

METHOD AND APPARATUS FOR LAYER BONDING OF DISPLAY ASSEMBLY

Cross-Reference To Related Applications

5 The present application is related to, and claims priority from, U.S. Provisional Patent Application Serial No. 61/076,456 filed on June 27, 2008, herein incorporated by reference, and is further related to, and claims priority from, U.S. Provisional Patent Application Serial No. 61/114,682 filed on November 14, 2008, herein incorporated by reference.

10 Statement Regarding Federally Sponsored Research

Not Applicable.

Background of The Invention

 The present invention is generally related to methods and apparatus for the assembly of display panels such as liquid crystal display (LCD) devices, and in particular, to a method and apparatus for bonding one or
15 more layers of glass, plastic, or other material of appropriate optical properties to a display module.

 Display panels, such as liquid crystal display modules, are widely used in all parts of modern technology, including such areas as consumer electronics, computer equipment, industrial machinery controls, automobiles
20 and aerospace applications. These display panels may include one or more layers of material disposed over the raw liquid crystal display module. For example, a protective overlay is most often desired for protection of the raw liquid crystal display module from mechanical and environmental forces. Raw display panes such as LCD modules, for example, usually have no protection
25 for the top polarizer layer and the underlying glass layers. The protective overlay can provide additional features such as support for anti-reflective coatings which can enhance the display visibility under varying lighting conditions. Other layers of material which may be disposed over the raw liquid crystal display module include touch-sensitive panels, optical filers, heaters,
30 and EMI shields.

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Since this bonding process is for visible displays, the bonding layer which secures each layer of material must be transparent and completely free of optical defects such as entrapped dirt and air bubbles. Freedom from entrapped air bubbles are a particular advantage of the invention. Using
5 traditional bonding techniques and apparatus, a bonding material such as an adhesive is utilized to secure a layer such as a protective overlay to a display module is applied in a bead first to only one surface, either the top surface of the display module or the underside of the protective overlay, followed by pressing another, un-wetted surface against the bead, and is likely to trap air
10 bubbles when the second un-wetted surface first touches the bead of bonding material.

Accordingly, it would be advantageous to provide a method and apparatus for the bonding of one or more material layers to a display module surface which yields a resulting assembly which is transparent and completely
15 free of optical defects such as entrapped dirt and air bubbles.

Brief Summary of The Invention

Briefly stated, the present disclosure provides a method and apparatus for the bonding of one or more material layers to an exposed surface of a display module such as an LCD assembly, to produce a resulting assembly
20 which is transparent and substantially free of optical defects such as entrapped dirt and air bubbles. During the bonding process of the present disclosure, a moving dispensing probe, or needle, dispenses a liquid bonding material between the exposed surface of the display module and the material to be bonded thereto over a pattern in a manner which continuously touches
25 (wets) both the material layer and the display module surface simultaneously. By simultaneously wetting both surfaces, and by dispensing the liquid bonding material in a predetermined pattern between the surfaces, the introduction of entrapped dirt and the formation of air bubbles is prevented as the two mating surfaces are subsequently pressed together.

The foregoing features, and advantages set forth in the present disclosure as well as presently preferred embodiments will become more apparent from the reading of the following description in connection with the accompanying drawings.

5 Brief Description Of The Several Views Of The Drawings

 In the accompanying drawings which form part of the specification:

 Figure 1 is cross-section of an assembled LCD and a material layer forming a protective overlay assembled by methods of the present disclosure;

 Figure 2 is a perspective view of a portion of the assembled LCD and
10 the protective overlay of Fig. 1;

 Figure 3 is an enlarged portion of the cross-section of Fig. 1;

 Figure 4 is a perspective illustration of a liquid bonding material dispenser of the present disclosure;

 Figures 5A and 5B illustrate a side view and a top view (looking
15 through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and a material layer forming a protective overlay prior to the application of a bonding material;

 Figure 6A and 6B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an adhesive
20 dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material is initially dispensed;

 Figure 7A and 7B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective
25 overlay as the bonding material is dispensed along a first segment;

 Figure 8A and 8B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material is dispensed along a second segment;

Figures 9A and 9B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material dispenser is withdrawn from
5 between the layers;

Figures 10A and 10B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material dispenser is repositioned between
10 the layers;

Figures 11A and 11B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material is dispensed along a third segment;

15 Figures 12A and 12B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material is dispensed along a fourth segment

20 Figures 13A and 13B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material dispenser is again withdrawn from between the layers;

25 Figures 14A and 14B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material dispenser is repositioned for dispensing adhesive to the central region;

