APPARATUS WITH EMBEDDED LIGHT GUIDING ELEMENT AND METHODS OF MANUFACTURING THE SAME

TECHNICAL FIELD

[0001] Embodiments of the invention relate to a light guide apparatus and, in particular, to a light guide apparatus with embedded light guiding element and methods for manufacturing such an apparatus.

BACKGROUND

[0002] Fixtures, such as wall panels and display shelves, are typically illuminated by an artificial light source (e.g. lamps and spotlights) to provide practical or aesthetic effects. It is also common to mount lamps or spotlights within the panels and shelves to provide lighting over the surfaces.

[0003] EP 1,532,325 B1 describes a building block made of cast material (e.g. concrete) with embedded light transmitting fibers. The fibers are arranged parallel to each other, and the two ends of the fibers terminate at opposite lateral surfaces of the building block. A light source can be positioned behind one of the lateral surfaces and the light is transmitted by the fibers to the opposite lateral surface. However, if the lateral surfaces are large, it would require a large light source to emit sufficient light to all the fibers in the building block.

SUMMARY

[0004] According to one embodiment of the invention, a light guide apparatus comprises a block and at least one light guiding element embedded in the block. The light guiding element extends from a first (e.g. top) surface of the block to a second non-opposing (e.g. side) surface of the block. The light guiding element has a first end disposed at the first surface of the block and a second end disposed at the second surface of the block. The light guiding element is operable to guide light from its second end towards its first end.

[0005] According to another embodiment of the invention, a plurality of light guiding elements are embedded in a block and are arranged to guide light between a first surface of the block and a second surface of the block. Each of the light guiding elements includes a first end and a second end. The first ends of the light guiding elements are spread or distributed across the first surface of the block. The second ends are bundled together at the second surface of the block. The bundled second ends of the light guiding elements facilitate the use of smaller and more compact light sources, such as slim fluorescent or light emitting diodes. Using a smaller light source further provides an advantage of reduced power consumption. The first and second surfaces may be non-opposing surfaces or opposing surfaces.

[0006] According to yet another embodiment of the invention, a method of fabricating a light guide apparatus comprises providing a molding tray and a plurality of light guiding elements. The first ends of the plurality of light guiding elements are secured to the base of the molding tray or secured in place relative to the molding tray. The second ends of the plurality of the light guiding elements are secured to the sidewall of the molding tray. Next, a molten material is supplied to the molding tray. The molten material is then cured or allowed to dry to form a block comprising the light guiding elements embedded therein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments of the invention will be readily understood by the following detailed description in conjunction with the accompanying drawings.

[0008] Figure 1 illustrates a three-dimensional perspective view of the light guide apparatus in accordance with one embodiment of the invention.

[0009] Figure 2 illustrates a top view of the light guide apparatus shown in Figure 1.

[0010] Figure 3 illustrates a side view of the light guide apparatus shown in Figure 1.

[0011] Figure 4 illustrates a cross-sectional view of the light guide apparatus along line A-A in Figure 1.

[0012] Figure 5 illustrates a three-dimensional perspective view of the light guide apparatus used as display shelves in accordance with one embodiment of the invention.

[0013] Figure 6 illustrates a cross-sectional side view of a display shelf shown in Figure 5.

[0014] Figures 7A – 7F illustrate a method of fabricating a light guide apparatus in accordance with one embodiment of the invention.

[0015] Figures 8A – 8C illustrate a method of fabricating a light guide apparatus in accordance with another embodiment of the invention.

DETAILED DESCRIPTION

[0016] In the following description, numerous specific details are set forth in order to provide a thorough understanding of various illustrative embodiments of the invention. It will be understood, however, to one skilled in the art, that embodiments of the invention may be practiced without some or all of these specific details. In other

instances, well known process operations have not been described in detail in order not to necessarily obscure pertinent aspects of embodiments being described.

