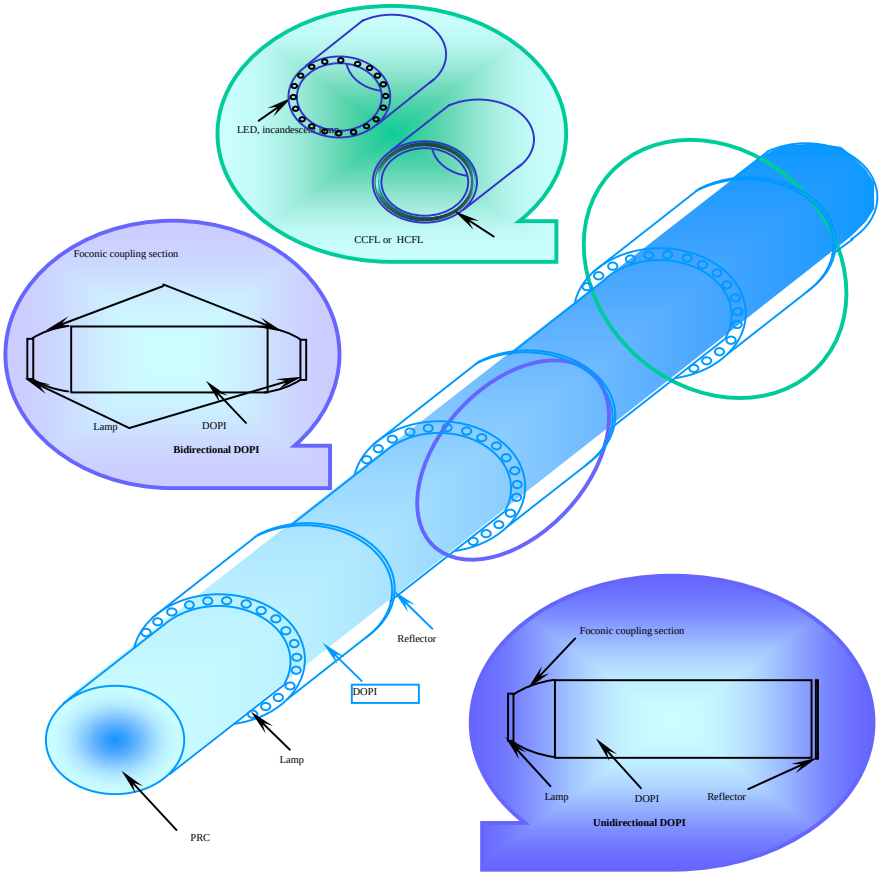

Figure 4. Doubly Hybrid PRC – DOPIs/DOPEs providing distributed flux injection and ejection over the whole length of PRC large core side emitting fiber for neon-like signage systems. This system enables to inject orders of magnitude higher flux into a core fiber and directionally ejects it without fiber attenuation losses, resulting in ground-breaking cost & performance improvements. Right: Actual devices with continuous & discrete lighting

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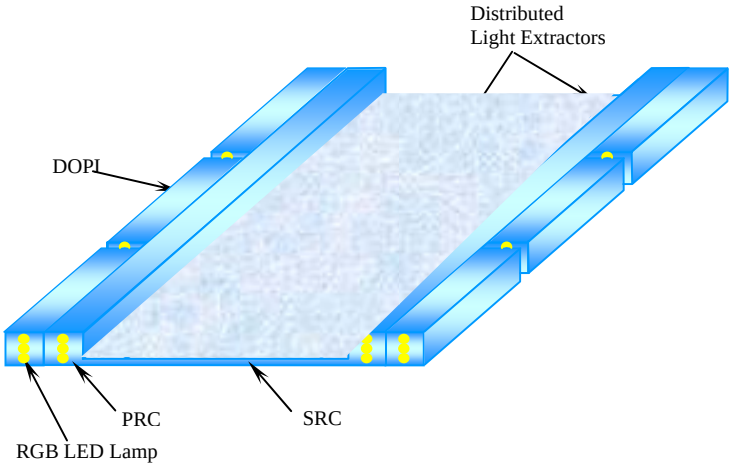

