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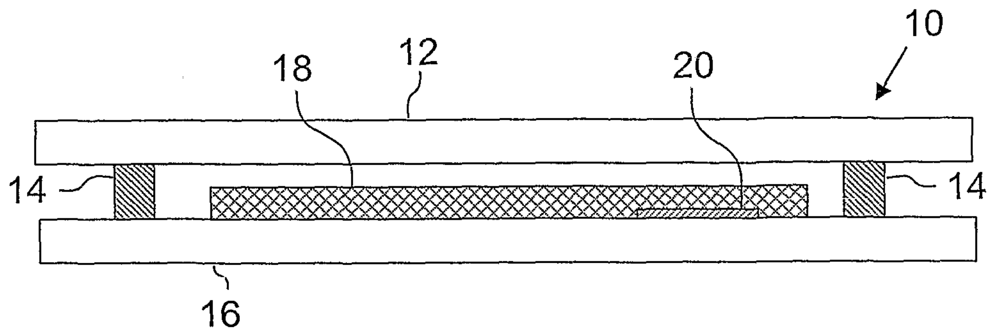
(54) Title: METHOD OF ENCAPSULATING A DISPLAY ELEMENT



(57) Abstract: A method of encapsulating a display device between substrates with a glass frit. The method includes depositing a frit having an optical absorption α which is a function of wavelength onto a first substrate wherein the deposited frit has a height h, placing a second substrate in contact with the frit, sealing together the substrates by traversing a laser light having a wavelength λ over the frit at a speed greater than about 5 mm/s, and wherein α • h at λ is greater than or equal to 0.4.

WO 2007/067403 A2

METHOD OF ENCAPSULATING A DISPLAY ELEMENT

[0001] This application claims the benefit of priority under 35 U.S.C. § 119(e) of U.S. Provisional Application Serial No. 60/748,296 filed on December 6, 2005, the content of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0002] The present invention relates to hermetically sealed glass packages suitable to protect thin film devices which are sensitive to the ambient environment, and more particularly to a method of sealing such devices

TECHNICAL BACKGROUND

[0003] OLEDs have been the subject of considerable research in recent years because of their use and potential use in a wide variety of electroluminescent devices. For instance, a single OLED can be used in a discrete light emitting device or an array of OLEDs can be used in lighting or flat-panel display applications (e.g., OLED displays). OLED flat panel displays in particular are known to be very bright and to have good color contrast and wide viewing angle. It is well known that the life of the OLED display can be significantly increased if the electrodes and organic layers located therein are hermetically sealed from the ambient environment. However, OLED displays, and in particular the electrodes and organic layers located therein, are susceptible to degradation resulting from interaction with oxygen and moisture leaking into the OLED display from the ambient environment. Unfortunately, in the past it has been very difficult to develop a sealing process to hermetically seal the OLED display. Some of the factors that made it difficult to properly seal the OLED display are briefly mentioned below:

- The hermetic seal should provide a barrier for oxygen (10^{-3}cc/m^2/day) and water (10^{-6} g/m^2/day).
- The size of the hermetic seal should be minimal (e.g., <2 mm) so it does not have an adverse effect on size of the OLED display.
- The temperature generated during the sealing process should not damage the materials (e.g., electrodes and organic layers) within the OLED display. For

instance, the first pixels of OLEDs which are located about 1-2mm from the seal in the OLED display should not be heated to more than 100°C during the sealing process.

- The gases released during sealing process should not contaminate the materials within the OLED display.
- The hermetic seal should enable electrical connections (e.g., thin-film chromium electrodes) to enter the OLED display.

[0004] One way to seal the OLED display is to form a hermetic seal by melting a low temperature frit doped with a material that is highly absorbent at a specific wavelength of light. For example, a high power laser may be used to heat and soften the frit which forms a hermetic seal between a cover glass with the frit located thereon and a substrate glass with OLEDs located thereon. The frit is typically ~1mm wide and ~6-100 um thick. If the absorption and thickness of the frit is uniform then sealing can be done at a constant laser energy and translation speed so as to provide a uniform temperature rise at the frit location. However, when the frit is relatively thin, 100% of the laser energy is not absorbed by the frit. For example, some of the laser energy can be absorbed or reflected by metal electrodes that are attached to the OLEDs on the substrate glass. Since it is desirable to use thin frits, and the metal electrodes have different reflectivity and absorption properties as well as different thermal conductivities from the bare substrate glass, this situation can create an uneven temperature distribution within the frit during the sealing process which subsequently can lead to a non-hermetic connection between the cover glass and the substrate glass. In addition, high absorption by the electrodes may result in overheating of, and subsequent damage to, the electrodes. This sealing problem may be solved by using one or more of the sealing techniques of the present invention.

