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COMPOSITE TRANSPARENT LIGHTING DEVICE – LOT 59 SAES PATENT

OCEAN TOMO®
BID-ASK™

Patent: main claims

1. Composite transparent lighting device (10; 20; 30) comprising a composite transparent element (11; 21; 31) and discrete light sources (13, 13'…; 23, 23'…; 33, 33') optically coupled with said composite transparent element perimeter (12, 12',…;22), a reflective frame (12; 12'…; 24; 34) defining the boundaries of the composite transparent lighting device (10; 20; 30), said reflective frame (12; 12'…; 24; 34) being present on at least 80% of the composite transparent lighting device perimeter (12, 12',…;22), characterized in that:

- **a.** said composite transparent element comprises a transparent matrix and a uniform dispersion of dielectric particles,
- **b.** said transparent matrix has an optical light extinction coefficient equal to or less than 0,009 cm^{-1} evaluated at 500 nm, and
- c. the volume concentration of said dielectric particles is comprised between:

$$c_{Max}\left[\frac{Vol}{Vol}\right]=\begin{cases}6\cdot 10^{-11,2}\cdot\left[\rho^3\left(\frac{m^2-1}{m^2+2}\right)^2\right]^{-1} & if\ 10^{-13}\le \rho^6\left(\frac{m^2-1}{m^2+2}\right)^2<10^{-7}\\ 10^{-5,3}\cdot\rho & if\ 10^{-7}\le \rho^6\left(\frac{m^2-1}{m^2+2}\right)^2<10^{10}\end{cases}$$

and

$$c_{Min}\left[\frac{Vol}{Vol}\right]=\begin{cases}6\cdot 10^{-12,8}\cdot\left[\rho^3\left(\frac{m^2-1}{m^2+2}\right)^2\right]^{-1} & if\ 10^{-13}\le \rho^6\left(\frac{m^2-1}{m^2+2}\right)^2<10^{-7}\\ 10^{-6,7}\cdot\rho & if\ 10^{-7}\le \rho^6\left(\frac{m^2-1}{m^2+2}\right)^2<10^{10}\end{cases}$$

where ρ is the average dielectric particle size expressed in µm, and m is the ratio between the refractive index of the dielectric particles and the refractive index of the transparent matrix evaluated at 500 nm.

2. Composite transparent lighting device according to claim 1 wherein said dielectric particle volume concentration is comprised:

- between 10^{-6} and 10^{-5} if 20 µm > $\rho \ge$ 5 µm,
- between 10^{-6} and 10^{-5} if 1 µm > ρ > 0,3 µm or
- between $10^{-4,5}$ and 10^{-3} if 0,1 µm > ρ > 0,04 µm.

General concept: transparent lighting devices

- The transparent lighting device can consist in:
  - ➢ Composite transparent element with uniform dispersion of scattering particles and peripheral light sources → Applications: interior walls, internal separators
  - ➢ Composite transparent element with uniform dispersion of scattering particles and peripheral light sources combined with structural glass sheets → Applications: Lightening windows