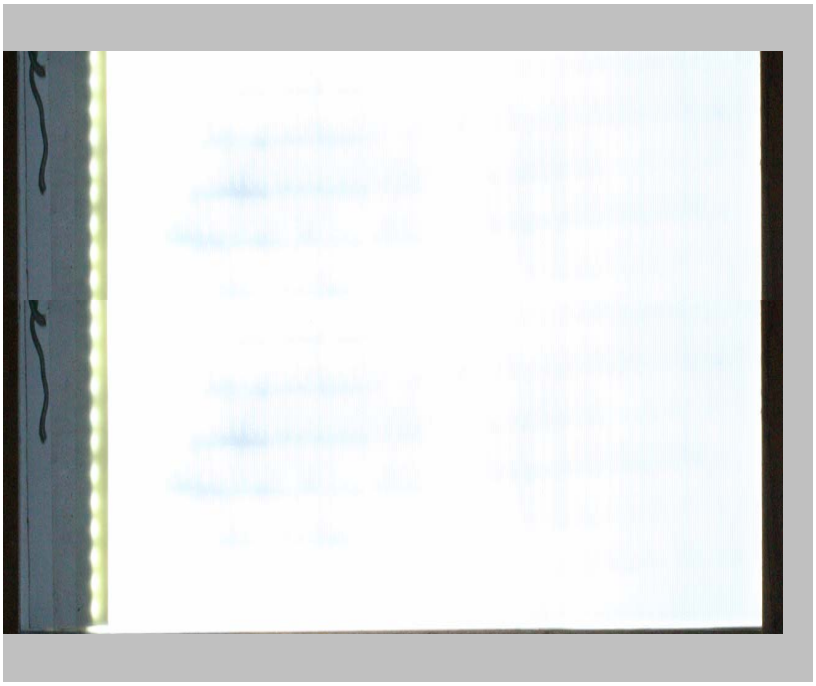

Figure 5 Hybrid Distributed Optical Pipe Injector - Ejector (DOPE – DOPI) for ultra-thin high bright large LED backlights.

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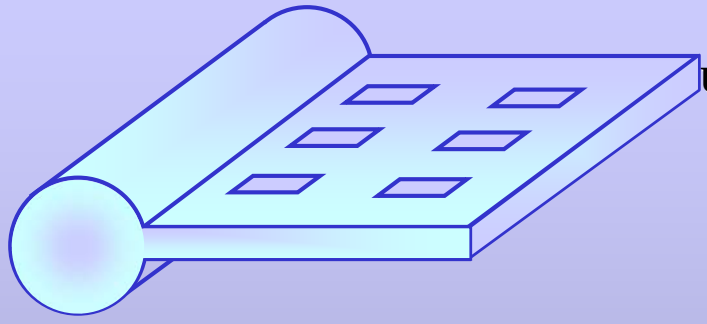

HOW – HOPE system with an SRC having localized discontinuous flux extracting cutouts.
Ultra-thin 100um SRC enables for the first time to illuminate a complete keyboard by a single RGB or white LED

Monolithic HOW – HOPE system with keyboard information carrying panel and a SRC having localized discontinuous flux extracting cutouts. An extracted light locally illuminates keyboard signs.

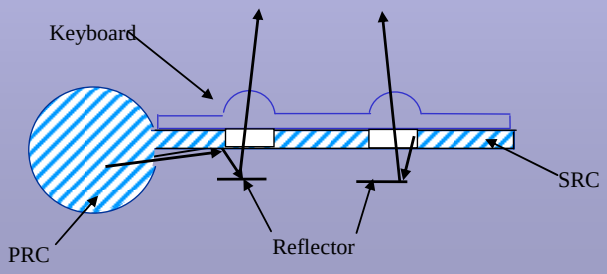

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Figure 6. Ultra-thin HOW™ Keypad & Keyboard backlights feature up to x50 power efficiency compared to standard systems and use just one low-grade LED replacing 10-20 similar lamps. With a thickness of 100 – 200 um it is suitable for the slimmest MP and large keyboards.