[0017] Embodiments of the invention describe a light guide apparatus and its methods of fabrication. The light guide apparatus comprises a block and at least one light guiding element embedded in the block. In one embodiment, the light guiding element extends from the top surface of the block to the side surface of the block (or non-opposing surfaces of the block) so as to guide light between the side surface of the block and the top surface of the block. The light guiding element has a first end at the top surface of the block and a second end at the side surface of the block, and is operable to guide light incident on the second end towards the first end.

[0018] In another embodiment, multiple light guiding elements are embedded in the block and are arranged to guide light between a first surface and a second surface of the block. The first ends of the light guiding elements are spread or distributed across the first surface of the block while the second ends are bundled or grouped together at the second surface of the block. In the following description and appended drawings, non-opposing first and second surfaces (e.g. top and side surfaces) are described for illustration. However, it is to be appreciated that the first and second surfaces may be opposing (e.g. top and bottom surfaces) in certain other embodiments.

[0019] Figure 1 illustrates a three-dimensional perspective view of a light guide apparatus in accordance with one embodiment of the invention. In an embodiment of the invention, the light guide apparatus 10 comprises a block 100 and a plurality of light guiding elements 200 embedded in the block 100. Figures 2 and 3 illustrate the respective top plan view and side view of the light guide apparatus 10. In one embodiment, the block 100 has a top surface 110, a bottom surface 120 and side surfaces 130, 140, 150, 160 extending from the top surface 110 to the bottom surface 120. Although Figure 1 shows the block 100 having a cuboid shape, it is to be appreciated

that the block 100 can be fabricated in other geometrical or non-geometrical forms, e.g. cylindrical shape.

[0020] The block 100 is made from a relatively opaque material such that light incident on the side surface 130 are mostly or fully transmitted through the light guiding elements 200. In one embodiment, the block 100 can be made from a sufficiently rigid material so that it can also serve as a load-bearing object. For example, the block 100 may include a material such as but not limited to polyester resin, acrylic, and concrete. If a material having high compressive strength is used for the block 100, load bearing applications can be implemented without adverse effects on the plurality of light guiding elements 200. In a specific embodiment, the block 100 has dimensions of around 3000mm (length) x 900mm (width) x 12mm (height). It is to be appreciated that the dimensions of the block 100 can be adjusted according to its application. In one embodiment, the block 100 is coated with a layer of ultra-violet (UV) retardant chemical, which provides UV protection and resistance to chemicals and solvents, and therefore would be suitable for outdoor applications.

[0021] Figure 4 illustrates a cross-sectional view of the block 100 along line A-A in Figure 1. In an embodiment of the invention, the plurality of light guiding elements 200 extend from the side surface 130 of the block 100 to the top surface 110 so as to guide light from the side surface 130 to the top surface 110. Each of the light guiding elements 200 has a first end 201 disposed at the top surface 110 of the block 100, and a second end 202 disposed at the side surface 130 of the block 100. In one embodiment, the first ends 201 of the light guiding elements 200 are substantially flushed or coplanar with the top surface 110 of the block 100. In another embodiment, the second ends 202 of the light guiding elements 200 are substantially flushed or co-planar with the side surface 130. The plurality of light guiding elements 200 are operable to guide light from their respective second end 202 towards the first end 201.

[0022] In one embodiment, the first ends 201 of the plurality of light guiding elements 200 are distributed or spread across the top surface 110 while the second ends 202 are bundled together at the side surface 130. The first ends 201 can be disposed in a matrix arrangement at the top surface 110 as shown in Figure 1, or randomly distributed across the top surface 110 (Figure 5). The second ends 202 of the plurality of light guiding elements 200 can be bundled into separate groups as shown in Figure 3. In an alternative embodiment, the second ends 202 are bundled together at the bottom surface 120 of the block 100.

[0023] In one embodiment, the plurality of light guiding elements 200 are optical fibers. The optical fibers can be made from a transparent thermoplastic material such as but not limited to poly(methyl methacrylate) (PMMA) and perfluorinated PMMA. Alternatively, the optical fiber may have a core surrounded by a fluorinated PMMA cladding. In another embodiment, the plurality of light guiding elements 200 are made of glass material.