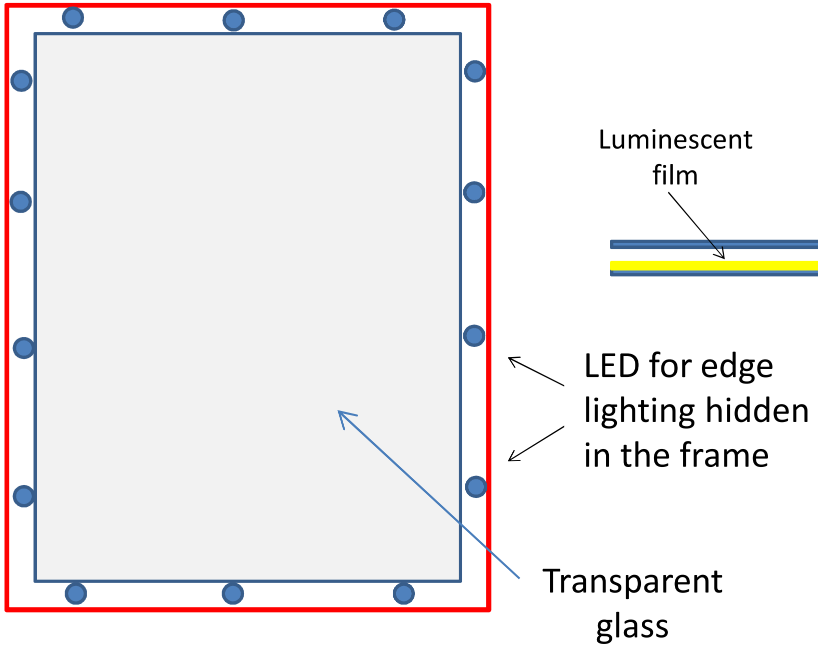
- The optical properties of the "transparent lighting device" can be fully determined by:
  - Geometrical "window" shape (physical dimensions of the composite transparent element)
  - Matrix transparency (wavelength dependent)
  - Peripheral light sources (LEDs number, power, angular beam profile, spectrum, etc.)
  - Edges finishing (reflectivity, shape, etc.)
  - Scatterers/phosphors properties (e.g. anisotropy factor and cross section)
  - Scatterers concentration

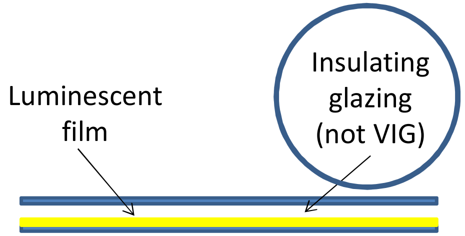
Lightening Window: the Idea

Our lightening window is composed of:

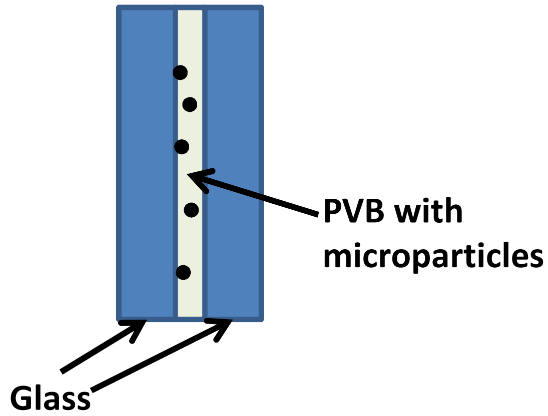
- A glazing system comprising two glass sheets with a PVB foil inserted between them.
- Inside the PVB foil, a suitable amount of microparticles having a very controlled size is uniformly dispersed, allowing to maintain a very high transparency.
- A suitable number of white LEDs is mounted in the frame, injecting light into the glazing (edge lighting system).
- The light is scattered outside the glazing by the microparticles dispersed in the PVB foil, thus transforming the transparent window in an uniform light source when the external ambient is dark.
- Different solutions could be adopted to preferentially address the light towards the internal side of the glazing, preventing the light dispersion outside the building.

Lightening Window: Key Features





Cross-section of the multilayer glass with functionalized PVB



<u>Outstanding properties</u>:

i. Area source (by multiple point sources)

ii. High efficiency

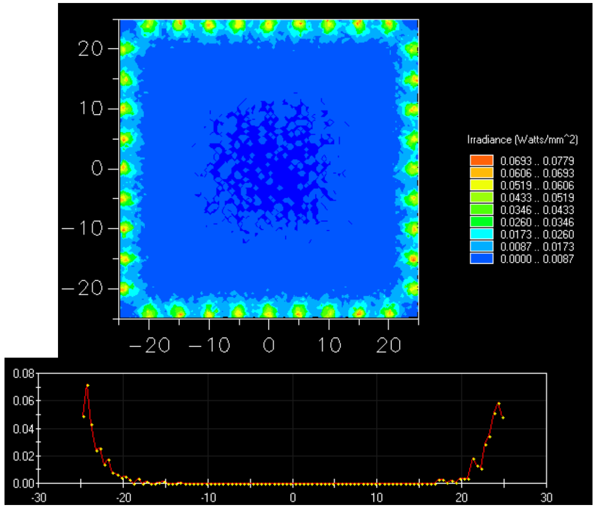
iii. Light quality – rendering

Lightening Window: Value Proposition

1. **Integration natural light – artificial light**
    2. Aesthetic
    3. Transparency
    4. Uniform light
    5. Light quality
    6. Lifetime

