[0033] The examination of two types of rays that can propagate in a perfectly symmetrical cylindrical light guide may assist in understanding how the non-circular core fiber 302 of the present invention can provide a “top hat” core irradiance distribution in the fiber core 350. It is possible for light to propagate forward as “skew rays” that spiral around the outer edge of the fiber core 350 without ever crossing through the center portion of the fiber core 350. This is depicted in FIG. 30 which shows a vertical cross-sectional view of a circular shaped core fiber 301 where the projected path of a propagating skew ray 366 that always stays near the edge of the fiber core 351. It is also possible to have meridional rays 368 with paths that lie on a plane so that rays that start on the central axis of the light guide always cross back though the central axis of the fiber core 351. In comparison and referring to FIG. 29, which shows a vertical cross-sectional view of a square shaped non-circular core fiber 302 with the projected path of similar propagating rays. The skew ray 370 still propagates without crossing the central axis of the fiber core 350, but now its path is such that its energy can at some locations be found near the edges of the fiber core 350 while in other locations it can be found closer the center of the fiber core 350. A meridional ray 372 that starts on the central axis of the fiber core 350 can have a path that samples much of the area of the fiber core 350 without ever crossing the axis again. These two examples demonstrate how introducing a large set of rays with a range of different launch angles into a non-circular core fiber 302 can yield a “top hat” core irradiance distribution after a short propagation length that corresponds to only a few internal reflections.

[0034] Our study indicates that replacing the non-circular core fiber 302 shown in FIG. 14 with any of the above-discussed different embodiments of the non-circular core fiber 302 would still allow the device 300 to provide the desired “top hat” core irradiance distribution (e.g., FIGS. 13-18). For example, the fiber core 350 of FIG. 13 is same as the fiber core 350 shown in FIG. 14. They both are constructed out of PMMA with a hexagonal geometry in a circumscribed ø660 μm diameter circle.

The non-circular core fiber 302 of FIG. 13 differs from the core fiber of FIG. 14

elliptical or spherical) centered on radius around the central axis of the fiber core 350 at 60º increments as shown in FIG. 21 and distributed down a predetermined longitudinal length of the fiber core 350 in linear, nonlinear, spiral pattern, or pseudo random pattern; and (iv) a pair of parallel cylinders 361 where each cylinder of a pair are located at a predetermined distance from the central axis of the fiber core 350, with subsequent pairs of cylinders that are located at different longitudinal locations along the length of the light diffusing section 308 are oriented at different angles around the central axis of the fiber core 350, (e.g. the pair of parallel cylinders 363 are located at a different cross section of the fiber and are clocked at 60º relative to the pair 361). Please note that while the embodiments discussed herein use 60º increments, other predetermined patterns such may also be suitable such as, without limitations, 45º, 72º, 90º, 120º, 180º increments.

[0043] Each scattering feature 362 can be created by a suitable art-disclosed laser. For example, a focused, mode-locked 532 nm 10 pico-second laser pulse at 1.5 Watts average power can create the features 362 shown in FIG. 10, which is comprised of three cylinders, each approximately 27 μm in diameter and 270 μm in length oriented around the central axis of the fiber core 350 at 60º increments. In another example, a series of 520 nm 400 femto-second laser pulses at 2.0 Watts average power focused through an objective lens with a numerical aperture of 0.4 can create the features 362 shown in FIG. 43 (discussed in more details below), each feature a sphere approximately 40 um in diameter centered around the central axis of the fiber core 350 at increments of 60º. Please note that while the embodiments discussed herein use 60º increments, other degree increments are also suitable such as 45º, 72º, 90º, 120º, 180º, etc.

[0044] The scattering characteristics of each of the features 362 are varied by material, geometry and processing. The proportion of light scattered per length or per feature 362 must increase as the density of light per length in the light diffusing section 308 decreases due to light being scattered out of the non-circular core fiber 302. This can be achieved by changing the number of

CLAIMS

1. A diffuser light blocking device comprising an end cap member having a length, a diameter, and a pocketing feature wherein:
   a. the diffuser light block device is designed to engage with a light diffuser having a distal portion having an exterior shape and a distal end surface;
   b. the pocketing feature includes a side wall and an end reflective surface;
   c. shape of the pocketing feature corresponds to the exterior shape of the distal portion of the diffuser;
   d. the pocketing features engages the distal portion;
   e. an overlapping section of the side wall of the pocketing feature surrounds side wall of the distal portion and prevents at least 95% of light output from the distal portion from escaping out of the side wall of the distal portion;
   f. the end reflective surface blocks any forward propagating light output from the distal end surface and returns at least 80% of light coming out of the distal end surface back towards the diffuser;
   g. the end cap member is thermally conductive allowing heat generated by absorption of the light output from the distal portion to be dispersed throughout the end cap member;
   h. the length and the diameter of the end cap member provide an exterior surface area that is at least 1,000% of surface area of distal end surface; and
   i. the diffuser light blocking device reduces creation of a diffuser irradiance hot spot.