SUMMARY

[0005] Embodiments of the present invention provide a method for sealing together two substrates, such as glass substrates for an OLED display device.

[0006] Briefly described, one embodiment of the method/apparatus/system, among others, can be implemented as described herein.

[0007] In one embodiment, a method for encapsulating a display element is provided comprising depositing a frit having an optical absorption α which is a function of wavelength onto a first substrate wherein the deposited frit has a height h, placing the first substrate on a second substrate with the frit therebetween, sealing together the substrates by traversing a laser light having a wavelength λ over the frit at a speed greater than about 5 mm/s and wherein $\alpha \cdot h$ at λ is greater than or equal to about 0.4, preferably between 0.4 and about 1.75 and more preferably between about 0.5 and 1.3.

[0008] In another embodiment of the invention a method is disclosed comprising depositing a frit having an optical absorption α which is a function of wavelength onto a first substrate in the shape of a frame having a height h, sandwiching the frit between the first substrate and a second substrate, the second substrate having a display element and at least one electrode disposed thereon, the at least one electrode extending between the frit and the second substrate, traversing a laser light having a wavelength λ over a length of the frit through the first substrate at a speed greater than about 5 mm/s to seal together the first and second substrates; and wherein $\alpha \cdot h$ at λ is greater than or equal to about 0.4, preferably between about 0.4 and about 1.75 and more preferably between about 0.5 and 1.3.

[0009] In still another embodiment, a method of encapsulating a display element is provided comprising depositing a frit having an optical absorption α which is a function of wavelength onto a first substrate in the form of a frame having a height h, pre-sintering the frit, placing the first substrate overtop a second substrate having one or more display elements comprising an organic material, and at least one metallic electrode, disposed thereon, such that the display element is positioned within the frame and the at least one electrode passes beneath the frit, heating the frit through the first substrate using a laser light having a peak wavelength λ to form a hermetic seal between the first and second substrates and wherein $\alpha \cdot h$ at λ is greater than or equal to about 0.4, preferably between about 0.4 and about 1.75 and more preferably between about 0.5 and 1.3.

[0010] The invention will be understood more easily and other objects, characteristics, details and advantages thereof will become more clearly apparent in the course of the following explanatory description, which is given, without in any way implying a limitation, with reference to the attached Figures. It is intended that all such additional systems, methods features and advantages be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a cross sectional side view of a display device according to the present invention.

[0012] FIG. 2 is a cross sectional side view of the first substrate and the frit deposited thereon.

[0013] FIG. 3 is a top view of the first substrate of FIG. 2 showing the frit deposited in the shape of a frame.

[0014] FIG. 4 is a top view of the second substrate having a display element and electrodes deposited thereon.

[0015] FIG. 5 is a partial cross sectional view of the display device of FIG. 1 showing the position of the laser and laser beam during the sealing operation.

[0016] FIG. 6 is a diagram showing several methods for sealing the first and second substrates.

Detailed Description

[0017] In the following detailed description, for purposes of explanation and not limitation, example embodiments disclosing specific details are set forth to provide a thorough understanding of the present invention. However, it will be apparent to one having ordinary skill in the art, having had the benefit of the present disclosure, that the present invention may be practiced in other embodiments that depart from the specific details disclosed herein. Moreover, descriptions of well-known devices, methods and materials may be omitted so as not to obscure the description of the present invention. Finally, wherever applicable, like reference numerals refer to like elements.

[0018] Although the sealing techniques of the present invention are described below with respect to manufacturing a hermetically sealed OLED display, it should be understood that the same or similar sealing techniques can be used to seal two glass plates to one another that can be used in a wide variety of applications and device. Accordingly, the sealing techniques of the present invention should not be construed in a limited manner.

[0019] FIG. 1 shows a cross-sectional side view of a hermetically sealed OLED display device in accordance with an embodiment of the present invention, generally designated by reference numeral **10** comprising first substrate **12**, frit **14**, second substrate **16**, at least one OLED element **18** and at least one electrode **20** in electrical contact with the OLED element. Although only a single OLED element is shown for simplicity, display device **10** may have many OLED elements disposed therein. It should be appreciated that another type of thin film device can be deposited besides OLED **18** if an OLED display **10** is not being made but instead another glass package like one used in an optical sensor is going to be made using the sealing technique(s) of the present invention.