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Figures 15A and 15B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as the bonding material dispenser applies the bonding material to the central region between the first through fourth previously applied segments;

Figures 16A and 16B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay upon completion of the dispensation of the bonding material;

Figures 17A and 17B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay as pressure is applied to uniformly distribute the bonding material between the layers;

Figures 18A and 18B illustrate a side view and a top view (looking through the transparent material layer) of the relative positions of an bonding material dispenser, the assembled LCD, and the material layer forming a protective overlay after application of pressure has fully dispensed the bonding material between the layers; and

Figure 19 is a representation of an exemplary assembly line configuration for assembling and bonding LCDs with one or more material layers according to the present disclosure.

Corresponding reference numerals indicate corresponding parts throughout the several figures of the drawings. It is to be understood that the drawings are for illustrating the concepts set forth in the present disclosure and are not to scale.

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details

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of construction and the arrangement of components set forth in the following description or illustrated in the drawings.

Detailed Description

The following detailed description illustrates the invention by way of example and not by way of limitation. The description enables one skilled in the art to make and use the present disclosure, and describes several embodiments, adaptations, variations, alternatives, and uses of the present disclosure, including what is presently believed to be the best mode of carrying out the present disclosure. Various aspects of the present disclosure are set forth and described in association with an LCD module, but those skilled in the art will recognize the wider range of application for the methods and apparatus set forth herein, and that such applications are not limited to LCD modules, but rather, may be utilized in many environments wherein one or more material layers are required to be bonded to a display panel or other surface in an optically transparent and uniform manner. For example, the method and apparatus of the present invention may be utilized to provide bonding of one or more material layers such as touch panels, optical filters, heaters, EMI shields, or protective overlays to the surfaces of display modules which utilize plasma technology, vacuum fluorescent technology (CRT's), and LED technology as well as LCD modules.

Turning to the figures, and to Figures 1-3 in particular, a bonded assembly 100 manufactured according to the methods of the present disclosure is shown generally. The bonded assembly 100 consists of an assembled display panel 102, such as an LCD module having an active display or LCD region 104 onto which has been bonded an one or more layers of material 106, such as a touch panel, an optical filter, a heater, an EMI shield, or an optically transparent protective overlay. The bonded assembly 100 may optionally further include a framework 108 surrounding the perimeter of the LCD module 102, as well as other device frames or supporting structures as required for the particular application in which the

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bonded assembly 100 is to be utilized. The material 106 may overlap a portion of the framework 108 to ensure a uniformly smooth upper surface to the bonded assembly 100. Those of ordinary skill will recognize that the characteristics of the material layers may be selected according to the application requirements of the bonded assembly 100, and may include
5 desired optical properties, material strengths, glare or glint optical properties, and scratch resistant properties as required. One suitable material which may be utilized is an optical glass. As best seen in Figures 1 and 3, the material layers 106 may be bonded directly to the surface of the LCD module 102 over
10 the active LCD region 104, or optionally to the surface of another material layer (not shown) previously bonded to the LCD module 102, by a layer of substantially uniform bonding material 110 which is free from entrapped air bubbles, unbonded regions, and contaminates.

To ensure the bonding material 110 is applied uniformly between the
15 surfaces to be bonded, an bonding material dispenser 200, such as shown in Figure, 4 is utilized. The bonding material dispenser 200 as shown consists generally of an elongated and flattened neck 202 extending from a base coupling 204. The base coupling is configured with a suitable adapter 206 to be operatively connected to a dispenser (not shown) for a supply of liquid
20 bonding material 110 (adhesive) which is dispensed to the base coupling 204 at a controlled rate of flow. The bonding material 110 flows through an internal passage 208 within the flattened neck to a dispensing tip 210. The dispensing tip 210 of the flattened neck includes dispensing openings 212A and 212B on both an upper and lower surface, which enable the flow of
25 bonding material 110 to disperse from the internal passage 208 and out the dispensing tip 210 in two directions simultaneously. Those skilled in the art will recognize that the specific configuration of the bonding material dispenser 200 may be varied from that shown in Figure 4, depending upon the particular application in which it is to be utilized. For example, the neck portion 202 may
30 have different geometry, and the dispensing tip 210 may include a varied

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number of dispensing openings 212, positioned as required to achieve the desired flow rate and flow uniformity of the bonding material 110 as it is dispensed there from.

