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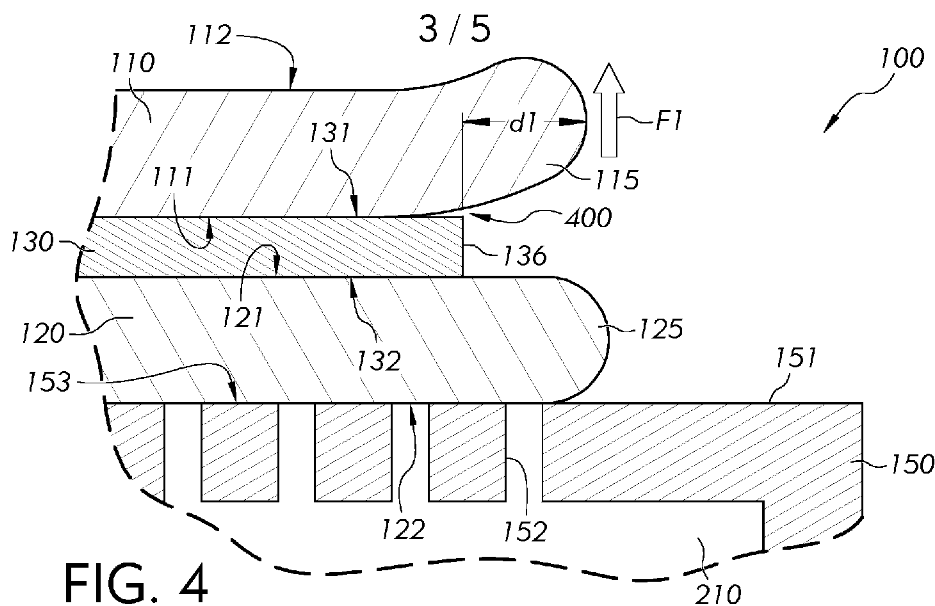

(57) Abstract: An apparatus (100) includes a first carrier (110), a second carrier (120), and a substrate (130) with a first major surface (131) of the substrate removably bonded to a first major surface (111) of the first carrier and a second major surface (132) of the substrate removably bonded to a first major surface (121) of the second carrier. A setback lateral distance (d1) from an outer peripheral edge (136) of an outer portion (135) of the substrate to at least one of an outer peripheral edge (117) of an outer portion of the first carrier and an outer peripheral edge (127) of an outer portion of the second carrier is greater than about 2 mm. Methods of processing the apparatus include initiating debonding at a first location of an outer peripheral bonded interface between the substrate and the first carrier by applying a force to the outer portion of the first carrier to separate a portion of the first carrier from the substrate.

[Continued on next page]

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APPARATUS AND METHODS FOR PROCESSING THE APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority under 35 U.S.C. § 119 of U.S. Provisional Application Serial No. 62/422,335 filed on November 15, 2016, the content of which is relied upon and incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates generally to an apparatus and methods of processing the apparatus and, more particularly, to an apparatus including a substrate removably bonded to a carrier and methods of processing the apparatus by initiating debonding at a location of an outer peripheral bonded interface between the substrate and the carrier.

BACKGROUND

[0003] Glass sheets are commonly used, for example, in display applications, for example liquid crystal displays (LCDs), electrophoretic displays (EPD), organic light emitting diode displays (OLEDs), plasma display panels (PDPs), touch sensors, photovoltaics, or the like. Glass sheets are commonly fabricated by flowing molten glass to a forming body whereby a glass ribbon may be formed by a variety of ribbon forming processes, for example, slot draw, float, down-draw, fusion down-draw, rolling, or up-draw. The glass ribbon may then be subsequently divided to provide thin, flexible sheets of glass suitable for further processing into a desired display application including, but not limited to, a substrate for mobile devices, wearables (e.g., watches), televisions, computers, tablets, and other display monitors. There is interest in providing and processing thin, flexible glass sheets in the fabrication of substrates including flexible electronics or other electronic devices. The fabrication of the substrates may include transport and handling of the thin, flexible glass sheets. Thus, there is a demand for apparatus including a substrate and methods for processing the substrate.

[0004] In one manner of handling the thin, flexible glass during processing of the substrate, the flexible glass is bonded to a carrier. Once bonded to the carrier, the characteristics and size of the carrier allow the bonded structure to be handled and transported in production without undesired bending of the glass sheet and without causing damage to the glass sheet. For example, a thin, flexible glass sheets may be

bonded to a relatively rigid carrier, and then functional components (e.g., a color filter, touch sensor, or thin-film transistor (TFT) components) may be attached to the thin, flexible glass sheet to produce a glass substrate that may be used in the production of electronic devices for display applications. Once transport, handling and other processing steps are complete, there is a desire to remove the substrate from the carrier. However, given the delicate nature of the substrate, the carrier and/or the substrate bonded to the carrier may be damaged when attempting to remove the substrate from the carrier. For example, based at least in part on the strength of the bond interface between the carrier and the substrate, significant force may need to be applied to break the bond. In addition, the carrier and the substrate may be damaged when attempting to peel and completely separate the carrier from the substrate. Practical solutions for separating the substrate from carrier without damaging the carrier and/or the substrate bonded to the carrier may be employed. Accordingly, there is a demand for specific characteristics of a carrier and a substrate removably bonded to the carrier that, for example, when combined with solutions for separating the substrate from carrier provide desirable initiation of debonding between the substrate and the carrier as well as desirable (i.e., damage free) complete separation of the substrate and the carrier.

SUMMARY

[0005] There are set forth exemplary embodiments of an apparatus including a substrate removably bonded to one or more carriers. Specific characteristics of the apparatus are provided that may, for example, facilitate initiation of debonding between the substrate and the one or more carriers as well as complete separation of the substrate and the one or more carriers. Methods of processing the apparatus are also provided.

[0006] Single substrates throughout the disclosure include a wide range of substrates including a single glass substrate (e.g., a single flexible glass substrate, or single rigid glass substrate), a single glass-ceramic substrate, a single ceramic substrate, or a single silicon substrate. As used herein the term “glass” is meant to include any material made at least partially of glass, including glass and glass-ceramics. “Glass-ceramics” include materials produced through controlled crystallization of glass. In embodiments, glass-ceramics have about 30% to about 90% crystallinity. Non-limiting examples of glass ceramic systems that may be used include Li2O × Al2O3 × nSiO2 (i.e. LAS system), MgO × Al2O3 × nSiO2 (i.e. MAS system), and ZnO × Al2O3 × nSiO2 (i.e. ZAS system). In some embodiments, the single substrate includes a single blank

substrate of material, for example a single blank glass substrate (e.g., a glass sheet including pristine surfaces separated from a glass ribbon produced by a down-draw fusion process or other technique), a single blank glass-ceramic substrate, a single blank silicon substrate (e.g., a single blank silicon wafer). If provided as a single blank glass substrate, the single blank glass substrate may be transparent, translucent, or opaque and may optionally include the same glass composition throughout the entire thickness of the single blank glass substrate from a first major surface to a second major surface of the single blank glass substrate. In some embodiments, the single blank glass substrate may include a single blank glass substrate that has been chemically strengthened. In some embodiments, the single blank glass substrate may include a polymer layer on one or both surfaces thereof.

[0007] Any of the single substrates of the disclosure may optionally include a wide range of functionality. For example, single glass substrates may include features that allow the single substrate to modify light or be incorporated into a display device, touch sensor component, or other device. In some embodiments, the single glass substrate may include color filters, polarizers, thin-film transistors (TFT) or other components. In some embodiments, if the single substrate is provided as a single silicon substrate, the single silicon substrate may include features that allow the single silicon substrate to be incorporated into an integrated circuit, a photovoltaic device, or other electrical component.

[0008] In some embodiments, the substrate may include a stack of single substrates, including, for example, any one or more single substrates. The stack of single substrates may be built by two or more single substrates stacked relative to one another with facing major surfaces of adjacent single substrates being bonded relative to one another. In some embodiments, the stack of single substrates may include a stack of single glass substrates. For example, a first single glass substrate may include a color filter and a second single glass substrate may include one or more thin-film transistors. The first and second single glass substrates may be bonded together as a stack of single substrates that may be formed as a display panel for display applications. Accordingly, substrates of the present disclosure may include any one or more single substrates or stack of single substrates.

[0009] Various methods beneficial to remove the substrate from one or more carriers bonded to the substrate are also provided. In some embodiments, a substrate

(e.g., one or more single substrates, stack of single substrates) is removably bonded to one or more carriers. In some embodiments, a first major surface of the substrate may be bonded to a single carrier. Additionally, in some embodiments both major surfaces of a substrate may be bonded to respective carriers with the substrate positioned between the respective carriers.

[0010] In some embodiments, after bonding the substrate to the one or more carriers, there is a desire to remove the one or more carriers without damaging the substrate. The present disclosure provides exemplary embodiments of the substrate and the one or more carriers that facilitate initiation of debonding and complete separation of the carriers from the substrate without contacting the substrate bonded to the carriers. Consequently, damage resulting from conventional techniques that contact the substrate may be avoided. For example, there are provided features that may facilitate initial debonding, between the carrier and the substrate bonded to the carrier, prior to fully removing (e.g., by peeling) the carrier from the substrate bonded to the carrier. The initial location of the bonded interface, where debonding is initiated, provides a desired point of weakness in the bonded interface. Thus, in some embodiments, subsequent peeling techniques may involve significantly less force as debonding has already been initiated. Because there is a reduction in the maximum applied force to completely separate the carrier from the substrate (e.g., by way of peeling), the associated stress applied to the substrate is likewise reduced, thereby further reducing possible damage to the substrate.

[0011] Some exemplary embodiments of the disclosure are described below with the understanding that any of the embodiments, including any one or more features of the various embodiments, may be used alone or in combination with one another.

[0012] Embodiment 1. An apparatus includes a first carrier, a second carrier, and a substrate. A first major surface of the first carrier faces a first major surface of the second carrier; and a first major surface of the substrate is removably bonded to the first major surface of the first carrier and a second major surface of the substrate is removably bonded to the first major surface of the second carrier. An outer portion of the substrate is disposed between an outer portion of the first carrier and an outer portion of the second carrier. A setback lateral distance from an outer peripheral edge of the outer portion of the substrate to at least one of an outer peripheral edge of the outer portion of the first

carrier and an outer peripheral edge of the outer portion of the second carrier is greater than about 2 mm.

[0013] Embodiment 2. The apparatus of embodiment 1, the setback lateral distance is from about 2 mm to about 60 mm.

[0014] Embodiment 3. The apparatus of any one of embodiments 1 and 2, the setback lateral distance is from about 2 mm to about 40 mm.

[0015] Embodiment 4. The apparatus of any one of embodiments 1-3, the setback lateral distance is from about 2 mm to about 20 mm.

[0016] Embodiment 5. The apparatus of any one of embodiments 1-4, the setback lateral distance is from about 2 mm to about 10 mm.

[0017] Embodiment 6. The apparatus of any one of embodiments 1-5, the setback lateral distance is from about 2 mm to about 6 mm.

[0018] Embodiment 7. The apparatus of any one of embodiments 1-6, a thickness of at least one of the first carrier, defined from the first major surface of the first carrier to a second major surface of the first carrier, and the second carrier, defined from the first major surface of the second carrier to a second major surface of the second carrier, is from about 200 microns to about 700 microns.

[0019] Embodiment 8. The apparatus of any one of embodiments 1-7, the substrate includes at least one of glass and silicon.

[0020] Embodiment 9. The apparatus of any one of embodiments 1-8, the substrate includes a first sheet and a second sheet, the first major surface of the substrate defines an outer surface of the first sheet, and the second major surface of the substrate defines an outer surface of the second sheet. An inner surface of the first sheet is bonded to an inner surface of the second sheet at an interface wall.

[0021] Embodiment 10. The apparatus of embodiment 9, a thickness of each of the first sheet and the second sheet defined from the outer surface to the inner surface of each sheet is from about 50 microns to about 300 microns.