[0020] In a preferred embodiment, first substrate **12** is a transparent glass plate like the ones manufactured and sold by Corning Incorporated under the brand names of Code 1737 glass or Eagle 2000™ glass. Alternatively, first substrate **12** can be any transparent glass plates like, for example, the ones manufactured and sold by Asahi Glass Co. (e.g., OA10 glass and OA21 glass), Nippon Electric Glass Co., NHTechno and Samsung Corning Precision Glass Co. Second substrate **16** may be the same glass substrate as first substrate **12**, or second substrate **16** may be a non-transparent substrate.

[0021] As shown in FIG. 2-3, prior to sealing first substrate **12** to second substrate **16**, frit **14** is deposited on first substrate **12**. Frit **14** can be applied to first substrate **12** by screen-printing or by a programmable auger robot which provides a well-shaped pattern on first substrate **12**. For example, frit **14** can be placed approximately 1 mm away from free edges **13** of first substrate **12**. In a preferred embodiment, frit **14** is a low temperature glass frit that has a substantial absorption cross-section at a predetermined wavelength which matches the operating wavelength of a laser used in the sealing process. Frit **14** may, for example, contain one or more absorbing ions chosen from the group including iron, copper, vanadium, neodymium and combinations thereof (for example). Frit **14** may also be doped with a filler (e.g., inversion filler, additive filler) which changes the coefficient of thermal expansion of frit **14** so that it matches or substantially matches the coefficient of thermal expansions of substrates **12** and **16**. Such frits generally have a thermal conductivity greater than about 500 $\mu m^2/s$, and typically about 800 $\mu m^2/s$, but may have a thermal conductivity in excess of 1000 $\mu m^2/s$. For a more detailed description regarding exemplary frit compositions that may be used in this application, reference is made to U.S. Patent Application No. 10/823,331 entitled "Glass Package that is Hermetically Sealed with a Frit and Method of Fabrication", the contents of which are incorporated by reference herein.

[0022] Frit **14** may also be pre-sintered prior to sealing first substrate **12** to second substrate **16**. To accomplish this, frit **14** which was deposited onto first substrate **12** is heated so that it becomes attached to first substrate **12**. Then, first substrate **12** with the frit pattern located thereon can then be placed in a furnace which "fires" frit **14** at a temperature that depends on the composition of the frit. During the pre-sintering phase, frit **14** is heated and organic binder materials contained within the frit are burned out.

[0023] After frit **14** is pre-sintered, it can be ground, if necessary, so that the height variation does not exceed about 2-4μm with a typical target height h which can range from about 10 μm to greater than 30 μm, depending on the application for the device, however more typically height h is about 12-15 μm. If the height variation is larger than about 2-4 μm, the gap may not close when frit **14** melts during sealing to a second substrate, or the gap may introduce stresses which can crack the substrates. Frit **12** height h is an important variable which allows the substrates to be sealed through substrate **12**. If frit **14** is too thin it does not leave enough material to absorb the laser irradiation, resulting in failure. If frit **14** is too thick it will be able to absorb enough energy at the first surface to melt the frit proximate the first surface, but the energy needed to melt the frit proximate the second surface may be prevented from reaching that region of the frit (i.e. proximate secondary substrate **16**) due to the thermal conductivity of the frit. This latter scenario is a rate limiting situation for sealing substrates with a thick frit layer, and may result in poor or spotty bonding of the two glass substrates.

[0024] After the pre-sintered frit **14** is ground, first substrate **12** may go through a mild ultrasonic cleaning environment to remove any debris that has accumulated to this point. The typical solutions used here can be considerably milder than the ones used for cleaning display glass which has no additional deposition. During cleaning, the temperature can be kept lower to avoid degradation of deposited frit **14**.

[0025] After cleaning, a final processing step can be performed to remove residual moisture. The pre-sintered first substrate **12** can be placed in a vacuum oven at a temperature of 100°C for 6 or more hours. After removal from the oven, the pre-sintered first substrate **12** can be placed in a clean room box to deter dust and debris from accumulating on it before performing the sealing process.

[0026] FIG. 3 illustrates second substrate **16**, prior to sealing to first substrate **12**, comprising one or more OLED elements **18** and one or more electrodes **20** for connecting the OLED element to other devices. The typical OLED **18** includes one or more organic layers (not shown) and anode/cathode electrodes **20**. However, it should be readily appreciated by those skilled in the art that any known OLED **18** or future OLED **18** can be used in the OLED display **10**.