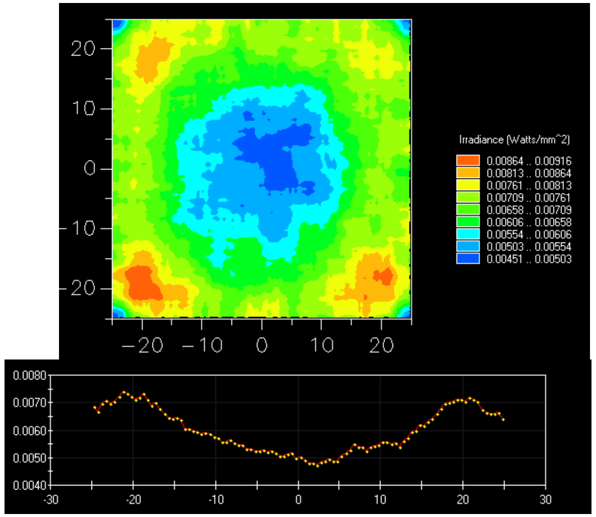
Technical Insights

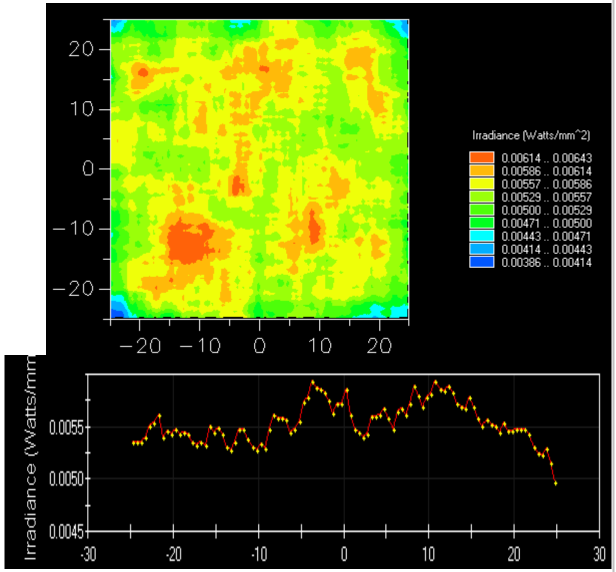
Preliminary experimental activities were carried out to validate the idea and to study key parameters for the composite transparent lighting element. No complete lightening windows were realized, but only small composite transparent elements.



Montecarlo-simulations were used to validate the concepts and to confirm the selected ranges for the important parameters.

The upper left panel shows a high particle concentration: the outcoming scattered light is concentrated to the edges, close to LEDs.