[0022] Embodiment 11. The apparatus of any one of embodiments 9 and 10, an offset lateral distance from the outer peripheral edge of the outer portion of the substrate to an outer peripheral edge of the interface wall is less than about 6 mm.

[0023] Embodiment 12. The apparatus of embodiment 11, the offset lateral distance is greater than zero and less than about 6 mm.

[0024] Embodiment 13. The apparatus of any one of embodiments 9-12, the interface wall includes an epoxy.

[0025] Embodiment 14. The apparatus of any one of claims 9-12, the interface wall includes a frit including glass.

[0026] Embodiment 15. The apparatus any one of embodiments 9-14, each of the first sheet and the second sheet includes at least one of glass and silicon.

[0027] Embodiment 16. A method of processing the apparatus of any one of embodiments 1-15 includes initiating debonding at a first location of an outer peripheral bonded interface between the substrate and the first carrier by applying a force to the outer portion of the first carrier to separate a portion of the first carrier from the substrate.

[0028] Embodiment 17. The method of embodiment 16, the force is applied to the outer portion of the first carrier without contacting any part of the substrate.

[0029] Embodiment 18. The method of any one of embodiments 16 and 17 includes inhibiting bending of the second carrier while applying the force to the outer portion of the first carrier.

[0030] Embodiment 19. The method of embodiment 18, inhibiting bending of the second carrier includes removably attaching a second major surface of the second carrier to a plate to inhibit bending of the second carrier while applying the force to the outer portion of the first carrier.

[0031] Embodiment 20. The method of any one of embodiments 16-19 includes initiating further debonding between the substrate and the first carrier to completely separate the first carrier from the substrate.

[0032] Embodiment 21. The method of embodiment 20 includes, after completely separating the first carrier from the substrate, then initiating debonding at a second location of an outer peripheral bonded interface between the substrate and the second carrier by applying a force to the second carrier to separate a portion of the second carrier from the substrate.

[0033] Embodiment 22. The method of embodiment 21, the force is applied to the outer portion of the second carrier.

[0034] Embodiment 23. The method of any one of embodiments 21 and 22 includes inhibiting bending of the substrate while applying the force to the outer portion of the second carrier.

[0035] Embodiment 24. The method of embodiment 23, inhibiting bending of the substrate includes removably attaching the first major surface of the substrate to a plate to inhibit bending of the substrate while applying the force to the outer portion of the second carrier.

[0036] Embodiment 25. The method of any one of embodiments 21-24 includes initiating further debonding between the substrate and the second carrier to completely separate the second carrier from the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] The above and other features and advantages of embodiments of the present disclosure are better understood when the following detailed description is read with reference to the accompanying drawings, in which:

[0038] **FIG. 1** is a schematic plan view of a second carrier being vacuum attached to a vacuum plate with a portion of a substrate, a first carrier, and the second carrier being broken away to illustrate vacuum ports of the vacuum plate in accordance with embodiments of the disclosure;

[0039] **FIG. 2** is a schematic cross-sectional view along either of lines **2-2** of **FIG. 1** in accordance with embodiments of the disclosure;

[0040] **FIG. 3** is an enlarged schematic view taken at view **3** of **FIG. 2** illustrating the first carrier, the second carrier, and the substrate including a first sheet, a second sheet, and an interface wall in accordance with embodiments of the disclosure;

[0041] **FIG. 4** is an alternate view of **FIG. 3** illustrating a method of initiating debonding at a first location of an outer peripheral bonded interface between the substrate and the first carrier in accordance with embodiments of the disclosure;

[0042] **FIG. 5** is an alternate view of **FIG. 4** illustrating a method of initiating further debonding between the substrate and the first carrier to completely separate the first carrier from the substrate in accordance with embodiments of the disclosure;

[0043] **FIG. 6** is an alternate view of **FIG. 3** illustrating, after completely separating the first carrier from the substrate, a method of initiating debonding at a second location of an outer peripheral bonded interface between the substrate and the second carrier in accordance with embodiments of the disclosure;

[0044] **FIG. 7** is an alternate view of **FIG. 6** illustrating, after initiating debonding at the second location, a method of initiating further debonding between the

substrate and the second carrier to completely separate the second carrier from the substrate in accordance with embodiments of the disclosure;

[0045] **FIG. 8** is a plot demonstrating applied force (on the vertical axis, in N/mm) to initiate debonding with respect to a setback lateral distance (on the horizontal axis, in mm) in accordance with embodiments of the disclosure; and

[0046] **FIG. 9** is a plot demonstrating percent initiation of a successful debond initiation (on the vertical axis, in percent) with respect to a setback lateral distance (on the horizontal axis, in mm) in accordance with embodiments of the disclosure.

DETAILED DESCRIPTION

[0047] Embodiments will now be described more fully hereinafter with reference to the accompanying drawings in which exemplary embodiments are shown. Whenever possible, the same reference numerals are used throughout the drawings to refer to the same or like parts. However, claims may encompass many different aspects of various embodiments and should not be construed as limited to the embodiments set forth herein.

[0048] To enable the handling and transport of a substrate during processing, the substrate may be bonded to a carrier. Relative to the substrate, characteristics and size of the carrier may allow the bonded substrate to be handled and transported during processing without significant bending of the substrate that may damage the substrate and/or damage components that may be mounted to the substrate. Unless otherwise noted, the substrate of any of the embodiments of the disclosure may include a single substrate or a stack of two or more single substrates. The single substrates may have a thickness of from about 50 microns to about 300 microns although other thicknesses may be provided in some embodiments. In some embodiments, a single flexible glass substrate or a stack of single flexible glass substrates may be removably bonded to a carrier using a binding agent, for example a polymer binding agent, silicone binding agents, forces naturally generated between one or more roughened abutting surfaces or other binding agents. In some embodiments, the substrate may be bonded to a carrier fabricated from glass, resin or other materials capable of withstanding conditions during processing of the substrate. The carrier may therefore optionally introduce a desired level of rigidity by providing a carrier with additional thickness that is combined with (or acts together with) the thickness of the substrate removably bonded to the carrier. In some embodiments, the carrier may include a plate (e.g., rigid plate) with a thickness that is greater than the thickness of the single substrate bonded to the carrier. Furthermore, in

some embodiments, the carrier may be selected to include a thickness where the overall thickness of the carrier and the substrate bonded to the carrier is within a range that may be employed with processing machinery and equipment configured to process relatively thick glass substrates having a thickness within the range of the overall thickness of the carrier and the substrate bonded to the carrier.

[0049] After bonding the substrate to the carrier, there may be a desire to remove the carrier from the substrate without damaging the substrate. For example, prior to processing the single substrate (e.g., by adding one or more functional components), there may be a desire to remove the single substrate from the carrier. Alternatively, in some embodiments, there may be a desire to remove the single substrate from the carrier after the substrate has been processed into a single substrate with one or more functional components and prior to creating the substrate as a stack of single substrates. Additionally, in some embodiments, there may be a desire to remove the carrier from the substrate including the stack of single substrates. Accordingly, irrespective of the particular configuration of the substrate, there may be a desire to eventually remove one or more carriers from the substrate. Due to the delicate nature of the substrate, in some embodiments, there may be a desire to remove one of the carriers from the substrate without contacting the substrate, and then remove the other carrier from the substrate. For example, in some embodiments, there may be a desire to initiate debonding at a predetermined location of an outer peripheral bonded interface between the substrate and the carrier. Such debonding initiation may reduce stress, and may reduce or eliminate possible resulting damage to the substrate and/or to the carrier that may otherwise occur without a debonding initiation step. In some embodiments, providing a debonding initiation step may target a relatively small location of the outer peripheral bonded interface to allow initial debonding over a small area with a first force, thereby providing a point of weakness in the bond between the substrate and the carrier that may allow easier complete removal (e.g., by peeling) of the carrier from the substrate with a second force that, in some embodiments, may be reduced compared to the first force.

[0050] As schematically shown in **FIG. 1** and in **FIG. 2**, which provides a cross-sectional view along either one of the two lines **2-2** of **FIG. 1** (i.e., each of the lines **2-2** in **FIG. 1** will produce the same cross section as shown in **FIG. 2**), in some embodiments, an apparatus **100** may include a first carrier **110**, a second carrier **120**, and a substrate **130**. Additionally, as shown in **FIG. 3**, which provides an enlarged view of the apparatus

100 taken at view **3** of **FIG. 2**, in some embodiments, the first carrier **110** may include a first major surface **111** and an opposing second major surface **112** with a thickness "**t1**" of the first carrier **110** defined from the first major surface **111** to the second major surface **112**. Similarly, the second carrier **120** may include a first major surface **121** and an opposing second major surface **122** with a thickness "**t2**" of the second carrier **120** defined from the first major surface **121** to the second major surface **122**. Likewise, the substrate **130** may include a first major surface **131** and an opposing second major surface **132** with a thickness "**t3**" of the substrate **130** defined from the first major surface **131** to the second major surface **132**. In some embodiments, at least one of the thickness "**t1**" of the first carrier **110** and the thickness "**t2**" of the second carrier **120** may be from about 200 microns to about 700 microns; however, in some embodiments, at least one of the thickness "**t1**" of the first carrier **110** and the thickness "**t2**" of the second carrier **120**, may be greater than or less than the explicit dimensions provided in disclosure without departing from the scope of the disclosure. In some embodiments, the first major surface **111** of the first carrier **110** may face the first major surface **121** of the second carrier **120** (e.g., with the substrate **130** removably bonded between the facing first major surfaces **111, 121**). Additionally, in some embodiments, the first major surface **131** of the substrate **130** may be removably bonded to the first major surface **111** of the first carrier **110** and the second major surface **132** of the substrate **130** may be removably bonded to the first major surface **121** of the second carrier **120**.

[0051] The substrate **130** may include a first sheet **141** and a second sheet **142** although a single sheet or three or more sheets may be provided in further embodiments. Additionally, in some embodiments, the substrate **130** may include at least one of glass and silicon. For example, in some embodiments, at least one of the first sheet **141** and the second sheet **142** may include a sheet of at least one of glass and silicon. As shown, in some embodiments, the first major surface **131** of the substrate **130** may be defined by an outer surface of the first sheet **141**, and the second major surface **132** of the substrate **130** may be defined by an outer surface of the second sheet **142**. Additionally, an inner surface **133** of the first sheet **141** may be bonded to an inner surface **134** of the second sheet **142** at an interface wall **145**. As shown, the interface wall **145** may comprise a single wall although the interface wall **145** may comprise a plurality of wall portions or other components in further embodiments. For instance, the interface wall **145** may comprise an inner interface wall portion and an outer interface wall portion

circumscribing the inner interface wall portion. In some embodiments, a thickness "**t4**" of the first sheet **141** defined from the outer surface **131** to the inner surface **133** may be from about 50 microns to about 300 microns. Likewise, in some embodiments, a thickness "**t5**" of the second sheet **142** defined from the outer surface **132** to the inner surface **134** may be from about 50 microns to about 300 microns.

[0052] Turning back to **FIG. 2**, in some embodiments, an outer portion **135** of the substrate **130** may be disposed between an outer portion **115** of the first carrier **110** and an outer portion **125** of the second carrier **120**. For example, as shown in **FIG. 3**, in some embodiments, an outer portion **143** of the first sheet **141** of the substrate **130** and an outer portion **144** of the second sheet **142** of the substrate **130** may be disposed between the outer portion **115** of the first carrier **110** and the outer portion **125** of the second carrier **120**.

[0053] In some embodiments, the first sheet **141** may be removably bonded to the first carrier **110** to provide a first bonded structure **113**. Similarly, in some embodiments, the second sheet **142** may be removably bonded to the second carrier **120** to provide a second bonded structure **123**. In some embodiments, the first bonded structure **113** may be processed with machinery and equipment designed to handle a component having one or more features (e.g., a same or similar size) as that of the first bonded structure **113**. In some embodiments, processing of the first bonded structure **113** may include, for example, adding one or more functional components (e.g., a color filter **305**) to the inner surface **133** of the first sheet **141**. In some embodiments, the first sheet **141** may be inflexible based at least on bonding of the relatively flexible first sheet **141** with the relatively rigid first carrier **110**. For example, when fully debonded from the first carrier **110**, the first sheet **141** may include a thin, flexible glass, the processing, handling, and transport of which may be difficult without at least the additional rigidity provided to the first bonded structure **113** from the first carrier **110**.

