

## **METHOD OF PRODUCING A PANEL HAVING AN AREA WITH LIGHT TRANSMISSIVITY**

### **CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit under 35 U.S.C. §119(e) of U.S. provisional application nos. 60/810,380, filed June 2, 2006, and 60/852,592, filed October 18, 2006, each of which is incorporated herein in its entirety by reference. This application is related to U.S. patent application 11/742,862, filed May 1, 2007.

### **FIELD OF THE DISCLOSURE**

[0002] The field of the technical subject matter relates to a process for thinning a panel prior to drilling and/or structurally reinforcing a thinned panel having a via pattern after drilling.

### **BACKGROUND**

[0003] Projecting a light through a housing or panel to provide information is commonplace. Examples include but are not limited to computer keyboards that include indication lights for functions such as “Caps Lock” or “Num Lock”; computer monitors that include an “on/off” light, automobiles that include lights to indicate whether heated seats are on or off, or whether an air bag is on or off; televisions with indicator lights, and a whole host of other consumer electronics.

[0004] A common way to provide for such lighting is to provide a projecting light that is visible when the light is off, and brightly lit to indicate when it is on. A collection of lights, or holes for lights, may be disruptive to the objectives of an industrial designer.

### **SUMMARY**

[0005] Disclosed are methods for improving light transmission and laser drill throughput by thinning a panel without substantially reducing the strength and durability of the panel having through-hole vias (e.g., microscopic through holes).

[0006] One method of filling a via in a panel with an optically transmissive material taught herein comprises forming a pocket in the panel where the pocket has a second thickness. The second thickness is less than the first thickness of the panel. The method in

this example further includes drilling at least one via in the pocket and filling the via with an optically transmissive material.

[0007] A method of producing an area of light transmissivity in a portion of a generally opaque panel comprises the steps of forming an area of reduced thickness in the panel, the reduced thickness defining a drilling surface opposite a substrate exit surface adapted to be visible to a user; using a laser, sequentially drilling a pattern of microscopic through holes in the reduced thickness area extending from the drilling surface through to the exit surface to define the area of light transmissivity; and, thereafter, substantially filling the through holes with a light transmissive material, the filling material extending substantially from the drilling surface through to the exit surface.

[0008] Another method of producing an area of light transmissivity in a portion of a generally opaque panel comprises forming a pocket cavity in the panel, the pocket cavity defining a drilling surface opposite a panel substrate exit surface adapted to be visible to a user; using a laser, sequentially drilling a plurality of microscopic through holes extending from the drilling surface through to the exit surface, each through hole having a larger diameter first opening in the drilling surface and a second opening having a smaller diameter in the exit surface connected by a tapered sidewall; substantially filling the through holes with a light transmissive material, the filling material extending from the drilling surface through to the exit surface, the plurality of filled second openings in the exit surface defining the area of light transmissivity; and at least partially filling the cavity pocket with a light transmissive reinforcing material.

[0009] Details of these aspects, and other inventive features of the disclosure are discussed below with reference to the drawing figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0011] FIG. 1 is a schematic representation of a via geometry and the micrographs of the array of vias taken from the back or drill surface in FIG. 1A and from the front or exit surface in FIG. 1B;

[0012] FIG. 2 is a schematic representation of an application where the vias are drilled through a panel having a standard thickness of about 400 $\mu$ m;

[0013] FIG. 3 is a schematic representation of an application where the vias are drilled through a panel having a thinner thickness of about 100 $\mu$ m;

[0014] FIG. 4 is a schematic representation of an application where the vias are drilled inside a thinned pocket area of a panel;

[0015] FIG. 5 is a schematic representation of the sequence of method steps of a panel having a thinned pocket area reinforced by a solid reinforcing material; and

[0016] FIG. 6 is a schematic representation of the sequence of method steps of a panel having a thinned pocket area reinforced by a liquid reinforcing material.

#### DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0017] A thinned panel having through-hole vias (also called micro-vias herein due to their relatively small size) made according to methods taught herein is shown in FIG. 1. The panel can be thinned using standard machining or the panel can be provided having a section including a reduced thickness. The panel may incorporate a micro-via pattern array 10 in a panel surface as shown in FIG. 2. After a micro-via pattern array 10 is drilled in the panel 12, a transparent or translucent material filler 32 may be applied to the drilled micro-vias. Then, a material having transparent or translucent and strengthening properties can be applied to the drilled micro-via substrate surface to reinforce the strength of the thinned panel as shown in FIGS. 3 and 4. The reinforcing material 36 could either be a solid that is bonded to the drilled surface or a liquid or viscous substance that cures to form a solid. The reinforcing material may also be used to color, diffuse, or apply lens effects or other artistic lighting effects in applications where lighted patterns are intended to be created with the micro-vias.

[0018] Referring to FIGS. 3-6 a method for reinforcing a thin panel 12 having via 10 with a light transmissive material and a product made from using the method is shown and described below. The method and steps for structurally reinforcing a thin substrate having via with light transmissive material is illustrated in FIGS. 5 and 6. A panel or substrate 12 is provided. Panel 12 is a relatively thin continuous sheet of material such as anodized aluminum. Panel 12 includes a first or drill surface 14 and an opposing second or exit surface 18 defining a panel thickness 20. When the panel or substrate is aluminum, the panel 12 should be about 400 micrometers ( $\mu$ m) thick in order for the panel 12 to retain its structural integrity after the via array 10 has been drilled in the panel drill surface 14. In an example of the present invention, the aluminum panel 12 provided has a thin thickness 20a, that is a

thickness of less than 400 micrometers ( $\mu\text{m}$ ), as shown in FIG. 3. Alternatively, where an aluminum panel 12 having a thickness 20 of about 400 micrometers ( $\mu\text{m}$ ) is provided, a portion of the panel 12 can be thinned on the drill surface 14 to a thinner thickness 20a as shown in FIG. 4.

[0019] In an application where an aluminum panel 12 having a thickness of 400 micrometers ( $\mu\text{m}$ ) is provided, the method includes thinning a pocket area 22 on the drill surface 14 to a thinner thickness 20a of about 100 micrometers ( $\mu\text{m}$ ). As shown in FIG. 4, the thinned pocket area 22 can be machined using a bore or other machined device. The size of the thinned pocket area 22 should be large enough to accommodate the desired via array pattern 10. The thinned pocket area 22 is shown in FIG. 4 as having a circular shape, but it is understood that the thinned pocket area 22 can be of other shapes and configurations. The thinned area 22 of the panel 12 improves light transmission and reduces the laser drill time of the vias.

[0020] In one application of the method shown in FIG. 5, act (referred hereafter as S) 1 includes drilling one or a plurality of micro-vias or holes 24 through the thinned panel 12. As shown in FIG. 1, in one aspect, the vias 24 are conical-shaped having sidewalls 26 and a first opening 28 in panel drill surface 14 and an opposing second opening 30 on panel exit surface 18. First via opening 28 is larger in diameter than second via opening 30. For example where the panel 12 is aluminum, first via opening 28 is approximately 90 - 100 micrometers ( $\mu\text{m}$ ) in diameter and second via opening 30 is approximately 30 - 40 micrometers ( $\mu\text{m}$ ) in diameter, as shown in FIGS. 1A and 1B. It is understood that larger or smaller openings and other via shapes and configurations may be used. The vias 24 in FIGS. 1A and 1B are drilled or machined out of the panel using a laser, such as a diode-pumped solid-state pulsed laser 40 in a circular or spiral pattern.

[0021] Optionally, cleaning the drilled vias 24 to remove any debris or deposits formed during the machining process can be performed. It has been shown that a CO<sub>2</sub> snow jet cleaning and isopropyl are effective in cleaning the vias. Other via cleaning techniques known by those skilled in the art may also be used. Ultrasonic cleaning using, for example, ultrasonic baths may be used. Also, the application of high-pressure air, like the snow jet, may be made from a source movably located in a similar manner to the drill 40 to clean the vias.