[0027] The sealing process includes placing first substrate **12**, including frit **14**, on top of second substrate **16**, with one or more OLEDs **18** and one or more electrodes **20** located on top of the second substrate, in such a manner that frit **14** and OLEDs/electrodes **18** and **20** are sandwiched between the two substrates **12** and **16** separated by frit **14**. Mild pressure can be applied to substrates **12** and **16** to keep them in contact during the sealing process. As shown in the close-up view of a portion of display device **10** depicted in FIG. 5, laser **22** directs its beam **24** on frit **14** through first substrate **12** and heats frit **14** such that frit **14** melts and forms a hermetic seal which connects and bonds substrate **12** to substrate **16**. The hermetic seal also protects OLEDs **18** by preventing oxygen and moisture in the ambient environment from entering into OLED display **10**.

[0028] Laser beam **24** can be defocused, for example, to an approximately 3.5mm spot diameter, to make the temperature gradient within frit **14** more gradual. However, it should be noted that it is desirable that laser beam **24** be wider than the width of frit **14**, thus laser beam **24** may be wider than 3.5 mm. Frit **14** generally needs a warm up and anneal phase before melting. In addition, the pre-sintered first substrate should be stored in an inert atmosphere to prevent re-adsorption of O_2 and H_20 before melting. The velocity of travel of laser beam **24** to the frit pattern can range from between about 0.5 mm/s to in excess of 40 mm/s, and as high as 300 mm/s depending on the set parameters. For fast sealing sealing speeds (laser beam traverse over frit **14**), e.g. greater than about 40 mm/s, it may be necessary to move laser beam **24** without moving the laser device itself. This may be accomplished, for example, by reflected the beam from a reflector mounted to a galvometer device. The power necessary to melt the frit and seal substrates 12 and 16 together may vary depending on the absorption coefficient α and thickness (height) h of frit **14**. The necessary power is also affected if a reflective or absorbent layer is placed beneath frit **14** such as certain lead materials **20**, and by the speed of traverse of the laser over the frit. Additionally, frit **14** can vary depending on the homogeneity of the frit, along with the filler particle size. This too can adversely affect the way the frit absorbs and consequently melts to substrates **12** and **16**.

[0029] FIGS. 5-6 illustrate the concept of how substrates **12** and **16** are placed in reference to laser beam **24**. A lens system (not shown) may be included but is not a requirement for delivery of energy from laser beam **24**. Again, the laser beam **24** can be defocused from focus point **26** to point **28** to reduce the temperature gradient as frit **14** is traversed by the laser beam **24**. It should be noted that if the gradient is too steep (focus is too tight) that the OLED display **10** may exhibit violent cracking resulting in immediate failure.

[0030] Several exemplary strategies that can be used to hold first substrate **12**, including frit **14**, in close contact with second substrate **16** for sealing purposes are shown in FIG. 6. The first approach is one where substrates **12** and **16** are placed on a steel block **30** with a magnet **32** on top of substrates **12** and **16**. The other approach is to place the substrates **12** and **16** between two clear silica discs **34** and **36** with low scratch/dig and extremely high flatness. These silica discs **34** and **36** can then be clamped in a variety of methods and are transparent to the near infrared irradiation. If the discs **34** and **36** are flat and extremely stiff, then relatively thin substrates **12** and **16** can adhere to their shape, maintaining flatness and direct contact with each other.

[0031] The motion of a stage (not shown) which holds substrates **12** and **16** can be controlled by a computer (not shown) which runs programs written to trace the pattern of frit **14** that has been dispensed onto first substrate **12**. Most patterns of frit **14** are rectangular in shape and have rounded corners. The radius of curvatures for the corners range between 0.5 mm and 4 mm and are necessary to reduce overheating in this area. Overheating can occur as the travel motion in the x direction is reduced while the y direction is increased and vice versa. To negate this effect of overheating, velocity, power, or radius of the laser beam **24** can be adjusted. For example, this effect can be overcome solely by keeping a radius of curvature larger than the overlap of the defocused laser beam **24**.

[0032] Because frit **14** is to some degree transparent, any layer, like electrodes **20** that resides under it, that are reflective, will create an additional heat source because the laser beam **24** reflects back into frit **14**. It is not a double dose, but substantially more than what is intended. Also, some of these electrodes **20** can be absorptive in the near IR which means they can have some substantial heating when irradiated by laser beam **24**. When electrodes **20** exhibit both absorption and reflection properties, it creates a very difficult effect to overcome with a sealing regime. This effect is considered a power density per unit time issue. Because electrodes **20** are scattered and placed indeterminately of where frit **14** is to be placed, it is necessary to manage the power density issue.

[0033] The sealing techniques of the present invention enable sealing laser **22** to heat and melt frit **14** during the sealing process, even though electrodes **20**, that may have different patterns and properties, pass under frit **14**. Using the sealing techniques of the present invention, damage to the electrodes during the sealing process can be avoided. To accomplish this, the sealing techniques should take into account several factors which can affect the rate of the heat diffusion and in turn the temperature of the frit **14** at the sealing point. First, as described above, the typical frit **14** transmission can vary from 2% to 30% depending on its composition and thickness.