[0024] It can be appreciated that the number of light guiding elements 200 in the block 100 can range from only one to a few thousands. In one embodiment, the proportion of the light guiding elements 200 is around 3% to 4% of the total volume of the block 100. The light guiding elements 200 are embedded in the block 100 and they are integral to the block 100. Hence, the block 100 and the light guiding elements 200 constitute a homogeneous structure.

[0025] The light guide apparatus 10 can be applied in various indoor and outdoor applications including, but not limited to, table tops, counter tops, building walls, wall panels, display stands or shelves, cabinets, parts of a showcase, and decorative applications. Figure 5 illustrates the light guide apparatus 10 used as display shelves in accordance with one embodiment of the invention. The light guide apparatus 10 are mounted to a wall 30 and supported by brackets 40.

[0026] Figure 6 illustrates a cross-sectional side view of a display shelf shown in Figure 5. In one embodiment, a light source 60 is positioned at the side surface 130 of the block 100 for emitting light to the plurality of light guiding elements 200. In particular, the light source 60 is substantially aligned to the second ends 202 of light guiding elements 200 so as to transmit light to the second ends 202. Each of the plurality of light guiding elements 200 is capable of guiding light incident on its second end 202 towards its first end 201. The light source 60 can be recessed within the wall 30. The light source 60 can be any form of artificial light source such as but not limited to fluorescent lamps (e.g. T5 slim fluorescent) and light emitting diodes (LEDs). By bundling the second ends 202 together, it enables the use of small or compact light sources to transmit light to the plurality of light guiding elements 200, which significantly reduces power consumption while ensuring that sufficient light is transmitted to the first ends 201 of the light guiding elements 200. For example, three individual LEDs 60 (represented as dashed lines in Figure 3) can be positioned over the second ends 202. In one embodiment, the three LEDs 60 can be individually controllable to turn on/off so that light is selectively emitted to the bundled second ends 202.

[0027] As apparent from the above description and appended drawings, embodiments of the invention provide an aesthetically pleasing light guide apparatus that may be integrated or formed with various fixtures indoors or outdoors. Particularly, the above-described arrangements allow discrete placement of one or more light sources to prevent visual detection of the light source(s). As illustrated in Figures 5 and 6, the light source(s) may be recessed within a wall or hidden from view (in other embodiments) for improved aesthetic appeal.

[0028] Further, since compact light source(s) may be used, power consumption and heat emission from the compact light source(s) are reduced. Even with the use of compact light source(s), the light guide apparatus is capable of transmitting light from a

point source (having a smaller surface area) and distributing light to various parts (having a larger aggregate surface area) over a block of material. This would increase illumination efficiency of the light guide apparatus. Consequently, objects placed upon the light guide apparatus may not require additional illumination from other or external light sources; therefore, heat emission and other problems associated with these other or external light sources can be eliminated.

[0029] Figures 7A – 7F illustrate a method of fabricating the light guide apparatus 10. In an embodiment of the invention, the method begins with providing a molding tray 700 having a base 710 and sidewalls 720, 730, 740, 750 (Figure 7A). The molding tray 700 can be made from materials, such as but not limited to stainless steel. In one embodiment, the size of the molding tray is about 3000mm (length) x 900mm (width).

[0030] Next, the first ends 201 of the plurality of light guiding elements 200 are secured to the base 710 of the molding tray 700, or secured in place relative to the molding tray 700 to prevent undesirable repositioning or slipping of the light guiding elements 200 relative to the molding tray 700. In an embodiment of the invention, the base 710 of the molding tray 700 includes a plurality of openings 711 as shown in Figure 7A. Each of the openings 711 has a diameter size larger than the light guiding element 200 to allow the light guiding element 200 to be inserted through it. For example, the light guiding element 200 has a diameter of around 0.75 mm, and the opening 711 has a diameter of around 1.00 mm. The first ends 201 of the light guiding elements 200 are inserted through the plurality of openings 711 as shown in Figure 7B. In one embodiment, the portions of the first ends 201 extended below the base 710 may be enlarged by melting the first ends 201 to form a knob (not shown) or tying the first ends 201 to form a knot (not shown). The enlarged first ends 201 would be prevented from slipping through the plurality of openings 711 and would be secured to the base 710 of

the molding tray 700. Alternatively, the first ends 201 may be enlarged by attaching a clip to each of the first ends 201 to prevent the first ends 201 from slipping through the openings 711. Alternatively, the first ends 201 can be secured in place relative to the molding tray 700 by other means, such as a fastener.