[0054] Similarly, in some embodiments, the second bonded structure **123** may be processed with machinery and equipment designed to handle a component having one or more features (e.g., a same or similar size) as that of the second bonded structure **123**. In some embodiments, processing of the second bonded structure **123** may include, for example, adding one or more functional components (e.g., thin-film transistor (TFT) components **310**) to the inner surface **134** of the second sheet **142** to create the second sheet **142**. In some embodiments, the second sheet **142** may be inflexible based at least

on bonding of the relatively flexible second sheet **142** with the relatively rigid second carrier **120**. For example, when fully debonded from the second carrier **120**, the second sheet **142** may include a thin, flexible glass, the processing, handling, and transport of which may be difficult without at least the additional rigidity provided to the second bonded structure **123** from the second carrier **120**.

[0055] Moreover, in some embodiments, the substrate **130** may be inflexible based at least on bonding of the relatively flexible substrate **130** with the relatively rigid first carrier **110** and second carrier **120**. For example, when fully debonded from the first carrier **110** and the second carrier **120**, the substrate **130** may include a thin, flexible glass panel for display applications, the processing, handling, and transport of which may be difficult without at least the additional rigidity provided to the substrate **130** from the first carrier **110** and/or the second carrier **120**. Accordingly, irrespective of the particular configuration of the substrate **130**, in some embodiments, the apparatus **100** may reduce chipping, cracking, scratching, scuffing, abrading, bending, breaking, or other damage to the substrate **130** that may otherwise occur if the substrate **130** was to be processed, handled, and transported without being removably bonded to at least one of the first carrier **110** and the second carrier **120**. Accordingly, the apparatus **100** may also improve processing, handling, and transport of the substrate **130** to provide a more efficient method of processing the substrate **130** than, for example, processing the substrate **130** without removably bonding the substrate **130** to at least one of the first carrier **110** and the second carrier **120**. Moreover, as discussed more fully below, the apparatus **100** may provide characteristics that facilitate initiation of debonding between the substrate **130** and at least one of the first carrier **110** and the second carrier **120** as well as characteristics that facilitate complete separation of at least one of the first carrier **110** and the second carrier **120** from the substrate **130**.

[0056] An exemplary method of processing the apparatus **100** is schematically illustrated in **FIGS. 4-7** which provide alternative views of the enlarged view of the apparatus **100** shown in **FIG. 3**. For simplicity and not limitation, the substrate **130** is schematically illustrated in **FIGS. 4-7** without depicting certain features including the first sheet **141**, the second sheet **142**, and the interface wall **145** shown in **FIG. 3**. Additionally, the apparatus **100** is shown with an optional vacuum device **150** including a plate **151** to which the apparatus **100** may be releasably secured. For example, as shown in **FIG. 1** and **FIG. 2**, the vacuum device **150** may include a vacuum plate **151** that may

include one or more vacuum ports **152** that open at a surface **153** (e.g., a substantially planar surface) of the vacuum plate **151**. In some embodiments, the one or more vacuum ports **152** may be in selective fluid communication with a vacuum source **205** (shown in **FIG. 2**) for example a vacuum tank or a vacuum pump. As shown in **FIG. 2**, a vacuum conduit **206**, for example a flexible hose, may provide fluid communication between the one or more vacuum ports **152** and the vacuum source **205**. In some embodiments, a vacuum chamber **210** may be in fluid communication with the one or more vacuum ports **152** such that the one or more vacuum ports **152** are in fluid communication with the vacuum conduit **206** and the vacuum source **205**. Accordingly, the vacuum device **150** may be employed to releasably secure the apparatus **100** (e.g., the first carrier **110**, the second carrier **120**, the substrate **130**) in place relative to the plate **151**.

[0057] In some embodiments, the plate **151** may include a rigid structure made out of metal (e.g., stainless steel, aluminum, etc.), plastic, resin or other material that may substantially resist bending under an applied bending moment. Accordingly, when the apparatus **100** is releasably secured to the plate **151**, in some embodiments, the plate **151** may likewise impart rigidity to the apparatus **100**. Based on the imparted rigidity from the plate **151**, in some embodiments, one or more of the first carrier **110**, the second carrier **120**, and the substrate **130** may also substantially resist bending under an applied bending moment. In some embodiments, releasably securing the apparatus **100** to the plate **151** may also allow one to reasonably control, and therefore predict, which of the first carrier **110** and the second carrier **120** will release from the substrate **130**. For example, by releasably securing the second carrier **120** to the plate **151**, bending of the apparatus **100** may be primarily limited to the first carrier **110**. Alternatively, by releasably securing the first carrier **110** to the plate **151**, bending of the apparatus **100** may be primarily limited to the second carrier **120**. Similarly, if one of the first carrier **110** or the second carrier **120** has been completely separated from the substrate **130**, by releasably securing the substrate **130** to the plate **151**, bending of the apparatus **100** may be primarily limited to the remaining first carrier **110** or the remaining second carrier **120**.

[0058] Although not shown, in some embodiments, one or more standoffs may also be provided to prevent actual engagement between a surface of the apparatus **100** and the surface **153** of the plate **151**. If provided, the standoffs may include a peripheral standoff, for example a ring circumscribing the one or more vacuum ports **152**. In addition or alternatively, the standoffs may include pillars distributed between one or

more vacuum ports **152** throughout the pattern of vacuum ports **152**. The pillars may include various materials, for example, a polymeric material. Additionally, the standoffs may extend a distance of about 1.6 mm (e.g., 1/16 of an inch) although other distances may be used in further embodiments. Moreover, in some embodiments, releasably securing the apparatus **100** to the plate **151** may be achieved without a vacuum source **205** and may include adhesive bonding or other techniques.

[0059] As schematically illustrated in **FIG. 1**, in some embodiments, a tool **170** may be employed to initiate debonding of at least one of the first carrier **110** and the second carrier **120** from the substrate **130**. In some embodiments, the tool **170** may be inserted in a direction **175** toward a rounded corner **171** of the substrate **130**. Alternatively, in some embodiments, the tool **170** may be inserted toward a chamfered corner **172** of the substrate **130**. Similarly, the tool **170** may be inserted toward a chamfered corner **173** of at least one of the first carrier **110** and the second carrier **120** or toward a rounded corner **174** of at least one of the first carrier **110** and the second carrier **120**. Unless otherwise noted, one or more corners of the first carrier **110**, the second carrier **120**, and the substrate **130** may include a rounded corner, a chamfered corner, or other shape corner, without departing from the scope of the disclosure.

[0060] In some embodiments, the tool **170** may be employed to engage at least one of the first carrier **110** and the second carrier **120** to impart a force on the at least one of the first carrier **110** and the second carrier **120**. Accordingly, in some embodiments, based at least on the force imparted on the at least one of the first carrier **110** and the second carrier **120**, the tool **170** may be employed to initiate debonding of the at least one of the first carrier **110** and the second carrier **120** from the substrate **130**. In some embodiments, the tool **170** may include a wedge to engage at least one of the first carrier **110** and the second carrier **120** to impart a force on the at least one of the first carrier **110** and the second carrier **120**. For example, in some embodiments, the wedge may be employed to pry the at least one of the first carrier **110** and the second carrier **120** from the substrate **130**. Additionally, in some embodiments, the tool **170** may include a rotatable wheel (not shown, but see, for example, US Provisional Application Serial No. 62/128396, filed on 04 March 2015) having a high coefficient of friction on an outer surface of the wheel. In some embodiments, the rotatable wheel may be employed to engage at least one of the first carrier **110** and the second carrier **120** to impart a force on the at least one of the first carrier **110** and the second carrier **120**. For example, in some

embodiments, the rotatable wheel may be employed to pry the at least one of the first carrier **110** and the second carrier **120** from the substrate **130**.

[0061] For example, as shown in **FIG. 4**, in some embodiments, the method may include initiating debonding at a first location **400** of an outer peripheral bonded interface between the substrate **130** and the first carrier **110** by applying a force "**F1**" to the outer portion **115** of the first carrier **110** to separate a portion of the first carrier **110** from the substrate **130**. In some embodiments, the force "**F1**" may be applied to the outer portion **115** of the first carrier **110** without contacting any part of the substrate **130**. Preventing any contact with the substrate **130** may avoid direct application of force to the substrate **130**, thereby reducing probability of damaging the substrate **130** that might otherwise occur with other techniques that may directly contact at least one of the substrate **130** and the first carrier **110** with an object (e.g., a blade, a wedge, a friction wheel) in an attempt to break the outer peripheral bonded interface.

[0062] Additionally, the method may include inhibiting bending of the second carrier **120** while applying the force "**F1**" to the outer portion **115** of the first carrier **110**. In some embodiments, inhibiting bending of the second carrier **120** may include removably attaching the second major surface **122** of the second carrier **120** to the plate **151** to inhibit bending of the second carrier **120** while applying the force "**F1**" to the outer portion **115** of the first carrier **110**. In some embodiments, inhibiting bending of the second carrier **120** may encourage debonding to initiate at the first location **400** of the outer peripheral bonded interface between the substrate **130** and the first carrier **110**.

[0063] As shown in **FIG. 5**, in some embodiments, the method may include initiating further debonding between the substrate **130** and the first carrier **110** to completely separate the first carrier **110** from the substrate **130**. For example, in some embodiments, a suction cup (e.g., vacuum cup **505**) may be employed to apply at least one of a lifting force and a peeling force to the first carrier **110** relative to the substrate **130** to debond the first major surface **111** of the first carrier **110** from the first major surface **131** of the substrate **130** thereby completely separating the first carrier **110** from the substrate **130**.

[0064] As shown in **FIG. 6**, in some embodiments, after completely separating the first carrier **110** from the substrate **130**, the method may then include initiating debonding at a second location **600** of an outer peripheral bonded interface between the substrate **130** and the second carrier **120** by applying a force "**F2**" to the second carrier

120 to separate a portion of the second carrier **120** from the substrate **130**. For example, the force "**F2**" may be applied to the outer portion **125** of the second carrier **120**. Additionally, the method may include inhibiting bending of the substrate **130** while applying the force "**F2**" to the outer portion **125** of the second carrier **120**. In some embodiments, inhibiting bending of the substrate **130** may include removably attaching the first major surface **131** of the substrate **130** to a plate **151** to inhibit bending of the substrate **130** while applying the force "**F2**" to the outer portion **125** of the second carrier **120**. For example, in some embodiments, after completely separating the first carrier **110** from the substrate **130**, the apparatus **100** may be flipped over to provide the substrate **130** facing the plate **151** with the second carrier **120** provided to be debonded from the substrate **130**. In some embodiments, inhibiting bending of the substrate **130** may encourage debonding to initiate at the second location **600** of the outer peripheral bonded interface between the substrate **130** and the second carrier **120**.

[0065] As shown in **FIG.** 7, in some embodiments, the method may include initiating further debonding between the substrate **130** and the second carrier **120** to completely separate the second carrier **120** from the substrate **130**. For example, in some embodiments, a suction cup (e.g., vacuum cup **505**) may be employed to apply at least one of a lifting force and a peeling force to the second carrier **120** relative to the substrate **130** to debond the first major surface **121** of the second carrier **120** from the second major surface **132** of the substrate **130** thereby completely separating the second carrier **120** from the substrate **130**.