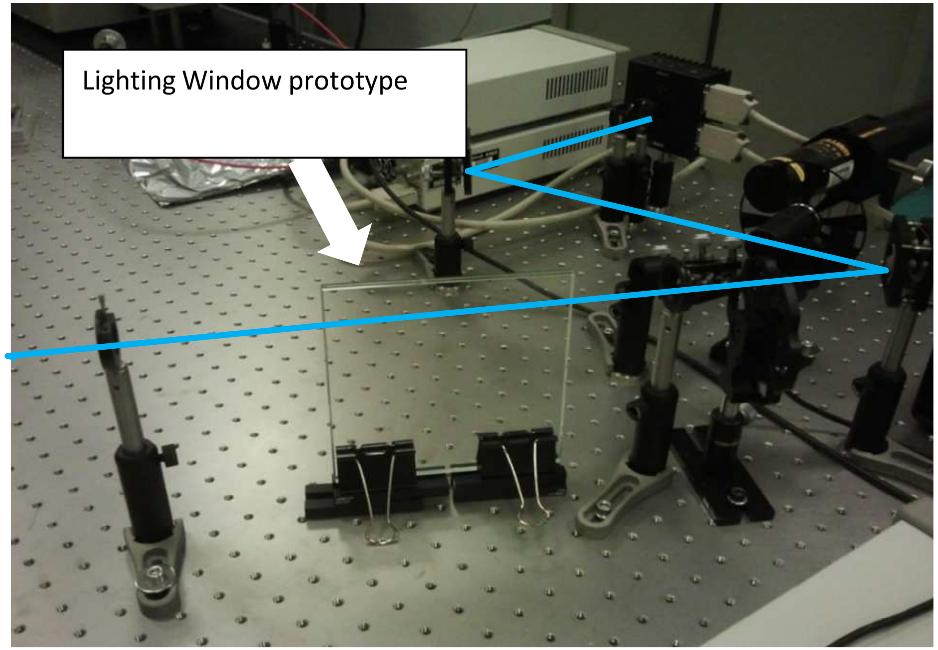


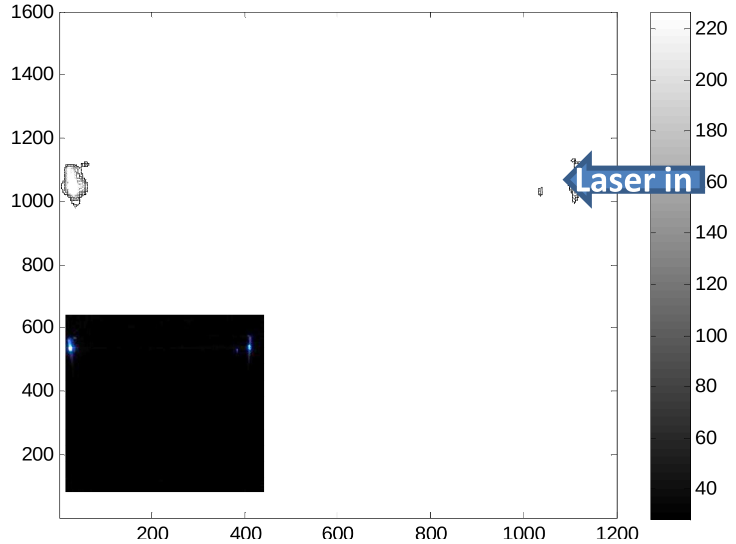


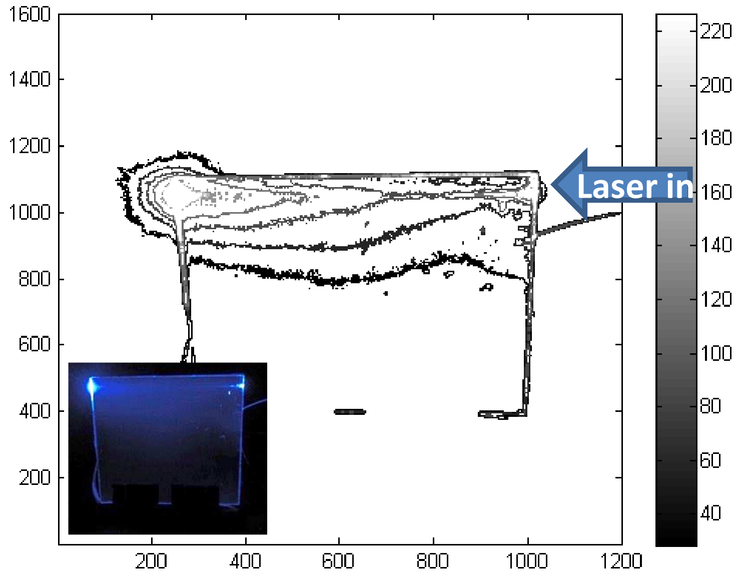
The bottom right panel indicates the optimum concentration with a flat and uniform light outcome. The central panel refers to an intermediate situation

Preliminary Experimental Results

Experimental set-up







Here is reported the blue light outcome in a panel without scattering particles (up right) with respect to a panel with scattering particles (down right).

It is possible to observe a rather uniform light distribution when scatterers are present.