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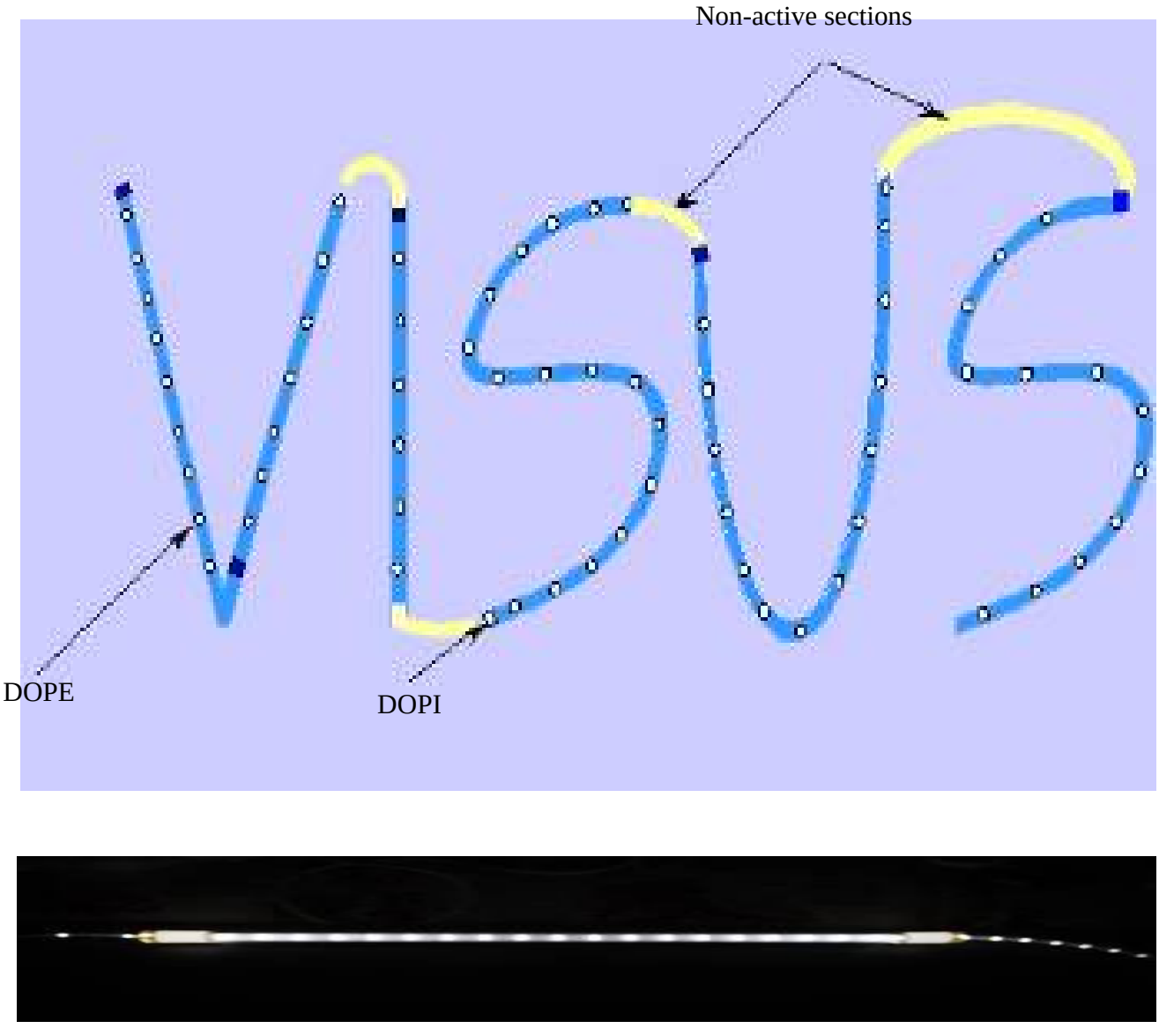

Figure 7 HOW – DOPI – DOPE system configured for signage channel letter has drastically reduced cost and makes for the first time a use of LEDs affordable also for large scale signage applications. Miniature DOPI Light Engines with few high efficacy LEDs and flexible fiber with directional point-like DOPE light extractors.