[0066] Unless otherwise noted, the order of processing the substrate **130** may occur in a variety of optional steps and be modified in accordance with embodiments of the disclosure, without departing from the scope of the disclosure. For example, in some embodiments, initiating debonding between the first carrier **110** and the substrate **130** may be conducted prior to initiating debonding between the second carrier and the substrate **130**. Additionally, in some embodiments, initiating further debonding between the first carrier **110** and the substrate **130** may be conducted after initiating debonding between first carrier **110** and the substrate **130** and prior to or after initiating debonding of the second carrier **120** from the substrate **130** as well as prior to or after initiating further debonding of the second carrier **120** from the substrate **130**. Likewise, in some embodiments, initiating further debonding between the second carrier **120** and the substrate **130** may be conducted after initiating debonding between second carrier **120**

and the substrate **130** and prior to or after initiating debonding of the first carrier **110** from the substrate **130** as well as prior to or after initiating further debonding of the first carrier **110** from the substrate **130**. Moreover, completely separating the first carrier **110** from the substrate **130** may be conducted prior to or after one or more of initiating debonding of the second carrier **120** from the substrate **130**, initiating further debonding of the second carrier **120** from the substrate **130**, and completely separating the second carrier **120** from the substrate **130**. Similarly, completely separating the second carrier **120** from the substrate **130** may be conducted prior to or after one or more of initiating debonding of the first carrier **110** from the substrate **130**, initiating further debonding of the first carrier **110** from the substrate **130**, and completely separating the first carrier **110** from the substrate **130**.

[0067] Turning back to **FIG. 3**, in some embodiments, a setback lateral distance "**d1**" (from an outer peripheral edge **136** of the outer portion **135** of the substrate **130** to at least one of an outer peripheral edge **117** of the outer portion **115** of the first carrier **110** and an outer peripheral edge **127** of the outer portion **125** of the second carrier **120)** may be greater than about 2 mm. In some embodiments, the outer peripheral edge **136** of the outer portion **135** of the substrate **130** may be defined by an outermost feature of at least one of an outer peripheral edge **147** of the outer portion **143** of the first sheet **141** and an outer peripheral edge **148** of the outer portion **144** of the second sheet **142**. In some embodiments, the setback lateral distance "**d1**" may define a dimension from the outer peripheral edge **136** of the outer portion **135** of the substrate **130** to a location at which a force to initiate debonding of at least one of the first carrier **110** from the substrate **130** and the second carrier **120** from the substrate **130** is applied. For example, as shown in **FIG. 4**, in some embodiments, a force "**F1**" may be applied to the first carrier **110** to initiate debonding of the first carrier **110** from the substrate **130** at the first location **400** of the outer peripheral bonded interface between the substrate **130** and the first carrier **110**. Accordingly, in some embodiments, the setback lateral distance "**d1**" multiplied by the force "**F1**" may define a bending moment applied to the outer peripheral bonded interface between the substrate **130** and the first carrier **110** at the first location **400**. Similarly, as shown in **FIG. 6**, in some embodiments, a force "**F2**" may be applied to the second carrier **120** to initiate debonding of the second carrier **120** from the substrate **130** at the second location **600** of the outer peripheral bonded interface between the substrate **130** and the second carrier **120**. Accordingly, in some embodiments, the setback lateral

distance "**d1**" multiplied by the force "**F2**" may define a bending moment applied to the outer peripheral bonded interface between the substrate **130** and the second carrier **120** at the second location **600**.

[0068] Turning back to **FIG. 3**, an offset lateral distance "**d2**" may be defined from the outer peripheral edge **136** of the outer portion **135** of the substrate **130** to an outer peripheral edge **146** of the interface wall **145**. In some embodiments, based on the offset lateral distance "**d2**," the interface wall **145** may be spaced a predetermined dimension from the outer peripheral edge **136** of the substrate **130**. Accordingly, in some embodiments, the interface wall **145** may provide a strong, permanent bond between the first sheet **141** and the second sheet **142** without features of the interface wall **145** contacting or interfering with the first carrier **110** and the second carrier **120**. For example, in some embodiments, the interface wall **145** may include an epoxy. Additionally, in some embodiments, the interface wall **145** may include a frit including glass (e.g., sintered frit). In some embodiments, the offset lateral distance "**d2**" may be constant relative to a boundary extending around a periphery of the substrate **130**; or the offset lateral distance "**d2**" may vary relative to the boundary extending around a periphery of the substrate **130**.

[0069] In some embodiments, if the outer peripheral edge **146** of the interface wall **145** is located directly at the outer peripheral edge **136** of the substrate **130** (e.g., the offset lateral distance "**d2**" equals zero), or if the outer peripheral edge **146** of the interface wall **145** extends beyond the outer peripheral edge **136** of the substrate **130**, the epoxy and/or the sintered frit may contact at least a portion of at least one of the first carrier **110** and the second carrier **120**. By contacting at least a portion of at least one of the first carrier **110** and the second carrier **120**, the interface wall **145** may interfere with attempts to debond at least one of the first carrier **110** and the second carrier **120** from the substrate **130**. For example, the interface wall **145** may bond to at least one of the first carrier **110** and the second carrier **120** making initiation of debonding at, for example, at least one of the first location **400** and the second location **600** more difficult. Providing the interface wall **145** at the offset lateral distance "**d2**" relative to the outer peripheral edge **136** of the substrate **130** may therefore ensure proper bonding between the first sheet **141** and the second sheet **142** as well as prevent contact between the interface wall **145** (e.g., the epoxy, the sintered frit) and at least a portion of at least one of the first carrier **110** and the second carrier **120**.

[0070] FIG. 8 illustrates a plot of applied force to initiate debonding (in N/mm, where 1 N equals approximately 0.225 lbf) on the vertical axis vs. setback lateral distance "**d1**" (in millimeters) on the horizontal axis. The plot markers represent actual data points while the plot lines illustrate a function fit to the actual data points. For example, the diamond shapes **801** represent data obtained from a finite element analysis model of the apparatus **100**; the X shapes **802** represent data obtained from Equation 1; and the square shapes **803** represent data obtained from Equation 2.

[0071]

$$\frac{F}{B} = \sqrt{\frac{GEh^3}{12x^2}}$$

Equation 1

[0072]

$$\frac{F}{B} = \sqrt{\frac{GE[h1^3 + (h1 + h2)^3]}{12x^2}}$$

Equation 2

[0073] Equation 1 and Equation 2 provide a ratio of the applied force (F) to initiate debonding between a carrier and a substrate per a bonded width (B) of the substrate, where the bonded width (B) is defined at the location at which debonding is to be initiated. An interfacial property (G) defines the energy per unit area for debonding initiation between the carrier and the substrate, and (E) is the elastic modulus of the carrier. With reference to **FIG. 3**, Equation 1 (from which data **802** is determined) is valid for configurations where the offset lateral distance "**d2**" is zero. Conversely, Equation 2 (from which data **803** is determined) is valid for configurations where the offset lateral distance "**d2**" is greater than zero. More particularly, Equation 2 (data **803)** is valid for configurations where the offset lateral distance "**d2**" is greater than the sum of the thickness (h1) of the carrier and the thickness (h2) of the sheet bonded to the carrier. Additionally, (x) in Equation 1 and Equation 2 is the setback lateral distance "**d1**" as illustrated in **FIGS. 3**, **4**, and **6**.

[0074] For example, with reference to **FIG. 3** and **FIG. 4**, when debonding the first carrier **110** from the substrate **130**, (h) in Equation 1 and (h1) in Equation 2 correspond to thickness "**t1**" of the first carrier **110**. In Equation 2, (h2) corresponds to thickness "**t4**" of the first sheet **141**. Additionally, (F) corresponds to the applied force "**F1**" (shown in **FIG. 4)** to initiate debonding between the first carrier **110** and the substrate **130**. The bonded width (B) of the substrate **130** is defined as the width at the first location **400** at which debonding is to be initiated. That is, the bonded width (B) is the dimension parallel to the major surface of the substrate **130** at the first location **400** that defines the outermost location where the first carrier **110** is bonded to the substrate **130** and where (upon application of the applied force) initiation of debonding is to occur. In some embodiments, the bonded width (B) may be based on a characteristic of the first location **400**, for example, the dimension of a chamfered or rounded corner of the substrate **130** bonded to the first carrier **110** as well as a dimension parallel to the major surface of the substrate **130** at which the debonding initiation between the substrate **130** and the first carrier **110** is to occur. The interfacial property (G) defines the energy per unit area for debonding between the first carrier **110** and the substrate **130** to initiate, and (E) is the elastic modulus of the first carrier **110**.

[0075] Likewise, with reference to **FIG. 3** and **FIG. 6**, when debonding the second carrier **120** from the substrate **130**, (h) in Equation 1 and (h1) in Equation 2 corresponds to thickness "**t2**" of the second carrier **120**. In Equation 2, (h2) corresponds to thickness "**t5**" of the second sheet **142**. Additionally, (F) corresponds to the applied force "**F2**" (shown in **FIG. 6)** to initiate debonding between the second carrier **120** and the substrate **130**. The bonded width (B) of the substrate **130** is defined as the width at the second location **600** at which debonding is to be initiated. That is, the bonded width (B) is the dimension parallel to the major surface of the substrate **130** at the second location **600** that defines the outermost location where the second carrier **120** is bonded to the substrate **130** and where (upon application of the applied force) initiation of debonding is to occur. In some embodiments, the bonded width (B) may be based on a characteristic of the second location **600**, for example, the dimension of a chamfered or rounded corner of the substrate **130** bonded to the second carrier **120** as well as a dimension parallel to the major surface of the substrate **130** at which the debonding initiation between the substrate **130** and the second carrier **120** is to occur. The interfacial property (G) defines

the energy per unit area for debonding between the second carrier **120** and the substrate **130** to initiate, and (E) is the elastic modulus of the second carrier **120**.

[0076] As shown in the plot in **FIG. 8**, for configurations where the offset lateral distance "**d2**" is zero (data **802**), the force (F) to initiate debonding is comparatively less than configurations where the offset lateral distance "**d2**" is greater than zero and, more particularly, for configurations where the offset lateral distance "**d2**" is greater than the sum of the thickness (h1) of the carrier and the thickness (h2) of the sheet bonded to the carrier (data **803**). This may be explained based at least in part on the understanding that the offset lateral distance "**d2**" corresponds to the location of the interface wall **145** that bonds the first sheet **141** to the second sheet **142**. For example, the bond provided between the first sheet **141** and the second sheet **142** by the interface wall **145** may be comparatively stronger (e.g., having a larger force to initiate debonding) than, for example, the bond provided between the first carrier **110** and the substrate **130** as well as the bond provided between the second carrier **120** and the substrate **130**. For example, in some embodiments, the bond provided by the interface wall **145** may be considered permanent (e.g., not to be debonded); whereas the bond between the first carrier **110** and the substrate **130** as well as the bond between the second carrier **120** and the substrate **130** may be considered temporary (e.g., to be debonded). Additionally, the stiffness of the first carrier **110** and the second carrier **120** with respect to bending may be relatively rigid compared to the stiffness of the first sheet **141** with respect to bending and the stiffness of the second sheet **142** with respect to bending. Thus, debonding is to initiate at the outer peripheral bonded interface between the substrate **130** and the first carrier **110** (e.g., at the first location **400**) and at the outer peripheral bonded interface between the substrate **130** and the second carrier **120** (e.g., at the second location **600**), and not at the interface wall **145** (e.g., between first sheet **141** and the interface wall **145** and/or the second sheet **142** and the interface wall **145**).

[0077] Therefore, if the overall bending stiffness of the substrate **130** (e.g., the first sheet **141**, the second sheet **142**, and the interface wall **145**) is greater than the bending stiffness of the first carrier **110** at the first location **400** and the second carrier **120** at the second location **600**, the applied force will, for example, bend the first carrier **110** relative to the substrate **130** to initiate debonding between the first carrier **110** and the substrate **130** at the first location **400** and bend the second carrier **120** relative to the substrate **130** to initiate debonding between the second carrier **120** and the substrate **130**

at the second location **600**. Accordingly, in some embodiments, based on the relative flexible nature of the first sheet **141** and the second sheet **142**, the interface wall **145** may control or define the overall bending stiffness of the substrate **130**. For example, cantilevered portions of the substrate **130** (e.g., outer portion **105**, including outer portion **143** and outer portion **144**) as well as cantilevered portions of at least one of the first carrier **110** (e.g., outer portion **115**) and the second carrier **120** (e.g., outer portion **125**) may bend when a force is applied to at least one of the first carrier **110** and the second carrier **120** relative to a location of maximum stiffness of the substrate **130**. Likewise, the maximum bending moment from the applied force may occur at the location of maximum stiffness of the substrate **130** about which the cantilevered portions of the substrate **130** and the cantilevered portions of the first carrier **110** and the second carrier **120** may bend. In some embodiments, the location of the interface wall **145**, based on the offset lateral distance "**d2**," may therefore control the location of maximum stiffness of the substrate **130** and may likewise control the location at which the maximum bending moment from the applied force to initiate debonding acts.