Interest for transparent Lightening Windows

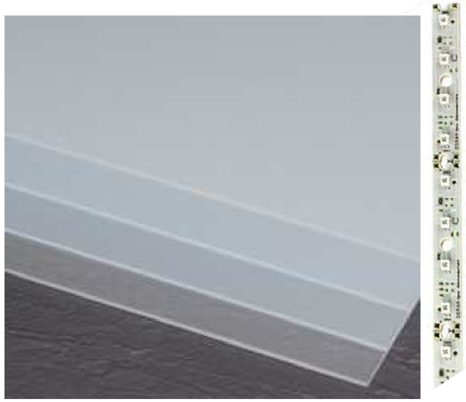
The interest for lightening windows is growing in the recent years, but suitable technologies are not yet consolidated.
Innovative smart lighting windows can transform buildings and lighting in offices and houses, as indicated also at the following link:
https://ec.europa.eu/info/business-economy-euro-0/small-business-success-stories/smart-window-lighting-way-success_en

→ The patented SAES technology promises to be a breaktrought to realize efficient, transparent and uniform lightening windows

Other competitive, not satisfactory technologies:

Transparent OLEDs:
small dimensions, high costs

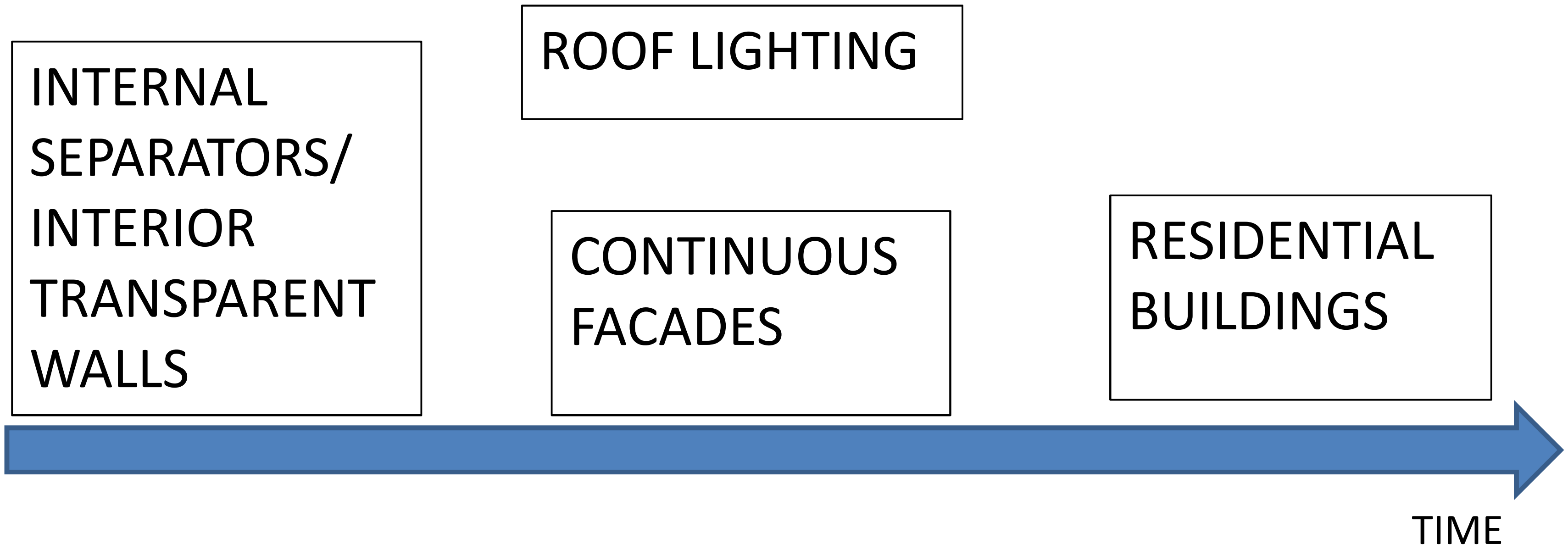
Colored/ opaque Light Panels:
low transparency, low efficiency



Design Lamps:
no transparency

Applications

Possible Evolution of the final applications



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Ocean Tomo assists clients – corporations, law firms, governments and institutional investors – in realizing Intellectual Capital Equity® value broadly defined.

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