[0022] In S2 shown in FIG. 5, the disclosed method can include applying a filler material coating 32 into the vias 24. The filler material 32 may be a visible light transmissive material. The exemplary UV curable filler material 32 is substantially clear when cured. As best seen in FIG. 1, the filler material 32 is applied to the substrate second surface 18 over the top of the second or smaller openings 30 of vias 24, filling the vias 24 as shown in FIG. 5. The filler material 32 as shown is applied with a syringe-type device 34. Although the step of filling the micro-vias is shown in FIG. 5, the method can proceed to S3 without filling the micro-vias with filler material 32.

[0023] Referring to FIG. 5 in S3, a reinforcing material 36 is applied to the thin panel 12. The reinforcing material 36 having transparent or translucent properties is applied to the drilled micro-via panel surface 14 to reinforce the strength of the thinned panel 12. As shown in FIG. 5, the reinforcing material 36 can be a solid preformed and/or pre-cured material having transparent or translucent properties, such as plastic or glass. A solid transparent reinforcing material 36 of the appropriate size is applied to the thin panel as shown in FIG. 3 or to the thinned pocket area 22 of a substrate as shown in FIGS. 4 and 5. The reinforcing material 36 provides the panel 12 with the structural support integrity of a panel having a normal thickness, for aluminum that of 400 micrometers ( $\mu\text{m}$ ).

[0024] If the vias have been filled in S2 and/or if the reinforcing material 36 is not pre-cured, the method may proceed to S4 where preferably a UV clear filler 32 and/or the reinforcing material 36 is then cured by exposing the filler material 32 to UV light through the transparent reinforcing material 36. When cured, the filler material 32 is optically transparent permitting passage of visible light through the filler material 32, the reinforcing material 36, and panel 12 through vias 24. The curing of the UV clear filler material 32 bonds the reinforcing material 36 to the panel 12.

[0025] In another example, the method shown in FIG. 6 includes drilling one or a plurality of micro-vias 24 through the thinned panel 12 in S11. As shown in FIG. 1, the vias 24 are conical-shaped having sidewalls 26 and a first opening 28 in first surface 14 and an opposing second opening 30 on second surface 18 as described above. It is understood that larger or smaller openings and other via shapes and configurations may be used. The drilled vias 24 can be cleaned to remove any debris or deposits formed during the machining process.

[0026] The filler material 32 may be a visible light transmissive material. The exemplary UV curable filler material 32 is substantially clear when cured. Filler material 32 also may have better transmission of audible sound through the filler material 32 than transmission of audible sound through panel 12 thickness 20. As best seen in FIG. 1, the filler material 32 is applied to the panel second surface 18 over the top of the second or smaller openings 30 of vias 24, filling the vias 24 as shown in FIG. 5. The filler material 32 as shown is applied with a syringe-type device 34. Although, the step of filling the micro-vias is shown in FIG. 5, the method can proceed to S3 without filling the micro-vias with filler material 32.

[0027] In S12 shown in FIG. 6, the disclosed method can include applying a liquid filler material coating 32, such as a clear UV curable epoxy, into the vias 24. As shown in FIG. 6, the filler material 32 is applied to the panel second surface 18 over the top of the second or smaller openings 30 of vias 24 with a syringe-type device 34. Other filler material 32 application devices and techniques known by those skilled in the art may be used. For example, a thin material film, rather than a curable liquid filler material, can be applied to the drill surface 12 of the aluminum panel 12, resulting in essentially unfilled vias.

[0028] If a liquid curable filler material 32 is applied to the micro-vias 24, the method proceeds to S13, where the filler material 32 is then cured by exposing the filler material 32 to UV light. Any excess or uncured filler material is removed from the panel 12. If necessary, the method may also include additional curing after the excess filler material is removed by, for example, a simple isopropanol wipe.

[0029] In S14, a reinforcing material 36 is applied to the thinned pocket area 22 of the panel as shown in FIG. 4 and 6. The reinforcing material 36 can be a liquid or viscous material that cures to form a solid material. A liquid transparent reinforcing material, such as a clear epoxy or other reinforcing material provides structural support to the thinned panel area. The reinforcing material 36 as shown is applied with a syringe-type device 38. Other application devices and techniques known by those skilled in the art may be used. The reinforcing material 36, when cured provides the panel with a uniform structural integrity like that of a panel having a conventional thickness.