[0078] In some embodiments, to provide successful debonding, initiation of debonding should occur at the outer peripheral bonded interface between the substrate **130** and the first carrier **110** (e.g., at the first location **400**) and at the outer peripheral bonded interface between the substrate **130** and the second carrier **120** (e.g., at the second location **600**). In other words, in order to minimize the applied force to initiate debonding, the maximum bending moment from the force applied to initiate debonding should be controlled to act at the first location **400** when debonding the first carrier **110** from the substrate **130** and at the second location **600** when debonding the second carrier **120** from the substrate **130**. For configurations where the offset lateral distance "**d2**" is zero (data **802**), the interface wall **145** provides the stiffest location of the substrate **130** (and therefore the maximum bending moment) directly at the first location **400** and the second location **600**. Likewise, for configurations where the offset lateral distance "**d2**" is greater than zero and, more particularly, for configurations where the offset lateral distance "**d2**" is greater than the sum of the thickness (h1) of the carrier and the thickness (h2) of the sheet bonded to the carrier (data **803**), the interface wall **145** provides the stiffest location of the substrate **130** (and therefore the maximum bending moment) at a spaced distance relative to the first location **400** and the second location **600**.

[0079] Accordingly, for debonding to initiate at the first location **400** or the second location **600** for configurations where the offset lateral distance "**d2**" is greater than zero and, more particularly, for configurations where the offset lateral distance "**d2**" is greater than the sum of the thickness (h1) of the carrier and the thickness (h2) of the sheet bonded to the carrier, the applied force increases relative to the applied force to initiate debonding at the first location **400** or the second location **600** for configurations where the offset lateral distance "**d2**" is zero. This is shown in **FIG. 8**, for example, when comparing the force to initiate debonding along the vertical axis between data **802** and data **803** for the same setback lateral distance "**d1**" along the horizontal axis. For example, for any setback lateral distance "**d1**" along the horizontal axis, the force along the vertical axis for data **802** is comparatively less than the force along the vertical axis for data **803**. That is, configurations where the offset lateral distance "**d2**" is zero (data **802**), have comparatively less force to initiate debonding than configurations where the offset lateral distance "**d2**" is greater than zero and, more particularly, for configurations where the offset lateral distance "**d2**" is greater than the sum of the thickness (h1) of the carrier and the thickness (h2) of the sheet bonded to the carrier (data **803**).

[0080] As noted above, in some embodiments, spacing the interface wall **145** away from the outer peripheral edge **136** of the substrate **130** may be desirable. Additionally, in some embodiments, spacing the interface wall **145** away from the outer peripheral edge **136** of the substrate **130** may result from one or more particular techniques of, for example, manufacturing (e.g., dispensing) the interface wall **145** relative to the first sheet **141** and the second sheet **142**. Accordingly, although providing the substrate **130** with an offset lateral distance "**d2**" equal to zero may, in some embodiments, minimize the force applied to initiate debonding, an offset lateral distance "**d2**" equal to zero may, nonetheless, be infeasible. Accordingly, in some embodiments, based on practical constraints or other considerations, providing the substrate **130** with an offset lateral distance "**d2**" greater than zero may be unavoidable or may be more desirable.

[0081] To ensure that debonding initiates, one option, therefore, is to increase the applied force to initiate debonding. However, as the applied force increases, the likelihood of damaging one or more of the first carrier **110**, the second carrier **120**, and the substrate **130** may also increase. For example, applying the force to initiate debonding may stress one or more of the first carrier **110**, the second carrier **120**, and the

substrate **130**. Therefore, increased applied forces may result in increased stresses in one or more of the first carrier **110**, the second carrier **120**, and the substrate **130**. Moreover, in some embodiments, because as the offset lateral distance "**d2**" increases, the force applied to initiate debonding also increases, there is a limit to how large the offset lateral distance "**d2**" may be before the applied force becomes too large and the likelihood of over-stressing one or more of the first carrier **110**, the second carrier **120**, and the substrate **130** becomes unavoidable. Accordingly, in some embodiments, the offset lateral distance "**d2**" may be may be less than about 6 mm. For example, the offset lateral distance "**d2**" may be greater than zero and less than about 6 mm. In some embodiments, the offset lateral distance "**d2**" may be greater than the sum of a thickness of the first carrier **110** or the second carrier **120** and a thickness of the substrate **130** (e.g., thickness "**t3**" in **FIG. 3**). Additionally, in some embodiments, the offset lateral distance "**d2**" may be greater than about 2 mm and less than about 6 mm, for example, greater than about 4 mm and less than about 6 mm, and all ranges and sub-ranges between the foregoing values.

[0082] Additionally, in some embodiments, the ability of the plate **151** to releasably secure the apparatus **100** may also limit the amount of force that may be applied to at least one of the first carrier **110** and the second carrier **120**. For example, an applied force greater than a counteracting force that releasably secures the apparatus **100** to the plate **151** may separate the apparatus **100** from the plate **151** prior to initiation of debonding. Therefore, in some embodiments, the offset lateral distance "**d2**" may be selected to control the applied force to initiate debonding relative to the counteracting force to releasably secure the apparatus **100** to the plate **151**. Moreover, in some embodiments, the counteracting force that releasably secures the apparatus **100** to the plate **151** may be selected to provide a threshold relative to the applied force above which the apparatus **100** will intentionally separate from the plate **151**, for example, prior to the point at which one or more of the first carrier **110**, the second carrier **120**, and the substrate **130** may break.

[0083] Another option to ensure that debonding initiates, without increasing the applied force to initiate debonding (and therefore without increasing the stress in one or more of the first carrier **110**, the second carrier **120**, and the substrate **130**) is to increase the setback lateral distance "**d1**." For example, as shown in the plot in **FIG. 8**, as the setback lateral distance "**d1**" increases along the horizontal axis, the force (F) to initiate

debonding decreases along the vertical axis. Accordingly, in some embodiments, an ability to apply a relatively smaller force to initiate debonding, by increasing the setback lateral distance "**d1**," may reduce the likelihood of damaging one or more of the first carrier **110**, the second carrier **120**, and the substrate **130**. Thus, decreasing the applied force to initiate debonding by, for example, increasing the setback lateral distance "**d1**," may likewise decrease stress applied to the one or more of the first carrier **110**, the second carrier **120**, and the substrate **130**. Decreasing the stress applied to the one or more of the first carrier **110**, the second carrier **120**, and the substrate **130** may provide increased successful debond initiation as shown in **FIG. 9**.

[0084] For example, **FIG. 9** illustrates a plot of percent successful debond initiation (as a percentage of success/failure) on the vertical axis vs. setback lateral distance (in millimeters) on the horizontal axis. The square plot markers represent actual data points while the plot line illustrates a function fit to the actual data points. Successful debonding initiation may refer to when at least a portion of the first carrier **110** debonds from the substrate **130** or when at least a portion of the second carrier **120** debonds from the substrate **130** without damage to the first carrier **110**, the second carrier **120**, or the substrate **130**. In some embodiments, successful debonding initiation may refer to when at least a portion of the first carrier **110** debonds from the substrate **130** or when at least a portion of the second carrier **120** debonds from the substrate **130** without the apparatus **100** separating from the plate **151**. Conversely, unsuccessful debonding initiation may occur when, for example, one or more of the first carrier **110**, the second carrier **120**, or the substrate **130** is damaged, the apparatus **100** separates from the plate **151**, or at least one of the first carrier **110** and the second carrier **120** otherwise fails to debond from the substrate **130**. Accordingly, in some embodiments, a successful debond initiation may provide a substrate **130** that may be employed in, for example, a display application; whereas, an unsuccessful debond initiation (e.g., failure) may provide a substrate **130** that cannot be reasonably employed and may, therefore, disadvantageously be discarded. Thus, a more efficient and less expensive processing of the substrate **130** may be obtained by provided the apparatus **100** with features corresponding to higher percent successful debond initiation. For example, a 100 percent successful debond initiation would provide a process where every substrate **130** that is processed is suitable to be employed in a particular application and where no substrate **130** is discarded.

[0085] As can be seen from the plot provided in **FIG. 9**, in some embodiments, the greater the setback lateral distance “**d1**”, the greater the percent successful debond initiation. For example, as can be seen, impressive results of from greater than about 70 percent successful debond initiation may be achieved in some embodiments with a setback lateral distance “**d1**” greater than about 2 mm. Additionally, impressive results of from greater than about 70 percent successful debond initiation to about 100 percent successful debond initiation may be achieved in some embodiments with a setback lateral distance “**d1**” from about 2 mm to about 10 mm. Moreover, even greater results (e.g., 100 percent successful debond initiation) may be achieved with a setback lateral distance “**d1**” from about 6 mm to about 10 mm. Accordingly, in some embodiments, increasing the setback lateral distance “**d1**” to greater than about 6 mm may provide 100 percent successful debond initiation.

[0086] In some embodiments, although 100 percent successful debond initiation may be achieved by providing a setback lateral distance “**d1**” of greater than about 6 mm, there may be practical considerations that otherwise dictate the extent to which increasing the setback lateral distance “**d1**” may be feasible. For example, for a given substrate **130**, increasing the setback lateral distance “**d1**” increases the size of at least one of the first carrier **110** and the second carrier **120** and, therefore, increases the amount of material from which the at least one of the first carrier **110** and the second carrier **120** is manufactured. In some embodiments, the material from which the at least one of the first carrier **110** and the second carrier **120** is manufactured may be expensive, and may therefore limit the extent to which increasing the setback lateral distance “**d1**” may be feasible. Additionally, in some embodiments, processing techniques and processing equipment may control the extent to which increasing the setback lateral distance “**d1**” may be feasible.

[0087] Moreover, in some embodiments, the setback lateral distance “**d1**” may be based on, for example, a size of the substrate **130**. For example, smaller substrates may include a comparatively smaller setback lateral distance “**d1**” than, for example, relatively larger substrates. In some embodiments, the setback lateral distance “**d1**” may therefore be defined based on a percentage of a size (e.g., length or width) of the substrate **130**. For example, considering the setback lateral distance “**d1**” as providing additional (e.g., waste) material with respect to at least one of the first carrier **110** and the second carrier **120**, in some embodiments, a maximum setback lateral distance “**d1**” of about 2.5% of

the size of the substrate **130** may provide an acceptable amount of waste material. Accordingly, in some embodiments, the setback lateral distance “**d1**” may be based on a relative size of the substrate **130**. In some embodiments, a larger substrate may be provided with a setback lateral distance “**d1**” from about 2 mm to about 60 mm, where about 60 mm corresponds to an acceptable amount of waste material of 2.5% of the size of the substrate. Moreover, in some embodiments, the setback lateral distance “**d1**” may be from about 2 mm to about 40 mm, for example, from about 2 mm to about 20 mm. Likewise, as set forth in the plots provided in **FIGS. 8** and **9**, in some embodiments, a relatively smaller substrate may be provided with a setback lateral distance “**d1**” from about 2 mm to about 10 mm, where about 10 mm corresponds to an acceptable amount of waste material of 2.5% of the size of the substrate. Thus, in some embodiments, increasing the setback lateral distance “**d1**” to increase the percent successful debond initiation may be balanced with practical considerations including, but not limited to, acceptable material waste of at least one of the first carrier **110** and the second carrier **120**. Accordingly, in some embodiments, based at least on one or more of the disclosed considerations, the setback lateral distance “**d1**” may include ranges and subranges (between the values set forth above) not explicitly disclosed without departing from the scope of the disclosure.