2. The device of claim 1 wherein a void exists between the distal end surface and the end reflective surface.

3. The device of claim 2 wherein the void is filled with a compound that matches

refractive index of the diffuser material.

4. The device of claim 2 wherein the void is filled with titanium oxide filled epoxy.

5. The device of claim 2 wherein a compound is used to fill the void and the compound has a characteristic selected from the group consisting of adhesiveness, light scattering, and a combination thereof.

6. The device of claim 1 wherein the overlapping section of the side wall of the pocketing feature prevents at least 98% of the light output from the distal portion from escaping out of the side wall of the distal portion.

7. The device of claim 1 wherein the end cap member is constructed out of aluminum.

8. The device of claim 1 wherein the end cap member is biocompatible.

9. The device of claim 1 wherein the end cap member is comprised of a sleeve and a rod wherein: (i) the rod is inserted into the sleeve; (ii) the sleeve provides the side wall of the pocketing feature including the overlapping section and the rod provides the end reflective surface of the pocketing feature.

10. The device of claim 1 wherein the end reflective surface return at least 98% of the light coming out of the distal end surface back towards the diffuser.

11. The device of claim 1 wherein the end cap member returns at least 80% of light output from the distal portion.

12. The device of claim 1 wherein the end cap member returns at least 90% of light output from the distal portion.

13. The device of claim 1 wherein the end cap member returns at least 98% of the light output from the distal portion.

14. The device of claim 1 wherein the exterior surface area of the end cap member ranges from 1,000% to 2,000% of the surface area of the distal end surface.

15. The device of claim 1 wherein the exterior surface area of the end cap member ranges from 1,500% to 2,000% of the surface area of the distal end surface.

16. The device of claim 1 wherein the exterior surface area of the end cap member ranges from 1,700% to 1,900% of the surface area of the distal end surface.

17. A diffuser light blocking device comprising an end cap member having a length, a diameter, and a pocketing feature wherein:
    a. the diffuser light block device is designed to engage with a light diffuser having a distal portion having an exterior shape and a distal end surface;
    b. the pocketing feature includes a side wall and an end reflective surface;
    c. shape of the pocketing feature corresponds to the exterior shape of the distal portion of the diffuser;
    d. the pocketing features engages the distal portion;
    e. an overlapping section of the side wall of the pocketing feature surrounds side wall of the distal portion and prevents at least 95% of light output from the distal portion from escaping out of the side wall of the distal portion;
    f. the end reflective surface blocks any forward propagating light output from the distal end surface and returns at least 90% of light coming out of the distal end surface back towards the diffuser;
    g. the end cap member is thermally conductive allowing heat generated by absorption of the light output from the distal portion to be dispersed

throughout the end cap member;

h. the length and the diameter of the end cap member provide an exterior surface area is from 1,700% to 1,900% of surface area of distal end surface;
i. the diffuser light blocking device reduces creation of a diffuser irradiance hot spot; and
j. a void exists between the distal end surface and the end reflective surface.

18. A cylindrical light diffusing device comprising: a fiber having a non-circular fiber core and a diffuser light blocking device wherein:
    a. the non-circular fiber core provides a “top hat” core irradiance distribution and has a latitudinal cross-sectional shape of a regular polygon;
    b. a light diffusing section having a diffusing proximal end surface, a diffusing distal end surface, and internal scattering features distributed within the fiber core of the light diffusing section along central axis of the fiber core, wherein the light diffusion section provides a “top hat” diffusing irradiance distribution, thereby limiting the variation of radially emitted irradiance longitudinally from the light diffusing section to be within +/- 15% of the average (“I_0”) optical irradiance;
    c. the light diffusing section further includes a distal portion having an exterior shape and the distal portion includes the diffusing distal end surface;
    d. the diffuser light blocking device is comprised of an end cap member having a length, a diameter, and a pocketing feature wherein:
        i) the pocketing feature includes a side wall and an end reflective surface;
        ii) shape of the pocketing feature corresponds to the exterior shape of the distal portion of the light diffusing section;
        iii) the pocketing features engages the distal portion;

iv) an overlapping section of the side wall of the pocketing feature surrounds side wall of the distal portion and prevents at least 95% of light output from the distal portion from escaping out of the side wall of the distal portion;

v) the end reflective surface blocks any forward propagating light output from the diffusing distal end surface and returns at least 80% of light coming out of the diffusing distal end surface back towards the diffusing section;

vi) the end cap member is thermally conductive allowing heat generated by absorption of the light output from the distal portion to be dispersed throughout the end cap member;

vii) the length and the diameter of the end cap member provide an exterior surface area that is at least 1,000% of surface area of diffusing distal end surface; and

viii) the diffuser light blocking device reduces creation of a diffuser irradiance hot spot.

19. The device of Claim 18 wherein the regular polygon is a hexagon.

20. The device of Claim 18 wherein the light diffusing section ranges from 10 mm to 40 mm.