During a bonding operation, the material layer 106 to be bonded to the
5 LCD module 102 is positioned and held in close proximity to the surface 104 of the LCD module or to a previously bonded material layer (not shown), but is separated there from by a uniform air gap 300, as shown in Figures 5A and 5B. Next, the elongated and flattened neck portion 202 of the bonding material dispenser 200 is moved into the air gap 300 between the material
10 layer 106 to be bonded and the surface 104 of the LCD module 102 (or previously bonded material layer) to an initial predetermined position at which the bonding material 110 will be initially introduced. The dispensing of the bonding material 110 is controlled in a way that allows beads of bonding material 110 emerging from the dispensing tip 210 to touch each of the
15 opposing mating surfaces simultaneously and continuously as the dispensing tip 210 is subsequently moved in a predetermined pattern between the surfaces. Preferably, the predetermined pattern is selected to ensure that the proper amount of bonding material 110 is dispensed between the surfaces, and that the bonding material 110 uniformly disperses without trapping air
20 bubbles or excessive overflow. Those of ordinary skill will recognize that while Figures 5A through 18B illustrate the positioning and placement of a material layer 106, such as a protective overlay, over an LCD module 102 from above, the process of the present disclosure may be carried out in different orientations as may be required to facilitate assembly. For example, the
25 process may be implemented by positioning the LCD module 102 above the material layer 106, and lowering it downward thereon during the bonding procedure.

In one embodiment of the present disclosure, a predetermined pattern for dispensing the bonding material 110 between the surfaces, such as
30 between a protective overlay material layer 106 and the LCD surface 104 is

illustrated in Figures 6A through 16B. The predetermined pattern consists generally of four linear segments S1, S2, S3, and S4 of bonding material applied between the layers 106, 104 to form a pair of inwardly directed chevrons (Figure 13B). A fifth segment S5 of bonding material 110 is then
5 applied as shown in Figure 15B to connect the apexes of each chevron across the central region surfaces, after which the bonding material dispenser 200 is withdrawn from between the layers (Figure 16B).

Once the bonding material 110 has been uniformly applied between the surfaces of the material layers 104, 106 in the predetermined pattern, and
10 the bonding material dispenser 200 withdrawn, a uniform compressive force F is applied to the assembled layers, as shown in Figs. 16A and 17A to urge the material layer 106 to be bonded towards the surface 104 of the LCD module 102. As the compressive force F is applied (Figs. 17A and 17B), the bonding material 110 flows from the dispenses segments S1-S5 between the layers
15 104, 106 and uniformly disperses there between (Figures. 18A and 18B). Wetting and capillary forces as well as the precisely calculated amount of bonding material 110 that is utilized in the predetermined pattern, and the pressed alignment, ensure an uniform bonding layer between the LCD display 102 and each material layer 106. Subsequent hardening or curing of the
20 bonding material 110 by any suitable means, such as a high intensity ultraviolet light source, finalizes the process of bonding the material layer 106 to the surface 104 of the LCD module 102 or to the surface of a previously bonded material layer (not shown).

It will be recognized that the predetermined pattern in which the
25 bonding material 110 is delivered between the layers to be bonded may be varied depending upon the various flow characteristics of the bonding material 110, the size of the region to be bonded, and the desired thickness of the bond.

Those of ordinary skill in the art will further recognize that the bonding
30 process of the present disclosure may be incorporated into an assembly line

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for the manufacture of the bonded display panels 100 or LCD assemblies, such as shown in Figure 19. For example, as seen in Figure 19, the apparatus for performing the bonding process of the present disclosure may be disposed at the juncture of an assembly line 400 which delivers individual
5 LCD modules 102 and an assembly line 500 which delivers the material layers 106 to be bonded thereto, i.e., protective overlays. In one exemplary system, the protective overlays may be manufactured by an injection molding process (Box 502), receive one or more layers of a desired optical coating, such as by sputtering techniques (Box 504), which is then hardened (such as
10 by UV light) (Box 506) prior to delivery to the bonding apparatus (Box 508) wherein they are joined with individual LCD modules 102. The finished bonded assemblies 100 are then distributed to a quality control check station (Box 510), packing station, or subsequent step in a manufacture of a finished product.

15 The present disclosure can be embodied in-part in the form of computer-implemented processes and apparatuses for practicing those processes. The present disclosure can also be embodied in-part in the form of computer program code containing instructions embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, or an other computer
20 readable storage medium, wherein, when the computer program code is loaded into, and executed by, an electronic device such as a computer, micro-processor or logic circuit, the device becomes an apparatus for practicing the present disclosure.