[0088] Likewise, although providing the substrate **130** with an offset lateral distance “**d2**” equal to zero may, in some embodiments, minimize the force applied to initiate debonding, it may nonetheless be infeasible or disadvantageous to provide an offset lateral distance “**d2**” equal to zero based on other considerations, as explained above. Moreover, the extent to which the offset lateral distance “**d2**” is greater than zero may, in some embodiments, be based, at least in part, on practical considerations of the apparatus **100**. For example, in some embodiments, the size of the area of the substrate **130** to which one or more functional components (e.g., color filter **305**, thin-film transistor (TFT) components **310**, shown in **FIG. 3**) may be added decreases, for a given substrate **130**, as the offset lateral distance “**d2**” increases. Additionally, as the offset lateral distance “**d2**” increases, additional (e.g., waste) substrate material of at least one of the first sheet **141** and the second sheet **142** increases. In some embodiments, the material from which the at least one of the first sheet **141** and the second sheet **142** is manufactured may be expensive, and may therefore limit the maximum dimension of the offset lateral distance “**d2**” that is acceptable. Additionally, in some embodiments,

processing techniques and processing equipment may control the dimension of the offset lateral distance “**d2**”. Thus, in some embodiments, the offset lateral distance “**d2**” may be selected, based at least in part, on practical consideration including, but not limited to, acceptable material waste of at least one of the first sheet **141** and the second sheet **142** and the size of the area of the substrate **130** to which one or more functional components may be added. Moreover, the offset lateral distance “**d2**” may be selected to provide an acceptable applied force to initiate debonding. Accordingly, in some embodiments, based at least one or more of the disclosed considerations, the offset lateral distance “**d2**” may include ranges and subranges (between the values set forth above) not explicitly disclosed without departing from the scope of the disclosure.

[0089] Directional terms as used herein—for example up, down, right, left, front, back, top, bottom—are made only with reference to the figures as drawn and are not intended to imply absolute orientation.

[0090] As used herein the terms "the," "a," or "an," mean "at least one," and should not be limited to "only one" unless explicitly indicated to the contrary. Thus, for example, reference to "a component" includes embodiments having two or more such components unless the context clearly indicates otherwise.

[0091] As used herein, the term “about” means that amounts, sizes, formulations, parameters, and other quantities and characteristics are not and need not be exact, but may be approximate and/or larger or smaller, as desired, reflecting tolerances, conversion factors, rounding off, measurement error and the like, and other factors known to those of skill in the art. When the term “about” is used in describing a value or an end-point of a range, the disclosure should be understood to include the specific value or end-point referred to. Whether or not a numerical value or end-point of a range in the specification recites “about,” the numerical value or end-point of a range is intended to include two embodiments: one modified by “about,” and one not modified by “about.” It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint.

[0092] The terms “substantial,” “substantially,” and variations thereof as used herein are intended to note that a described feature is equal or approximately equal to a value or description. For example, a “substantially planar” surface is intended to denote a surface that is planar or approximately planar. Moreover, as defined above, “substantially” is intended to denote that two values are equal or approximately equal. In

some embodiments, "substantially" may denote values within about 10% of each other, such as within about 5% of each other, or within about 2% of each other.

[0093] The above embodiments, and the features of those embodiments, are exemplary and may be provided alone or in any combination with any one or more features of other embodiments provided herein without departing from the scope of the disclosure.

[0094] It will be apparent to those skilled in the art that various modifications and variations may be made to the present disclosure without departing from the spirit and scope of the disclosure. Thus, it is intended that the present disclosure cover the modifications and variations of this disclosure provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. An apparatus comprising:

a first carrier;

a second carrier, a first major surface of the first carrier facing a first major surface of the second carrier;

a substrate with a first major surface of the substrate removably bonded to the first major surface of the first carrier and a second major surface of the substrate removably bonded to the first major surface of the second carrier; and

an outer portion of the substrate is disposed between an outer portion of the first carrier and an outer portion of the second carrier, a setback lateral distance from an outer peripheral edge of the outer portion of the substrate to at least one of an outer peripheral edge of the outer portion of the first carrier and an outer peripheral edge of the outer portion of the second carrier is greater than about 2 mm.

2. The apparatus of claim 1, the setback lateral distance is from about 2 mm to about 60 mm.

3. The apparatus of any one of claims 1 and 2, the setback lateral distance is from about 2 mm to about 40 mm.

4. The apparatus of any one of claims 1-3, the setback lateral distance is from about 2 mm to about 20 mm.

5. The apparatus of any one of claims 1-4, the setback lateral distance is from about 2 mm to about 10 mm.

6. The apparatus of any one of claims 1-5, the setback lateral distance is from about 2 mm to about 6 mm.

7. The apparatus of any one of claims 1-6, a thickness of at least one of the first carrier, defined from the first major surface of the first carrier to a second major surface of the first carrier, and the second carrier, defined from the first major surface

of the second carrier to a second major surface of the second carrier, is from about 200 microns to about 700 microns.

8. The apparatus of any one of claims 1-7, the substrate comprises at least one of glass and silicon.

9. The apparatus of any one of claims 1-8, the substrate comprising a first sheet and a second sheet, the first major surface of the substrate defining an outer surface of the first sheet, and the second major surface of the substrate defining an outer surface of the second sheet, an inner surface of the first sheet is bonded to an inner surface of the second sheet at an interface wall.

10. The apparatus of claim 9, a thickness of each of the first sheet and the second sheet defined from the outer surface to the inner surface of each sheet is from about 50 microns to about 300 microns.

11. The apparatus of any one of claims 9 and 10, an offset lateral distance from the outer peripheral edge of the outer portion of the substrate to an outer peripheral edge of the interface wall is less than about 6 mm.

12. The apparatus of claim 11, the offset lateral distance is greater than zero and less than about 6 mm.

13. The apparatus of any one of claims 9-12, the interface wall comprises an epoxy.

14. The apparatus of any one of claims 9-12, the interface wall comprises a frit comprising glass.

15. The apparatus any one of claims 9-14, each of the first sheet and the second sheet comprises at least one of glass and silicon.

16. A method of processing the apparatus of any one of claims 1-15, comprising:

initiating debonding at a first location of an outer peripheral bonded interface between the substrate and the first carrier by applying a force to the outer portion of the first carrier to separate a portion of the first carrier from the substrate.

17. The method of claim 16, the force is applied to the outer portion of the first carrier without contacting any part of the substrate.

18. The method of any one of claims 16 and 17, comprising inhibiting bending of the second carrier while applying the force to the outer portion of the first carrier.

19. The method of claim 18, inhibiting bending of the second carrier comprises removably attaching a second major surface of the second carrier to a plate to inhibit bending of the second carrier while applying the force to the outer portion of the first carrier.

20. The method of any one of claims 16-19, comprising initiating further debonding between the substrate and the first carrier to completely separate the first carrier from the substrate.

21. The method of claim 20, comprising, after completely separating the first carrier from the substrate, then initiating debonding at a second location of an outer peripheral bonded interface between the substrate and the second carrier by applying a force to the second carrier to separate a portion of the second carrier from the substrate.

22. The method of claim 21, the force is applied to the outer portion of the second carrier.

23. The method of any one of claim 21 and 22, comprising inhibiting bending of the substrate while applying the force to the outer portion of the second carrier.

24. The method of claim 23, inhibiting bending of the substrate comprises removably attaching the first major surface of the substrate to a plate to inhibit

bending of the substrate while applying the force to the outer portion of the second carrier.

25. The method of any one of claims 21-24, comprising initiating further debonding between the substrate and the second carrier to completely separate the second carrier from the substrate.