[0031] Next, the seconds ends 202 of the plurality of light guiding elements 200 are secured to the sidewall 720 of the molding tray 700. In one embodiment, the sidewall 720 has a plurality of sidewall openings 721. If the plurality of light guiding elements 200 use optical fibers, the optical fibers have sufficient flexibility to be bent and then bundled at the sidewall openings 721 as shown in Figure 7C. In one embodiment, the second ends 202 can be secured to the sidewall 720 by using a fastener. It is to be appreciated that the second ends 202 of the plurality of light guiding elements 200 may be secured to the sidewall 720 either before or after the first ends 201 are secured to the molding tray 700.

[0032] Subsequently, a molten material 800 is supplied to the molding tray 700 as shown in Figure 7D. The molten material 800 is selected with an operating temperature less than the melting point of the plurality of light guiding elements 200 so that it does not damage the light guiding elements 200. For example, the molten material 800 may be a polyester resin composite material having a molten operating temperature of around 70 – 80 degrees Celsius (°C), and the light guiding elements 200 include PMMA optical fibers having a melting temperature of around 150 – 180 degrees Celsius (°C). In one embodiment, the molten material 800 is supplied to the molding tray 700 such that it covers the entire length of the plurality of light guiding elements 200. The supply of the molten material 800 can be done in a single step or multiple steps. Alternatively, other techniques such as injection molding can be used to supply the molten material 800 to the molding tray 700.

[0033] The molten material 800 is then allowed to harden to form the block 100 of the light guide apparatus 10 comprising the light guiding elements 200 embedded therein. In one embodiment, the molten material 800 in the molding tray 700 can be placed in a drying oven/chamber to cure the molten material 800.

[0034] Next, the hardened molten material forming the block 100 is removed from the molding tray 700 as shown in Figure 7E. In one embodiment, high-pressure air is injected between the sidewalls 720, 730, 740, 750 of the molding tray 700 and the block 100 to facilitate the removal of the block 100 from the molding tray 700. Then, a grinding or polishing step is performed on the block 100 as shown in Figure 7F in accordance with one embodiment of the invention. The polishing step can be performed by using any polishing techniques, such as but not limited to a polishing conveyor machine 900 (Figure 7F). In one embodiment, the block 100 is polished until the ends 201/202 of the plurality of light guiding elements 200 are substantially flushed with the respective surfaces of the block 100.

[0035] Figures 8A – 8C illustrate another method of fabricating the light guide apparatus 10. The method begins with providing a molding tray 701 (Figure 8A) that may be similar to the molding tray 700 shown in Figure 7A but without any sidewall openings. A strip holder 600 having a plurality of openings 610 is provided to secure the second ends 202 of the plurality of light guiding elements 200. In one embodiment, the strip holder 600 can be made of a stainless steel material. In one embodiment, the plurality of light guide elements 200 are trimmed to the desired length before they are secured to the strip holder 600.

[0036] Next, the first ends 201 of the plurality of light guiding elements 200 are secured in place relative to the molding tray 701 as shown in Figure 8B. In one embodiment, the first ends 201 are secured to the base 710 using similar methods described in relation to Figure 7B. The second ends 202 of the light guiding elements

200 are bundled and secured to the strip holder 600. Then, the strip holder 600 is mounted to or disposed at the sidewall 720 of the molding tray 701 as shown in Figure 8C. Subsequently, a molten material 800 is supplied to the molding tray 701, and then allowed to harden to form the block 100 before the block 100 is removed for polishing, which may be similar to the processes described in Figures 7D, 7E and 7F.

[0037] Several embodiments of the invention have thus been described. However, those ordinarily skilled in the art will recognize that the invention is not limited to the embodiments described, but can be practiced with modification and alteration within the spirit and scope of the appended claims that follow.