The present disclosure can also be embodied in-part in the form of
25 computer program code, for example, whether stored in a storage medium, loaded into and/or executed by a computer, or transmitted over some transmission medium, such as over electrical wiring or cabling, through fiber optics, or via electromagnetic radiation, wherein, when the computer program code is loaded into and executed by a computer, the computer becomes an
30 apparatus for practicing the present disclosure. When implemented in a

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general-purpose microprocessor, the computer program code segments configure the microprocessor to create specific logic circuits.

As various changes could be made in the above constructions without departing from the scope of the disclosure, it is intended that all matter
5 contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

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Claims:

1. A method for bonding one or more material layers to a display panel in a bonded assembly, comprising:
 - positioning a material layer in alignment adjacent to a surface of the display panel, said material layer separated from said display panel surface by a uniform air gap;
 - positioning a bonding material dispenser at a predetermined position within said uniform air gap;
 - dispensing a bonding material from said bonding material dispenser as said bonding material dispenser is moved through a predetermined pattern within said air gap, said bonding material contacting the material layer and the display panel surface simultaneously during dispensation;
 - withdrawing said bonding material dispenser from said uniform air gap upon completion of said predetermined pattern of adhesive dispensation; and
 - applying a uniform compressive force to urge said material layer and said display panel together, entrapping said bonding material in a uniform layer there between; and
 - curing said entrapped bonding material to bond said material layer to said surface of the display panel.
2. The method of Claim 1 wherein said predetermined pattern is composed of a plurality of discrete segment along which said bonding material is dispensed.
3. The method of Claim 1 wherein said predetermined pattern is selected to achieve uniform distribution of bonding material between said material layer and said display panel surface.
4. The method of Claim 1 wherein said predetermined pattern is selected to displace voids from said uniform air gap during said application of compressive force.
5. The method of Claim 1 wherein said display panel is an LCD module.

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6. The method of Claim 1 wherein said material layer is a protective overlay.

7. The method of Claim 1 wherein said display panel surface is composed of at least one layer of material previously bonded to said display
5 panel.

8. The method of Claim 1 further including, subsequent to said curing step, positioning a second material layer in alignment over said bonded material layer, said second material layer separated from said bonded material layer by a second uniform air gap;

10 positioning a bonding material dispenser at a predetermined position within said second uniform air gap;

dispensing a bonding material from said bonding material dispenser as said bonding material dispenser is moved over a predetermined pattern within said second air gap, said bonding material contacting the second material
15 layer and the bonded material layer simultaneously during dispensation;

withdrawing said bonding material dispenser from said second uniform air gap upon completion of said predetermined pattern of bonding material dispensation; and

20 applying a second uniform compressive force to urge said second material layer and said bonded material layer together, entrapping said bonding material in a uniform layer there between; and

curing said entrapped bonding material between each of said layers.

9. The method of Claim 8 wherein said steps of position, dispensing, withdrawing, applying, and curing are repeated for each material
25 layer in the bonded display assembly.

10. The method of Claim 1 wherein said material layer is selected from a set of material layers including a touch panel, an optical filter, a heater, an EMI shield, and a protective overlay.

11. A bonded display assembly made by the method of either Claim
30 1.

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12. A bonded display assembly made by the method of either Claim
8.

13. A bonded display assembly made by the method of either Claim
9.

5 14. An bonding material dispenser for applying a liquid bonding
material between at least two adjacent surfaces, comprising:

a base coupling adapted for coupled to a dispensing source of liquid
bonding material;

a neck portion having an internal passage for receiving a flow of liquid
10 bonding material through said base coupling; and

a dispensing tip at a distal end of said neck portion, said dispensing tip
having a plurality of dispensing openings for discharging said liquid bonding
material from said internal passage.

15 15. The bonding material dispenser of Claim 14 wherein said neck
portion has an elongated and flattened configuration.

16. The bonding material dispenser of Claim 14 wherein said
plurality of dispensing openings include first and second dispensing openings
disposed on opposite sides of said dispensing tip.

20 17. The bonding material dispenser of Claim 14 wherein said
plurality of dispensing openings are configured to facilitate dispensation of the
liquid bonding material at a desired rate of flow.

18. The bonding material dispenser of Claim 14 wherein said
plurality of dispensing openings are configured to facilitate dispensation of the
liquid bonding material into simultaneous contact with each adjacent surface.

25 19. The bonding material dispenser of Claim 14 wherein said
adjacent surfaces are substantially parallel, separated by an air gap, and
wherein at least one of said surfaces is a display panel and wherein at least
one of said surfaces is a material layer to be bonded to said display panel.