[0030] The use of vias 24 and an optically transparent reinforcing material 36 and/or filler material 32 produces a smooth and continuous panel surface to the naked eye that is capable of displaying controlled images through the vias from interior illumination. The

resultant panel 12 can be used in all manner of application. The disclosed method and resultant panel is applicable in virtually all applications where a visually continuous and uninterrupted panel surface is desired having the capability to produce illuminated messages, images or other perceptible characteristics for the user.

[0031] For example, the panel 12 of FIGS. 3 and 4 is in the form of a panel. The panel 12 can be incorporated in a conventional housing as previously discussed or can be integral with a housing. When the panel 12, as part of a housing, is back lit with an LED, fluorescent or incandescent light, or other lighting device, the light emitted from the vias forms a pattern visible to the viewer.

[0032] In another example, the panel can be thinned in a small area without application of a reinforcing material to the thinned area. In this example, thinning the small area of the panel should not reduce the structural strength of the panel, obviating the need for a reinforcing material. The size of the thinned area possible in the panel in order maintain the structural integrity of the panel as a whole is dependent on the density of the drilled micro-via array, the strength of the panel material, and/or the shape of the drilled vias, etc.

[0033] While the method has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the method is not to be limited to the disclosed embodiments but, on the contrary, is intended to cover various modifications and equivalent steps and arrangements included within the spirit and scope of the invention and any appended claims.

### Claims

1. A method of producing an area of light transmissivity in a portion of a generally opaque panel comprising the steps of:  
forming an area of reduced thickness in the panel, the reduced thickness defining a drilling surface opposite a substrate exit surface adapted to be visible to a user;  
using a laser, sequentially drilling a pattern of microscopic through holes in the reduced thickness area extending from the drilling surface through to the exit surface to define the area of light transmissivity; and, thereafter,  
substantially filling the through holes with a light transmissive material, the filling material extending substantially from the drilling surface through to the exit surface.
2. The method of claim 1 wherein the material is a curable polymeric material which solidifies upon curing.
3. The method of claim 1 wherein the step of filling in the through holes also includes filling the area of reduced thickness.
4. The method of claim 1 wherein the through holes are substantially conical, the drilled through holes each having a first larger diameter opening and a second smaller diameter opening connected by a tapered sidewall .
5. The method of claim 2 wherein the method further comprises the step of curing the polymeric material by exposure to ultraviolet light.
6. The method of claim 1 wherein the through holes are microscopic so as to be essentially invisible to the naked eye.
7. The method of claim 4 wherein the first larger diameter opening of each drilled conical hole is formed in the drilled surface in the reduced thickness area and the second smaller diameter opening is formed in the exit surface, the exit surface serving as a visible surface of the panel when in use.

8. The method of claim 7 wherein the second smaller diameter openings in the exit surface form the pattern, are individually substantially invisible to the naked eye and define the area of light transmissivity.

9. The method of claim 7 wherein drilling the conical through holes comprises circular or spiral drilling the through holes.

10. The method of claim 1 further comprising:  
applying a reinforcing material to the panel adjacent the reduced area thickness to strengthen the panel.

11. The method of claim 10 wherein the reinforcing material is applied over a portion of the filler material.

12. A method of producing an area of light transmissivity in a portion of a generally opaque panel comprising:

forming a pocket cavity in the panel, the pocket cavity defining a drilling surface opposite a panel substrate exit surface adapted to be visible to a user;

using a laser, sequentially drilling a plurality of microscopic through holes extending from the drilling surface through to the exit surface, each through hole having a larger diameter first opening in the drilling surface and a second opening having a smaller diameter in the exit surface connected by a tapered sidewall;

substantially filling the through holes with a light transmissive material, the filling material extending from the drilling surface through to the exit surface, the plurality of filled second openings in the exit surface defining the area of light transmissivity; and

at least partially filling the cavity pocket with a light transmissive reinforcing material.