WHAT IS CLAIMED IS:

1. A light guide apparatus comprising:

a block; and

a plurality of light guiding elements embedded in the block and arranged to guide light between a first surface and a second surface of the block, each of the plurality of light guiding elements having a first end and a second end,

wherein the first ends of the plurality of light guiding elements are distributed across the first surface of the block,

wherein the second ends of the plurality of light guiding elements are bundled at the second surface of the block, and

wherein each of the plurality of light guiding element is operable to guide light from the second end to the first end.

2. The light guide apparatus of claim 1, wherein the first surface and the second surface of the block are non-opposing.

3. The light guide apparatus of claim 1, wherein the block includes a material selected from the group consisting of a polyester resin composite material, an acrylic material and a concrete material.

4. The light guide apparatus of claim 1, wherein the plurality of light guiding elements include optical fibers.

5. The light guide apparatus of claim 4, wherein the plurality of light guiding elements include a poly(methyl methacrylate) (PMMA) or a perfluorinated PMMA.

6. The light guide apparatus of claim 1, further comprising a light source coupled to the second surface of the block for emitting light to the second ends of the plurality of light guiding elements.

7. The light guide apparatus of claim 6, wherein the light source is selected from the group consisting of fluorescent lamp and light emitting diode (LED).

8. A method of fabricating a light guide apparatus, the method comprising:

providing a molding tray having a base and at least one sidewall;

providing a plurality of light guiding elements, each of the plurality of light guiding elements having a first end and a second end;

securing the first ends of the plurality of light guiding elements in place relative to the molding tray;

securing the second ends of the plurality of light guiding elements to the at least one sidewall of the molding tray;

supplying a molten material to the molding tray; and

curing the molten material to form a block with the plurality of light guiding elements embedded therein.

9. The method of claim 8, wherein securing the first ends of the plurality of light guiding elements in place relative to the molding tray including:

inserting the first ends of the plurality of light guiding elements through a plurality of openings at the base of the molding tray; and

enlarging each of the first ends for preventing the first ends from slipping through the plurality of openings.

10. The method of claim 8, wherein securing the second ends of the plurality of light guiding elements to the at least one sidewall of the molding tray including:

bundling the second ends at a plurality of sidewall openings at the at least one sidewall of the molding tray.

11. The method of claim 8, wherein securing the second ends of the plurality of light guiding elements to the at least one sidewall of the molding tray including:

providing a strip holder having a plurality of openings;

bundling and securing the second ends of the plurality of light guiding elements to the plurality of openings of the strip holder; and

mounting the strip holder to the at least one sidewall of the molding tray.

12. The method of claim 8, wherein the molten material includes a material selected from the group consisting of a polyester resin composite material, an acrylic material and a concrete material.

13. The method of claim 8, wherein the plurality of light guiding elements include optical fibers.

14. A light guide apparatus comprising:

a block; and

at least one light guiding element embedded in the block and extending from a first surface of the block to a second non-opposing surface of the block, wherein the at least one light guiding element having

a first end disposed at the first surface of the block, and

a second end disposed at the second surface of the block, and

wherein the at least one light guiding element is operable to guide light from the second end towards the first end.

15. The light guide apparatus of claim 14, wherein the first end is substantially flushed with the first surface of the block.

16. The light guide apparatus of claim 14, wherein the second end is substantially flushed with the second surface of the block.

17. The light guide apparatus of claim 14, wherein the block includes a material selected from the group consisting of a polyester resin composite material, an acrylic material and a concrete material.

18. The light guide apparatus of claim 14, wherein the light guiding element includes an optical fiber.

19. The light guide apparatus of claim 18, wherein the light guiding element includes a poly(methyl methacrylate) (PMMA) or a perfluorinated PMMA.

20. The light guide apparatus of claim 14, further comprising a light source coupled to the second surface of the block for emitting light to the second end of the at least one light guiding element.

21. The light guide apparatus of claim 20, wherein the light source is selected from the group consisting of fluorescent lamp and light emitting diode (LED).