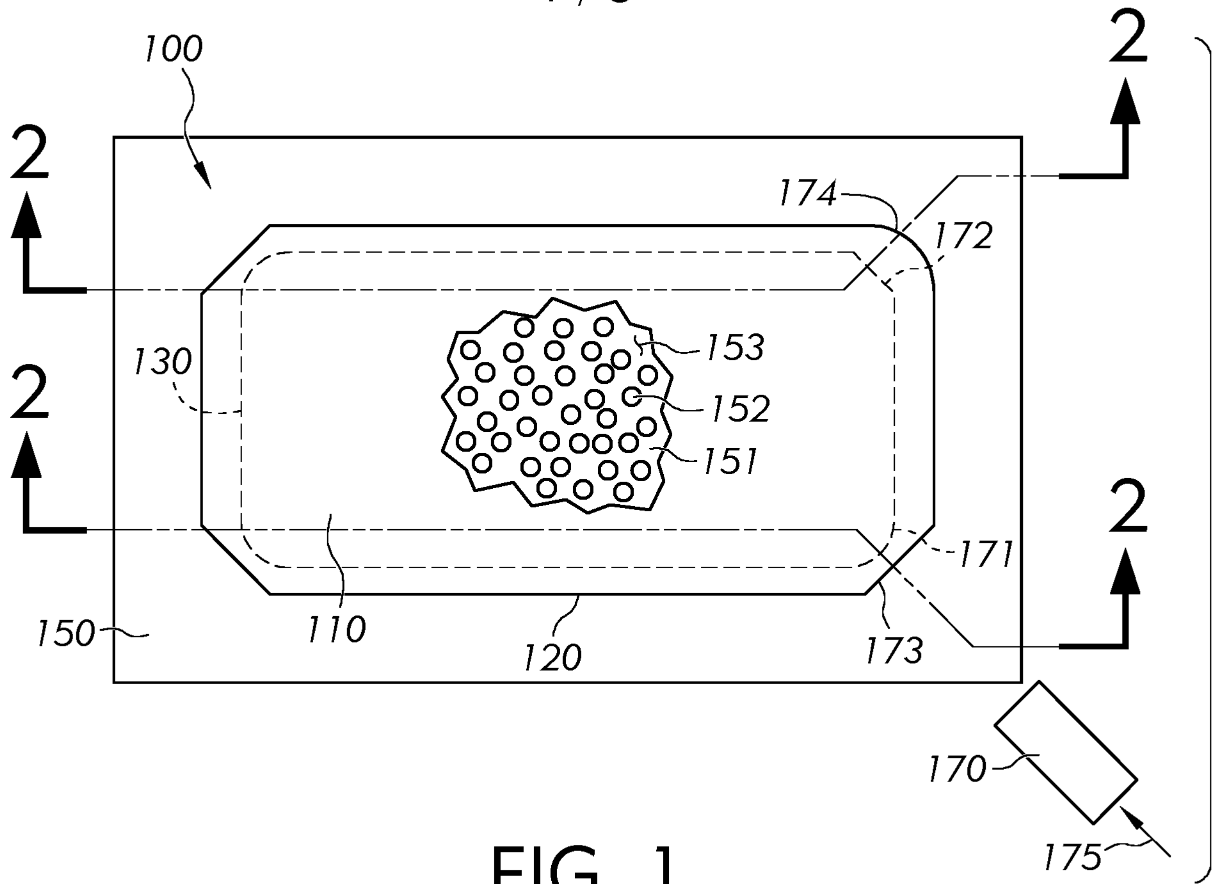

FIG. 1

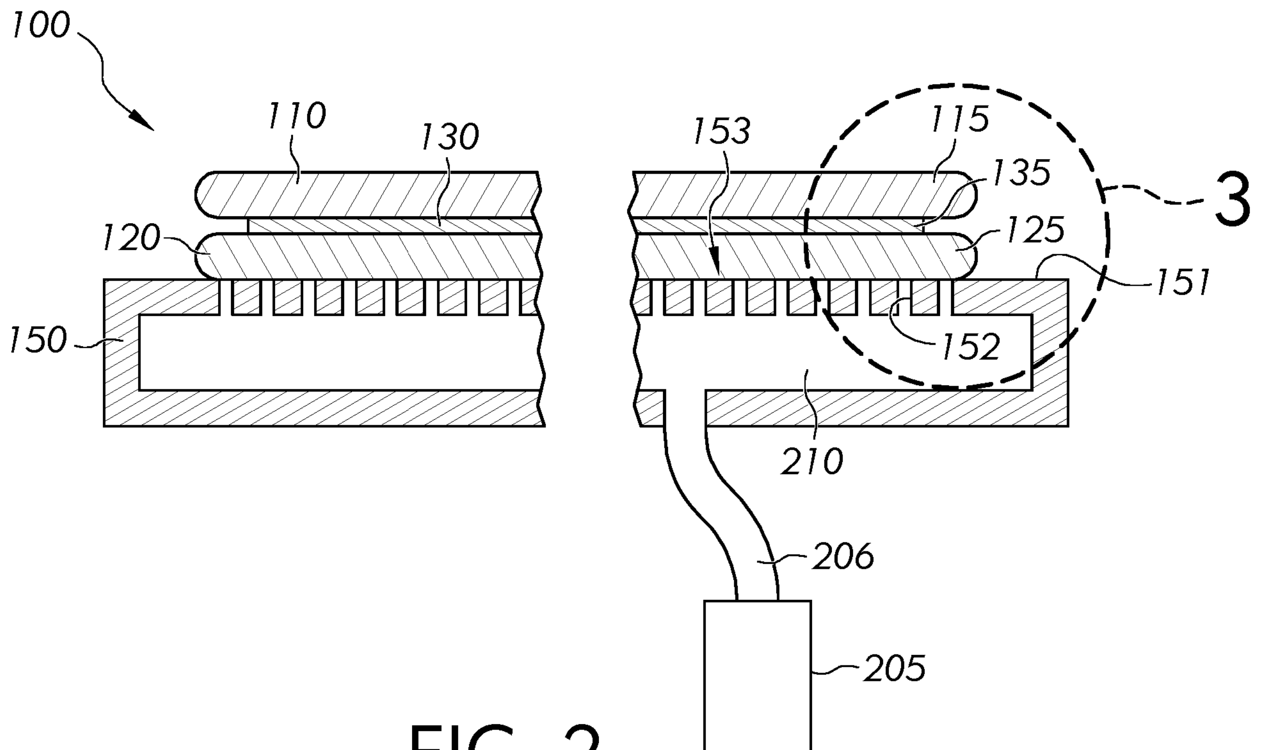

FIG. 2

FIG. 3

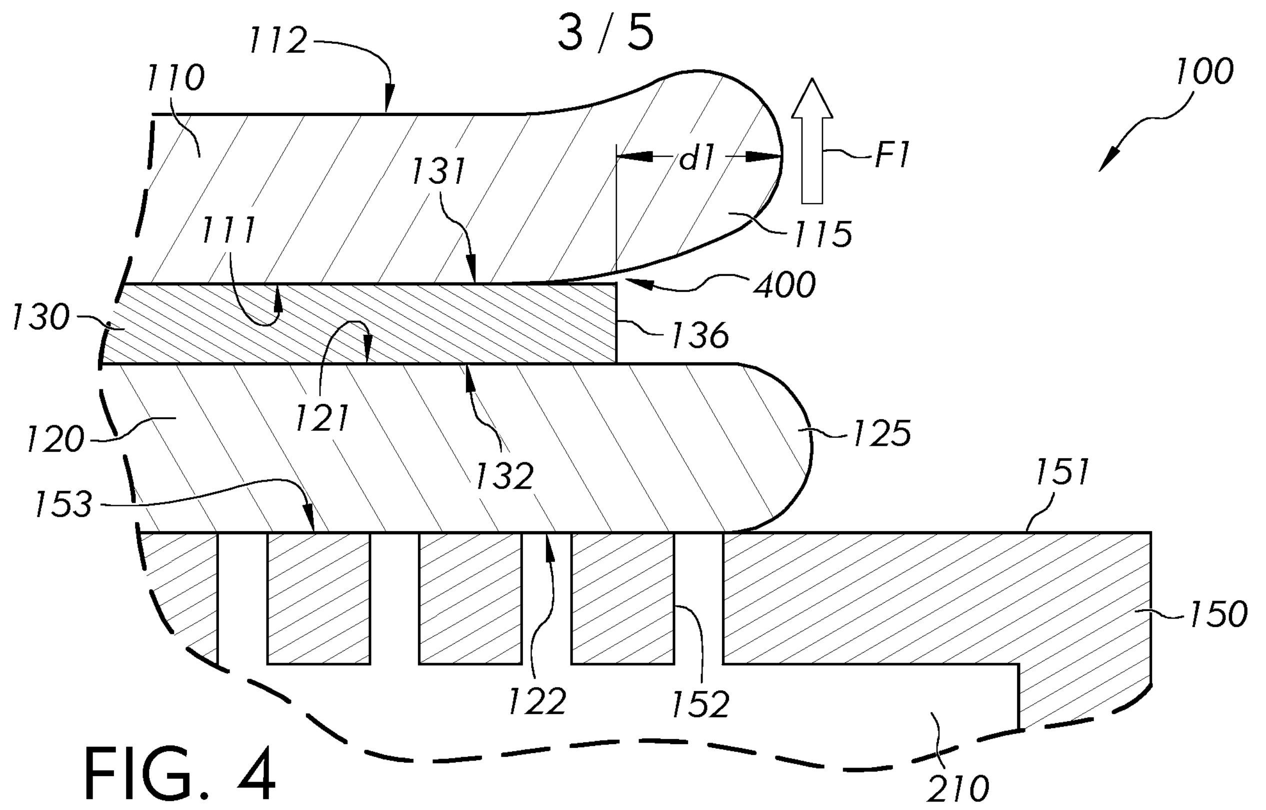

FIG. 4

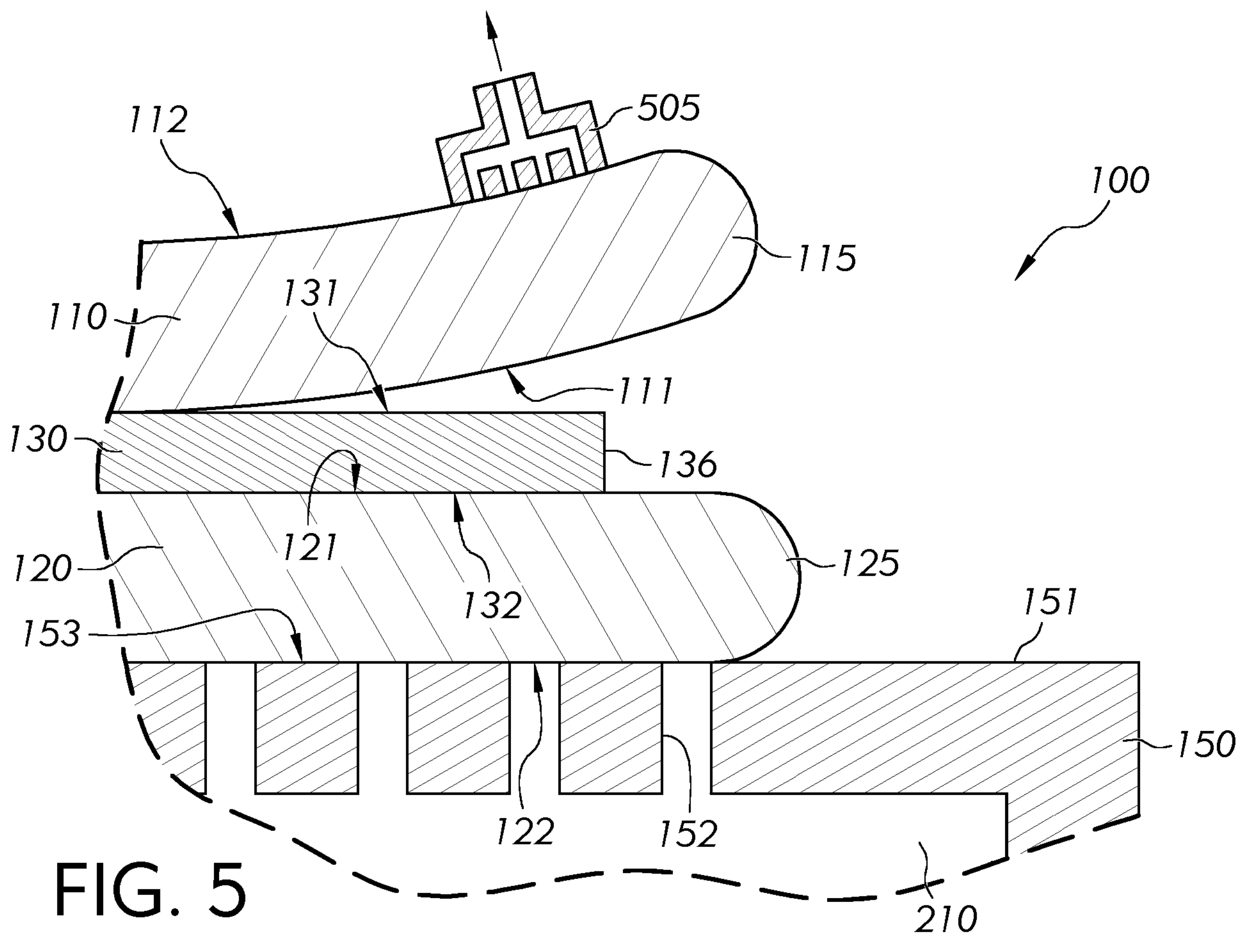

FIG. 5

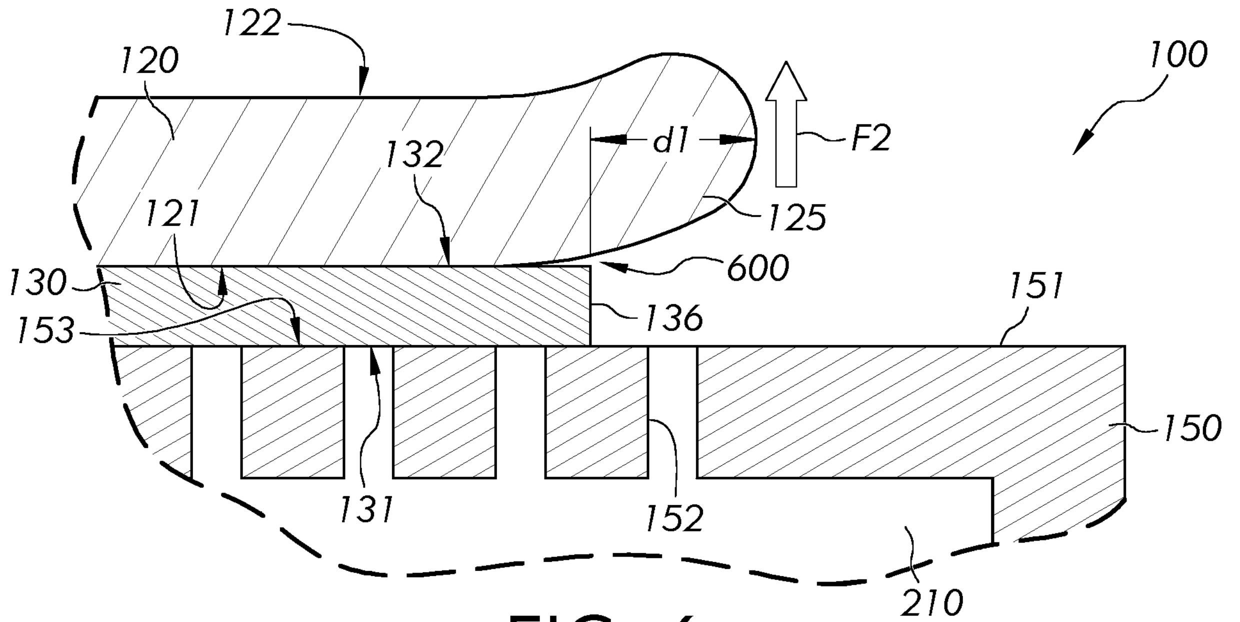

FIG. 6

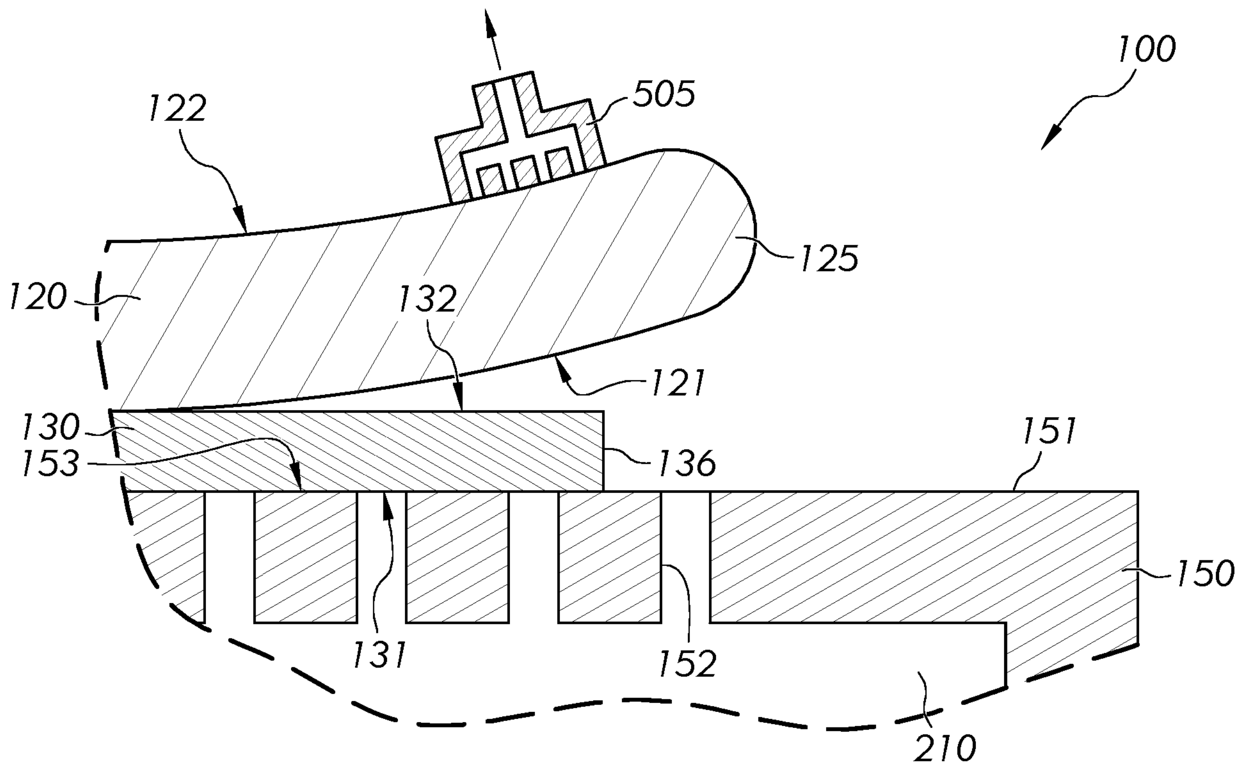

FIG. 7

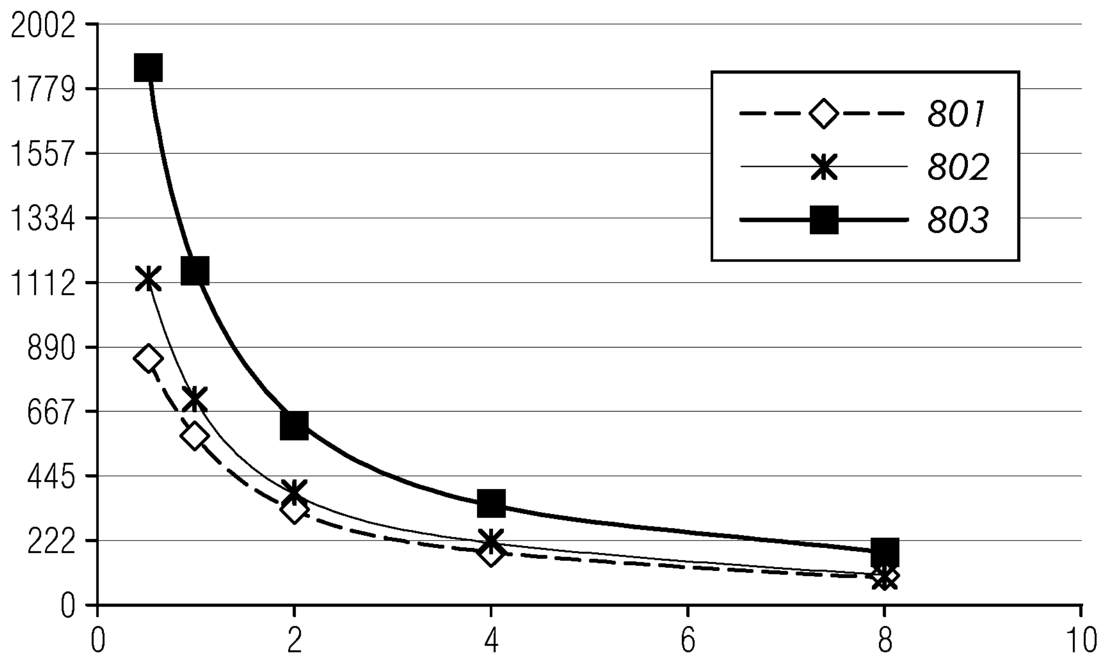

FIG. 8

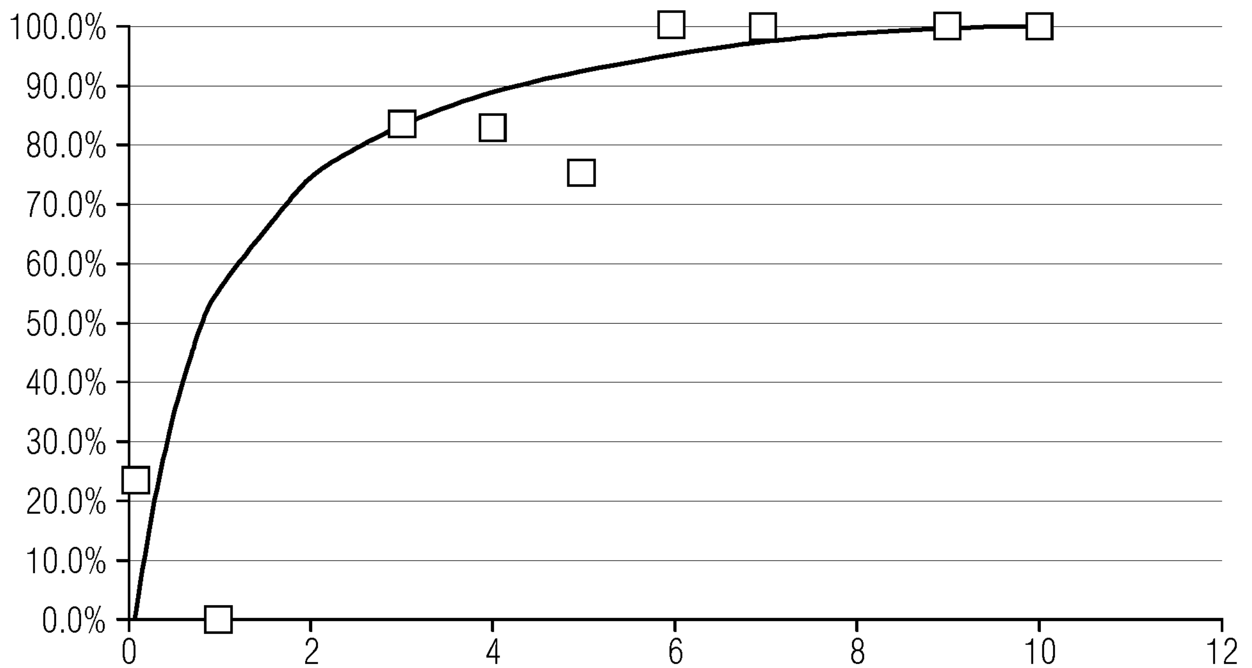

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/060775

A. CLASSIFICATION OF SUBJECT MATTER
INV. B32B43/00 B65G49/06
ADD. G02F1/13

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B32B H05K B65G G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2016/081391 A1 (CORNING INC [US]) 26 May 2016 (2016-05-26) paragraphs [0073], [0074] figures 9,10	1-8, 17-25 9-15
Y	US 2004/189195 A1 (ALLEMAND PIERRE-MARC [US]) 30 September 2004 (2004-09-30) figure 1A	9-13,15
Y	Futaba Corporation: "Structure¦Futaba Corporation", , 22 May 2015 (2015-05-22), XP055447780, Retrieved from the Internet: URL:https://web.archive.org/web/20150522054031/https://www.futaba.co.jp/en/display/vfdinfo/vinfo_kozo.html [retrieved on 2018-02-05] Second figure	9-12,14, 15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 February 2018	14/02/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bataille, Laurent

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/060775

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	& Futaba Corporation: "Structure¦Futaba Corporation", , 22 May 2015 (2015-05-22), XP055447783, Retrieved from the Internet: URL:https://www.futaba.co.jp/en/dbps_data/_material_/radicon_eng/Display_and_Module/vfd/images/vinfo_vfd02.jpg [retrieved on 2018-02-05]	
X	US 2011/308739 A1 (MCCUTCHEON JEREMY W [US] ET AL) 22 December 2011 (2011-12-22) figures 9-13	1-8, 16-25