Second, electrodes **20**, depending on their composition, can absorb or reflect the light transmitted through frit **14**.

[0034] In general, the relationship between the traverse speed V of the laser and the absorption α (in units of inverse distance, e.g. 1/μm) of the frit can be derived from the diffusion relationship:

$$V = 4BD / r^2 \tag{1}$$

where V is the traverse speed of the laser light over frit **14**, D is the thermal conductivity coefficient of the frit, r is the diffusion length in the frit and B is a scaling factor. Since the total thickness of the frit is the sum of the directly melted thickness and the thickness of the frit melted by heat diffusion,

$$h = r + 1 / \alpha \tag{2}$$

where α is the absorption coefficient of the frit. Thus, V can be expressed as:

$$V = 4BD / (h - 1/\alpha)^2 \tag{3}$$

which is valid for h > 1/α (i.e. a highly absorbing frit). Equation (3) illustrates how closely linked are sealing (traverse) speed, absorption of the frit and thermal conductivity.

[0035] On the other hand, a lower absorbing frit may allow faster sealing speeds. Unfortunately, faster sealing speeds generally require a higher output power from the laser. In the case where the electrodes absorb the laser light (i.e. the electrodes are absorbing at the output wavelength(s) of the laser), the electrodes may be heated to a temperature sufficient to damage the electrodes. To determine an appropriate sealing speed while considering the presence of the electrodes, the following relationship may be used:

$$V = 4BD / (h - (1 + A \cdot 10^{-\alpha h}) / \alpha - (R / \alpha) \cdot 10^{-\alpha h})^2 \tag{4}$$

where A is the electrode absorption and R is the electrode reflectance.

[0036] Generally, commercially viable sealing speeds exceed 5 mm/s, while optical powers greater than 10-15 watts may result in damage to electrodes at that speed. For example, optical powers in excess of about 10W may damage chromium electrodes, and molybdenum electrodes may be damaged at optical powers in excess of about

15W (at a spot diameter 2ω less than about 1.8mm). It is desirable that the spot diameter of the laser beam at the surface of the frit be at least as large or larger than the width of the frit. As used herein, spot diameter equals 2ω were w is that distance from the beam axis where the beam intensity is $1/e^2$ the maximum beam intensity. Preferably, the spot diameter of the laser beam at the surface of the frit should be between about 1.8 mm and 25 mm. Preferably, the traverse rate should be between about 0.5 mm/s and 300 mm/s. In general, peak optical powers should be between 0.5W and 1.5kW, depending upon traverse rate, spot diameter and so forth.

[0037] As a guide, and assuming a spot diameter of 1.8 mm which exceeds the width of the line of frit: for a traverse rate less than or equal to about 5 mm/s the peak optical power should be maintained less than about 15W; for a traverse rate greater than 5 mm/s and less than or equal to 10 mm/s, the peak optical power should be maintained less than or equal to 25W; for a traverse rate greater than 10 mm/s and less than or equal to 20 mm/s the peak optical power should be maintained less than about 36W; for a traverse rate greater than 20 mm/s and less than or equal to 40 mm/s, the peak optical power should be maintained less than about 45W. Again, these are guidelines, and the optical powers, traverse rates and spot diameter may vary for a specific application.

[0038] We have found that by selecting frit **14** to have an appropriate absorption α at the wavelength of the laser beam **24**, or conversely selecting the wavelength of the laser based on the absorption properties of the frit, such that the parameter $\alpha \cdot h$ (where h is expressed in μm) is greater than or equal to a value of about 0.4, and preferably between a value of about 0.4 and 1.75, damage to the electrodes can be avoided without complex schemes for varying the laser power, for example, as the laser traverses the frit overtop the electrodes. More preferably, $\alpha \cdot h$ is between about 0.5 and 1.3.

[0039] It should be emphasized that the above-described embodiments of the present invention, particularly any "preferred" embodiments, are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the invention. Many variations and modifications may be made to the above-described embodiments of the invention without departing substantially from the spirit and principles of the invention. All such modifications and variations are intended to be included herein within the scope of this disclosure and the present invention and protected by the following claims.

What is claimed is:

1. A method for encapsulating a display element comprising:

depositing a frit having an optical absorption α which is a function of wavelength onto a first substrate wherein the deposited frit has a height h;

placing a second substrate in contact with the frit;

sealing together the substrates by traversing a laser beam having a wavelength λ over the frit at a speed greater than or equal to about 0.5 mm/s; and

wherein $\alpha \cdot h$ at λ is greater than or equal to about 0.4.