X	US 2015/059987 A1 (KUMAKURA KAYO [JP] ET AL) 5 March 2015 (2015-03-05) figures 1,3A-3C	1-8, 16-25
X	WO 2016/141119 A1 (CORNING INC [US]) 9 September 2016 (2016-09-09) cited in the application figure 3	1-8, 16-20

3

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/060775

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2016081391 A1	26-05-2016	CN 107108132 A	29-08-2017
		EP 3221241 A1	27-09-2017
		JP 2017536699 A	07-12-2017
		KR 20170085087 A	21-07-2017
		SG 11201704065S A	29-06-2017
		TW 201628952 A	16-08-2016
		WO 2016081391 A1	26-05-2016
US 2004189195 A1	30-09-2004	US 2004189195 A1	30-09-2004
		US 2008042561 A1	21-02-2008
		US 2011284916 A1	24-11-2011
		US 2011285004 A1	24-11-2011
		US 2013089971 A1	11-04-2013
		US 2015139864 A1	21-05-2015
US 2011308739 A1	22-12-2011	AT 14714 U1	15-04-2016
		AT 510068 A2	15-01-2012
		CA 2709626 A1	21-12-2011
		CN 102290367 A	21-12-2011
		DE 102010027703 A1	22-12-2011
		EP 2398040 A1	21-12-2011
		EP 2398041 A1	21-12-2011
		IL 207044 A	30-06-2016
		JP 5111573 B2	09-01-2013
		JP 5848205 B2	27-01-2016
		JP 2012004522 A	05-01-2012
		JP 2012212939 A	01-11-2012
		KR 20110139072 A	28-12-2011
		RU 2010129938 A	27-01-2012
		SG 177039 A1	30-01-2012
		TW 201201304 A	01-01-2012
		US 2011308739 A1	22-12-2011
		WO 2011162778 A1	29-12-2011
US 2015059987 A1	05-03-2015	CN 105493631 A	13-04-2016
		JP 2015173088 A	01-10-2015
		KR 20160052587 A	12-05-2016
		TW 201524252 A	16-06-2015
		US 2015059987 A1	05-03-2015
		US 2016243812 A1	25-08-2016
		US 2017334187 A1	23-11-2017
		WO 2015029806 A1	05-03-2015
WO 2016141119 A1	09-09-2016	CN 107567384 A	09-01-2018
		EP 3265313 A1	10-01-2018
		KR 20170125868 A	15-11-2017
		SG 11201707090Y A	28-09-2017
		TW 201636221 A	16-10-2016
		WO 2016141119 A1	09-09-2016