2. The method according to claim 1 wherein $\alpha \cdot h$ is between about 0.4 and about 1.75 at λ.

3. The method according to claim 1 wherein the speed is greater between about 0.5 mm/s and 300 mm/s.

4. The method according to claim 1 wherein $\alpha \cdot h$ is between about 0.5 and about 1.3 at λ.

5. The method according to claim 1 wherein h is greater than about 10 μm.

6. The method according to claim 1 wherein a peak power of the laser beam is between about 0.5W and 1.5kW.

7. The method according to claim 1 wherein a spot diameter 2ω of the laser beam at a surface of the frit is between about 1.8 and 25 mm.

8. The method according to claim 1 wherein a thermal conductivity of the frit is greater than about 500 $\mu m^2/s$.

9. The method according to claim 1 wherein the frit is doped with a dopant selected from the goup consisting of iron, copper, vanadium, neodymium, and combinations

thereof.

10. A method for encapsulating a display element comprising:

depositing a frit having an optical absorption α which is a function of wavelength onto a first substrate in the shape of a frame having a height h;

sandwiching the frit between the first substrate and a second substrate having a display element and at least one electrode disposed thereon, the at least one electrode extending between the frit and the second substrate;

traversing a laser light having a wavelength λ over a length of the frit through the first substrate at a speed greater than or equal to about 5 mm/s to seal together the first and second substrates; and

wherein $\alpha \cdot h$ at λ_1 is greater than or equal to about 0.4.

11. The method according to claim 10 wherein the display element comprises an organic material.

12. The method according to claim 10 wherein the speed is between about 0.5 mm/s and 300 mm/s.

13. The method according to claim 10 further comprising prior to the sandwiching, pre-sintering the frit.

14. A method of encapsulating a display element comprising:

depositing a frit having an optical absorption α which is a function of wavelength onto a first substrate in the form of a frame having a height h;

pre-sintering the frit;

placing the first substrate overtop a second substrate having one or more display elements comprising an organic material, and at least one metallic electrode, disposed thereon, such that the display element is positioned within the frame and the at least one electrode passes beneath the frit;

heating the frit through the first substrate using a laser beam having a peak wavelength λ to form a hermetic seal between the first and second substrates; and wherein $\alpha \cdot h$ at λ is greater than or equal to about 0.4.

15. The method according to claim 14 wherein the heating comprises traversing the laser light over the frit at a speed greater than or equal to about 0.5 mm/s.

16. The method according to claim 14 wherein $\alpha \cdot h$ is between about 0.5 and about 1.3 at λ.

17. The method according to claim 14 wherein a thermal conductivity of the frit is greater than about 500 $\mu m^2/s$.

18. The method according to claim 14 wherein the frit has a thermal conductivity greater than about 800 mm^2/s.

19. The method according to claim 14 wherein the laser beam has a peak optical power between about 0.5W and 1.5kW.

20. The method according to claim 14 wherein a spot diameter 2ω of the laser beam at a surface of the frit is between about 1.8 and 25 mm

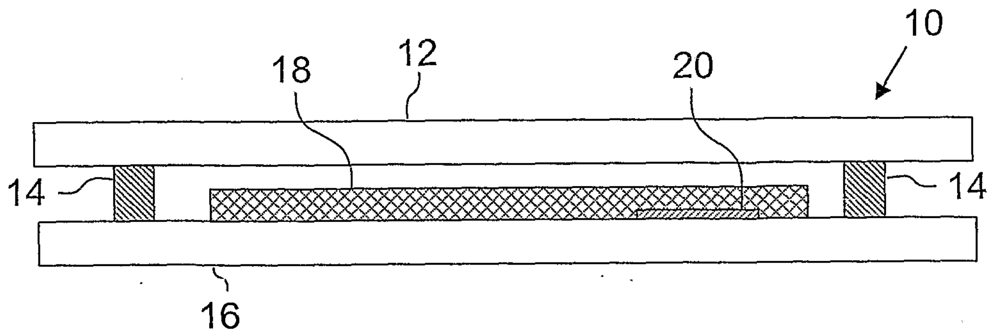


FIG. 1

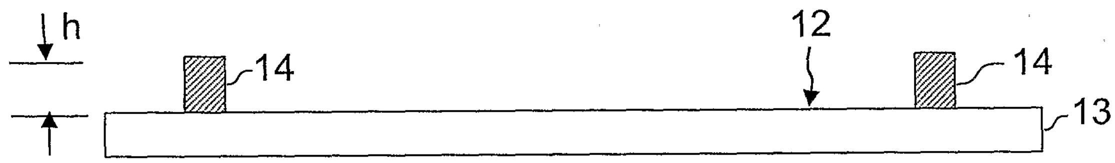


FIG. 2

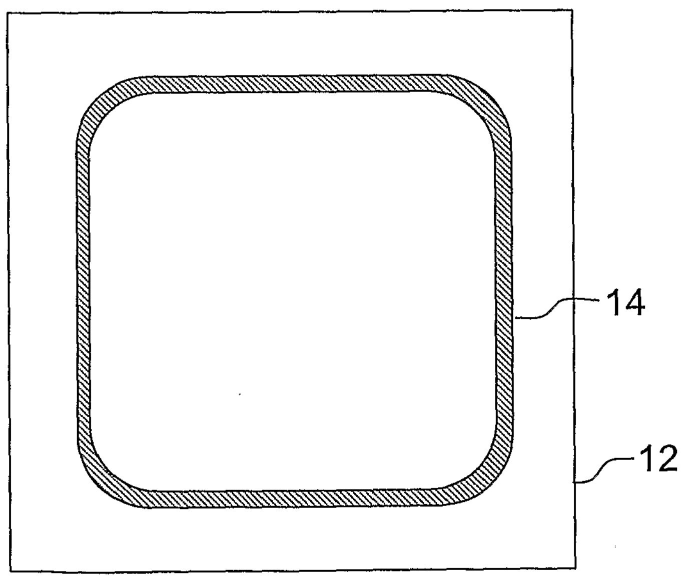


FIG. 3

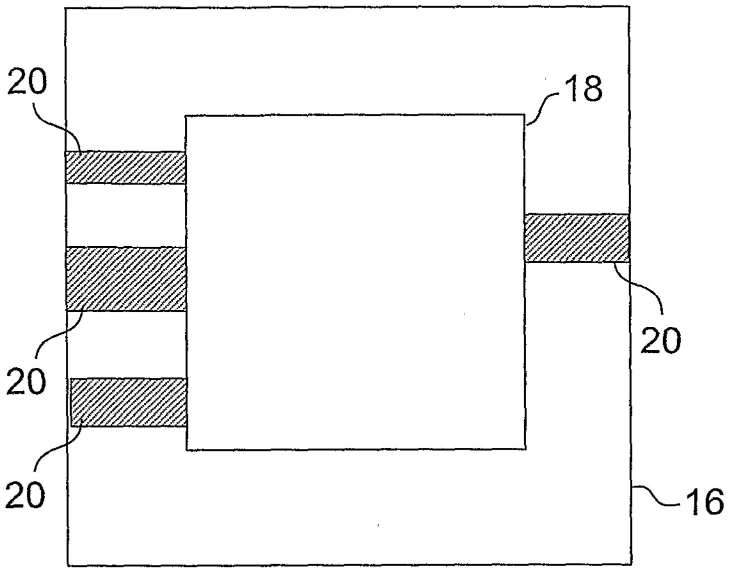


FIG. 4

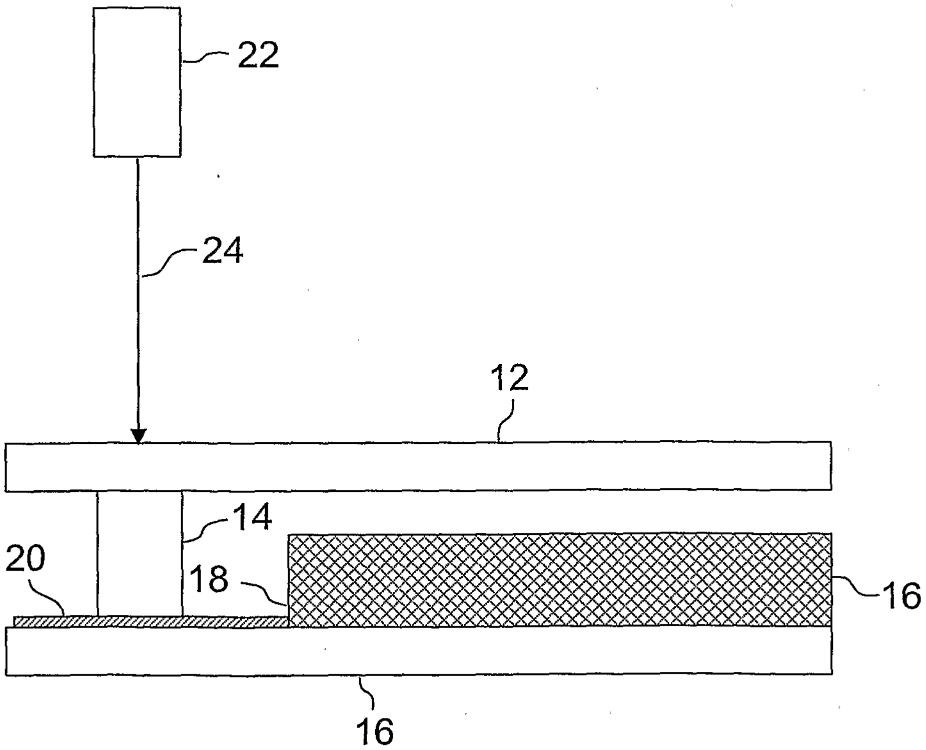


FIG. 5

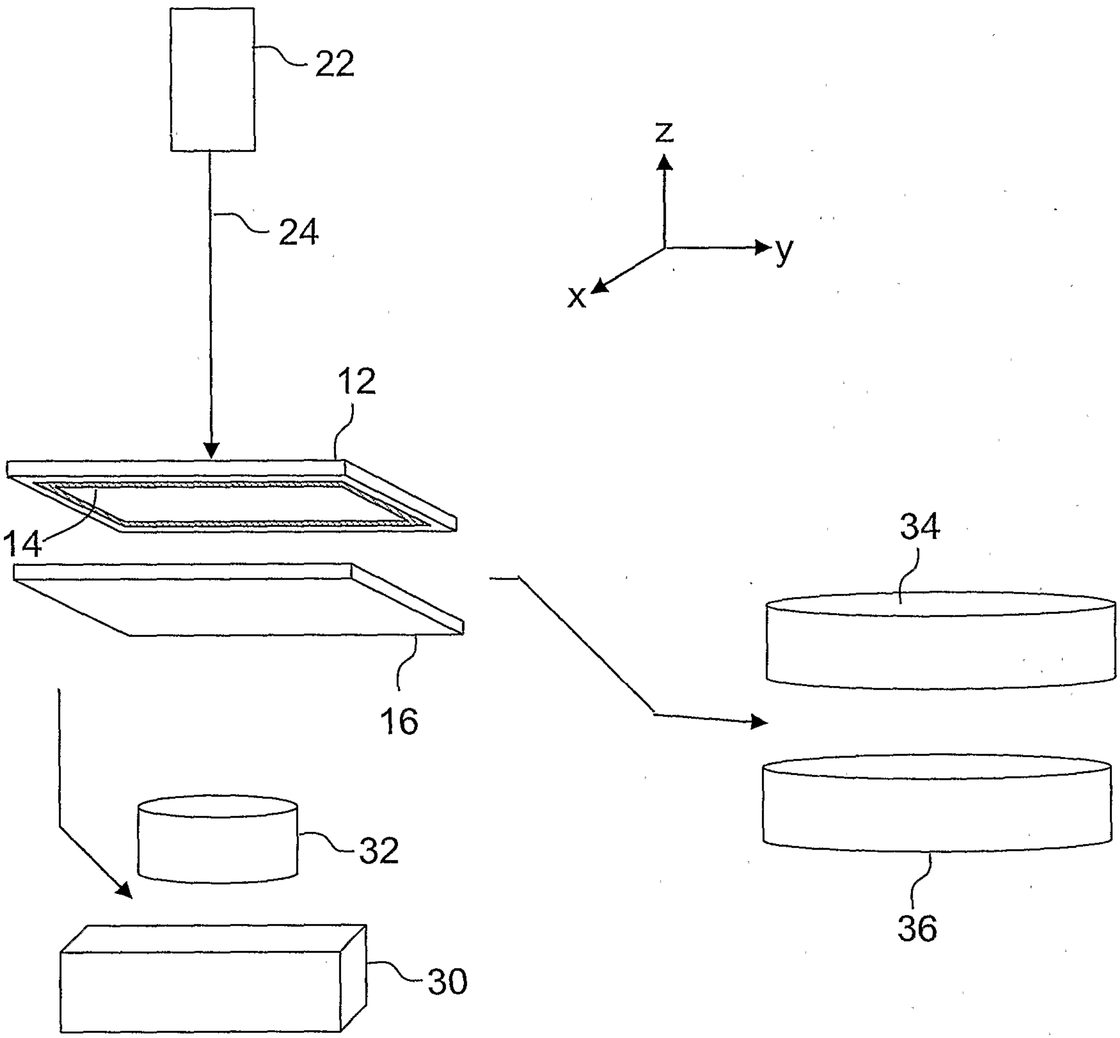


FIG. 6